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Late Carboniferous Assemblages of Schwagerinids (Foraminifera, Schwagerinida) in Two Types of Organogenic Structures of the Central Urals

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Abstract—Two types of organogenic structures of the Central Uralian Melekhov Horizon (Gzhelian Stage, Upper Carboniferous) contain essentially different schwagerinid assemblages. Owing to the diversity of its surface biotopes, the algal-palaeoaplysinal biohermal massif is characterized by a diversity of genera and ecological groups (nine and three, respectively). The biostromal palaeoaplysinal massif contains a less diverse schwagerinid assemblage (five genera and one ecological group), which formed in uniform biotic and abiotic environments of the massif's smooth surface.

INTRODUCTION

In modern paleontological studies, a particular significance is attached to the comprehensive ecological characterization of a fossil group. Analysis of the group should reveal the character of the dependence of the group on various abiotic factors, its biological affinities, and the position and role in ancient ecosystems. Paleoecological studies of orthostratigarphic groups are of great importance, because they present possible errors in biostratigraphic subdivision and correlation of different-facies sections.

This article presents results of the analysis of an interesting aspect of schwagerinid ecology on the basis of materials derived from the Kos'va River sections (the Central Urals). Two different types of organogenic structures of the Melekhov Horizon (the fusulinid *Daixina bosbytauensis–Globifusulina robusta* Zone, Gzhelian Stage, Upper Carboniferous)[1] that appear to be characterized by noticeably different schwagerinid assemblages. The taxonomic composition of the assemblages was controlled by a set of biotic and abiotic factors that was specific for each type of organogenic structures.

MATERIAL

The work is mainly based on my collections of 1996–1999. In addition, the large collection of oriented sections of Yu.A. Echlakov (Kama Research Institute of Integrated Investigations of Deep and Superdeep Wells, Perm) and thin sections from the Polenov Museum of Paleontology and Historical Geology of the Regional Geology Department of Perm State University are used. About 300 slides for each type of organogenic structures were examined.

THE MELEKHOV ORGANOGENIC STRUCTURES ON THE KOS'VA RIVER

The Melekhov Horizon crops out in the Mal'tsevka, Kholodnyi Log, Ostanets, Nizhnyaya Gubakha, and Belaya Gora sections along the Kos'va River in the Gubakha Mountain area (*Mezhdunarodnyi* ..., 1991; Vilesov, 2000). In all sections, except for Mal'tsevka, the horizon is composed of limestones containing abundant schwagerinids. In the Perm Urals–Cis–Urals region, the stratigraphic distribution of fusulinids in the Melekhov Horizon indicates the existence of two fusulinid zones: *Occidentoschwagerina ancestralis* in the lower part of the horizon and *Occidentoschwagerina konovalovae* in the upper part (Vilesov, 2000). The upper fusulinid zone is well exposed in all Kos'va sections. We refer to this part of the Melekhov Horizon to establish more accurate correlations.

The Kholodnyi Log section is located on the right bank of the Kos'va River, 5 km upstream from the Nizhnyaya Gubakha railroad station (Fig. 1). The Melekhov Horizon of the section is mostly composed of light-colored massive-to-bedded limestones, which form along the strike a chain of bun-shaped organogenic structures—bioherms (Fig. 2a; the bed-by-bed description of the section is given in *Mezhdunarodnyi* ..., 1991; Vilesov, 2000). The bioherms are from 60 to 100 m long and up to 11–13.5 m thick, corresponding in range to the upper fusulinid zone of the Melekhov Horizon. Interbiohermal bedded facies are covered by turf in the Kholodnyi Log section but are

[1] The Melekhov Horizon was introduced into the Upper Carboniferous stratigraphic scale for the Russian platform in 1994 (Makhlina and Isakova, 1997). In my opinion, this unit can be also used in the regional stratigraphic schemes of the Urals (Vilesov, 1999).

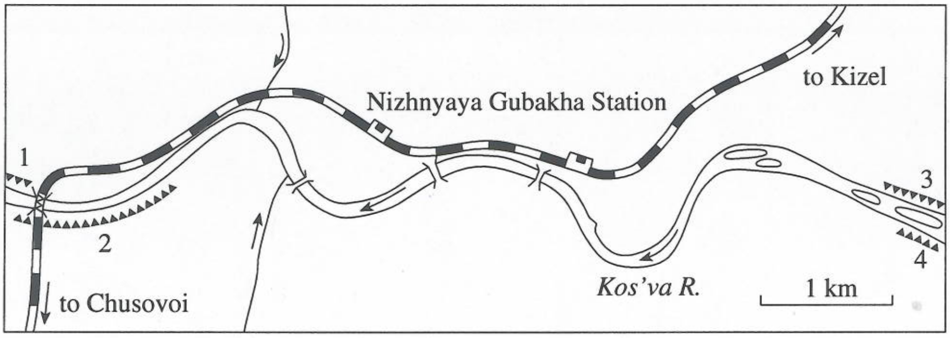

Fig. 1. Location of the sections: (1) Belaya Gora, (2) Nizhnyaya Gubakha, (3) Kholodnyi Log, and (4) Ostanets.

