

沟鞭藻 *Horologinella* Cookson and Eisenack 1962 的 形态学和分类学

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提要 *Horologinella* 属最初的定义包含小个体的和具特有的滴漏器形的微体化石。归到该属的不同类型可分成形态构造不同的两类: 具板式和非板式类型, 进一步证实了在 *Horologinella* 属的分类上颇混乱的情形。在本组合中, 具板式类型极少见, 与这类孢粉类型有关的形态学、地层分布及古环境特征的资料非常少见。文中描述了中西伯利亚北部阿纳巴尔湾早白垩世的 *H. anabarensis* Pestchevitskaya 的许多保存良好的标本, 利用这些保存良好的标本可以研究 *Horologinella* 类型的详细板式形态。前、后腰区和顶区的反映板式及第一块顶板片的对应位置和反映纵沟的构造, 说明 *Horologinella* 具板式的类型与膝沟藻目的沟鞭藻囊胞, 尤其是与瑞提膝沟藻亚目的分子有很密切的关系。古生物学和孢粉学的资料显示 *H. anabarensis* 和有利于微体浮游植物组合发育的浅海环境有关。

关键词 沟鞭藻 白垩纪 西北利亚

TAXONOMY AND MORPHOLOGY OF DINOFLAGELLATE CYST GENUS *HOROLOGINELLA* COOKSON AND EISENACK 1962

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Abstract Following the original definition the genus *Horologinella* includes the microfossils of small size and specific hour-glass shape. Various types assigned to this genus can be divided into two groups of sufficiently different morphology: tabulated and nontabulated forms, that confirms rather confusion situation withing the taxonomy of genus *Horologinella*. Tabulated *Horologinella* forms have been extremely rare observed in palynological assemblages and a little information is available concerning the morphology, stratigraphic range and palaeoenvironmental characteristic of these palynomorphs. A good preservation of numerous specimens of species *H. anabarensis* Pestchevitskaya 2001, described from Lower Cretaceous sediments of Anabar Bay section (North of Middle Siberia), allows to investigate the morphology of tabulated *Horologinella* forms in details. The paratabulation pattern of precingular, postcingular and apical series as well as configuration of first apical homologue and parasulcal structure suggest that tabulated forms of *Horologinella* have close affinities to gonyaulacalean dinoflagellate cysts, especially to members of suborder Rhaetogonyaulacaceae. Paleontological and palynological data evidence that *H. anabarensis* is associated with shallow marine environments favorable for the development of rather rich microphytoplankton assemblage.

Key words Dinoflagellate, Cretaceous, Siberia

INTRODUCTION

This paper represents the results of preliminary investigations on genus *Horologinella*, especially of tabulated

forms, concerning its morphology, taxonomy, systematic affinities and palaeoenvironmental applications. This genus consists of 18 species from different stratigraphic levels including small microfossils of specific hour-glass shape.

The comparative analysis revealed that this genus contains two groups of sufficiently different morphology: tabulated and nontabulated forms. *Horologinella* forms of nontabulated group are rather widespread, while tabulated group includes the type species *Horologinella lineata* Cookson and Eisenack 1962 only, which has not been later observed in palynological assemblages. The tabulated species *Horologinella anabarensis* Pestchevitskaya 2001 was described from Valanginian deposits of the Anabar region (North of Middle Siberia) (Text-fig. 1; Pestchevitskaya, 2001). Detailed morphological study of well preserved *H. anabarensis* specimens revealed some interesting features of their sculpture, paratabulation pattern and archeopyle type as well as nature and relationships of wall layers. New information on morphology of *Horologinella* tabulated forms allows to discuss their systematic affinities.

PREVIOUS RESEARCHES ON GENUS *HOROLOGINELLA*

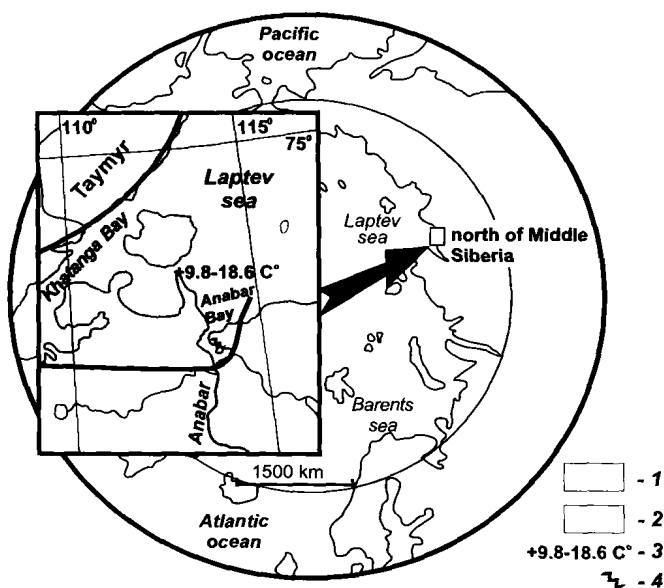
Genus *Horologinella* was erected by Cookson and Eisenack (1962), describing five new species from Cretaceous (probably Aptian-Albian) sediments of Western Australia (Pl. II, figs. 8-9). It was erected purely as a form genus without implication of any systematic affinities. They regarded the described specimens as microphytoplankton of uncertain systematic attribution.

