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Fusulinid-Based Zonation of the Melekhov Horizon (Upper Carboniferous, Gzhelian Stage) in the Perm' Region

A. P. Vilesov

Perm' State University, ul. Bukireva 15, Perm', 614600 Russia

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Abstract—Introduction of the Melekhov Horizon into the regional stratigraphic scale for the Upper Carboniferous of the Russian Platform is discussed. The new horizon corresponds to a separate regional sedimentation cycle that resulted in substantial reorganizations of benthic schwagerinid assemblages (Foraminifera, Schwagerinida) during the earliest and latest Melekhov epochs. It is suggested to include the Melekhov Horizon in regional stratigraphic schemes of the Urals. The subdivision of the new horizon in sections of the Perm' region into local *Occidentoschwagerina ancestralis* and *Occidentoschwagerina konovalovae* fusulinid zones is substantiated. Characteristics of the distinguished zones are presented, and their stratotype sections are described. The possibility of distinguishing these zones in sections of the southern Urals, southern Timan Ridge, Oka-Tsna Rampart, and Samarskaya Luka area is analyzed.

Key words: *Melekhov Horizon, Gzhelian, Carboniferous, fusulinids, zonal units, correlation, the Perm' region*

INTRODUCTION

On October 24, 1994, the Melekhov Horizon was considered and approved to be the unit of the regional stratigraphic scale for the Upper Paleozoic of the Russian Platform by the Bureau of the Russian Interdepartmental Stratigraphic Committee (RISC) for the central and southern Russian platform. The horizon corresponds in range to the *Daixina bosbytauensis–Daixina robusta* fusulinid zone (Makhlina and Isakova, 1997) also traceable confidently in the eastern sections of the Russian platform and in the Urals foredeep (*Pogranichnye otlozheniya...*, 1986; Konovalova, 1991; and others). The last circumstance allows us to use a new horizon in regional stratigraphic schemes of the Urals as well.

Makhlina and Isakova (1997), who introduced the new unit, explain the necessity of recognizing the *Daixina bosbytauensis–Daixina robusta* Zone and corresponding horizon as a consequence of their new position in the general stratigraphic scale. According to the resolution endorsed by the ISC Bureau on March 9, 1992, the boundary between the Carboniferous and Permian is placed at the base level of the fusulinid *Schwagerina vulgaris–Schwagerina fusiformis* Zone (*Postanovleniya MSK...*, 1992).[1] The underlying *Daixina bosbytauensis–Daixina robusta* Zone, the base of which was determined earlier as the lower boundary of the Asselian Stage and Permian System (*Postanovleniya MSK...*, 1985), was included thus into the Gzhelian Stage of the Upper Carboniferous that inevitably attributes the horizon rank to the zone.

In addition to formal reasons, there are other serious grounds for distinguishing the *Daixina bosbytauensis–Daixina robusta* Zone as a separate horizon:[2] the upper and lower boundaries of the zone are ecostratigraphic and mark certain events and corresponding substantial changes in the regional physicogeographical conditions responsible for taxonomic reorganizations in benthic assemblages of the past epicontinental sea.

The onset of transgression that replaced a considerable regression of the Late Carboniferous time was at the Melekhov time (Kalmykova, 1980; Kalmykova and Kashik, 1988; and others). The event is recorded in the holostratotype of the Melekhov Horizon, whose basal layer overlies an uneven surface of the variegated dolomitic marl bed (the so-called "Sinyukha") topmost in the Noginsk Horizon (Makhlina and Isakova, 1997). The transgression started in the Melekhov time and continued throughout the Asselian. The Asselian megacycle of transgressive sedimentation is subdivided in the Russian platform into two smaller mesocycles, the older one corresponding to the Melekhov and Kholodnyi Log horizons and the younger, spanning the range of the Shikhany Horizon. The former transgressive mesocycle of the second order comprises three first-

[1] In my opinion, the more plausible level for the Carboniferous–Permian boundary is the base of the *Daixina bosbytauensis–Daixina robusta* Zone (Vilesov, 1997b).

[2] Vilesov (1999) revised the generic affiliation of the *Daixina? robusta* Rauser group. Schwagerinids of the group were assumed to be primitive representatives of the *Globifusulina* genus. In this work, the generic affiliation of the *Daixina? robusta* Rauser and other "tumid Daixina forms" is given in accord with the changed nomenclature.

order cycles, one of which correlates with the Melekhov Horizon, whereas two others are equivalents of the Kholodnyi Log Horizon (Kalmykova and Kashik, 1974, 1988, and others).

General changes in the physicogeographical conditions at the beginning of the Melekhov time affected the biota of the East European paleogeographic province. The effect was especially dramatic for schwagerinids, the fast evolving and well studied group of fusulinids.

The appearance of several new genera in the order Schwagerinida was coeval to the onset of the Melekhov phase of the Asselian transgression. New genera quickly displaced genera dominant in assemblages of the Noginsk time of the Gzhelian Stage (Kalmykova, 1980; Rauser-Chernousova and Reitlinger, 1977; and others). Taxa that appear in the Melekhov time were genera *Occidentoschwagerina, Globifusulina, Praepseudofusulina*, and *Rugosochusenella*, subgenus *Bosbytauella* of the genus *Daixina*, and a peculiar group of *Triticites? fornicatus* Kanmera. The genus *Jigulites* and subgenus *Daixina*, both dominant among schwagerinids in the Noginsk time, died out. In the Melekhov schwagerinid assemblages, the "tumid Daixina" forms that represented primitive ancestors of the genus *Globifusulina*, become dominant, abundant and diverse in different facies environments. Schwagerinids of the Melekhov time populated a new habitat—the water layer above the bottom inhabited by algae and sedentary invertebrates. Thus the peculiar epibenthic group of schwagerinids appeared (the *Occidentoschwagerina* genus and some later genera with the "Schwagerina"-type spiral). Its emergence in the new habitat was favored by aromorphous transformation of skeletons. Genera from the Noginsk sediments (for instance, *Schellwienia, Rugosofusulina*) display the renewed species composition. The new genera migrated quickly from radiation centers to new epicontinental sea areas simultaneously with the gradual development of transgression. Their radiation was followed by active speciation. A glowing example is the genus *Praepseudofusulina* that originated in the Volga paleozoogeographic region (regional zoning after Kalmykova, 1980). Migrating eastward, northward, and northeastward, this genus gave rise to many new species inadequately studied so far.

The next transgressive sedimentation cycle of the first order also connected with reorganizations in schwagerinid assemblages is that of the latest Melekhov–earliest Kholodnyi Log time. The *Globifusulina* genus remained dominant at that time, but composition of prevailing species was renewed and primitive species of the genus were gradually replaced by higher forms. Representatives of the *Schwagerina* genus appear among epibenthic groups and quickly replaced *Occidentoschwagerina* forms. The schwagerinid assemblages of the Kholodnyi Log time differed from the Melekhov assemblages in that they were less endemic.

Thus, the necessity of distinguishing the Melekhov Horizon is evident from the history of schwagerinids, the most important Late Paleozoic orthostratigraphic group, which is reckoned to be the basic one when distinguishing and substantiating the Upper Carboniferous and Lower Permian horizons included in stratigraphic scales for the Russian platform and the Urals.

FUSULINID-BASED ZONATION OF THE MELEKHOV HORIZON

The comprehensive study on schwagerinid phylogeny and succession of their assemblages in the sections enables subdivision of the Melekhov Horizon into the local fusulinid zones. In particular, Davydov distinguished the *Daixina (Bosbytauella) postsokensis* and *Daixina (Bosbytauella) postgalloway* zones within this interval of sections studied in the southern Urals (Popov *et al.*, 1985; Davydov and Popov, 1986; and others). He also recognized the same zones in the Donetsk foredeep (Davydov, 1992). The possibility that analogs of the Melekhov Horizon can be subdivided on the basis of fusulinids was demonstrated for southern Timan Ridge as well (Konovalova, 1991).

My recent study of stratigraphic ranges of schwagerinids in the Gzhelian–Asselian boundary interval in the Perm' region allowed me to distinguish here the Melekhov Horizon with two local fusulinid zones of *Globifusulina robusta–Schellwienia porrecta* and *Praepseudofusulina netkatchensis* replacing one another upward in the section (Vilesov, 1997a, 1997b). Both local zones are reliably traced in a series of well-studied sections and correlated with local zonal units of the southern Urals. Their extension to the southern Timan Ridge seems to be possible.

This work presents substantiation and most complete characteristics of local fusulinid zones of the Melekhov Horizon in the Perm' region. Before proceeding further, we should consider first the most suitable candidates for the zonal index species.