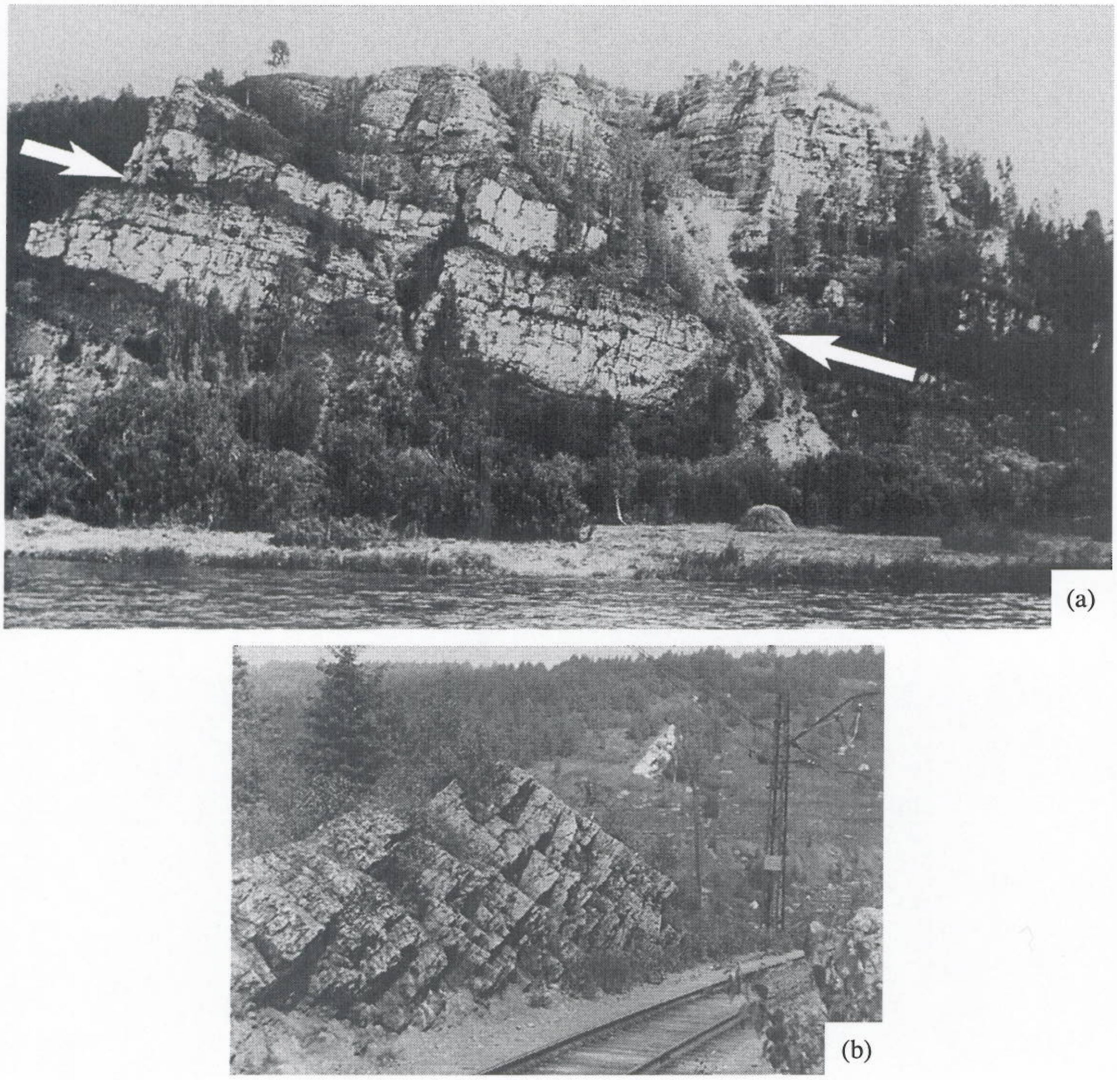

Fig. 2. The Melekhovo organogenic structures in the Kos'va River sections. (a) Fragment of the biohermal massif of the Kholodnyi Log section. The massive-bedded biohermal limestones of the Melekhov Horizon occur below the Carboniferous–Permian boundary indicated by arrows. The maximal height of the cliffs from the water edge is 120 m. The photograph was made from the Kos'va left bank at the Ostanets section; (b) palaeoaplysinal biostrome of the Nizhnyaya Gubakha and Belaya Gora sections (a fragment of the biostrome of the Nizhnyaya Gubakha section in the railroad cutting is seen in the foreground; a fragment of the same organogenic structure of the Belaya Gora section can be seen on the Kos'va right bank in the background).

