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New Data on Ammonites and Stratigraphy of the Volgian Stage in Spitzbergen

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Abstract—The stratigraphy of the Volgian in Spitzbergen is refined based on the new fossil collections. The lower Volgian is poorly characterized by ammonites being not subdivided into zones, and the only recognized stratigraphic unit within it are the Beds with *Paravirgatites* sp. in the upper part of the lower Volgian. The *Pavlovia rugosa, Dorsoplanites ilovaiskii, Crendonites anguinus*, and *Praechetaites exoticus* zones, the *antiquus, erschovae, sachsi, sokolovi, laevigatus*, and *lambecki* faunal horizons, and Beds with *Laugeites* cf. *groenlandicus* are recognized for the first time in the middle Volgian of Spitzbergen. Two successive levels are identified in the upper Volgian *Craspedites okensis* Zone characterized by differing morphotypes of *Craspedites okensis*. The *Craspedites taimyrense* Zone is proposed instead of the *Craspedites nodiger* Zone. No ammonites of the terminal Volgian *Chetaites chetae* Zone have so far been found in Spitzbergen. New species of *Epivirgatites sokolovi* sp. nov., *E. laevigatus* sp. nov., *Praechetaites erschovae* sp. nov., and *P. confusus* sp. nov. are described. The diagnosis of the genus *Praechetaites* is expanded.

Key words: Volgian, Spitzbergen, ammonites, zonal scale.

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INTRODUCTION

The Jurassic–Cretaceous boundary beds have been extensively studied in recent years. There are a number of reasons for the increased interest in this stratigraphic interval, including the considerable hydrocarbon potential of synchronous beds in the Barents Sea shelf, the recent discovery of numerous Jurassic marine vertebrates in the Volgian of Spitzbergen, and the search for a geochemical anomaly near the Jurassic–Cretaceous boundary.

However the succession of ammonite zones of the Volgian of Spitzbergen used at present is only partly based on detailed data from sections, because it is largely based on random fossil occurrences during geological mapping, which have not been revised for over 25 years. The zonal scheme of the Volgian of Spitzbergen developed by Russian stratigraphers (Ershova, 1969, 1983; Ershova and Pchelina, 1979) is composed of a succession of ammonite zones in various regions: in Greenland, Eastern Europe and in the Subpolar Urals. In the present paper, a detailed stratigraphic scheme of the Volgian is proposed based on the results of field work in 2006–2007 at Festningen Cape and Agard Bay (Myklegardfjellet Mountain), analysis of published data and re-examination of collections (see below).

HISTORY OF STUDIES OF THE VOLGIAN IN SPITZBERGEN

The first data on the presence of equivalents of the Volgian in Spitzbergen were published in the 1860s when Lindström (1865) published a small paper on the Triassic and Jurassic of this region. He also indicated the presence of equivalents of the two upper stages of the Moscow Basin Jurassic (i.e., Middle- and Upper Volgian in their modern understanding) in different regions of Spitzbergen, figured and described several fossils of this age including *Ammonites triplicatus* (=*Dorsoplanites* cf. *sachsi* Michlv.) found in the Sassenfjord and in the vicinity of the Agard Bay. Shortly after, Lundgren (1883) described Volgian *Buchia* from the Advent Bay and recorded, but did not figure *Ammonites triplicatus* from Dunerbukhta.

New data on the Volgian of Spitzbergen were obtained during the expedition of Martin Conway in 1896. Ammonites collected on this expedition were examined by Spath (1921), who recorded the Volgian species *Virgatites* cf. *polygyratus*, *V.* cf. *scythicus*, *V.* cf. *nikitini*, *Craspedites* sp. cf. *nodiger*, *Craspedites* sp. nov.(?) from the Starostin Cape[1]. Later Spath (1924) concluded that these *Craspedites* can be dated as infra-Valanginian, and later (Spath, 1947, p. 60) he again

[1] The fossils were likely to have been collected in the vicinity of Festningen Cape, because only Carboniferous and Permian rocks are exposed near the Starostin Cape.

did not assign the Spitzbergen taxa to *Virgatites*. I re-examined Spath's collection in the Natural History Museum, London and showed that the majority of ammonites dated by Spath as Volgian (and some Kimmeridgian specimens) are in fact Volgian, although two ammonites identified by Spath as *Craspedites*, apparently represent Valanginian Polyptychitidae. Among the Volgian ammonites of Spath's collection, I identified *Dorsoplanites* spp., *Crendonites* sp. and *Glaucolithites* sp. also important to pan-boreal correlation.

These were shortly followed by the reports on the material collected by Norwegian expeditions led by Hoel (1908-1915), mainly on Festningen Cape. Jurassic fossils collected on this expedition were transferred for examination to Sokolov (1922), who was able to make only preliminary identifications. Concluding the paper, Sokolov noted that Beds 17–20[2] of the Festningen Cape section containing *Aucella pallasi* and *Perisphinctes scythicus* belong to the Portlandian, whereas the overlying beds contained unidentifiable ammonites. In his opinion, the higher portion of the Portlandian with *Amm. triplicatus* Lundgr. non Sow. was present only near the Delta Cape. After the death of D.N. Sokolov the collections were considered lost, and in 1921 a new expedition was organized, Mesozoic material from which was examined by H. Frebold. In the Festningen section, Frebold (1928) recognized the lower Portlandian with *Virgatites* cf. *scythicus* (Vischn.) (Frebold, 1928, p. 13, level 17 =? *Praechetaites* sp.[3] upper Portlandian with *Perisphinctes* cf. *polygyratus* Pavl. non Trautsch. (Frebold, 1928, p. 13, pl. 1, fig. 3 =*Praechetaites* cf. *exoticus*, level 19; fig. 4 = *Glaucolithites* sp., level 18) and upper Volgian (Aquilonian)–Ryazanian with *Craspedites* sp. cf. *pressulum* (Bogosl.) (this ammonite remained unfigured, but level 20, where it came from, is of Volgian age). Later Frebold and Stoll (1937) positively dated this level as Upper Jurassic (Portlandian).