In my previous publications (Vilesov, 1997a and 1997b), the chosen index species for local zones of the Melekhov Horizon in the Perm' region were not quite appropriate and did not meet current requirements for zonal biochronological scales (Chernykh, 1995). Since *Bosbytauella* species, e.g., *Daixina (Bosbytauella)* forms, whose phylogeny was used by Davydov as a basis for fusulinid zonation in the southern Urals, is missing from the regional sections, they cannot be taken for index species of local zones. At the first glance, the *Globifusulina* genus dominant in schwagerinid assemblages of the Melekhov time appears to be suitable for selection of zonal index species. However, the phylogeny of globifusulins is poorly understood at present thus being inappropriate for biozonation. The complimentary study of the genus taxonomic diversity and revision of stratigraphic ranges of its species

should be done, because published data are controversial and require verification.

The study on phylogenetic lines of several fast-evolving schwagerinid genera established that representatives of the genus *Occidentoschwagerina* can be used as zonal index species of the Melekhov Horizon. Their evolution was analyzed in detail in a special work (Vilesov, 1998), where general phylogenetic tendencies of this peculiar schwagerinid group were outlined.

In the Melekhov time, this group evolved displaying the following characteristic features: the growing isolation of juvenarium, the height increase in mature convolutions, the diminishing folding of septa, and the general growth of shells in size. All that resulted in appearance of tumid occidentoschwagerins, for instance, of *Occidentoschwagerina konovalovae* Vilesov and *O. sartauensis* (Davidov), in the later half of the Melekhov time that was followed later, in the earliest Asselian, by origin of first schwagerins still possessing many features of the ancestor genus (*Schwagerina fusiformis* Krot., *S. poljarica* Grozd., and others).

The phylogenetic line of *Occidentoschwagerina ancestralis* Echlakov, 1977, *Occidentoschwagerina konovalovae* Vilesov, 1998 and, finally, *Schwagerina fusiformis* Krotow, 1888, where the aforementioned evolutionary trends are well pronounced, can be used as a basis for the biozonation. Taking occidentoschwagerins for index species of zonal units of the Melekhov Horizon, we obtain in addition the phylogenetic substantiation of the Carboniferous–Permian boundary, because schwagerins (*Schwagerina* Moeller, sensu Rauser) representing index species of the Asselian zonation are, in my opinion, direct descendants of the former (Vilesov, 1998).[3]

STRATOTYPES OF LOCAL ZONAL UNITS OF THE MELEKHOV HORIZON

Before substantiation of local zones of the Melekhov Horizon, it is necessary to present first the description and paleontological characteristics of their stratotypes.

The Ostanets section (Beds 2–4) is selected as stratotype of the *Occidentoschwagerina ancestralis* Zone, and the Kholodnyi Log section (Exposure 24, beds 2–4) is that of the *Occidentoschwagerina konovalovae* Zone. Both sections are located at the Kos'va River, 1.5 km upstream of the settlement of Verkhnyaya Gubakha (Mt. Gubakha, Perm' region, Russia; see Fig. 1).

Kholodnyi Log Section

The Kholodnyi Log section corresponding to stratotype of the Kholodnyi Log Horizon of the Asselian Stage is simultaneously the parastratotype of some fusulinid zones. The section is exposed in cliffs up to 120 m high along the right bank of the Kos'va River and on both sides of the Kholodnyi Log (a ravine). In this site, the succession of Upper Carboniferous and Lower Permian limestone beds yields abundant and diverse marine fossils. The comprehensive description of the Carboniferous rocks was published by Shcherbakova *et al.* (1972), whereas the detailed description of Permian strata is given by Ekhlakov and Zolotova (1986), whose data are reproduced in a later publication (*Permian System...*, 1993). As the result of recent studies, characteristics of fusulinid assemblages from Permian deposits were verified and better understood. Presented below is the new description of Exposure 24 at the Kholodnyi Log site (Fig. 2), where almost the whole Upper Carboniferous Melekhov Horizon and the basal part of the Lower Permian Kholodnyi Log Horizon are exposed (the exposure number is after Zolotova and Ekhlakov).

Upper Carboniferous

Gzhelian Stage

Melekhov Horizon

Daixina bosbytauensis–Globifusulina robusta Zone

Local *Occidentoschwagerina ancestralis* Zone

Bed 1: light gray to yellowish algal–detrital, locally bryozoan- or crinoidal–detrital limestone; the rock is extremely tough, massive to bedded, fine-grained, and bituminous in the upper half of the bed. Organic remains: calcareous algae, smaller foraminifers, fenestrate and ramified bryozoans, solitary corals, crinoids, and brachiopods. Identified species of rare schwagerinids are *Globifusulina vozhgalensis biconica* (Poloz.), *G. tumifacta* (Echlak. et Scherbak.), *G. robusta* (Raus.), *G. pechorica* (Vol.), *Occidentoschwagerina ancestralis* Echlak., *O. acerba* Vilesov. The bed thickness is 4.90 m.

Local *Occidentoschwagerina konovalovae* Zone

Bed 2: Yellowish-gray to light gray algal–palaeoaplisid limestone; the rock is fissured, fine-grained, massive to bedded, bearing calcareous algae *Globuliferoporella symetrica* (Johnson), *Pseudoepimastopora* sp., and *Giroporella dissecta* Tchuv. in association with smaller foraminifers (*Tetrataxis* sp., *Ammovertella* sp., *Climacammina* sp., *Globivalvulina* sp.), crinoids, brachiopods, gastropods, and ramified bryozoans. Schwagerinids are abundant in the upper part of the bed that yields *Globifusulina* aff. *pomposa* (Sjom.), *G*: cf. *tumifacta* (Echlak. et Scherbak.), *G. versabile* (Bensh), *Rugosochusenella simplex* (Mikh.), *Triticites? fornicatus* (Kanmera), *T.? subschwagerinoides* f. *grandis* (Grozd.), *T.*? aff. *uniensis* (Grozd. et Leb.), *T. kreekensis* Thompson, *Occidentoschwagerina* cf. *simplex* (Vol.), *O. konovalovae* Vilesov, and *Praepseudofusulina propria* (I. Tchern.). The bed thickness is 2.50 m.

[3] It should be noted that I follow in this work the systematics elaborated by Rauser-Chernousova with co-authors (1996) for the subfamily Schwagerininae Dunbar et Henbest and order Schwagerinida.