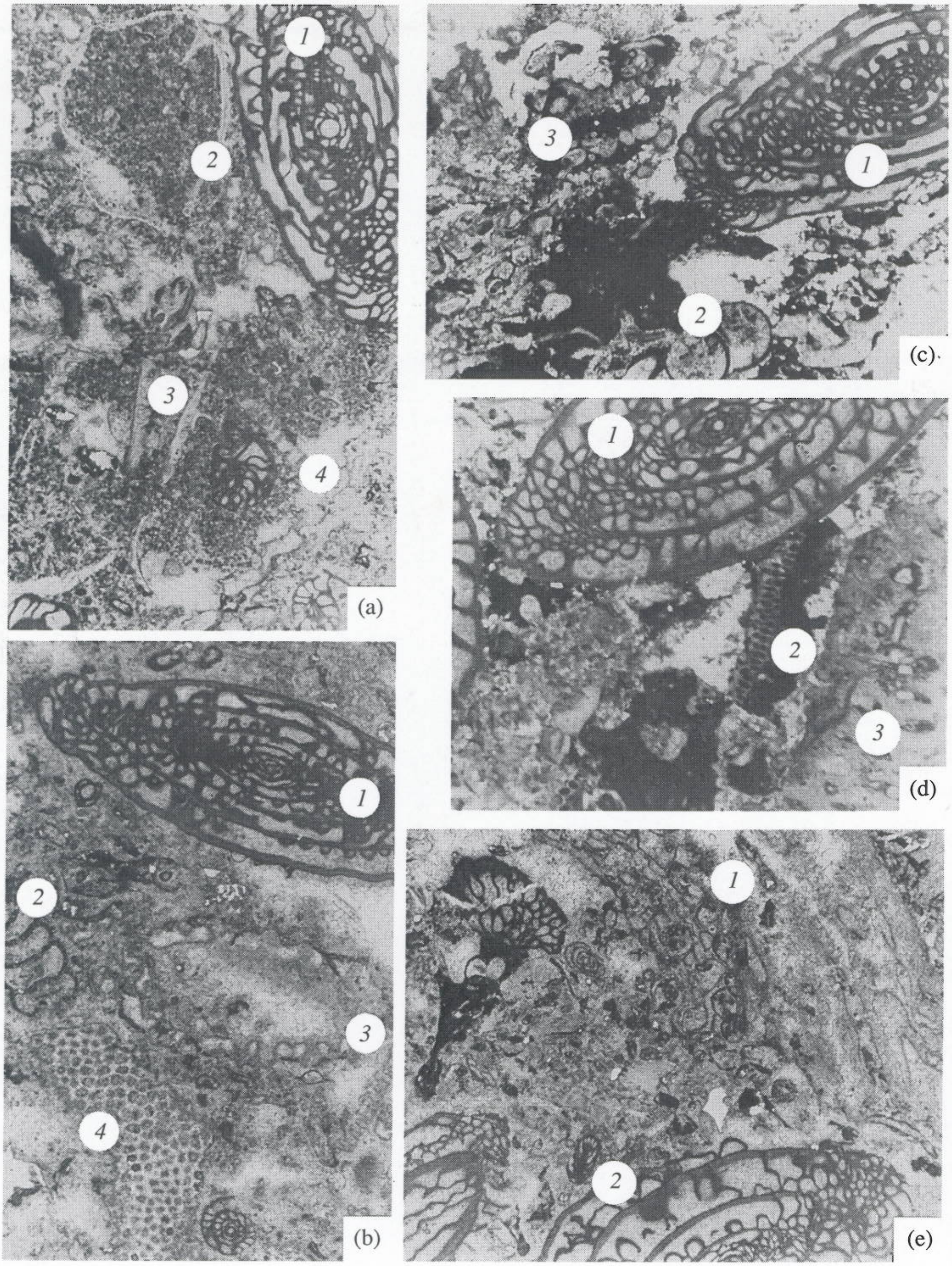

Fig. 3. The Melekhov biohermal limestones of the Kholodnyi Log section. (a) Foraminiferal–algal limestone, Bed 3, thin section no. 24-3-3/11: (*1*) oblique section of the *Rugosofusulina aktjubensis* Rauser test, (*2*) section of a brachiopod test, (*3*) skeletal fragments of bryozoans of the Fenestellida order, (*4*) fragment of algal body of *Epimastopora* sp., radial section; (b) Foraminiferal–algal limestone, Bed 2, thin section no. 24-2-2/2: (*1*) axial section of *Rugosochusenella* aff. *simplex* (Z. Mikh.) test, (*2*) longitudinal section of the *Climacammina* sp. test, (*3*) cross section of the algal body of *Gyroporella dissecta* Tchuvashov, (*4*) tangential section of the fragmental algal body of *Pseudoepimastopora* sp.; (c) Foraminiferal–algal limestone, Bed 3, thin section no. 24-3-1/9: (*1*) oblique section of the *Pseudofusulinoides* sp. test, (*2*) *Eotuberitina* sp. tests, (*3*) fragments of algal body of *Pseudoepimastopora?* sp.; (d) Algal–palaeoaplysinal limestone bearing foraminifers, Bed 3, thin section no. 24-3-1/2: (*1*) axial section of the *Occidentoschwagerina kosvaensis* Echlak. test, (*2*) fragments of algal body of *Anthracoporella?* sp., (*3*) fragment of cenosteum of *Palaeoaplysina laminaeformis* Krotow; (e) Foraminiferal–bryozoan limestone, Bed 3, thin section no. 24-3-8/5: (*1*) fragment of tangential section of encrusting colonial bryozoans of the Cystoporida Order, (*2*) paraxial section of the *Occidentoschwagerina konovalovae* Vilesov test. Magnification is 17 in all cases.