Almost at the same time with the Frebold's paper Zhirmunsky (1927) published results of identifications of fossils from the Upper Jurassic and Lower Cretaceous from the eastern coast of Spitzbergen collected by the expedition of the Marine Research Institute, in summer 1925. Among Volgian fossils, he mainly indicated bivalves, but also mentioned ammonites identified as *Olcostephanus lomonossovi* Vischn. and *Perisphinctes* sp. Unfortunately, these ammonites remained undescribed and unfigured, and Zhirmunsky's collection is likely to have been lost[4].

Shortly after that, Frebold (1930) figured other Volgian ammonites from various regions of Spitzbergen. These were middle Volgian taxa, which he identified as similar to *"Perisphinctes"* (*Dorsoplanites*) *panderi*. These ammonites mainly belong to the Arctic species of *Dorsoplanites*, which had not been described prior to Frebold's paper. These are *D. flavus* Spath (*Perisphinctes* cf. *panderi* in Frebold, 1930, pl. XII, fig. 1), *Dorsoplanites* sp. nov. (*Perisphinctes* cf. *panderi* in Frebold, 1930, pl. XI, fig. 2). Some *"Perisphinctes panderi"* figured by Frebold belong to other middle Volgian genera *Taimyrosphinctes* (*Perisphinctes* cf. *panderi* in Frebold, 1930, pl. XIII, fig. 1) and *?Epivirgatites* (*Perisphinctes* cf. *panderi* in Frebold, 1930, pl. X, figs. 2–6, pl. XI, fig. 1; these ammonites also resemble *Dorsoplanites ilovaiskii* Mesezhn.). In addition, Frebold described and figured *Perisphinctes* sp. indet. aff. *nikitini* (Frebold, 1930, pl. XIV. fig. 3), which can tentatively be identified as *Dorsoplanites gracilis* Spath or *D. subovalis* Mesezhn.

Sokolov and Bodylevsky (1931) published a paper based on an incomplete manuscript by Sokolov on Mesozoic fossils of Spitzbergen, which was supplemented and prepared for publication by V.I. Bodylevsky. The paper contained descriptions and illustrations of some Volgian ammonites, such as *Perisphinctes* aff. *panderi* Orb. (Sokolov and Bodylevsky, 1931, p. 88, pl. VIII, fig. 2 =*Dorsoplanites* or *Epivirgatites*), *P.* ex gr. *scythicus* Vischn. (Sokolov and Bodylevsky, 1931, p. 89, pl. VIII, fig. 6 =*Praechetaites* cf. *tenuicostatus* (Shulg.), level 18 of the Festningen section), *Perisphinctes* sp. A (Sokolov and Bodylevsky, 1931, p. 90, pl. IX, fig. 3 =*Epivirgatites sokolovi* Bodylevsky in Rogov, sp. nov.[5] *Perisphinctes* sp. A (Sokolov and Bodylevsky, 1931, p. 91, pl. IX, fig. 4 =*Dorsoplanites* sp. nov., pl. XIV. fig. 1 =*Glaucolithites* sp. or *Taimyrosphinctes* sp.) and *Perisphinctes* sp. sp. (Sokolov and Bodylevsky, 1931, p. 93, pl. IX, fig. 5 =*Laugeites* cf. *biplicatus* Mesezhn., level 18 of the Festningen section). From a higher level 20 of the Festningen section Frebold (1928) recorded *Craspedites* sp. cf. *pressulus* and *subpressulus* (these species with a high branching coefficient are readily distinguished from early members of *Craspedites*; these ammonites were found considerably lower than *Craspedites*, found by the present author and possibly belong to *Laugeites* ex gr.

[2] Later publications did not mention beds, but indicated levels from where the fossils of Hoel's expedition, and later by Orvin's expedition were collected (see Sokolov and Bodylevsky, 1931; Frebold and Stoll, 1937; Hoel and Orvin, 1937). Unfortunately these occurrences cannot be positively correlated with the present author's data because of the significant discrepancies in the published thicknesses.

[3] All re-identifications are by the present author.

[4] The Marine Research Institute later became the Russian Federal Research Institute of Fishery and Oceanography (VNIRO). No paleontological collections are are presently kept in this institute.

[5] Schulgina in (Saks and Schulgina, 1972) identified this ammonite as *Chetaites sibiricus*, and Ershova in (Ershova and Pchelina, 1979) suggested that it belonged to the genus *Laugeites*.

lambecki or *Praechetaites*). From this level, Sokolov and Bodylevsky, (1931) recorded *Perisphinctes* ex gr. *scythicus* (?=*Praechetaites* sp.).

Shortly after that Tyrrell (1933) published a paper with data on the Mesozoic of Spitzbergen mainly obtained in the expeditions of 1919 and 1920 studying the eastern coast of Spitzbergen and adjacent islands. Tyrrell recorded *Virgatites* sp. from Agard Mountain, identified by Spath. However, later Spath (1947, p. 60) changed his earlier identifications, concluding that the resemblance of *Virgatites*, which he had previously identified from Spitzbergen, with typical Russian specimens, is a product of an erroneous identification of homeomorphic specimens of apparently different ages.