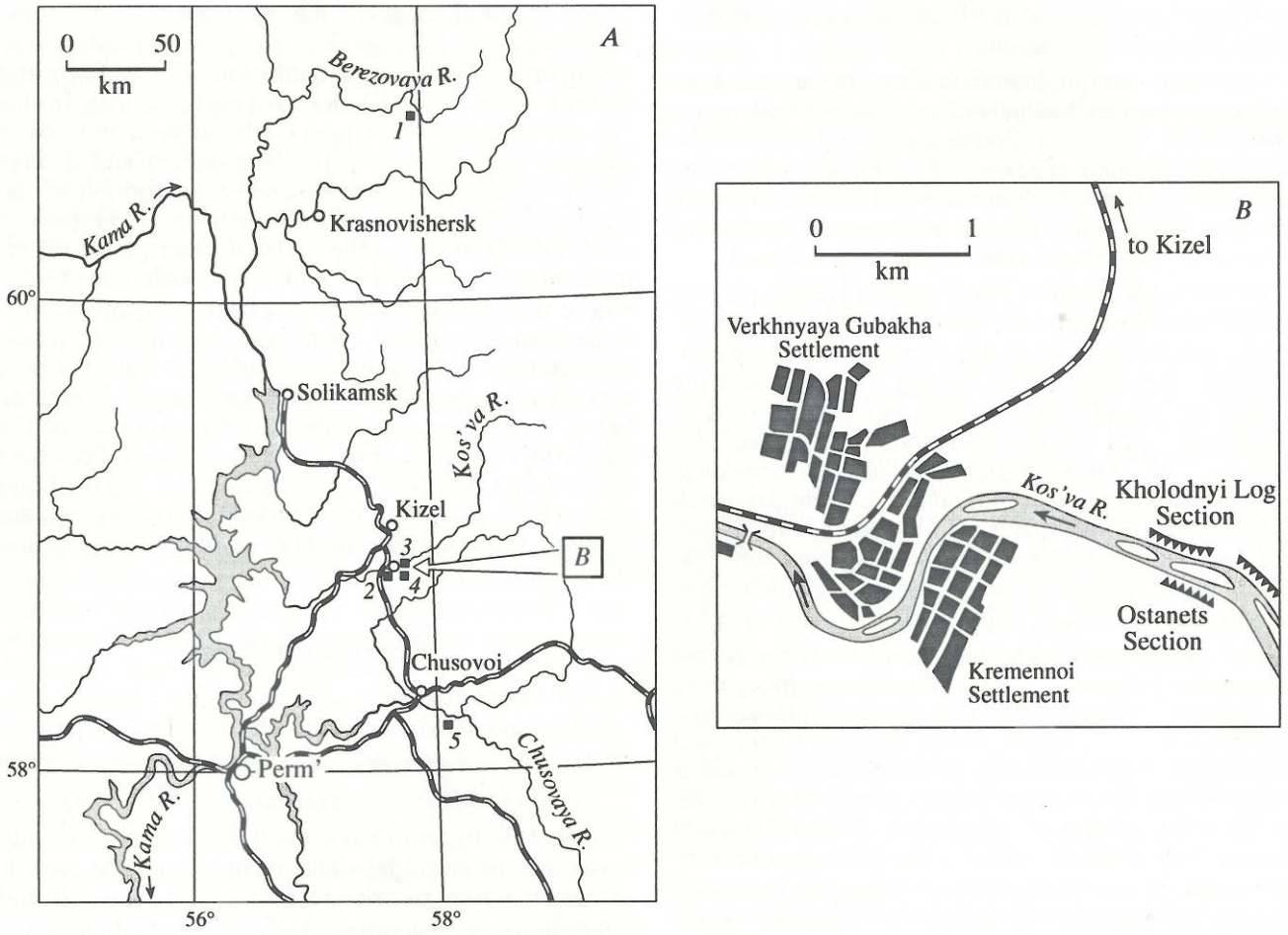


Fig. 1. Exposures of the Melekhov Horizon in the Perm' region (*A*) and stratotype section localities (*B*): (*1*) Kamen' Stolby; (*2*) Most and Nizhnyaya Gubakha; (*3*) Kholodnyi Log; (*4*) Ostanets; (*5*) Plakun.

Bed 3: gray to light gray palaeoaplisid–algal, algal–palaeoaplisid, locally foraminiferal–algal limestones with abundant and diverse detritus; the rocks are massive to bedded, porous, fine- to medium-grained, slightly bituminous in the upper part of the bed. Groups of organic remains: calcareous algae *Globuliferoporella* sp., *Pseudoepimastopora* sp., *Epimastopora grandis* Tchuv. et Anf., *Giroporella* sp., and *Tubiphytes* sp.; smaller foraminifers *Amovertella* sp., *Eotuberitina* sp., *Bradyina* sp., *Climacammina* sp., *Tetrataxis* sp., *Dekerella* sp., *Rectocornuspira* sp., *Tikhinella* sp., *Mesolasiodiscus* sp., and others; solitary Rugosa; brachiopods; crinoids; ramified and fenestrate bryozoans. Identified schwagerinid species are *Globifusulina vozhgalensis* (Raus.), *G. tumifacta* (Echlak. et Scherbak.), *G. versabile* (Bensh), *G. berestyankica* (Vilesov), *Rugosochusenella simplex* (Mikh.), *R. paragregaria* (Raus.), *Triticites? fornicatus* (Kanmera), *T.? subschwagerinoides* f. *grandis* (Grozd.), *T.*? aff. *uniensis* (Grozd. et Leb.), *Occidentoschwagerina* aff. *simplex* (Vol.), *O. kosvaensis* Echlak., *O. konovalovae* Vilesov, *O. ancestralis* Echlak., *O. echlakovi* Vilesov, *Rugosofusulina* cf. *aktjubensis* Raus., *R. subundulata* Sjom., *Praepseudofusulina impercepta* (Jagof.), *P. netkatchensis* (Ketat), *P. fastuosa* (Ketat), *Andersonites triangulatus* (Zol.), *Pseudofusulina*? aff. *diserta* Scherb., and others. The bed thickness is 7.00 m.

Bed 4: dark gray algal–detrital fine-grained clayey limestone; the rock is indistinctly bedded, bituminous in the lower part, silicified and dolomitic in the upper part. Organic remains: calcareous algae, smaller foraminifers of genera *Bradyina* and *Ammodiscoides*, rare schwagerinids (identified species is *Anderssonites ognevae* Vilesov), large solitary Rugosa, tabulates, and brachiopods. The bed thickness is 1.20 m.

Lower Permian

Asselian Stage

Kholodnyi Log Horizon

Schwagerina vulgaris–Sch. fusiformis Zone

Bed 5: gray to light gray organogenic–detrital limestones; the rocks are fine- to medium-grained, massive or bedded, and highly recrystallized. An interlayer of brownish gray fusulinid–crinoidal limestone 0.20 m thick occurs at the bed base. Organic remains: calcareous algae, palaeoaplisinds, smaller foraminifers,

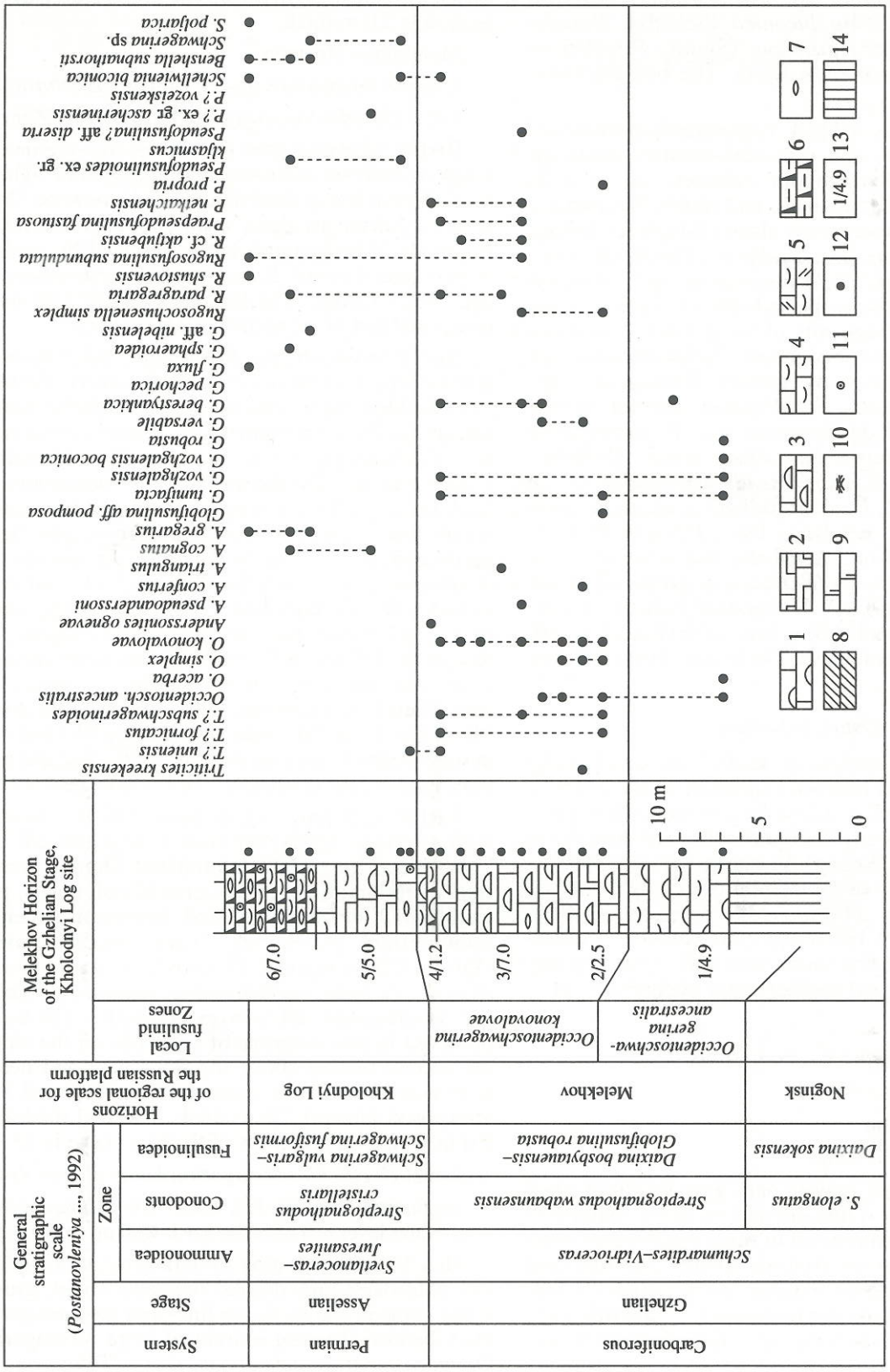


Fig. 2. Stratotype of the local *Occidentoschwagerina konovalovae* Zone of the Melekhov Horizon, Perm' region, Kholodnyi Log site. (1–7) limestone types: (1) massive- to thick-bedded algal, (2) massive- to thick-bedded palaeoaplisinid, (3) palaeoaplisinid–algal, (4) detrital, (5) slimy–detrital, (6) medium- to thin-bedded bituminous and clayey, (7) fusulinid; (8) medium- to thin-bedded dolomite; (9) dolomitized limestone; (10) bryozoans; (11) crinoids; (12) sampling levels of fusulinids; (13) bed number and thickness, m; (14) unexposed intervals and talus.

crinoids, brachiopods, tabulates. Schwagerinids are recrystallized and deformed; species identified among them are *Schwagerina* sp., *Anderssonites cognatus* (Echlak.), *Schellwienia biconica* (Scherb.), *Pseudofusulinoides* ex gr. *kljasmicus* (Sjom), *Pseudofusulina*? ex gr. *ascherinensis* Sjom. The bed thickness is 5.0 m.