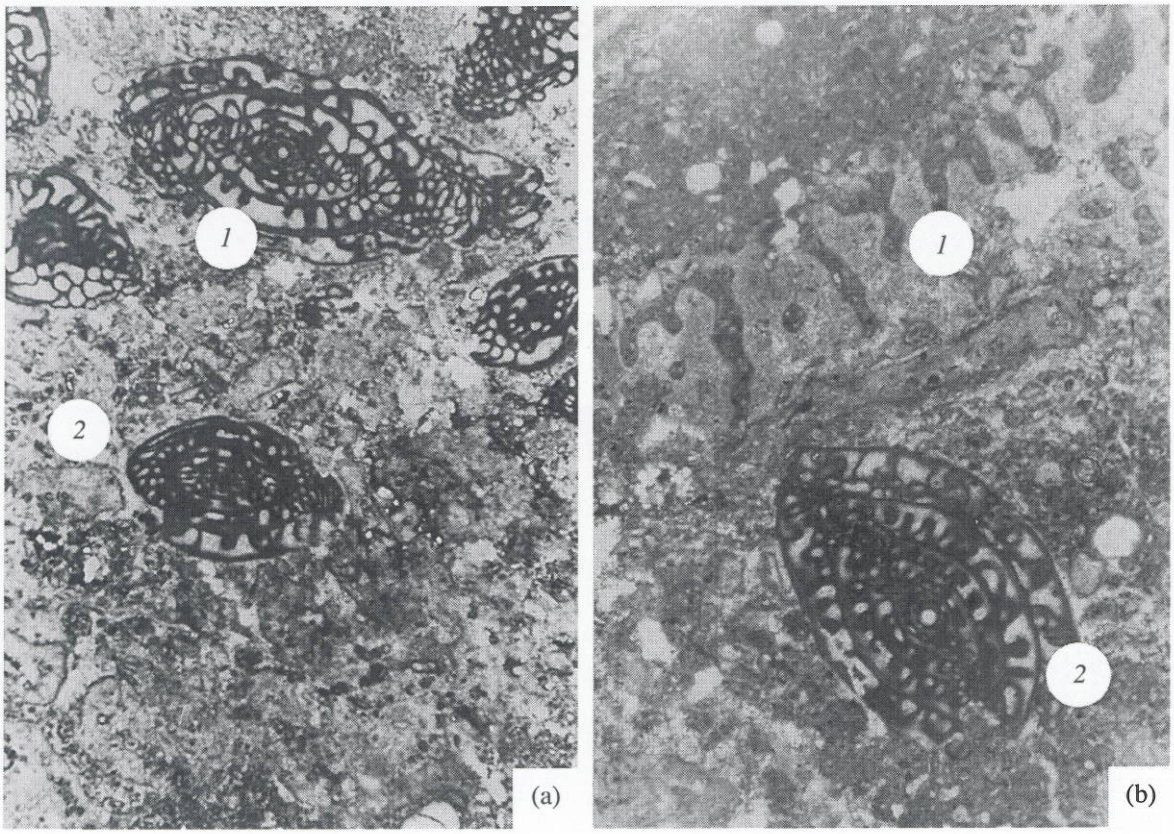

Fig. 4. The Melekhov biostromal limestones of the Nizhnyaya Gubakha section. (a) Palaeoaplysinal limestone bearing foraminifers: (*1*) oblique section of the *Schellwienia porrecta* (Sjom.) test, (*2*) fragment of algal body of *Epimastopora?* sp., tangential section; (b) Palaeoaplysinal limestone: (*1*) vertical section of palaeoaplysinal cenosteum, (*2*) axial section of *Anderssonites* aff. *anderssoni* (Schell.) test. Magnification is 17 in all cases.

exposed in the neighboring Ostanets section on the left bank of the river (see below). Some contiguous bioherms of the Kholodnyi Log section form a complex organogenic structure, which can be classified as a biohermal massif (*Iskopaemye* ..., 1968; Zadorozhnaya, 1984).

The Melekhov bioherms of the Kholodnyi Log section are mainly built by two groups of organisms, i.e., colonial hydrozoans *Palaeoaplysina laminaeformis* Krotow and green calcareous algae represented by the genera *Gyroporella, Pseudoepimastopora, Epimastopora, Globuliferoporella, Anthracoporella*, and *Sphenoporella* (Chlorophyta, Dasycladales). Palaeoaplysinids and calcareous algae served as sediment stabilizers, frame-builders, and cement of the bioherms. Other groups of bioherm-builders were of a minor importance.

The dominating varieties of the Melekhov biohermal rocks of the Kholodnyi Log section are light gray palaeoaplysinal, algal–palaeoaplysinal, palaeoaplysinal–algal, and foraminiferal–algal limestones (Figs. 3a–3d). Biohermal limestones of other structure, such as foraminiferal–bryozoan (Fig. 3e), crinoidal and some others, are of subordinate significance.

The Melekhov bioherms of the Kholodnyi Log section contain a highly diverse association of fossils. In addition to colonial hydrozoans and algae, there are different foraminifers (including schwagerinids); tabulates; gastropods; brachiopods; fenestrate, ramified, and encrusting bryozoans; crinoids; and others.

In the Ostanets section, situated 200 m from the Kholodnyi Log section on the opposite river bank (Fig. 1), the upper half of the Melekhov Horizon is mainly composed of dark-colored fine- and polydetrital, bedded to fine-bedded, bituminous clayey limestones (Scherbakova, 1986; Vilesov, 2000). The *Occidentoschwagerina konovalovae* Zone is estimated to be 9 m thick (compared to 11–13.5 m in the Kholodnyi Log section).

The lesser thickness and lithological peculiarities of the *konovalae* Zone suggest that the upper part of the Melekhov Horizon of the Ostanets section is represented by an interbiohermal facies. Previously, Scherbakova (1986) considered these sediments to be a biohermal slope facies.

In the Nizhnyaya Gubakha and Belaya Gora sections, the Melekhov Horizon is formed by thick-bedded palaeoaplysinal limestones, which constitute a stratiform organogenic structure not less than 400 m long (Fig. 2b). Thickness of the Melekhov Horizon is 13 m and that of the *konovalovae* Zone is 6 m (Vilesov, 1997, 2000). According to the generally accepted classification (*Iskopaemye* ..., 1968; Zadorozhnaya, 1984), this type structure can be attributed to a biostromal massif.

The Nizhnyaya Gubakha section is exposed in cliffs on the left bank of the Kos'va River, 1.5 km downstream from the Nizhnyaya Gubakha railroad station (Fig. 1). The extension of the section is about 1 km. Its upper part formed by the Melekhov biostromal limestones is exposed at the railroad bridge across the Kos'va River (Fig. 2b). The bed-by-bed description of the section is given in (Vilesov, 1997).

The Belaya Gora section is a natural continuation of the Nizhnyaya Gubakha section. Its bedrocks are exposed on the right bank of the Kos'va River near the railroad bridge (Fig. 1) and in cliffs downstream the river. The section exhibits the deposits of the Gzhelian Stage of the Upper Carboniferous and three stages of the Lower Permian (for bed-by-bed description of the Belaya Gora section see Pnev *et al.*, 1971; Zolotova and Provorov, 1974). The Belaya Gora section is more than 1 km in extent.