Generic diagnosis was mainly based on the resemblance of general appearance of the microfossils, not drawing special attention to some morphological peculiarities, such as the structure and relationships of wall layers or the presence of paratabulation, which are now considered as the valuable diagnostic features.

The type species *H. lineata* exhibits some morphological features, which are characteristic for dinoflagellate cysts (dinocysts). The presence of reflected tabulation is clearly indicated by parasutural ridges (Pl. II, figs. 8, 9). The wall consists of two layers, the periphragm and ectophragm supported by small processes, clearly visible at the cyst margins, although Cookson and Eisenack described the shell as consists of one layer. The presence of archeopyle is indicated by an angular outline of the opening, although the details of the reflected apical plate series are difficult to distinguish. Four other species exhibit the same shape being more or less symmetrical about a vertical medial line and having a strong equatorial constriction, but they lack of specific dinocyst characters, first of all paratabulation. These species show an "apical" opening but with no indications of a relation to reflected paratabulation (Pl. II, figs. 4-7).

The species described later can be divided into the same two groups, tabulated and nontabulated forms. The former exhibit some affinities to dinocysts and the latter with unknown nature. The nontabular features of most species of nontabulated group have been observed by many palynologists (Cookson, 1965; De Coninck, 1986; He Chenquan 1984, 1991; Jardine *et al.*, 1972; Jiabo, 1978; Martin, 1984; Staplin, 1960; Zhang Lujin, 1984). This group is rather heterogeneous (Pl. II, figs. 11-18). Most of the species are characterized by specific hour-glass shape, which is the distinctive feature of this genus. However a number of species (*H. corrugata* de Coninck, *H. extrema* Cookson and Eisenack, *H. obliqua* Cookson and Eisenack, *H. spinosa* Cookson, *H. wicanderi* Martin, *H. sichuanensis* Zhang) were questionably assigned to the genus *Horologinella*, as they do not completely satisfy the requirements of the generic diagnosis, varying in shape or in wall structure (Pl. II, figs. 4, 7, 11, 14, 18).

It should be noted, that possible natural affinities of the individual forms assigned to genus *Horologinella* are rarely discussed in the publications. Species of *Horologinella* are usually described as acritarchs. Never-



Text-fig. 1 The location of the Valanginian outcrope on the eastern side of the Anabar Bay
1. Middle sublitoral; 2. Upper sublitoral; 3. Palaeotemperatures, (Zakharov and Yudovny, 1974); 4. Valanginian outcrope

Substage	Biostratigraphic subdivision of Lower Valanginian of the North Middle Siberia				
	Ammonite zones (Shenfil, 1992; Bokova, Ivanova, 1991; Zakharov et. al., 1997)	Belemnite zones	Bivalve zones	Forams zones	Dinocysts zones
LOWER VALANGINIAN	<i>Beani</i>	<i>Cylindroteuthis harabyllensis</i>	<i>Buchia keyserlingi</i>	<i>Cribrostomoides infracretaceous</i>	<i>Aldorfia sp.A.</i>
	<i>Ramulicosta</i>				
	<i>Astieriptychus</i>	<i>Acroteuthis chetae</i>	<i>Buchia inflata</i>	<i>Valanginella tatarica</i>	<i>Dingodinium spp.-</i> <i>Trichodinium speetonese</i>
	<i>Quadrifidus</i>				
	<i>Klimovskiensis</i>				<i>Pareodinia spp.</i>

Text-fig. 2 Lower Valanginian zonal scales for the northern regions of Middle Siberia

theless one of the nontabulated species, *H. horologia* (Playford) Jardine was originally described as an angiospermous taxon *Tetraporina horologia* Naumova (1950). Subsequently Playford (1963) discussed possible algal affinity of these palynomorphs noting their close superficial resemblance to some green algae and aplanospores. The assignment of *Tetraporina horologia* to genus *Horologinella* was caused by its remarkable morphological similarity to some nontabulated *Horologinella* forms.

De Coninck (1986) regarded genus *Horologinella* as a dinocyst taxon apparently taking into consideration the morphology of type species *H. lineata*. He noted the existence of both peri- and endophragms in *H. lineata*, and transferred the questionable species *H. spinosa* to a new acritarch genus *Paucilobimorpha* de Coninck (1986) because of it lacks of any indication of tabulation and single-layered structure with specific spinate ornamentation on its surface. Later Prossl (1994) gave new emendation to *Paucilobimorpha*, and considered *Tritonites* Marshall and Partridge 1988 as its junior synonym. He proposed a new combination for another three species of *Horologinella* (*H. extrema*, *H. apiculata*, *H. incurvata*), assigning them to genus *Paucilobimorpha*.