Bed 6: dark gray to black, organogenic–polydetrital (mainly fusulinid– and crinoidal–detrital) limestone with numerous Syringopora colonies; the rock is microlaminated, fine-grained, and highly bituminous. Organic remains: calcareous algae (*Tubiphytes* forms), smaller foraminifers (*Deckerella* sp., *Eotuberitina* sp., *Climacammina* sp., *Palaeotextularia* sp., *Globivalvulina* sp., *Ammodiscus* sp., and others), crinoids (commonly articulate fragments of the columns), brachiopods, and ramified bryozoans. Schwagerinids are abundant, represented by species *Schwagerina* sp., *S. poljarica* (Grozd.), *Schellwienia uberata* (Kon.), *Rugosofusulina* cf. *burkemensis* Vol., *R. subundulata* Sjom., *Rugosochusenella shustovensis* (Scherb.), *R. paragregaria* (Raus.), *Pseudofusulinoides* ex gr. *kljasmicus* (Sjom.), *Pseudofusulina*? ex gr. *ascherinensis* Sjom., *P.*? aff. *netchaevi* Dav., *P.? signata* Kon., *P.? vosejskensis* Kon., *Benshella subnathorsti* (Lee), *Anderssonites cognatus* (Echlak.), *A. gregarius* (Lee), *A*: ex gr. *gregarius* (Lee), *A. cognatus* (Echlak.), *Globifusulina fluxa* (Grozd.), *G. sphaeroidea* (Raus.), *G*: aff. *nibelensis* (Vol.), and others. The bed thickness is 7.0 m.

Ostanets Section

The Ostanets section is studied in small rocky scarps and separate bedrock exposures on the left river bank opposite the Kholodnyi Log section. The uppermost Gzhelian (Upper Carboniferous) and lowermost Asselian (Lower Permian) limestone with various fossils are main rocks of the section originally described by Shcherbakova (1986). My own observations allowed me to draw biostratigraphic boundaries differently (Fig. 3). The bed succession in the Ostanets section is as follows (bed numbers after Shcherbakova).

Upper Carboniferous

Gzhelian Stage

Noginsk Horizon

Daixina sokensis Zone

Bed 1: brownish gray to dark gray fusulinid–algal limestone; the rock is fine-grained, compact, massive to bedded and microlaminated in some interlayers (interlayers show numerous stylolite sutures and fusulinid compressions). Organic remains: palaeoaplisinids, calcareous algae, and smaller foraminifers (*Tuberitina* sp., *Brunsia* sp., *Eotubertina* sp., *Globivalvulina* sp., *Tikhinella* sp., *Climacammina* sp.). Determined fusulinid species are *Quasifusulina longissima* Moell., *Ruzhenzevites* sp., *Daixina* aff. *transitoria* Alks. et Poloz., *D. licharevi* Dav., *Jigulites* cf. *magnus* Ros., and *Triticites rossicus* Bensh. In the stripped exposure bedrocks, the bed is 1.0 m thick. The unexposed part of the section is 2.0 m thick.

Melekhovo Horizon

Daixina bosbytauensis–Globifusulina robusta Zone

Local *Occidentoschwagerina ancestralis* Zone

Bed 2: brownish gray dolomites, fine-grained with small bituminous inclusions and interbeds of light gray algal–detrital fine-grained dolomitized limestone. Organic remains: calcareous algae, smaller foraminifers, and rare fusulinids. Schwagerinids are represented by *Anderssonites paraanderssoni* (Raus.) and *Occidentoschwagerina ancestralis* Echlak. The bed thickness is 1.00 m. The unexposed part of the section is 2.50 m thick.

Bed 3: brownish gray fine-grained palaeoaplisinid–detrital limestone with microcloddy matrix; the rock is thick-bedded, hard, and dolomitic. Organic remains: calcareous algae (*Tubiphytes* sp., *Pseudoepimastopora* sp., *Globuliferoporella* sp.), smaller foraminifers (*Tuberitina* sp., *Eotuberitina* sp., *Climacammina* sp., *Nodosaria* sp., *Bradyina* sp.), palaeoaplisinids, solitary corals, brachiopods, ostracods, and bryozoans. Schwagerinids are represented by the following species: *Occidentoschwagerina acerba* Vilesov, *O. ancestralis* Echlak., *O.* aff. *ancestralis* Echlak., *O.* aff. *simplex* (Vol.), *Globifusulina* aff. *pomposa* (Sjom.), *G. tumifacta* (Echlak. et Scherbak.), *Anderssonites anderssoni* (Schellw.), *A. ognevae* Vilesov, *A. paraanderssoni* (Raus.), *A. subovatus* Kon.), *Schellwienia porrecta* (Sjom.), and *Sch.*? aff. *antropovi* (Malk.). The bed is seen in small bedrock outcrops on slopes of the first and second terraces above the floodplain. The bed thickness is 1.50 m.

Bed 4: light gray to gray palaeoaplisinid limestone with grumous matrix; the rock is fine-grained, thick-bedded, and irregularly dolomitized. Organic remains: smaller foraminifers, corals, crinoid columnals, palaeoaplisinids, brachiopods, and bryozoans. Identified schwagerinid species are *Anderssonites gerasimovi* (Vilesov), *A. confertus* (Vilesov), *A. paraanderssoni* (Raus.), *Occidentoschwagerina ancestralis* Echlak., and *Schellwienia*? aff. *antropovi* (Malk.). The bed was observed in two outcrops of bedrocks on the slope of the second terrace above the floodplain and near the river-water level. The outcrops are separated by an unexposed interval 2.0 m thick. The bed thickness is 8.0 m. The total thickness of the local zone is 13 m.

Local *Occidentoschwagerina konovalovae* Zone

Beginning from Bed 5, rocks are exposed near the river-water level in a blind bedrock wall up to 4.0 m high.

Bed 5: brownish gray to dark gray palaeoaplisinid and palaeoaplisinid–detrital limestones with grumous slimy cement; the rocks are fine- and medium-grained, thick-bedded, bearing individual large schwagerinids. Organic remains: calcareous algae (*Tubiphytes* sp.), smaller foraminifers (*Tuberitina* sp., *Eotuberitina* sp., *Globivalvulina* sp., *Climacammina* sp., *Brunsia* sp.,