The Melekhov biostromal massif of the Nizhnyaya Gubakha and Belaya Gora sections is mainly built by colonial hydrozoans *Palaeoaplysina laminaeformis* Krotow. The dominating rock type is light gray and gray thick-bedded palaeoaplysinal limestones (Fig. 4). The biostromal massif contains taxonomically poor benthic assemblage, which includes palaeoaplysinids and foraminifers as well as green calcareous algae (mostly *Pseudoepimastopora*), rare brachiopods, bryozoans, and crinoids.

According to Tchuvashov (1974, 1978), the Kos'va organogenic structures were formed in a shallow-water setting; with the depth being not more than 25–50 m. Tectonically, the region under consideration is located on the eastern margin of the Russian plate adjacent to the western edge of the Ural foredeep (Mizens, 1997).

SCHWAGERINID ASSEMBLAGES OF THE MELEKHOV ORGANOGENIC STRUCTURES

The schwagerinid assemblages of the described organogenic structures are considerably different.

In the Melekhov biohermal massif of the Kholodnyi Log section, schwagerinids are (1) highly diverse at both generic and species levels and (2) represented by three different ecological groups.

Let us consider these features in more detail.

The biohermal sediments of the Melekhov Horizon of the Kholodnyi Log section yielded nine schwagerinid genera, such as *Rogusofusulina, Rugosochusenella, Praepseudofusulina, Schellwienia, Anderssonites, Globifusulina, Pseudofusulinoides, Occidentoschwagerina*, and *Triticites?* [peculiar group *Triticites? fornicatus* (Kanmera)]. The genera *Globifusulina, Occidentoschwagerina*, and *Praepseudofusulina* show the highest species diversity (table).

Three substrate-dependent ecological groups of schwagerinids can be distinguished in the Melekhov bioherms of the Kholodnyi Log section (table).

In the biohermal limestones, the most abundant forms are those having inflated enlighten test with indistinct septal fluting, thin-walled narrow juvenarium, and wide outer volutions (the genus *Occidentoschwagerina* and the group *Triticites? fornicatus*). Such test morphology is commonly considered to permit schwagerinids to live attached to the overgrowth of macrophytes and sessile invertebrates (Rauser-Tchernoussowa and Kulik, 1949; Ross, 1963). Rauser-Tchernoussowa (1975) proposed to term this peculiar ecological group of schwagerinids *epibenthos*. This term is not suitable, because epibenthos, or epifauna, is traditionally the true benthic organisms living on the bottom (Konstantinov, 1972). In general hydrobiology, organisms inhabiting the substrates above the bottom (overgrowth of macrophytes and others) are usually called *periphyton* (Konstantinov, 1972; Odum, 1971; Protasov, 1982; Wetzel, 1983).

Schwagerinids of the periphyton group occur in particular abundance in algal and palaeoaplysinal–algal limestones of bioherms.

Two other ecological groups of the schwagerinids derived from the Melekhov biohermal deposits of the Kholodnyi Log section are strictly benthic. The generally accepted ecological classification of benthic organisms is based on specific types of bottom sediments (Konstantinov, 1972). The distribution of schwagerinids is strongly controlled by the type of the bottom (Bensh, 1982).

Lithophilic benthic forms[2] (the classification of Konstantinov, 1972) are confined to hard bottom areas, which are characteristic of active hydrodynamic conditions. Of the schwagerinids of the Melekhov bioherm limestones of the Kholodnyi Log section, the genera *Globifusulina, Schellwienia, Anderssonites, Praepseudofusulina*, and *Pseudofusulinoides* belong to this ecological group.

The test morphology of the lithophilic benthos is devidence for the adaptation to open bottom areas under active hydrodynamic conditions (Figs. 5, 6). First, the schwagerinids of this group show intense septal fluting that makes the test very firm. Second, characteristic additional deposits (on the septa and wall, at the tunnel, and along the test axis) significantly increase the specific weight of the body to prevent removal of the animal with bottom water currents. Of the genera listed above, only *Praepseudofusulina* has no distinct morphological features adapted to open bottom areas. However, their ecological assignment can be reliably determined from their association with other lithophilic benthic forms.

[2] Greek *lithophilic* (stone-loving).

Schwagerinid distribution in two types of the Melekhov organogenic structures of the Central Urals

Schwagerinids			Bioherm	Biostrome
Ecological group		Species		
Periphyton		*Triticites? fornicatus* (Kanmera)	+	
		T.? subschwagerinoides (Grozdilova)	+	
		T.? aff. *uniensis* (Grozdilova et Lebedeva)	+	
		Occidentoschwagerina ancestralis Echlakov	+	
		O. echlakovi Vilesov	+	
		O. konovalovae Vilesov	+	
		O. kosvaensis Echlakov	+	
		O. cf. *simplex* (Volozhanina)	+	
Benthos	Pelophilic	*Rugosochusenella paragregaria* (Rauser)	+	
		R. simplex (Z. Mikhailova)	+	
		Rugosofusulina cf. *aktjubensis* Rauser	+	
		R. subundulata Sjomina	+	
	Lithophilic	*Praepseudofusulina propria* (I. Tchernova)	+	+
		P. buzulukensis (Dobrokhotova)		+
		P. impercepta (Jagofarova)	+	
		P. netkatchensis (Ketat)	+	+
		P. saratovensis (I. Tchernova)	+	+
		P. aff. *urmarensis* (Scherbovich)		+
		P. fastuosa (Ketat)	+	
		Schellwienia ex gr. *cognata* (Konovalova)		+
		S. lilia (Konovalova)		+
		S. porrecta (Sjomina)	+	+
		S. vozeiensis (Konovalova)	+	+
		Anderssonites aff. *anderssoni* (Schellwien)		+
		A. confertus (Vilesov)		+
		A. ognevae (Vilesov)	+	
		A. pseudoanderssoni (Sjomina)	+	+
		A. triangulatus (Zolotova)	+	
		Globifusulina berestyankica (Vilesov)	+	+
		G. aff. *confinis* (Sjomina)		+
		G. cf. *cybaea* (Sjomina)		+
		G. gracilis (Sjomina)		+
		G. aff. *pomposa* (Sjomina)	+	
		G. robusta (Rauser)	+	+
		G. shentalinensis (Jagofarova)		+
		G. tumifacta (Echlakov et Scherbakova)	+	+
		G. versabile (Bensh)	+	+
		G. vozhgalensis (Rauser)	+	+
		Pseudofusulinoides aff. *disertus* (Scherbovich)	+	+