Stover and Evitt (1978) regarded only the type species, *H. lineata*, as a dinocyst. Nevertheless, one more species with distinct dinocyst characters, *H. spinosigiberrosa* was described by Brideaux and Fisher (1976). The species is distinguished in bearing short apiculate processes densely connected and arranged along parasutures to form parasutural ridges (Pl. II, figs. 2, 3). Although Brideaux and Fisher proposed its paratabulation as ?4", 5"-6", 0c, 5", 0" they did not satisfied with their interpretation because apex and antapex are free of processes making impossible the precise determination of paraplates shape and number in these

areas. They analysed the figured specimens of *H. lineata* and suggested the probable paratabulation formula for this species as ?4", 5"-?6", 0c, 6", ?1p, ?1", noting that apical paraplate series and the presence of paraplates 6", 1p and 1" are difficult to confirm. They also believed, that genus *Horologinella* contains forms of various morphology, and future investigations will lead to a new combination of this genus. Subsequently Backhouse (1988) transferred *H. spinosigiberrosa* to his new genus *Tetrachacysta* on the basis of some characters of paratabulation, archeopyle type and wall sculpture.

It should be stressed, that the majority of *Horologinella* species lack the morphological features evidenced their dinocyst affinities, with some of them being transferred to acritarchs (Fensome *et al.*, 1990; Williams *et al.*, 1998), as the type species *H. lineata* exhibits distinct dinocyst characters.

This short review shows rather confusion situation within the taxonomy of genus *Horologinella* and the necessity of its revision. It seems logical and valid that the type species provides sufficient details for the characterization of the genus. Following this principle, genus *Horologinella* should be restricted so as to contain species with morphological features closely related to those of its type species *H. lineata*. It means that genus *Horologinella* should include the tabulated forms only. Other species assigned to this genus require different generic combination.

DETAILED MORPHOLOGY AND SYSTEMATIC AFFINITIES OF *HOROLOGINELLA* TABULATED FORMS

During the palynological investigation of Lower Cretaceous sediments from the Anabar Bay section (North of Middle Siberia, Text-fig. 1a), new species *H. anabarensis* Pestchevitskaya provided more information on the morphology of the genus (Pestchevitskaya, 2001). The stratigraphy

of Anabar Bay section is based on macrofauna, foraminifera and dinoflagellate cyst assemblages (Saks *et al.*, 1963; Bogomolov *et al.*, 1983; Bogomolov, 1989, Pestchevitskaya, 2000). Four ammonite zones and three dinocyst zones were recognized in the section (Text-fig. 2). Numerous *Horologinella* specimens of good preservation were recovered from the most abundant microphytoplankton assemblage yielded from the calcareous layers within the *Euryptychites astierptychus* ammonite zone.

Their morphology is rather specific. Being hour-glass shaped with narrow equatorial constriction, that is characteristic for genus *Horologinella*, *H. anabarensis* is distinguished in having epicyst remarkably smaller than hypocyst and higher parasutural ridges (Pl. I, figs. 1, 7). The visible double-lined contour suggests the wall consisting of two closely appressed layers, autophragm and ectophragm (Pl. II, fig. 10). Autophragm is rather thick, smooth or scabrate within the areas of paraplates. Along the margins of the paraplates it bears short bifurcate parasutural processes, which are covered by a thin smooth ectophragm, that allows to suggest the cyst is suturocavate. The same double line outlined the cyst is visible on *H. lineata* figured specimens (Pl. II, figs. 8, 9). In previous descriptions an autophragm only was suggested for tabulated *Horologinella* forms, and double line outlined the cyst was interpreted as the ridges indicating the reflected tabulation. But if so the processes formed the parasutural ridges would be clearly observed through the scanning electron microscope.