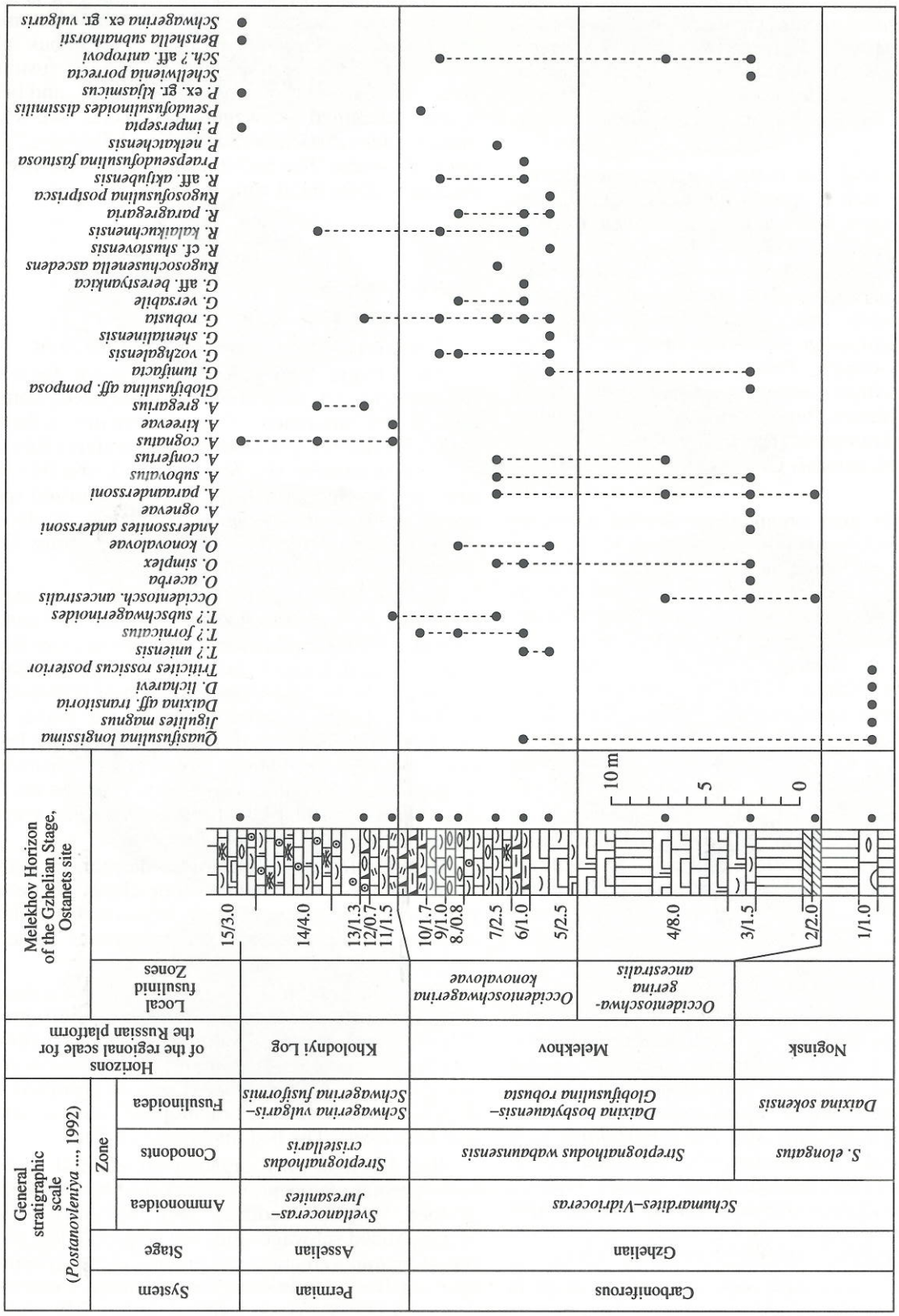


Fig. 3. Stratotype of the local *Occidentoschwagerina ancestralis* Zone of the Melekhov Horizon, Perm' region, Ostanets site (symbols as in Fig. 2).

Tetrataxis sp., *Monotaxinoides* sp.), palaeoaplisinids, brachiopods, corals, and bryozoans. Determined schwagerinid species are *Globifusulina vozhgalensis* (Raus.), *G. shentalenensis* (Jagof.), *G. robusta* (Raus.), *G.* cf. *robusta* (Raus.), *G. tumifacta* (Echl. et Scherb.), *Rugosochusenella* cf. *shustovensis* (Scherb.), *R. paragregaria* (Raus.), *Rugosofusulina postprisca* Bensh, and *Triticites? uniensis* Grozd. et Leb. The bed thickness is 2.5 m.

Bed 6: brownish gray to black organogenic–detrital limestone; the rock is fine- to medium-grained, thin-bedded to foliated, bituminous, and clayey. Organic remains: calcareous algae (*Tubiphytes* sp.), smaller foraminifers (*Bradyina* sp., *Tuberitina* sp., *Nankinella* sp., *Pseudoendothira* sp.), corals, and crinoids. Identified fusulinid species are *Quasifusulina longissima* (Moell.), *Globifusulina robusta* (Raus.), *G*: aff. *berestyankica* (Vilesov), *Praepseudofusulina fastuosa* (Ketat), *Occidentoschwagerina simplex* (Vol.), *O*: cf. *konovalovae* Vilesov, *Rugosochusenella kalaikuchnensis* Dav., *R. paragregaria* (Raus.), *Triticites? fornicatus* Kanmera, *T.*? cf. *uniensis* Grozd. et Leb. The bed thickness is 1.0 m.

Bed 7: light gray organogenic–detrital limestone with fine-grained matrix; the rock is fine- to medium-grained, medium-bedded, and fissured. Organic remains: calcareous algae, smaller foraminifers (*Nankinella* sp., *Tetrataxis* sp., and others), bryozoans, and crinoids. Identified schwagerinid species are *Anderssonites subovatus* (Kon.), *A. confertus* (Vilesov), *Globifusulina robusta* (Raus.), *Triticites? subschwagerinoides* f. *grandis* Grozd., *Rugosofusulina* cf. *aktjubensis* Raus., *Rugosochusenella ascedens* (Raus.), *Occidentoschwagerina simplex* (Vol.), and *Praepseudofusulina netkatchensis* (Ketat). The bed thickness is 2.5 m.

Bed 8: brownish gray fusulinid limestone; the rock is medium-bedded, with even bedding planes. Organic remains: fusulinids, crinoid columnals, and solitary corals. Limestone yielded schwagerinids *Globifusulina vozhgalensis* (Raus.), *G.* cf. *versabile* (Bensh), *Triticites? fornikatus* (Kanmera), *Occidentoschwagerina konovalovae* Vilesov, and *Rugosochusenella paragregaria* (Raus.). The bed thickness is 0.8 m.

Bed 9: dark brownish gray organogenic–detrital (algal– and foraminiferal–detrital) limestones with grumous cement; the rocks are fine- to medium-grained, medium-bedded, rudaceous in the upper part. Organic remains: calcareous algae (*Epimastopora* sp.), smaller foraminifers (*Glomospira* sp., *Palaeotextularia* sp.), crinoid columnals, and brachiopods. Identified schwagerinid species are *Globifusulina robusta* (Raus.), *G. vozhgalensis* (Raus.), *Occidentoschwagerina* sp., *Rugosofusulina* ex gr. *aktjubensis* Raus., and *Schellwienia?* aff. *antropovi* (Malk.). The bed thickness is 1.0 m.

Bed 10: limestone dark brownish gray to black in color; the rock is fine- to medium-grained, micro- and thin-bedded, slimy–detrital, clayey, and bituminous. The basal part is algal–detrital and foliated, with compressed fusulinids on bedding planes; in the central part, limestone is highly bituminous, foliated, with microstylolites; in the top interval, the rock is slimy-detrital and compact, with irregular bituminous impregnations. Organic remains: calcareous algae, smaller foraminifers, poorly preserved fusulinids, palaeoaplisinids, bryozoans, crinoid stems, and brachiopods. Identified schwagerinid species are *Pseudofusulinoides dissimilis* (Scherb.) and *Triticites? fornikatus* Kanmera. The bed thickness is 1.7 m. The total thickness of the local zone is 9.5 m.

Lower Permian

Asselian State

Kholodnyi Log Section

Schwagerina vulgaris–Sch. fusiformis Zone

Bed 11: gray slimy–detrital limestone; the rock is medium-grained, thin- to medium-bedded, compact, clayey, and bituminous. Organic remains: calcareous algae (*Tubiphytes* sp.), smaller foraminifers (*Tuberitina* sp., *Climacammina* sp., *Bradyina* sp.), crinoid columnals, and brachiopods. Identified schwagerinid species are *Anderssonites cognatus* (Echlak.), *A. kireevae* (Scherb.), and *Triticites? subschwagerinoides* Grozd. The bed thickness is 1.5 m.

Bed 12: dark gray, slightly brownish limestones; the rocks are organogenic–detrital (remains of fusulinids, crinoids, and algae dominate in detritus) or algal–detrital, coarse-grained, foliated, and bituminous. In the basal part, limestone shows light spots consisting of coarse-grained crystalline calcite. Organic remains: calcareous algae, smaller foraminifers (*Brunsia* sp., *Nodosaria* sp.), bryozoans, crinoid columnals, brachiopods, palaeoaplisinids, and solitary corals. Identified schwagerinid species are: *Globifusulina* aff. *robusta* (Raus.) and *Anderssonites gregarius* (Lee). The bed thickness is 0.7 m.

Bed 13: light gray, crinoidal–detrital, medium- to coarse-grained, massive limestone clayey in the upper part. Organic remains: crinoids, bryozoans, smaller foraminifers, solitary corals, and calcareous algae. The bed thickness is 1.3 m.

Bed 14: gray to dark gray, bryozoan–crinoidal–detrital limestone; the rock is fine- to medium-grained, foliated, and partly dolomitized. Organic remains: smaller foraminifers, fusulinids (*Anderssonites cognatus* (Echlak.), *A. gregarius* (Lee), *Rugosochusenella kalaikuchnensis* (Dav.), brachiopods, corals, crinoids, and bryozoans. The bed thickness is 4.0 m.