Różycky (1959) published on the Volgian of Torell Land, from where he recorded middle Volgian and upper Volgian (including *Craspedites* cf. *subditus*) ammonites. Late data on the Volgian of Torell Land and the Agard Bay were also published by Birkenmajer (1975, 1980). In the section of Myklegardfjellet Mountain he collected Middle Jurassic–Lower Cretaceous fossils, among which Wierzbowsky identified the lower Volgian *Pectinatites* (*P.* (?*Virgatosphinctoides*) sp.: Birkenmajer et al., 1982, p. 117, pl. 37, fig. 8). However, the ornamentation of this specimen and its high stratigraphic position in the section suggest that this is the middle–upper Volgian *Praechetaites*, similar to *P. exoticus*. This is supported by identifications of *Buchia*, which were collected in association with this ammonite (according to V.A. Zakharov, these species of *Buchia* are typical of the upper Volgian and lower Ryazanian).

The geological mapping of the USSR Geologic Survey on Spitzbergen which began from the 1960s, immediately resulted in the accumulation of large amount of new data. Pchelina (1965) among Volgian fossils indicated taxa previously unknown from Spitzbergen, including the lower Volgian *Pectinatites*, and also the middle Volgian *Pavlovia* and *Laugeites*. Shortly after Ershova (1969) described the section of the upper Volgian beds of Myklegardfjellet Mountain and the upper Volgian *Craspedites*, including both new species (*Craspedites* (*C.*) *bodylevskii*, *C.* (*Taimyroceras*) *agardensis*), and taxa previously recorded from the Volgian of the Russian Platform (*C.* (*C.*) ex gr. *nodiger, C.* (*C.*) cf. *mosquensis*, *C.* (*C.*) *okensis*) and northern Siberia (*C.* (*C.*) cf. *pseudonodiger*). This allowed her to establish the *Okensis* and *Nodiger* Zones in the upper Volgian of Spitzbergen. Later Ershova and Pchelina (1979) recognized Beds with *Virgatosphinctes* spp. at the base of the upper Volgian of Spitzbergen. In the same paper they briefly described other Volgian units of Spitzbergen. The lower Volgian was considered as Beds with *Pectinatites* sp. and *Subplanites* sp., whereas the Middle Volgian contained (from bottom to top) *Panderi, Maximus*, and *Groenlandicus* Zones. The same zonation of the Volgian was used by Ershova (1983), where she characterized strata in greater detail and figured typical fossils. Unfortunately, Ershova did not figure the lower Volgian specimens, and those could not be located in the collections of VNIIOkeangeologiya. I can agree with some identifications of the Volgian specimens published by Ershova (1923) These are *Dorsoplanites maximus* (Ershova, 1983, pl. 20, fig. 1), *D. sibiriakovi* (Ershova, 1983, pl. 19, fig. 1; the specimen identified as *D. maximus* figured on pl. 18 should also be assigned to *D. sibiriakovi*), *"Virgatosphinctes"* (=*Praechetaites*) ex gr. *tenuicostatus* (Ershova, 1983, pl. 24, fig. 1 (only); other ammonites, figured under this name by Ershova (1983) and by Ershova and Pchelina (1979) belong to *Laugeites parvus*, *Laugeites* cf. *borealis* (Ershova, 1983, pl. 23, fig. 2; pl. 25, figs. 1–4). At the same time *Dorsoplanites panderi* (d'Orb.), figured by Ershova (1983, pl. 16, figs. 1–2; pl. 17, fig. 1), possess straight ribs with a high branching coefficient, running vertically to the umbilical wall or rursiradiate. I re-identified these ammonites as *Dorsoplanites triplex* Spath. The specimen that Ershova identified as *Dorsoplanites jamesoni* (Ershova, 1983, pl. 20, fig. 2) has rapidly weakening secondary ribbing, which is not typical of this species, but is observed in specimens related to *D. flavus* Spath. The ammonite identified by Ershova as *Pavlovia* aff. *kochi* (Ershova, 1983, pl. 22, fig. 1) should probably be re-identified as *Glaucolithites* cf. *groenlandicus* (Spath), although it differs from the Greenland specimen of this species by a considerably smaller shell. Shells of *"Laugeites* ex gr. *groenlandicus"* (Ershova, 1983, pl. 23, figs. 1, 4; pl. 24. figs. 5-6) possess pronounced constrictions and weak ornamentation, which distinguishes them from the typical *L. groenlandicus* (Callomon and Birkelund, 1982, fig. 5.2). Constrictions of these ammonites resemble those of *L. lambecki*, from which they are distinguished by smaller size and weak ornamentation.

The zonal scale proposed by Ershova, without changes, was accepted for the review of the geology of Svalbard (Harland and Kelly, 1997). After that, the Volgian ammonites of Spitzbergen have not been figured except for a few specimens (Rogov and Zakharov, 2007, 2009; Rogov and Guzhikov, 2009). In addition, characteristic ammonites were figured, including the lower Volgian *Paravirgatites* and the upper Volgian *Kachpurites* in an unpublished report of VNIIOkenageologiya (Schulgina, 1995). The specimens could not be located in the collections in VNIIOkeangeologiya.

MATERIAL

During the field seasons of 2006–2007, I examined two Volgian sections on the western and eastern coasts of Spitzbergen, in the vicinity of the Festningen Cape [6] and Agard Bay, on the slopes of Myklegardfjellet Mountain (Fig. 1). In the vicinity of the Festningen

[6] In the Russian literature can also be cited as Festningensodden Cape or Festing.