The lithophilic benthic forms were extracted from palaeoaplysinal and algal-palaeoaplysinal bioherm sediments. Schwagerinids from the palaeoaplysinal limestones belong only to this ecological group.

The third ecological group of the schwagerinids is pelophilic benthos.[3] It occurs in lowered muddy bottom

[3] Greek *pelophilic* (mud-loving).

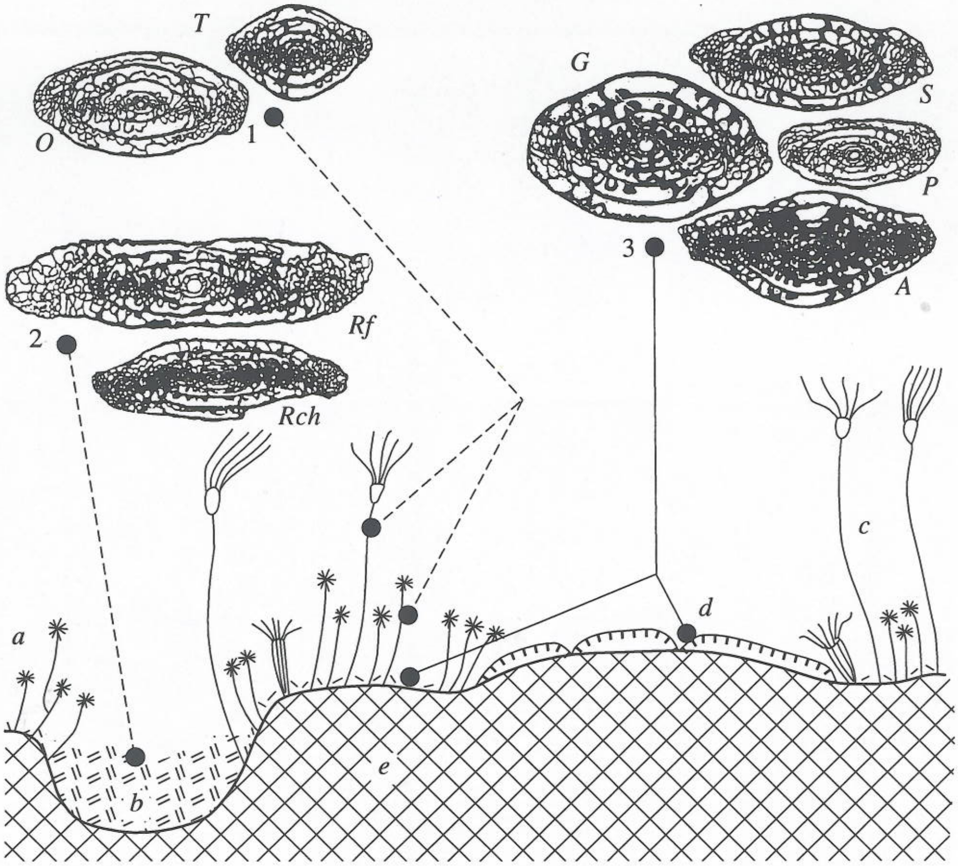

Fig. 5. Three ecological groups of schwagerinids confined to different areas of the Melekhov bioherm of the Kholodnyi Log section. (1–3) Ecological groups of schwagerinids: (1) periphyton: (*O*) *Occidentoschwagerina*, (*T*) *Triticites* of the group *T.? fornicatus* (Kanmera), (2) pelophilic benthos: (*Rf*) *Rugosofusulina,* (*Rch*) *Rugosochusenella*, (3) lithophilic benthos: (*G*) *Globifusunina*, (*S*) *Schellwienia*, (*P*) *Praepseudofusulina*, (*A*) *Anderssonites*. (*a–e*) Biohermal surface: (*a*) overgrowth of green calcareous algae, (*b*) pit filled with mud, (*c*) crinoids, (*d*) palaeoapsynal colonies, (*e*) lithified area of the bioherm.