Bed 15: light gray, organogenic–detrital limestone with grumous cement; the rock is fine- to medium-grained, medium-bedded, and dolomitic. Highly recrystallized schwagerinids are common near the bed top. Organic remains: calcareous algae (*Tubiphytes* sp.), smaller foraminifers (*Tuberitina* sp., *Palaeotextularia* sp.), bryozoans, crinoid columnals, palaeoaplisinids, and brachiopods. Identified schwagerinid species are *Benshella subnathorsti* (Lee), *Andersso-*

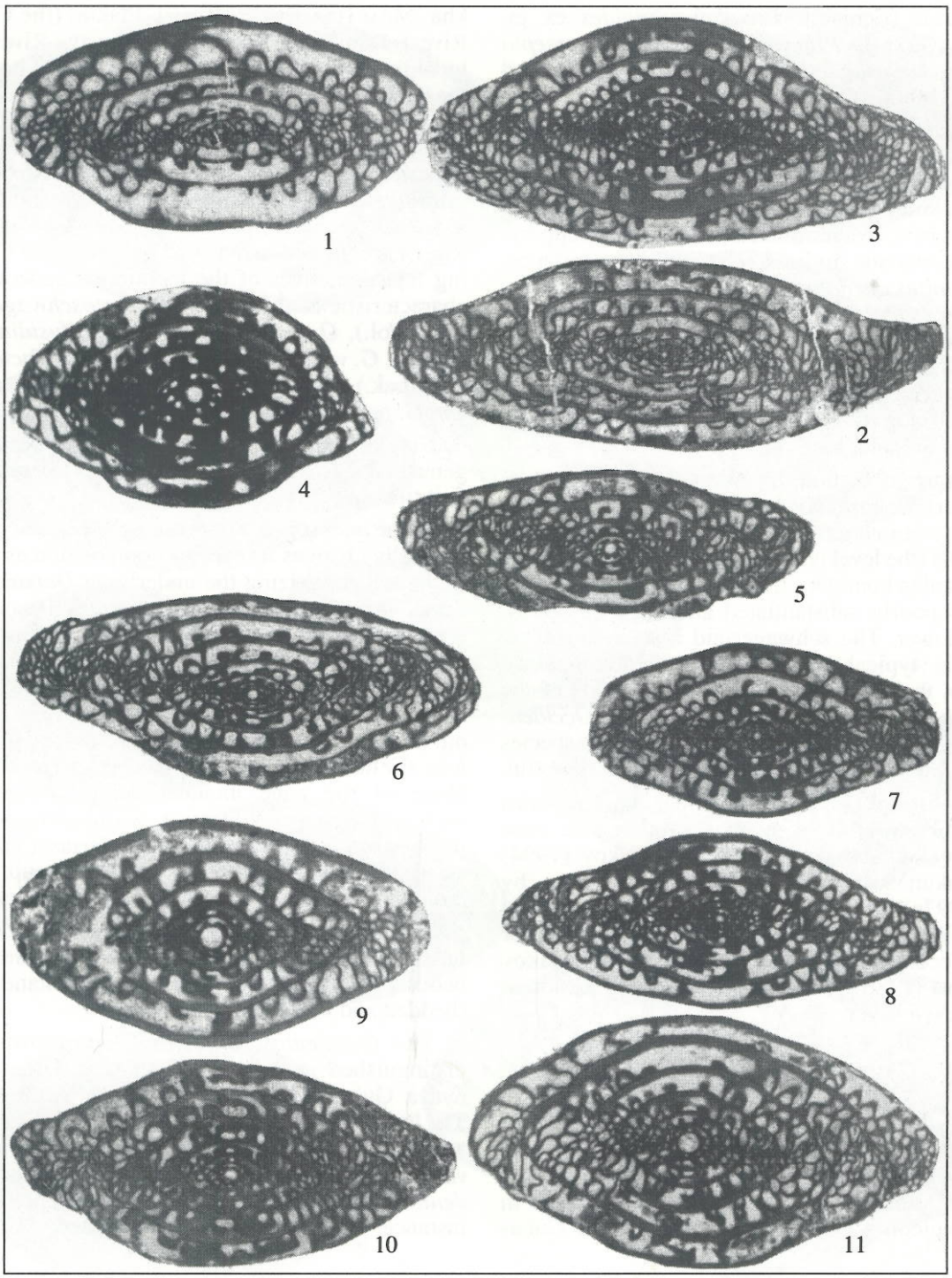


Plate I. Schwagerinids from the *Occidentoschwagerina ancestralis* Zone of the Melekhov Horizon, the Perm' region (magnification 15 for all specimens, except for figs. 2, 4, and 11): (1) *Occidentoschwagerina ancestralis* Echlakov, specimen 3-4/2, axial section, the Ostanets site, Bed 3; (2) *Occidentoschwagerina acerba* Vilesov, holotype, specimen 3-1/1, axial section, ×12.5, ditto, Bed 3; (3) *Anderssonites ognevae* Vilesov, specimen 3-4/1, axial section, ditto, Bed 3; (4) *Triticites? nadezhdae* (Grozdilova), specimen Z-2-19, axial section, ×20, the Nizhnyaya Gubakha site, Bed 7; (5) *Schellwienia emaciata* (Konovalova), specimen Zh-3-2, axial section, ditto, Bed 7; (6) *Schellwienia visotchnajaensis* (Konovalova), specimen 3303, axial section, ditto, Bed 7; (7) *Schellwienia porrecta* (Sjomina), specimen Z-2-16, axial section, ditto, Bed 7; (8) *Schellwienia acuminulata* (Echlakov), specimen Z-2-32, axial section, ditto, Bed 7; (9) *Globifusulina* cf. *vozhgalensis* (Rauser), specimen 3-1/3, axial section, the Ostanets site, Bed 3; (10) *Globifusulina pechorica* (Volozhanina), specimen K-1-1, axial section, the Nizhnyaya Gubakha site, Bed 9 (foot); (11) *Globifusulina tumifacta* (Echlakov et Scherbakova), specimen 3-1/6, oblique section, (×12.5), the Ostanets section, Bed 3.

nites cognatus (Echlak.), *Pseudofusulinoides* ex gr. *kljasmicus* (Sjom.), *Praepseudofusulina impersepta* (Jagof.), and *Schwagerina* ex gr. *vulgaris*: The bed thickness is 3.0 m.

In the Ostanets Section, the boundary between systems is drawn slightly below the first appearance level of *Schwagerina* representatives. In this case, the boundary position is established on the basis of following changes in schwagerinid assemblages: the appearance of characteristic *Anderssonites* forms, for instance, of *Anderssonites cognatus* (Echlak.); the complete disappearance of *Occidentoschwagerina* species and globifusulinids of the group *Globifusulina robusta* (Raus.). In other sections along the Kos'va River (Kholodnyi Log, Nizhnyaya Gubakha), the appearance of schwagerinids is concurrent with the mentioned changes in assemblages.

In the Ostanets section, Shcherbakova (1986) separated the *Daixina bosbytauensis–Globifusulina robusta* and *Schwagerina vulgaris–Sch. fusiformis* zones at the base of Bed 8 (the level is now accepted for the Carboniferous–Permian boundary). In my opinion, the boundary level is poorly substantiated and must be placed somewhat lower. The schwagerinid assemblage from beds 8–10 is typical of the Melekhov Horizon, since dominant in the assemblage are globifusulinids of the group *Globifusulina robusta* (Raus.) and *Occidentoschwagerina* forms; the only schwagerinid species from Bed 8 was identified by Shcherbakova as doubtful.

The lithological and paleontological characteristics of the Melekhov Horizon in the Perm' region were described by Shcherbakova and Shcherbakov (1994) for the Plakun section at the Chusovaya River, by Vilesov (1997c) for the Nizhnyaya Gubakha section at the Kos'va River, by Zolotova and Provorov (1974) for the Most Section at the same river, and by Ekhlakov and Zolotova (1986) for the Kamen' Stolby section at the Berezovaya River.

SUBSTANTIATION AND CHARACTERISTICS OF LOCAL FUSULINID ZONES OF THE MELEKHOV HORIZON

The *Occidentoschwagerina ancestralis* Zone is basal in the Melekhov Horizon. It is distinguished in sections Kholodnyi Log, Ostanets, Nizhnyaya Gubakha, Most (the Kos'va River), Plakun (the Chusovaya River), Kamen' Stolby (the Berezovaya River); all the localities are shown in Fig. 1. The lower boundary of the zone coincides with the base of the *Daixina bosbytauensis–Globifusulina robusta* Zone and is drawn at the appearance level of species *Occidentoschwagerina ancestralis* Echlak (Plate I). The appearance of other primitive *Occidentoschwagerina* forms and first *Globifusulina* species (the group *Globifusulina robusta* Raus.) is confined to the zone base as well. The following representatives of the mentioned genera are most characteristic of the zone: *Occidentoschwagerina simplex* (Vol.), *O. acerba* Vilesov, *Globifusulina robusta* (Raus.), *G. vozhgalensis* (Raus.), *G. tumifacta* (Echl. et Scherbak.), *G. pechorica* (Vol.), *G. subrobusta* (Dav.), and *G. pomposa* (Sjom.).