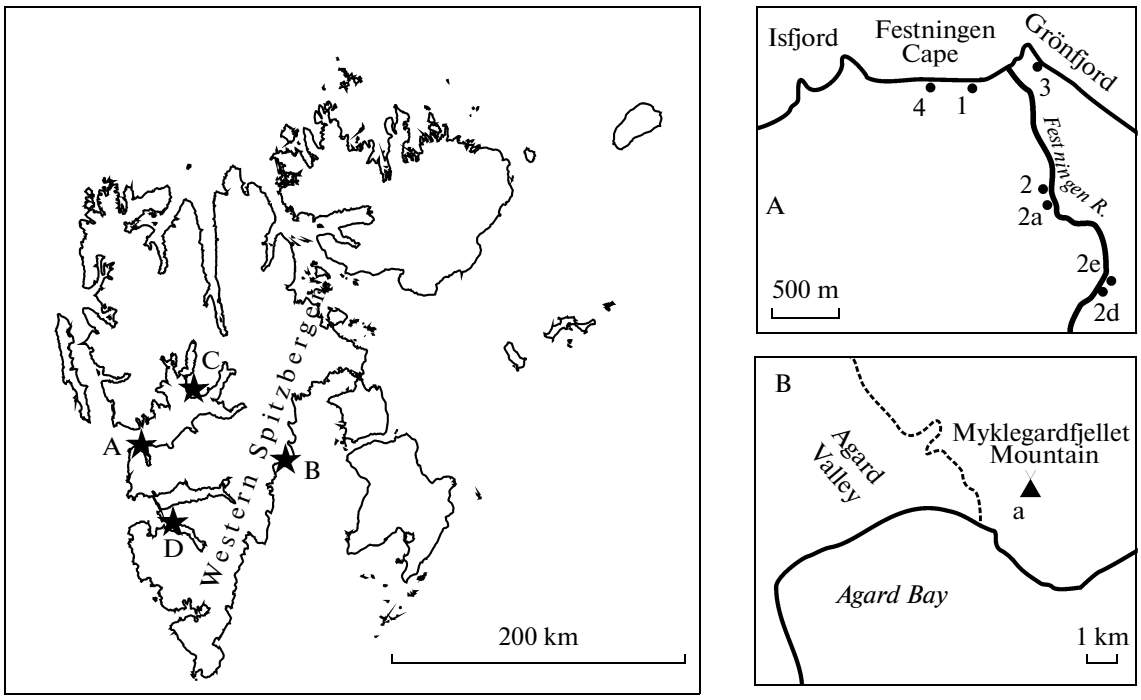
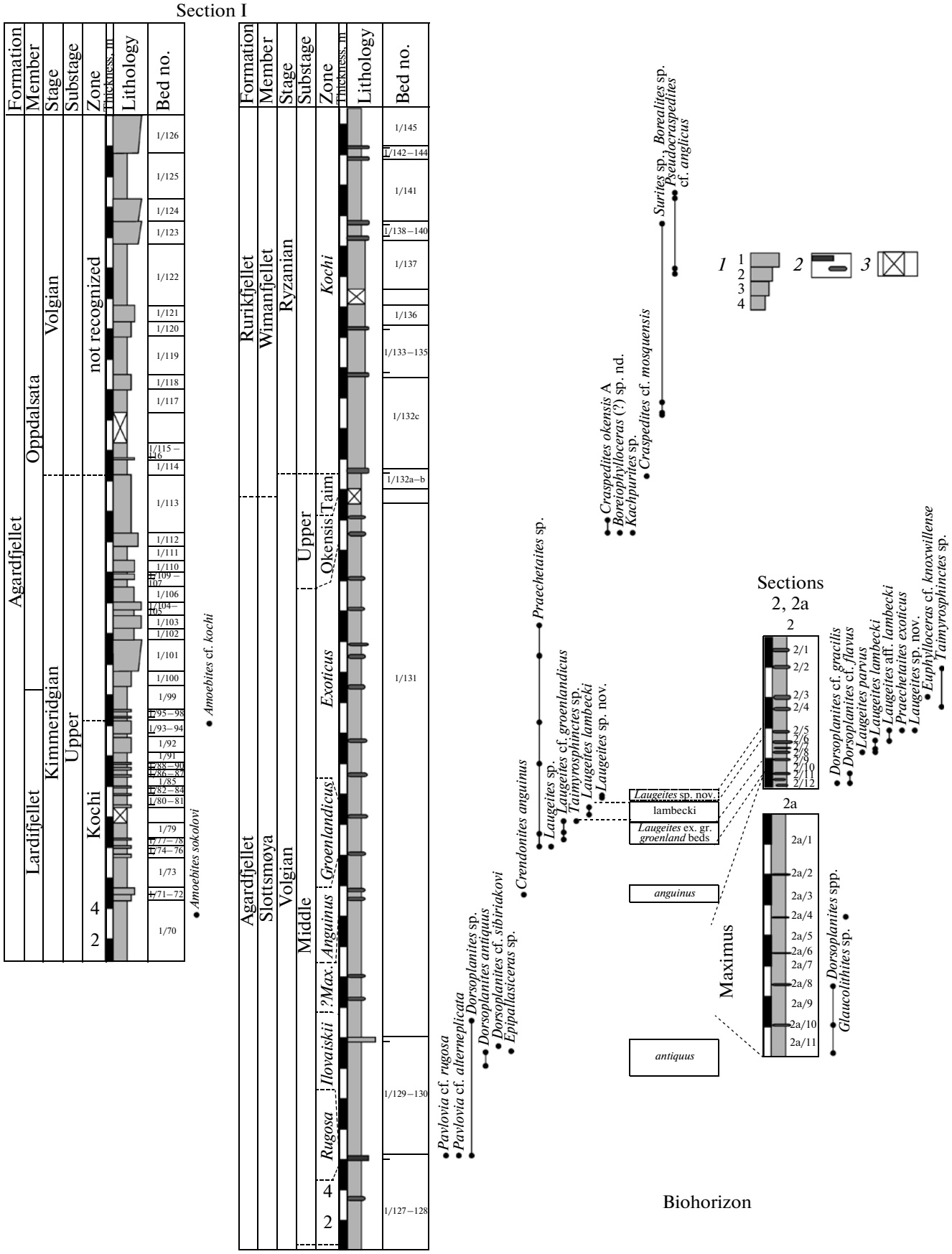