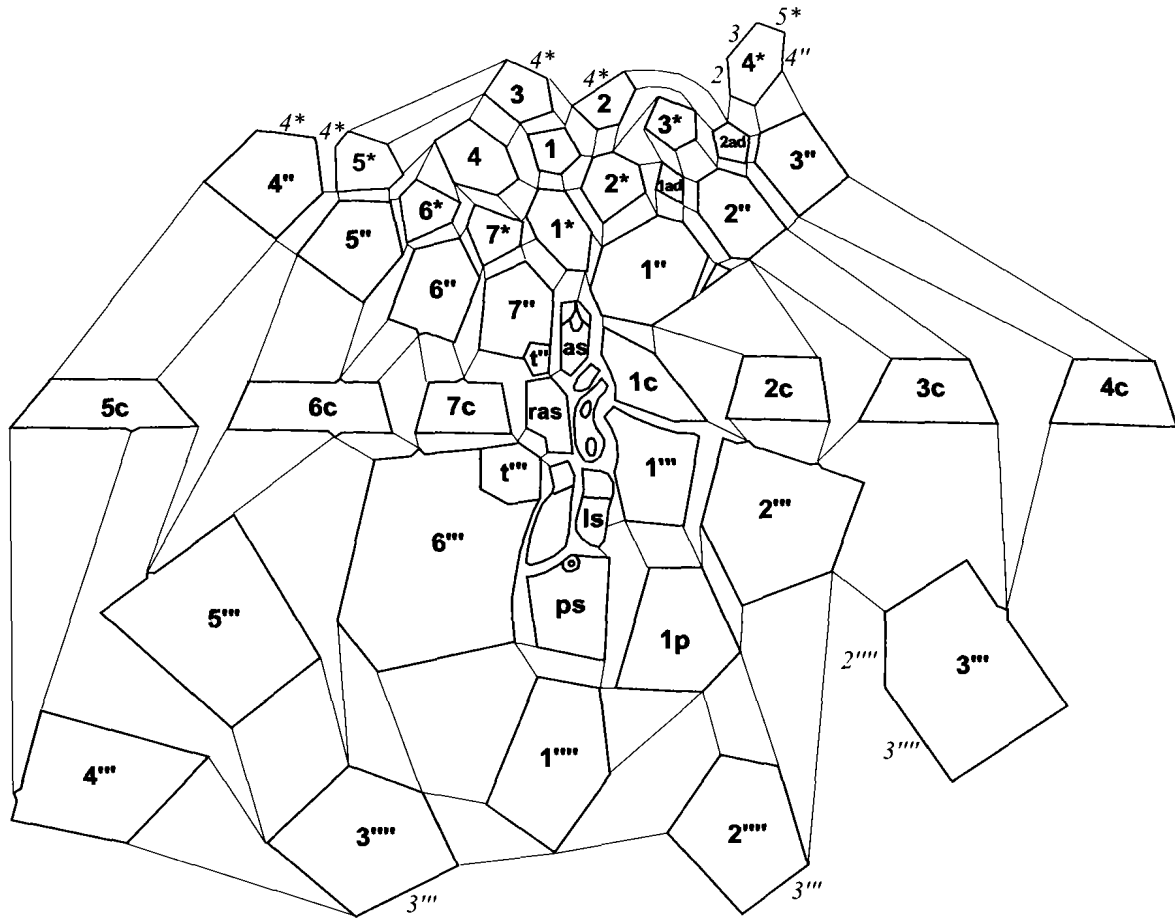
Paratabulation of *H. anabarensis* is distinctly indicated by parasutural ridges, which consist of rather densely situated bifurcate processes, covered by ectophragm defining the large paraplates. Smaller paraplates are faintly evidenced by parasutural features of low relief. Kofoid formula of paratabulation: 13'?, 7', 7c, 5s, 6', 1-2p?, 3' (Text-fig.3). It is interesting to note, that the same position and shape of three first postcingular paraplates (1', 2', 3') as well as posterior paraplate (1p) for both *H. anabarensis* and *H. lineata*, that may suggest the similar paratabulation pattern of hypocyst for these two species. Dorsal and ventral views (Pl. I, figs. 1, 2, 5-7) confirm the paratabulation scheme of precingular and postcingular series, although a number of posterior paraplates are questionable. Posterior paraplate (1p) shows constant position and configuration. But some-

times on the left of this paraplate, an additional paraplate (2p?), contacting the second and third postcingular paraplates, has been observed (Pl. I, fig. 2). An adequate interpretation of this paraplate is problematic and requires more investigations. On some specimens two small additional paraplates are visible on the right of parasulcal area: one in the precingular series and one in the postcingular series (Pl. I, fig. 1). They may be interpreted as transitional precingular (t'') and transitional postcingular (t') paraplates accordingly.

An antapical view illustrates the position and shape of fundital paraplates, and confirms the number of antapical paraplates (Pl. I, fig.3). Paracingulum is slightly laevorotatory and is indicated by conspicuous equatorial constriction. Seven cingular paraplates are delimited by fine parasutural features of low relief. Parasulcal area is rather wide (Pl. I, fig. 1) and comprises five sulcal paraplates, as, ras, rs, ls, ps. Tear-drop-shaped flagellar pore complex is clearly visible on some specimens. Sometimes fine features delimit two small paraplates within the area of anterior sulcal paraplate as well as divide right and left sulcal paraplates into two parts. On some specimens two additional pores can be observed: one at the boundary of anterior sulcal paraplate with first apical homologue and other at the boundary of right, left and posterior sulcal paraplates (Pl. II, fig. 1).