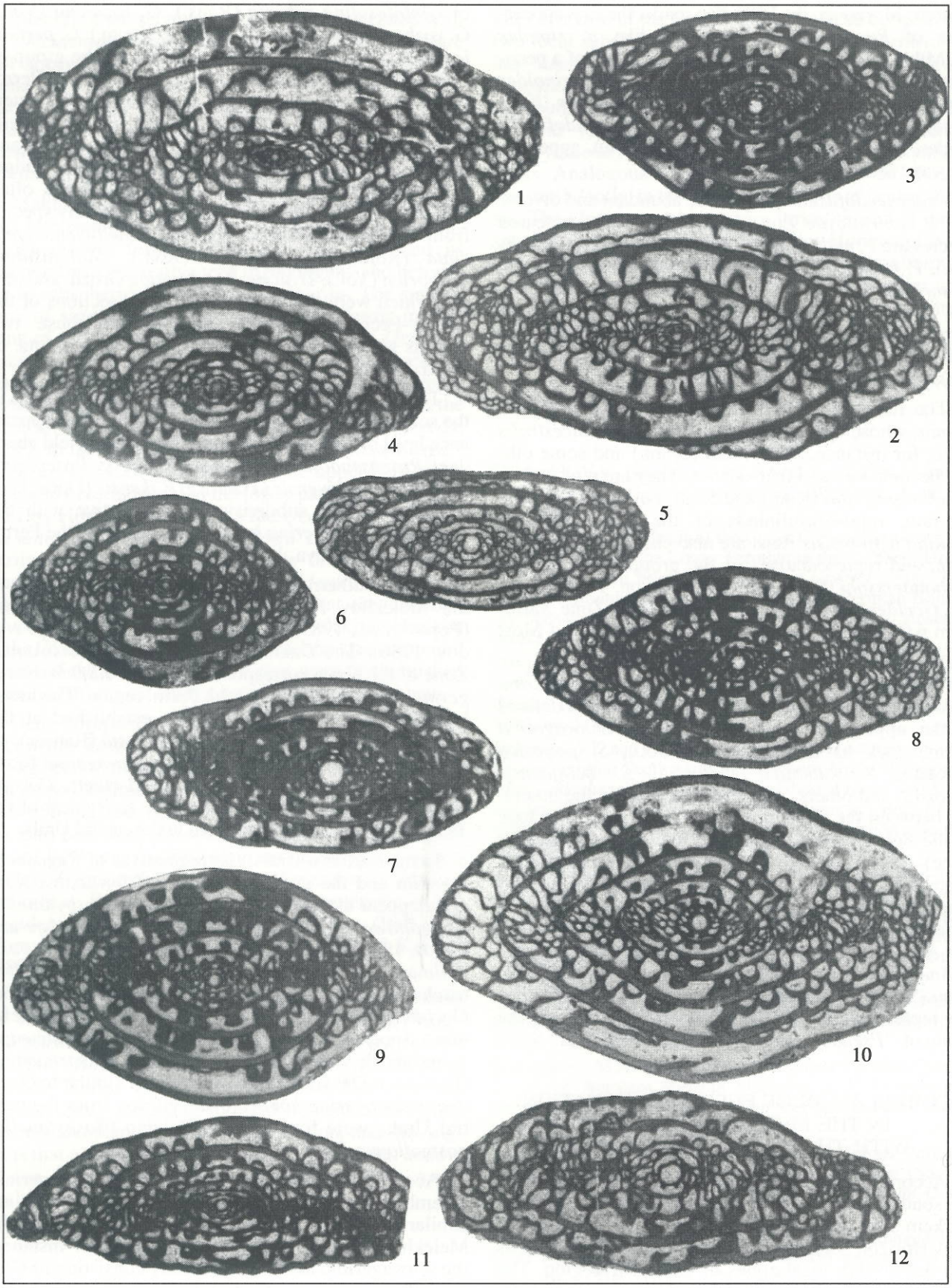
Single representatives of the *Praepseudofusulina* genus, e.g., *P. cara minima* (Isak.), also appear for the first time in the *ancestralis* Zone.

In the *ancestralis* Zone, the *Schellwienia* group substantially changes its species composition as compared to that characterizing the underlying *Daixina sokensis* Zone, and new *Schellwienia* species become sometimes dominant in the fusulinid assemblage, for instance, in the Nizhnyaya Gubakha section (Vilesov, 1997c). The most characteristic of the group are *Schellwienia porrecta* (Sjom.), *S. voseiensis* (Kon.), *S. emaciata* (Kon.), *S. visotchnajaensis* (Kon.), and *S. acuminulata* (Echlak.). In addition, the schwagerinid assemblage of the zone includes *Anderssonites* species, namely *A. ognevae* Vilesov, *A. paraanderssoni* (Raus.), *A. subovatus* (Kon.), and *A. confertus* (Vilesov), all associated with representatives of the group *Triticites? nadaezhdae* (Grozd.) peculiar in morphology.

The *Occidentoschwagerina ancestralis* Zone varies in thickness from 4 m in the Plakun section (normal bedded limestones) to 13 m in the Ostanets Section (bedded and biohermal limestones).

The *Occidentoschwagerina konovalovae* Zone is distinguished in the Kholodnyi Log, Ostanets, Nizhnyaya Gubakha, Most, and Kamen' Stolby sections. The lower boundary of the zone corresponds to the first appearance level of *Occidentoschwagerina konovalovae* Vilesov (Plate II). Some other species of the *Occidentoschwagerina* genus appear here as well, for instance, *O. kosvaensis* Echlak. and *O. echlakovi*

Plate II. Schwagerinids from the *Occidentoschwagerina konovalovae* Zone of the Melekhov Horizon, the Perm' region (magnification 15, except for Fig. 4): (1) *Occidentoschwagerina konovalovae* Vilesov, holotype, specimen 24-2-3/3, axial section, the Kholodnyi Log site, Exposure 24, Bed 2; (2) *Occidentoschwagerina echlakovi* Vilesov, holotype, specimen 24-2-2/5, axial section, ditto, Exposure 24, Bed 2; (3) *Globifusulina ponderosa* (Alksne), specimen N-3-3, axial section, the Nizhnyaya Gubakha Section, Bed 9; (4) *Praepseudofusulina netkatchensis* f. *ventricosa* (Ketat), specimen F-1-5, axial section, ×20, ditto, Bed 9; (5) *Praepseudofusulina netkatchensis* f. *ovata* (Ketat), specimen 4493, axial section, the Kamen' Stolby site, Exposure 21, Bed 12; (6) *Likharevites subschwagerinoides forma grandis* (Grozdilova), specimen 24-2-2/6, axial section, the Kholodnyi Log site, Exposure 24, Bed 2; (7) *Praepseudofusulina* aff. *busulukensis* (Dobrokhotova), specimen 3298, axial section, the Nizhnyaya Gubakha site, Bed 9; (8) *Globifusulina vozhgalensis* (Rauser), specimen U-3-3, axial section, ditto, Bed 9; (9) *Globifusulina* cf. *robusta* (Rauser), specimen T-1-2, axial section, ditto, Bed 2; (10) *Globifusulina versabile* (Bensh), specimen F-2-2, slightly biased section, the Nizhnyaya Gubakha Section, Bed 9 (middle part); (11) *Rugosochusenella simplex* (Z. Mikhailova), specimen 24-3-3/17, axial section, the Kholodnyi Log Section, Exposure 24, Bed 3; (12) *Rugosofusulina aktjubensis* Rauser, specimen 24-3-8/3, oblique section, the Kholodnyi Log site, Exposure 24, Bed 3.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Vilesov. Moreover, the level also marks the first appearance of *Rugosochusenella* forms, like *R. simplex* (Z. Mikh.) and *R. paragregaria* (Raus.), and of a peculiar group consisting of *T.? subschwagerinoides* (Grozd.), *T.? uniensis* (Grozd.), *T.? fornicatus* (Kanmera). Rare representatives of the genus *Pseudofusulinoides*, for instance, *P. dissimilis* (Scherb.), appear at the same level.

Praepseudofusulina forms are abundant and diverse in the *konovalovae* Zone, where the newly appeared species are *P. netkatchensis* (Ketat), *P. propria* (I. Tchern.), *P. busulukensis* (Dobr.), *P. impercepta* (Jagof.), *P. saratovensis* (I. Tchern.), *P. urmarensis* (Scherb.), and others. The *Globifusulina* genus becomes more diverse in the zone and includes newcomers *G. versabile* (Bensh), *G. gracilis* (Sjom.), *G. ponderosa* (Alksne), *G. confinis* (Sjom.), and others.