Fig. 1. Schematic location of examined sections. A—Festningen section; numbers indicate sections (coordinates of the sections: 1—78°5′53.07″ N, 13°55′34.57″ E (coordinates of the middle Volgian region); 2—78°5′27.94″ N, 13°57,0.28″ E; 2a—78°5′24.30″ N, 13°57′2.54″ E); B—Myklegardfjellet section (a – area studied; coordinates of the sections: AB—78°03′15.9″ N, 18°42′24.1″ E (Bed AB3); AC—78°02′56″ N, 18°40′10″ E (Bed AC22); AD—78°02′19.6″ N, 18°41′51.5″ E (Bed AD28)); C—Janusfjellet Mountain, D—Van Keulen fjord (some material from the collections of VNIIOkeangeologiya comes from regions C and D).

Cape (Fig. 2) I examined a continuous section in the cliffs of Isfjord (section 1) and a series of isolated sections on the banks of the Festningen River (sections 2, 2 a–f), whereas on the slope of Myklegardfjellet Mountain (Fig. 3) I examined three parallel, partly overlapping sections (AB, AC, AD). In addition, I used collections of Volgian ammonites by E.S. Ershova, T.M. Pchelina, V.A. Basov, M.D. Burdykina and others, housed in the TsNIGR Museum (specimens TsNIGR...) and VNIIOkeangeologiya (St. Petersburg), in the Spath Collection (Natural History Museum, London, specimens NHM....) and in the collection of the CASP (Cambridge), formerly known as Cambridge Arctic Shelf Programme. The collection studied is stored in the Vernadsky State Geological Museum, Russian Academy of Sciences (Moscow).

The Volgian State of Spitzbergen is represented by the upper part of the Agardfjellet Formation (Bathonian–Volgian), which is subdivided into several members (Dypvik et al., 1991), differing in the granulometric composition of rocks and types of nodules. The age of the shale Slottsmøya Member, well characterized in both examined sections by middle–late Volgian ammonites, is certain, whereas a more coarsely grained underlying Oppdalsata Member recognized in some regions does not contain index molluskan taxa, and can be only tentatively dated as late Kimmeridgian(?)—early Volgian. In the section of the Festningen Cape, the Slottsmøya Member overlies a considerably coarsely Oppdalsata Member containing several thick beds of sandstone (Fig. 2), but the section of Myklegardfjellet Mountain is generally represented by more fine-grained facies and these sandstone beds are not recognized there (Fig. 3). The Volgian beds in the section near the Festningen Cape are overlain by the Rurikfjellet Formation lithologically similar to the Volgian beds, but with larger sideritic nodules and more coarse-grained rocks. In the section of Myklegardfjellet Mountain, Myklegardfjellet Bed represented by easily recognized yellow strongly weathered silts are recognized at the base of this formation (Figs. 2, 3). This bed are the Ryazanian in age. In the Janusfjellet section, they contain *Borealites* sp., and in the Agard Bay, *Buchia okensis* and *B. volgensis* (Basov et al., 1997).

Fig. 2. Volgian Ammonites and stratigraphy of the Festningen section. (*1*) thickness of beds in the log corresponding to the granulometric composition of rocks: (1) sandstones, (2) arenacous siltstone, (3) silty shale, (4) shale); (*2*) carbonate nodules (mainly sideritic), (*3*) gaps in observations.


Section I
Formation
Member
Stage
Substage
Zone
Thickness, m
Lithology
Bed no.
Agardfjellet
Oppdalsata
Lardifjellet
Kimmeridgian
Volgian
Upper
not recognized
Kochi
Amoebites cf. kochi
Amoebites sokolovi
Rurikfjellet
Wimanfjellet
Slottsmøya
Middle
Ryzanian
Kochi
Okensis
Taim.
Exoticus
Groenlandicus
Anguinus
?Max.
Ilovaiskii
Rugosa
Craspedites okensis A
Boreiophylloceras (?) sp. nd.
Kachpurites sp.
Craspedites cf. mosquensis
Surites sp.
Borealites sp.
Pseudocraspedites cf. anglicus
Praechetaites sp.
Crendonites anguinus
Laugeites sp.
Laugeites cf. groenlandicus
Taimyrosphinctes sp.
Laugeites lambecki
Laugeites sp. nov.
Pavlovia cf. rugosa
Pavlovia cf. alternepliсata
Dorsoplanites sp.
Dorsoplanites antiquus
Dorsoplanites cf. sibiriakovi
Epipallasiceras sp.
Laugeites sp. nov.
lambecki
Laugeites ex. gr. groenland beds
anguinus
antiquus
Sections 2, 2a
Maximus
Dorsoplanites cf. gracilis
Dorsoplanites cf. flavus
Laugeites parvus
Laugeites lambecki
Laugeites aff. lambecki
Praechetaites exoticus
Laugeites sp. nov.
Euphylloceras cf. knoxwillense
Taimyrosphinctes sp.
Dorsoplanites spp.
Glaucolithites sp.
Biohorizon