The detailed paratabulation pattern of climactal series is questionable and difficult to examine due to small size of cysts and rarely observations of apical view. Some of the climactal paraplates are visible on the dorsal and ventral views of the cyst (Pl. I, figs. 1, 2, 4, 5). These paraplates are shaded and delimited by continuous lines in the reconstruction scheme. But, the position and configuration of other dorsal climactal paraplates are problematic and delimited by dashed lines and are not shaded (Text-fig.4). The notation used herein to describe the paratabulation of climactal series is informal. The asterisks denote the paraplates contacting the precingular series. The paraplates contacting the apical pore complex are marked with numbers without any labels. It is possible that there are additional paraplates between apical and precingular series, which are suggested in some specimens by the shape of paraplates 2*, 3*, 4* and by the position of parasutural features (Pl. I, figs. 2, 5). Thus, it should be stressed, that for the reconstruction of complete paratabulation pattern of climactal area, more investigations are needed.

The archeopyle is detached and probably formed by



Text-fig.3 Exploded diagram of the paratabulation pattern of *Horologinella anabarensis*

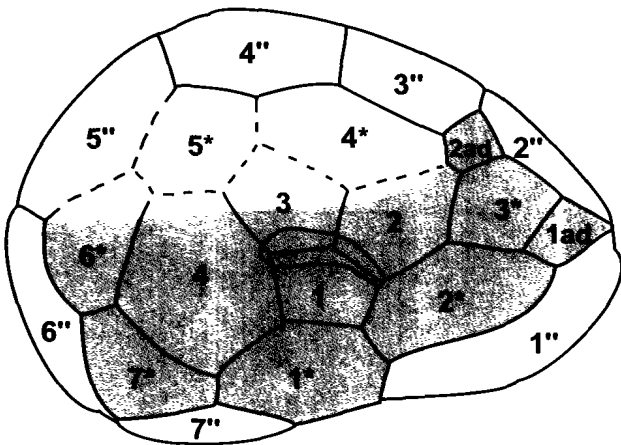
1. Problematic paraplates are delimited by dashed lines and are not shaded.
2. The asterisks denote the paraplates, which contact the precingular series. 3. The paraplates contacting the apical pore complex are denoted with numbers without any labels. 4. The contacts with adjacent paraplates are denoted with the numbers in Italik.

the lost of all paraplates of climactal series, being removed as an operculum of apical type (Pl. I, fig. 7). If so it consists of 13 apical paraplates, but a different combination of climactal paraplates is possible due to a probable variation

of the plate arrangement.

The combination of very peculiar shape, wall structure and paratabulation pattern makes the tabulated forms of *Horologinella* outstanding against other dinoflagellates. Stover and Evitt (1978) in the description of this genus noted, that no similar forms are known among dinoflagellates.

The specific features of paratabulation pattern suggest the relation of tabulated forms of *Horologinella* being related to gonyaulacaleans according the conception proposed by Fensome *et al.* (1993). Gonyaulacalean paratabulation pattern typically consists of six precingular and six postcingular paraplates (Text-fig. 5). The same pattern has been observed for *H. anabarensis* specimens. An asymmetrical configuration of the first apical homologue also confirms the relation of tabulated forms of *Horologinella* to gonyaulacalean dinocysts. Sulcal flagellar pore complex, which is immediately posterior to the anterior sulcal paraplate (as) and not contacts the posterior



Text-fig.4 Paratabulation pattern of climactal area
Informal notation is explained in fig. 3

sulcal paraplate (ps), is a characteristic feature of order Gonyaulacales. *Horologinella* possesses a specific right accessory sulcal paraplate (ras) posterior to the anterior sulcal paraplate (as), which is lack in peridinialean. The paratabulation pattern of apical and antapical areas of *H. anabarensis* suggests, that tabulated forms of *Horologinella* are related more closely to Rhaetogonyaulacineans dinocysts, which possess more than five climactal paraplates and at least three fundital paraplates, of which dorsalmost does not contact the distalmost postcingular paraplate (Text-fig. 6).