The renewal is also evident in the genus *Schellwienia*, whose species characteristic of the *ancestralis* Zone, for instance, *S. porrecta* (Sjom.) and some others, become rare and then die out. They are replaced by *Schellwienia lilia* (Kon.) and *S.* aff. *cognata* (Kon.). In addition, rugosofusulininds of the group *Rugosofusulina aktjubensis* Raus are also characteristic of the zone, and representatives of the group *Anderssonites paraanderssoni* (Raus.) are still common. Thickness of the *Occidentoschwagerina konovalovae* Zone varies from 6.0 m in sections Nizhnyaya Gubakha and Most to 15.0 m in the stratotype section.

The upper boundary of the *Occidentoschwagerina konovalovae* (and of the Melekhov Horizon) is defined at the appearance level of primitive *Schwagerina* forms, such as *S. fusiformis* (Krot.), *S. poljarica* (Grozd.), *S. kumajica* (Scherb.), *S. belajaensis* (Grozd.), and others. This level determines the boundary between the Carboniferous and Permian (the base of the *Schwagerina vulgaris–Schwagerina fusiformis* Zone). New *Globifusulina* species *G. sphaeroidea* (Raus.), *G. nibelensis* (Vol.), *G. elliptica* (Vol.), and others appear at this level together with a peculiar endemic group of *Anderssonites cognatus* (Echlakov) and *Anderssonites gregarius* (Lee) replacing the group of *Anderssonites paraanderssoni* (Raus.) and *A. anderssoni* (Schell.). Peculiar in the basal schwagerinid zone are representatives of the genus *Benshella*, i.e., the group of *"Pseudofusulina" subnathorsti* (Lee).

CORRELATION OF FUSULINID ZONATION IN THE MELEKHOV HORIZON WITH THAT IN ADJACENT AREAS

According to data of Konovalova (1991) obtained in the southeastern Timan Ridge (Well 308, the Yuzhnyi Burkem site), the interval corresponding to the Melekhov Horizon is subdivided into two schwagerinid beds correlative with local zones of the Perm' region. The *Globifusulina robusta* Beds were distinguished by Konovalova on the basis of their assemblage consisting of *Globifusulina robusta* (Raus.), *G. raznicini* (Vol.), *G. vozhgalensis* (Raus.), *G. pomposa* (Sjom.), *G. pechorica* (Vol.), and others, which coexist with the group of *Anderssonites paraanderssoni* (Raus.). In the Perm' region, a similar schwagerinid assemblage is characteristic of the local *Occidentoschwagerina ancestralis* Zone, where it is more diverse at the species and generic rank than the assemblage of the Timan Ridge. *Occidentoschwagerina* and *Schellwienia* forms often play a significant part in the assemblage. Many species from the Perm' region, for instance, *Schellwienia emaciata* (Kon.), S. voseiensis (Kon.), *Globifusulina pechorica* (Vol.), *Triticites? nadezhdae* Grozd, and others, which were described earlier from sections of the Timan–Pechora province, suggest that these two regions were well connected in the Melekhov time of the Gzhelian Age.

The *Pseudofusulinoides kljasmicus* (Sjom.) Beds in the southeastern Timan Ridge correspond to the appearance level of *Pseudofusulinoides* forms and yield abundant *Praepseudofusulina* species, such as *Praepseudofusulina saratovensis* (Tchern.), *P. ikensis* (Dobrokh.), and others. This subdivision is correlative with the *Occidentoschwagerina konovalovae* Zone of the Perm' region (Konovalova, 1991).

In the southern Urals, the interval corresponding to the Melekhov Horizon is divided into two zones (Popov *et al.*, 1985; Davydov and Popov, 1986; Davydov, 1986). The *Daixina (Bosbytauella) postsokensis* Zone of the Urals corresponds to the *Occidentoschwagerina ancestralis* Zone of the Perm' region. The lower boundary of the Uralian zone is established at the appearance level of *Globifusulina robusta* (Rauser), *G. vozhgalensis* (Rauser), and *Occidentoschwagerina* forms similar to *O. ancestralis* Echlakov, and others. *Daixina* (*Bosbytauella*) species from this zone are typical of the Tethyan sections, being unknown in the central Urals.

In the southern Urals, representatives of *Rugosochusenella* and the group of *Triticites? fornicatus* Kanmera appear at the base of the *Daixina* (*Bosbytauella*) *postgalloway* Zone (Popov *et al.*, 1985; Davydov and Popov, 1986). Accordingly, we may correlate the *postgalloway* Zone of the southern Urals with the *Occidentoschwagerina konovalovae* Zone of the Perm' region. *Occidentoschwagerina* forms suggest the same correlation: species *Occidentoschwagerina sarykumensis* Scherbovich sensu Davidov, 1986 and *O. sartauensis* (Davidov) (Davydov, 1986), the former similar to *Occidentoschwagerina konovalovae* Vilesov from the central Urals, were found in the *Daixina (Bosbytauella) postgalloway* Zone of the southern Urals.

According to data of Semina (1961), schwagerinid assemblages from beds in the Oka-Tsna Rampart are similar to fauna characterizing both local zones of the Melekhov Horizon in the Perm' region. For instance, the schwagerinid assemblage mostly consisting of *Globifusulina pomposa* (Sjom.) is distinguished in the Exposure 111 near the village of Golyshevo and marks

an interval of the section, which can be correlated with the *Occidentoschwagerina ancestralis* Zone. Exposure 114 above the Exposure 111 yielded abundant specimens of *Pseudofusulinoides kljasmicus* (Sjom.) in association with *Globifusulina pomposa* (Sjom.) and *Anderssonites pseudoanderssoni* (Sjom.). Consequently, this interval is correlative with the *Occidentoschwagerina konovalovae* Zone of the Perm' region.

Makhlina and Isakova (1997) published additional data interesting for correlation. In particular, *Occidentoschwagerina insolita* (Isakova) was described as *Daixina* form more advanced in phylogeny and belonging to subspherical occidentoschwagerins. The appearance of similar *Occidentoschwagerina* forms in sections of the Perm' region is confined to the *Occidentoschwagerina konovalovae* Zone. Similar *Occidentoschwagerina* species, for instance, *Occidentoschwagerina sartauensis* (Davidov) and others, appear at the same level in sections of the southern Urals (Davydov, 1986). In the Oka-Tsna Rampart, *Occidentoschwagerina insolita* (Isakova) is found in the upper part of the Melekhov Horizon and in the lower part of the Kholodnyi Log Horizon. This allows the *Occidentoschwagerina konovalovae* Zone of the Perm' region to be arbitrarily correlated with upper beds of the Melekhov Horizon, which also yield *Occidentoschwagerina insolita* (Isakova). It is significant that the endemic schwagerinid assemblage from the Melekhov Horizon of the Oka-Tsna Rampart is impoverished, as compared to that of the Urals, and zones that were distinguished in the Perm' region cannot be easily recognized here.

Beds comparable with the *Occidentoschwagerina ancestralis* Zone are hardly traceable in the Yablonevyi Ovrag section of the Samarskaya Luka site. It is likely that coeval sediments are represented here by dolomite beds 35b and 36a (after Murav'ev *et al.*, 1983) underlying marl beds with abundant schwagerinid fauna represented by *Praepseudofusulina orenburgensis cognata* (Ketat), *P. netkatchensis* (Ketat), *P. ustzajensis* (Malk.), and others. Fauna of this kind is characteristic of the *Occidentoschwagerina konovalovae* Zone (Bed 36b; Murav'ev *et al.*, 1983,1984; Kalmykova and Kashik, 1988).

According to data on sections in the Volgograd area, the Volga region (Zolotukhina and Ketat, 1984), *Praepseudofusulina* forms are rare in the lower part of the *Daixina* (*Bosbytauella*) *bosbytauensis–Globifusulina robusta* Zone, or in *Bosbytauella bosbytauensis* (Bensh) Beds according to local nomenclature. They become abundant upwards in the section, and this suggests that analogs of the *Occidentoschwagerina konovalovae* and *Occidentoschwagerina ancestralis* zones could be distinguished in this area as well.

CONCLUSION

Thus, the study on stratigraphic ranges and history of fusulinids shows that, in the Perm' region, the Melekhov Horizon of the Gzhelian Stage can be divided into two local subdivisions: the lower *Occidentoschwagerina ancestralis* and upper *Occidentoschwagerina konovalovae* zones. Both zones are found to extend to the southern Timan Range and correlate with the local *Daixina (Bosbytauella) postsokensis* and *Daixina (Bosbytauella) postgalloway* zones of the southern Urals. Analogous zones can be distinguished, though less confidently, in the platform sections of central Russia. The *Occidentoschwagerina* forms chosen as index species of zonal units of the Melekhov Horizon provide the phylogenetic substantiation for the Carboniferous–Permian boundary, because the *Schwagerina* index species for the Asselian biozonation seem to be the direct descendants of the genus *Occidentoschwagerina.*

Reviewers A.S. Alekseev and N.V. Goreva

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