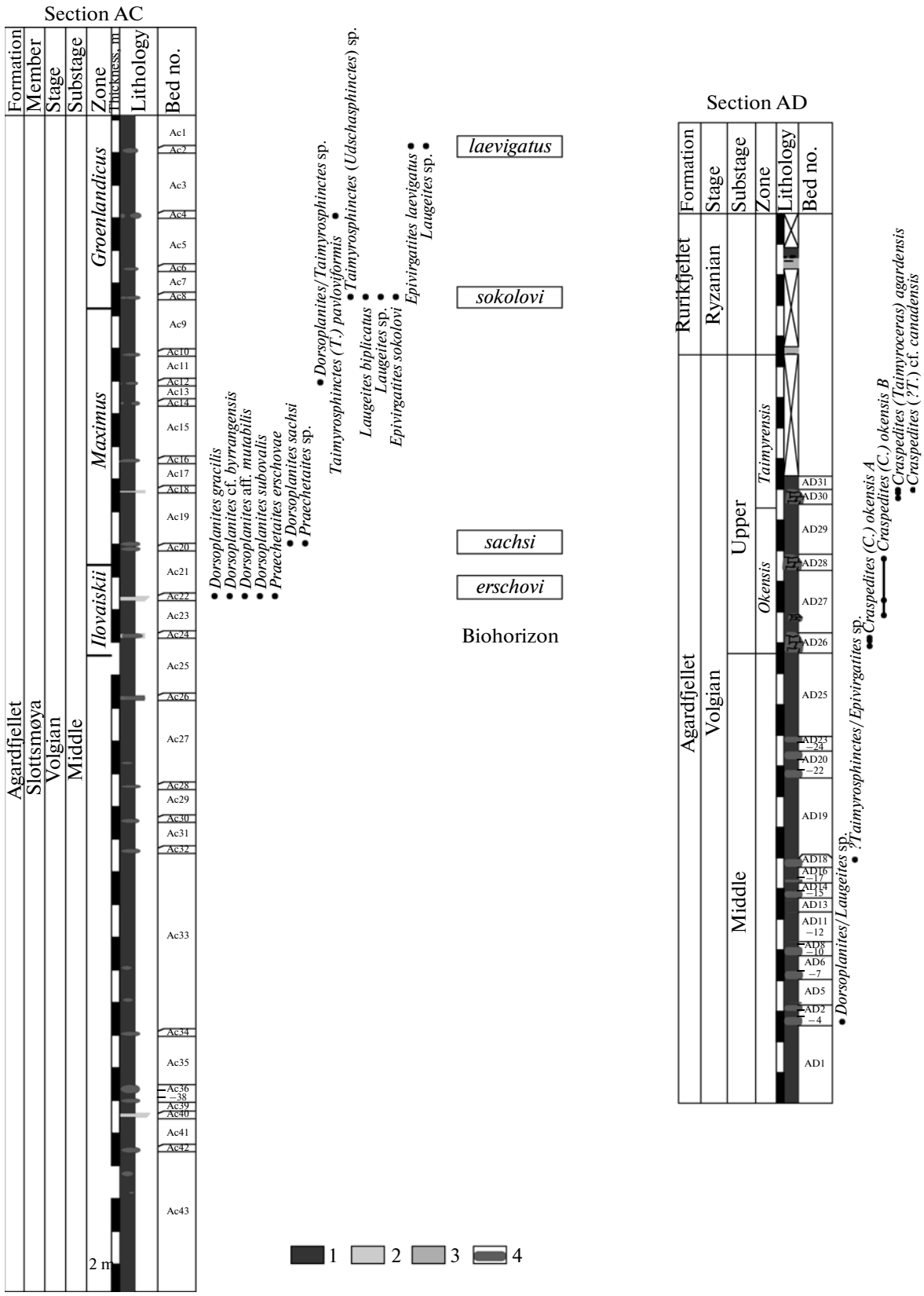


Fig. 3. Volgian Ammonites and stratigraphy of the Myklegardfjellet section. (1) shale, (2) argillaceous siltstone, (3) silty clay; (4) nodules of marl and/or siderite.

In the coastal section near the Festningen Cape, which we examined in 2006 the section is measured from bottom to top and begin from the upper Callovian. The strata below Bed 1/70 belong to the upper Callovian–lower Kimmeridgian interval and are not discussed in this paper. Beds AC62-AC78 of the Myklegardfjellet Mountain section are also dated as Kimmeridgian.

ZONAL SCALE OF THE VOLGIAN IN SPITZBERGEN

Lower Substage

Beds with Paravirgatites sp.

Description. The Lower Volgian ammonites are extremely rare in Spitzbergen. Ershova (1983) established lower Volgian "Beds with *Subplanites* and *Pectinatites"*. In the sections studied, the lower Volgian Substage can possibly include "barren" gaps between the last occurrences of Kimmeridgian ammonites and first occurrences of middle Volgian ammonites. Most likely, records of *Subplanites* were in fact occurrences of *Pectinatites* or *Paravirgatites*, as happened with *Pectinatites* from the lower reaches of the Lena River (Rogov and Zakharov, 2009). The only lower Volgian ammonite from Spitzbergen was figured in an unpublished paper by Schulgina (1995, pl. 39, fig. 3; this paper, pl. I, fig. 1). The specimen is apparently lost, but judging from the photograph it belongs to the late representative of Pectinatitinae characteristic of the *Paravirgatites paravirgatus* Subzone of the *Pectinatites pectinatus* Zone. This specimen is similar to *Paravirgatites* sp. A (Callomon and Birkelund, 1982), found in the "*Paravirgatites* fauna" of East Greenland, dated as the upper subzone of the *Pectinatus* Zone. This is supported by the records of *Paravirgatites boidini* on Spitzbergen (Pchelina, 1965) because small ammonites resembling *Pavlovia* (also found in the topmost lower Volgian) have usually been figured in Russian publications under this name (Mikhailov, 1964. pl. 5, fig. 2; Zakharov and Mesezhnikov, 1974. pl. 13, fig. 3). So far no paleontological evidence exists for the presence of the lower levels of the lower Volgian on Spitzbergen.