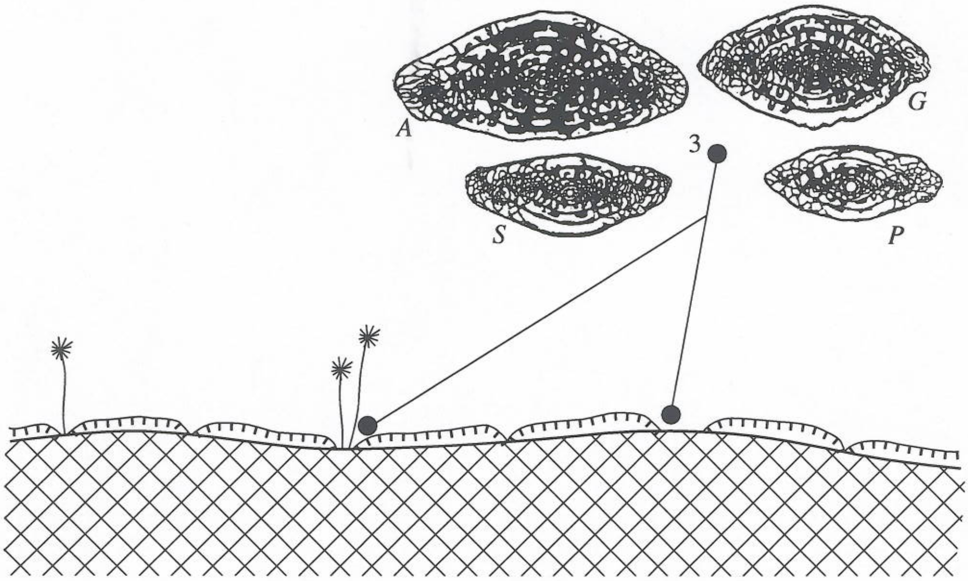

Fig. 6. The surface of the palaeoaplysinal biostrome and the related ecological group of schwagerinids. For symbols see Fig. 5.

areas in the calm hydrodynamic conditions. Schwagerinids of this group are represented by most of *Rugosofusulina* species (Rauser-Tchernoussowa, 1975; Bensh, 1982).

Characterization of usual biotopes of *Rugosofusulina* can be inferred from its morphological features such as indistinct septal fluting and elongate-cylindrical test, which enabled the organisms to hold on the surface of soft sediment.

Some morphological features of the *Rugosofusulina* test, such as a crinkled tectorium and heavily wavy wall, are still of disputable significance. Their adaptive significance should not be excluded.

The pelophilic benthic group also includes representatives of *Rugosochusenella*, which are usually associated with *Rugosofusulina*. They have heavily wavy thin wall, elongate involute test, and indistinct septal fluting (Fig. 5).

In the Kholodnyi Log bioherms, the pelophilic forms are less abundant than periphytonic and lithophilic ones. They usually occur in algal limestones. Noteworthy is that *Rugosofusulina* and *Rugosochesenella* demonstrate the highest abundance and diversity in the thin-bedded fine- and small-grained detrital clayey limestones of the Ostanets section (the *Occidentoschwagerina konovalovae* Zone) (Scherbakova, 1986), where they exceed in frequency the species of other ecological groups.

The schwagerinid assemblage from the biostromal palaeoaplysinal limestones of the Nizhnyaya Gubakha and Belaya Gora sections has less diverse generic composition than that from the bioherms of the Kholodnyi Log section. Only five genera, i.e., *Praepseudofusulina, Schellwienia, Anderssonites, Globifusulina*, and *Pseudofusulinoides*, were found in these sections. The poor generic composition is combined with a high species diversity of *Praepseudofusulina, Schellwienia*, and *Globifusulina* (table). All schwagerinid species from the biostromal massif belong to a single ecological group, i.e., lithophilic benthos.

INTERPRETATION OF RESULTS

The essential differences between the schwagerinid assemblages of the bioherm and biostromal massifs were determined by a set of biotic and abiotic factors that was specific for each type of the organogenic structures.

In the bioherm, the patchy distribution of two main bioherm-builders (*Palaeoaplysina* and green calcareous algae) resulted in irregular growth of different areas of the organogenic structure. Owing to the complicated relief of the bioherm, there were different biotopes inhabited by the specific groups of schwagerinids (Fig. 5).

Representatives of *Occidentoschwagerina* and the group *Triticites? fornicatus* (Kanmera) (periphyton) coated the overgrowth of different green calcareous algae and sessile invertebrates (e.g., crinoids). These biotopes were formed under a moderate hydrodynamic regime.

Abundant palaeoaplysinal colonies, less frequent algae, and scarce corals and crinoids inhabited the elevated, unsilted, and relatively smooth areas of the bioherm that were under active hydrodynamic condition. These biotopes contain schwagerinids of the lithophilic benthos group (representatives of *Globifusulina, Schellwienia, Anderssonites, Praepseudofusulina*, and, occasionally, *Pseudofusulinoides*).

The lowered bioherm areas (pits, sinkholes) were filled with fine-detrital silty sediments stabilized by algal bodies under a calm hydrodynamic regime. In these areas, there were pelophilic benthic forms represented by *Rugosofusulina* and *Rugosochusenella,* which were especially abundant in the bioherm slopes and interbioherm depressions (Scherbakova, 1966).

In the biostrome surface of the Nizhnyaya Gubakha and Belaya Gora sections, the biotic and abiotic factors were determined to a great extent by dominating colonial hydrozoans superseding all other sessile benthic groups (Fig. 6). The colonial palaeoaplysinids form creeping mats over large bottom areas. The mats leveled the bottom by filling holes and smoothing unevenness (Tchuvashov, 1973). Therefore, the active hydrodynamic regime was characteristic of the entire relatively flat biostrome surface and the rate of sedimentation (fine- and small-grained detritus) was lower than that in the coeval organogenic structure of the Kholodnyi Log section. For this reason, the *Occidentoschwagerina konovalovae* Zone of the Nizhnyaya Gubakha and Belaya Gora sections are more than two times thinner than that of the Kholodnyi Log section (5 or 6 m compared to 11–13 m, respectively).

The environmental conditions were uniform throughout the entire biostrome area. Because of the hard substrate covered by numerous palaeoaplysinal colonies and active bottom hydrodynamics, the schwagerinid assemblages were poor. There were no biotopes favorable for the schwagerinids of the periphyton or pelophilic benthic groups. The schwagerinid assemblage of the palaeoaplysinal biostrome consisted only of representatives of a single ecological group, that is the lithophilic benthos (table, Fig. 6).