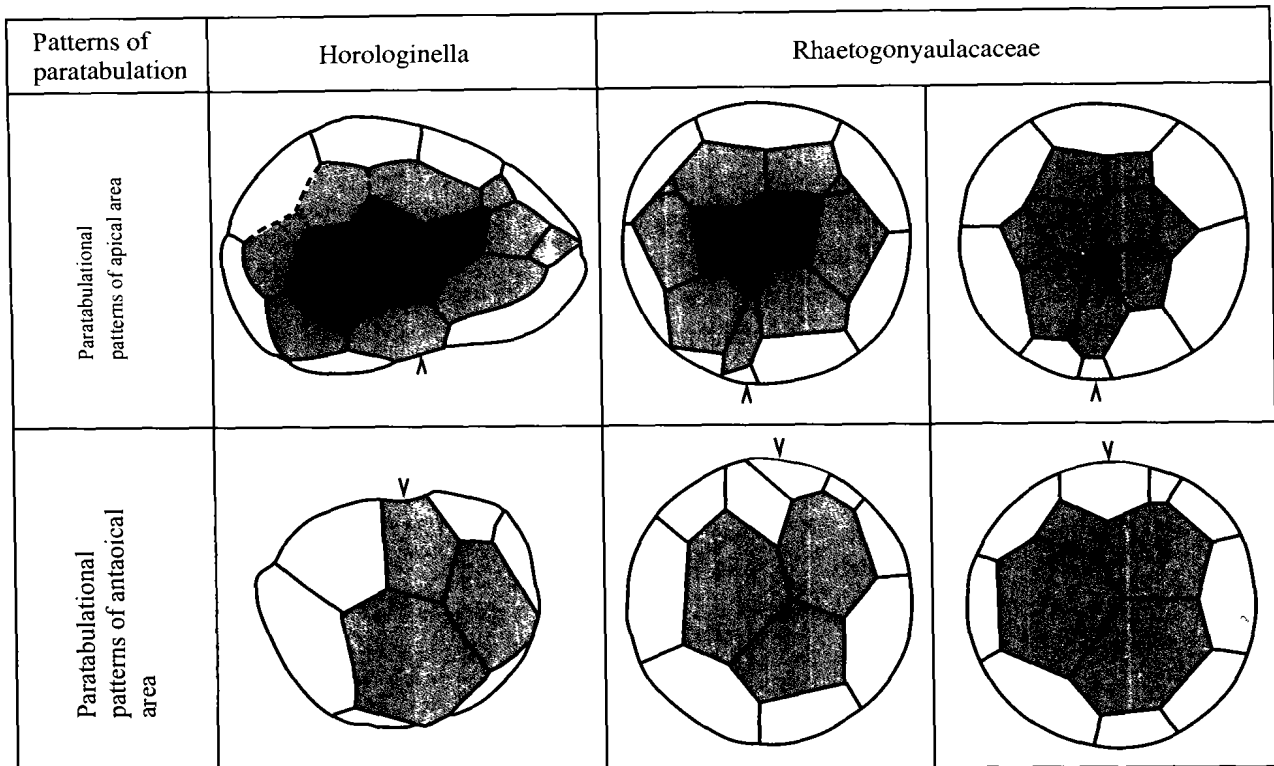
PALAEOECOLOGY OF HOROLOGINELLA

Tabulated species of *Horologinella* have been described from different stratigraphic levels (Lower Valanginian and Aptian-Albian), but they are extremely rare in palynological assemblages. Thus, the data available are not enough to estimate their real stratigraphic ranges and potential.

Tabulated forms of *Horologinella* seem to appear for short periods of geological time and reflect some specific palaeoenvironments. In that case they may provide a detailed facial information. Unfortunately, the palaeoenvironments, in which these dinocysts were yielded, have not been described in the publications. There has been so far no mention of paleoecology of tabulated *Horologinella* in publications. Fortunately, comprehensive geological investigations of Lower Cretaceous sediments of the Anabar Bay section (Zakharov and Yudovny, 1974) provided detailed information on palaeoenvironments of Anabar area, which help us to elucidate paleoecology of *Horologinella*. Palaeoenvironmental investigations of the Anabar Bay section dealt with detailed lithofacial and geochemical analyses, paleontological and taphonomical studies as well as estimation of palaeotemperatures, palaeodepth and palaeosalinity. The results suggest that this region was under environment of shallow marine basin of a normal salinity with average temperatures of 15-18 °C during Lower Valanginian.

Specific paratabulation features	Horologinella	Gonyaulacales	Peridinales
Typical configuration of the first apical paraplate			
Typical arrangement of sulcal paraplates and their relationships with flagellar pore			
Position of transitional cingular/sulcal paraplate			

Text-fig. 5 A comparison of specific paratabulation features of *Horologinella* tabulated forms, Gonyaulacales and Peridinales
Comments: Paratabulation patterns of Gonyaulacales and Peridinales are based on Fensome *et al.* (1993).



Text-fig. 6 A comparison of paratabulation patterns of apical and antapical areas for *Horologinella* tabulated forms and Rhaetogonyaulacaceae
Comments: Paratabulation pattern of Rhaetogonyaulacaceae is based on Fensome *et al.* (1993)

H. anabarensis is associated with rather rich microphytoplankton assemblage including abundant acanthomorph acritarchs, diverse dinocysts and green algae (Pestchevitskaya, 2000). Dinocysts are dominated by holocavate *Dingodinium-Chlamydomorphella* group, *Cleistosphaeridium* spp. and *Escharisphaeridia-Sentusidinium* group, which are considered as an indicative feature of shallow marine environments, possibly somewhat distant from the coast (Lebedeva and Nikitenko, 1998). Chorate dinocysts are rather barren and include 3 genera only: *Cleistosphaeridium* spp., *Oligosphaeridium* spp., *Spiniferites* spp. Various acritarchs are represented by species of *Micrhystridium*, *Solisphaeridium*, *Polygonium*, *Veryhachium*. Prasinophytes comprise rare *Cymatiosphaera* spp., *Pterospermella* spp. and numerous *Leiosphaeridia* spp. Abundant *Leiosphaeridia* spp. and acritarchs may be considered as an evidence of shallow water inshore environments.