Middle Substage

Pavlovia rugosa Zone

Description. The zone is established in the lower part of the former "*Dorsoplanites panderi*" Zone, and its lower boundary is drawn based on the appearance in the section of *Pavlovia* cf. *rugosa*. The section near the Festningen Cape at this level contains small *Pavlovia* with widely spaced coarse ribs (*Pavlovia* cf. *rugosa* Spath, pl. I, fig. 4), found in association with less commonly found, unidentifiable at the species level *Dorsoplanites* (pl. I, fig. 9), and *Pavlovia* cf. *alterniplicata* Spath (pl. I, fig. 8). *Pavlovia*, similar to *P.* cf. *rugosa* (pl. I, figs. 2, 5), apparently from the same stratigraphic level were found loosely in the section of Myklegardfjellet Mountain. In addition, collections of VNIIOkeangeologiya (collection of T.M. Pchelina) contain *Pavlovia* with more thinly ribbed early whorls (pl. I, fig. 3), resembling *P. iatriensis* Ilov. and *P. pallasioides* (Sow.), apparently from a lower stratigraphic level (in East Greenland *Pavlovia*, similar to *P. pallasioides* Neav., were found in the basal middle Volgian *Dorsoplanites primus* Zone, whereas *P. iatriensis* is typical of a younger *Pavlovia iatriensis* Zone). This suggests that equivalents of *Pavlovia iatriensis* can also be present on Spitzbergen.

Boundary. The lower boundary is established based on the appearance of *Pavlovia* cf. *rugosa*, and the upper boundary is based on the appearance of numerous *Dorsoplanites* spp. (*D. gracilis, D. antiquus*, etc.).

Remarks. This zone is for the first time established on Spitzbergen and corresponds to the basal part of the former "*Dorsoplanites panderi*" Zone. It is possible that in the future this stratigraphic unit will be more finely subdivided.

Correlation. This zone is correlated with the *P. rugosa* Zone of East Greenland and with the *Strajewskia strajewskii* Zone of the Subpolar Urals based on the presence of small *Pavlovia* with relatively widely spaced ribs.

Dorsoplanites ilovaiskii Zone

Description. An interval dominated by small *Dorsoplanites*, and lacking *Pavlovia* is present in Spitzbergen. The interval under consideration was assigned to the *D. ilovaiskii* Zone (Rogov and Zakharov, 2007). The assemblage of ammonites found at this level is similar to that of the *Ilovaiskii* Zone of the Subpolar Urals and Taimyr, and despite the absence of the index species, this zone can be readily identified based on the occurrences of *Dorsoplanites antiquus* Spath, *D. gracilis* Spath, *D.* cf. *sibiriakovi* (Ilov.), *D. subovalis* Mes., *D.* cf. *byrrangensis* Mes.

Composition. The *D. ilovaiskii* of Spitzbergen contains two intervals with a noticeably differing ammonite assemblages. One of these referred to the *antiquus* Biohorizon, is established in the section near the Festningen Cape in the interval 6.0–6.7 m above the base of Bed 1/129. This level is typified by occurrences of *Dorsoplanites antiquus* Spath (pl. I, fig. 6), *D. gracilis* Spath (including species similar to *D. gracilis* ε sensu Callomon and Birkelund (pl. I, fig. 6), *D.* cf. *sibiriakovi* (Ilov.) (pl. I, fig. 11), and also *Epipallasiceras* sp. (pl. I, figs. 10, 12). In the section of Myklegardfjellet Mountain, the *D. ilovaiskii* Zone contains the assemblage dominated by small *D. subovalis* Mes. (pl. II, fig. 8), *D.* cf. *byrrangensis* Mes., *D. gracilis* Spath; along with *Praechetaites erschovae* sp. nov. and rare large *Dorsoplanites* aff. *mutabilis* Spath. This assemblage found in the Myklegardfjellet Mountain section, in Bed AC22, apparently corresponds to a higher