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REFERENCES

Bensh, F.R., *Fuzulinidovye zony i yarusnoe raschlenenie verkhnego karbona i nizhnei permi Srednei Azii* (The Upper Carboniferous–Lower Permian Stages and Fusulinid Zones of Central Asia), Tashkent: Akad. Nauk, 1982.

Iskopaemye rify i metody ikh izucheniya (Fosil Reefs and Methods of Their Investigations), Smirnov, G.A. and Klyuzhina, M.P., Eds., Sverdlovsk: Akad. Nauk SSSR, 1968.

Konstantinov, A.S., *Obshchaya gidrobiologiya* (General Hydrobiology), Moscow: Vysshaya Shkola, 1972.

Makhlina, M.Kh. and Isakova, T.N., Melekhov Horizon as a New Stratigraphic Unit of the Gzhelian Stage of the Upper Carboniferous, *Stratigr. Geol. Korrelyatsiya*, 1997, vol. 5, no. 5, pp. 44–53.

Mezhdunarodnyi kongress "Permskaya sistema zemnogo shara": Putevoditel' geologicheskikh ekskursii, Part 3: *Permskaya geologicheskaya sistema Permskogo Priural'ya* (International Congress "The Permian System of the Globe": Guidebook to Geological Excursions, Part 3: The Permian System of the Cis-Ural Region near Perm'), Sofronitskii, P.A. and Ozhgibesov, V.P., Eds., Sverdlovsk: Ural. Otd., Akad. Nauk SSSR, 1991.

Mizens, G.A., *Verkhnepaleozoiskii flish Zapadnogo Urala* (The Upper Paleozoic Flysch of the Western Urals), Yekaterinburg: Ural. Otd., Ross. Akad. Nauk, 1997.

Odum, E.P., *Fundamental of Ecology*, Philadelphia, 1971. Translated under the title *Osnovy ekologii*, Moscow: Mir, 1975.

Pnev, V.P., Gvozdilova, L.P., Izotova, M.N. *et al.*, Belogorsk (Tastub) Horizon of the Sakmarian Stage of the Western Urals, *Zap. Leningrad Univ.*, 1971, vol. 59, issue 2, pp. 128–143.

Protasov, A.A., Periphyton: Terms and Main Definitions, *Hydrobiol. Zh.*, 1982, vol. 18, no. 1, pp. 7–12.

Rauser-Tchernoussowa, D.M., Paleoecology of the Asselian and Sakmarian Fusulinids of the Shakhtau Biohermal Massif, Bashkiriya, *Vopr. Mikropaleontol.*, 1975, issue 18, pp. 96–122.

Rauser-Tchernoussowa, D.M. and Kulik, E.L., On Facies Dependence of Fusulinids and Stages in Their Development, *Izv. Akad. Nauk SSSR, Ser. Geol.*, 1949, no. 6, pp. 131–148.

Ross, S.A., Standard Wolfcampian Series (Permian), Glass Mountains, Texas, *Mem. Geol. Soc. Am.*, 1963, vol. 88, pp. 1–205.

Scherbakova, M.V., The Carboniferous–Permian Boundary Beds in the Ostanets Section on the Kos'va River, in *Pogranichnye otlozheniya karbona i permi Urala, Priural'ya i Srednei Azii* (The Carboniferous–Permian Boundary Deposits of the Urals, Cis-Urals, and Central Asia), Moscow: Nauka, 1986, pp. 18–21.

Tchuvashov, B.I., Morphology, Ecology, and Systematic Position of the Genus *Palaeoaplysina, Paleontol. Zh.*, 1973, no. 4, pp. 3–8.

Tchuvashov, B.I., Permian Calcareous Algae of the Urals, *Tr. Inst. Geol. Geokhim., Ural. Nauchn. Tsentra Akad. Nauk SSSR*, 1974, issue 109, pp. 3–76.

Vilesov, A.P., The Carboniferous–Permian Boundary Beds of the Nizhnyaya Gubakha Section, the Central Urals, *Vestn. Perm. Univ.*, 1997, issue 4: Geol., pp. 93–100.

Vilesov, A.P., The Melekhov Horizon of the Gzhelian Stage (Additional Substantiation), in *Geologiya Zapadnogo Urala na poroge XXI veka* (The Western Urals Geology at the Threshold of the 21th Century), Perm: Perm. Gos. Univ., 1999, pp. 149–152.

Vilesov, A.P., Fusulinid-Based Zonation of the Melekhov Horizon (Upper Carboniferous, Gzhelian Stage) in the Perm Region, *Stratigr. Geol. Korrelyatsiya*, 2000, vol. 8, no. 5, pp. 29–42.

Wetzel, R.G., Recommendations for Future Research on Periphyton, in *Periphyton of Freshwater Ecosystems*, Wetzel, R.G., Ed., Hague: 1983, pp. 339–346.

Zadorozhnaya, N.M., Organogenic Structures, in *Prakticheskaya stratigrafiya (Razrabotka stratigraficheskoi bazy krupnomasshtabnykh geologos'emochnykh rabot)* (Practical Stratigraphy; Development of Stratigraphic Framework for Large-Scale Geological Mapping), Leningrad: Nedra, 1984, pp. 187–217.

Zolotova, V.P. and Provorov, Yu.A., The Most Section, in *Putevoditel' ekskursii po nizhnepermskim otlozheniyam po rekam Kos've, Sylve i Kame, Permskaya oblast'* (Guide to the Excursion to the Lower Permian Sections along the Kos'va, Sylva, and Kama Rivers, Perm Region), Sofronitskii, P.A., Ed., Perm: Perm. Gos. Univ., 1974, pp. 35–49.