The microphytoplankton assemblage containing *H. anabarensis* was recovered from calcareous layers and is much richer than those from terrigenous sediments. The latter are dominated by *Leiosphaeridia* group whereas the former by acanthomorph acritarchs. It is known that calcareous deposits, in comparison with terrigenous ones,

are formed under higher temperatures (Golbert, 1987). Apparently such conditions are favorable for microphytoplankton development, which is confirmed by diverse and rather rich microphytoplankton assemblage revealed from calcareous deposits. Thus, it may be suggested, that *H. anabarensis* is associated with somewhat warmer temperature conditions, than it is reconstructed for Early Valanginian of the Anabar palaeobasin in general.

CONCLUSIONS

The present investigation of *H. anabarensis* provides more information on morphology of tabulated *Horologinella* and its detailed paratabulation. The specific features of paratabulation pattern of *H. anabarensis* suggest that the affinities of tabulated forms of *Horologinella* to gonyaulacalean dinoflagellates, especially to members of suborder Rhaetogonyaulacaceae. Detailed paleontological, paleoecological and palynological investigations of Lower Valanginian deposits of the Anabar Bay section indicate that *H. anabarensis* is associated with shallow marine environments of a normal salinity, with average temperatures somewhat higher than 15-18 °C. The palaeoenvironments

was favorable for the development of rather rich microphytoplankton assemblage including predominant acanthomorph acritarchs as well as diverse dinocysts and green algae.

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EXPLANATIONS OF PLATES

Plate I

1-7. *Horologinella anabarensis* Pestchevitskaya, eastern side of the Anabar Bay, section 1A, layer 12, calcareous layer, Lower Valanginian, ammonite zone *Euryptychites astieriptychus*.

1a. Holotype, ventral position, apex, slide 18.1/ No.26, light microscope Biolam R-17, x 1300.

1b. A scheme of paratabulation of the specimen represented on the fig. 1a.

2a. Dorsal position, scanning electron microscope, JSM-35, x 1500.

2b. A scheme of paratabulation of the specimen represented on the fig. 2a.

3a. Antapical position, scanning electron microscope, JSM-35, x 1500.

3b. A scheme of paratabulation of the specimen represented on the fig. 3a.

4a. Ventral position, apex, slide 18.1/ No.27, light microscope Biolam R-17, x 1100.

4b. A scheme of paratabulation of the specimen represented on the fig. 4a.

5a. Dorsal position, scanning electron microscope, JSM-35, x 1600.

5b. A scheme of paratabulation of the specimen represented on the fig. 5a.

6. Ventral position, slide 18.1/ No.2/2, light microscope Biolam P-17, x 850.

7a. Dorsal position, archeopyle, slide 18.1/ No.2/1, light microscope Biolam P-17, x 1200.

7b. A scheme of paratabulation of the specimen represented on the fig. 7a.

Plate II

Comments: Arrows in fig. 2 indicate the additional sulcal pores.

1a. *Horologinella anabarensis* Pestchevitskaya, 2001, ventral position, sulcus, scanning electron microscope, JSM-35, x1300, eastern side of the Anabar Bay, section 1A, layer 12, calcareous layer, Lower Valanginian, ammonite zone *Euryptychites astieriptychus*.

1b. A scheme of paratabulation of the specimen represented on the fig. 16a.

2. *Horologinella spinosigibberosa* Brideaux and Fisher, 1976, p.22-24, Pl. 5, fig. 10, x1250, Arctic Canada, Husky and Mould Bay formations, Late Oxfordian-Upper Kimmeridgian.

3. *Horologinella spinosigibberosa* Brideaux and Fisher, 1976, p.22-24, Pl. 5, fig. 6, holotype, x900, Arctic Canada, Husky and Mould Bay formations, Late Oxfordian-Upper Kimmeridgian.

4. *Horologinella ? extrema* Cookson and Eisenack, 1962, p. 272, pl. 37, fig. 10, x 500, holotype, Western Australia, Perth region, Aptian-Albian.

5. *Horologinella incurvata* Cookson and Eisenack, 1962, p. 272, pl. 37, fig. 5, x 750, holotype, Western Australia, Perth region, Aptian-Albian.

6. *Horologinella apiculata* Cookson and Eisenack, 1962, p. 272, pl. 37, fig. 4, x 600, holotype, Western Australia, Perth region, Aptian-Albian.

7. *Horologinella obliqua* Cookson and Eisenack, 1962, p. 272, pl. 37, fig. 9, x 400, holotype, Western Australia, Perth region, Aptian-Albian.

8. *Horologinella lineata* Cookson and Eisenack, 1962, p. 272, pl. 37, fig. 3, x 1000, holotype, Western Australia, Perth region, Aptian-Albian.

9. *Horologinella lineata* Cookson and Eisenack, 1962, p. 272, pl. 37, fig. 1, x 1000, holotype, Western Australia, Perth region, Aptian-Albian.

10. *Horologinella anabarensis* Pestchevitskaya, 2001, dorsal position, slide 18.1/ No.28, light microscope Biolam P-17, x 1200, eastern side of the Anabar Bay, section 1A, layer 12, calcareous layer, Lower Valanginian, ammonite zone *Euryptychites astieriptychus*.

11. *Horologinella? wicanderi* Martin, 1984, p. 22-23, pl. 4, fig.4, x 1000, holotype, Ardenne Belge, Bassin de Dinant, Lower Famenian.

12. *Horologinella micirugis* He, 1984, p.163, pl. 10, fig. 14, x 600, holotype, China, Beibu Gulf, Yongning Group, Oligocene-Early Miocene.

13. *Horologinella disparilis* He, 1984, p. 162-163, pl. 8, fig. 22, x 600, holotype, China, Beibu Gulf, Yongning Group, Oligocene-Early Miocene.

14. *Horologinella? spinosa* Cookson, 1965, p. 89, Pl. 10, fig. 11, holotype, South-Eastern Australia, Victoria, Upper Eocene, Brown's Greek Clays, sand, clay and gritty clay.

15. *Horologinella scabrosa* He, 1984, p. 162, pl. 8, fig 20, x600, holotype, China, Beibu Gulf, Yongning Group, Oligocene-Early Miocene.

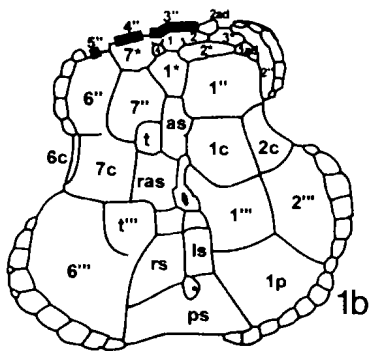
16. *Horologinella horologia* (Staplin) Jardine, in Playford, 1963, p. 658-659, Pl. 95, fig. 15, x 500, Spitsbergen, Billefjorden Sandstones, Lower Carboniferous, Mississippian.

17. *Horologinella tenuissima* He, 1991, p. 52, pl. 5, fig 10, x 600, holotype, China, Western Tarim, Lower Member of Qimugen Formation, Palaeocene.

18. *Horologinella? corrugata* de Coninck, 1986, p. 13, pl. 3, fig. 14, x 500, Southern Netherlands, Upper Eocene, Sands of Asse.



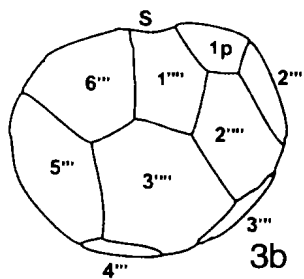
1a



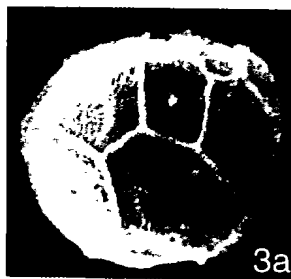
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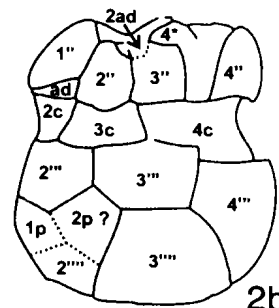
2a



3b



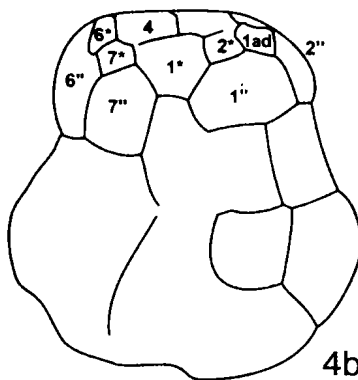
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2b



5a



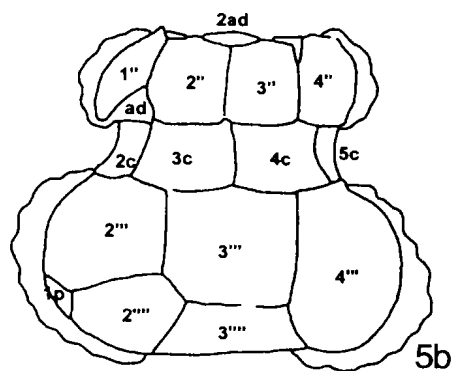
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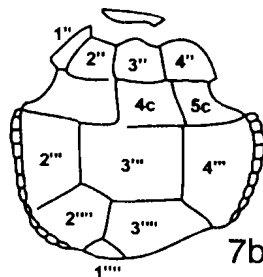
4a



6



5b



7b



7a