Plate I

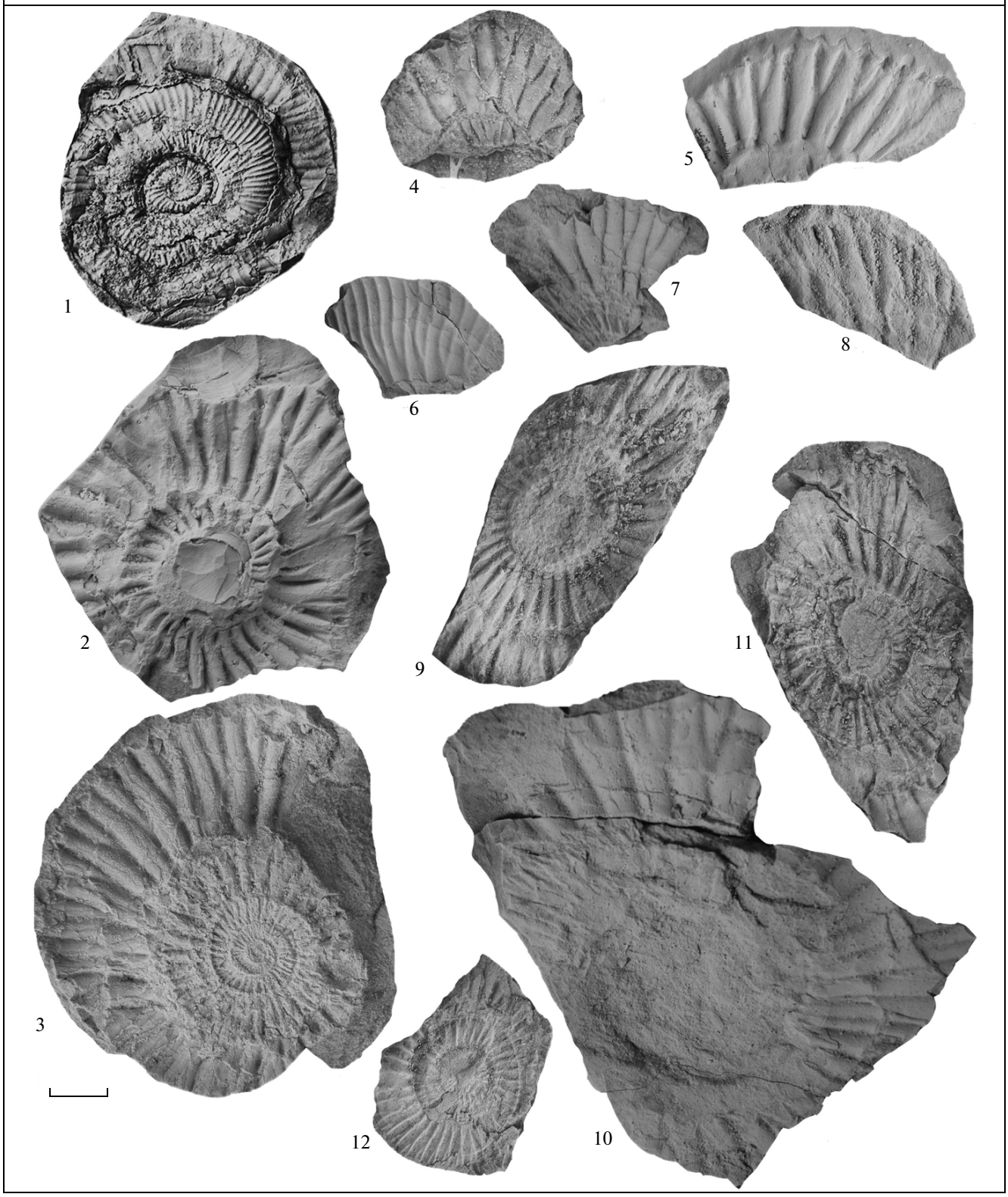


Plate I. Lower- and middle Volgian ammonites of Spitzbergen. For all plates: scale bar = 1 cm; the ammonites (except those marked) are photographed by the present author with the ammonium chloride coating.

(1) *Paravirgatites* sp. (specimen figured by Schulgina (1995, pl. 39. fig. 3)), VNIIOkeangeologiya 163/1924, apparently lost, Janusfjellet, Outcrop 48, Bed 30, lower Volgian, beds with *Paravirgatites* sp.; (2, 4. 5) *Pavlovia* cf. *rugosa* Spath, middle Volgian, *Rugosa* Zone: (2, 5) Myklegardfjellet section A, collected not in situ A3. (2) SGM VH-20/108, (5) SGM VH-20/42, (4) SGM VH-20/41; Festningen, section 1, Bed 128; (3) *Pavlovia* cf. *iatriensis* Ilov., SGM VH-20/51, Van Keulen fjord, Outcrop 13, coll. by T.M. Pchelina; (6) *Dorsoplanites gracilis* Spath, SGM VH-20/48; Festningen, section 1.6 m above the base of Bed 129. middle Volgian, *Ilovaiskii* Zone, *antiquus* Biohorizon; (7) *Dorsoplanites antiquus* Spath, SGM VH-20/111. Festningen, section 1, 6.5 m above the base of Bed 129. middle Volgian, *Ilovaiskii* Zone, *antiquus* Biohorizon; (8) *Pavlovia* cf. *alterniplicata* Spath, SGM VH-20/109; Festningen, section 1, Bed 128, middle Volgian, *Rugosa* Zone; (9) *Dorsoplanites* sp., SGM VH-20/23; the same bed; (10, 12) *Epipallasiceras* sp.; Festningen, section 1, middle Volgian, *Ilovaiskii* Zone, *antiquus* Biohorizon: (10) SGM VH-20/37; 6.7 m above the base of Bed 129; (12) SGM VH-20/44; 6.5 m above the base of Bed 129; (11) *Dorsoplanites* cf. *sibiriakovi* Ilov., SGM VH-20/38; Festningen, section 1, 6.7 m above the base of Bed 129; middle Volgian, *Ilovaiskii* Zone, *antiquus* Biohorizon.

stratigraphic level. It is proposed to recognize this level as the *P. erschovae* Biohorizon.

Correlation. This zone is correlated with the equivalent zones in Taimyr, Subpolar Urals, and Franz-Joseph Land. The ammonite assemblage of the *antiquus* Biohorizon is similar to that of the corresponding fauna of East Greenland, whereas ammonites from the *erschovae* Biohorizon are similar to ammonites from the *Ilovaiskii* Zone of Taimyr (it is possible that the section on the Dyabakatara River contains only the uppermost portion of the *D. ilovaiskii* Zone). The *erschovae* Biohorizon also contains forms similar to *D. mutabilis,* which are found in East Greenland in the upper part of the *Gracilis* Zone (Fauna 40). The presence of ammonites closely similar to *P. erschovae* (see below) in the borehole core from Western Siberia suggests a wide distribution of this biohorizon.

Boundary. The lower boundary is drawn based on the entry of numerous small *Dorsoplanites* spp., and the upper boundary is based on the appearance of *Dorsoplanites* ex gr. *maximus* Spath and *D. flavus* Spath.

Dorsoplanites maximus Zone

Description. This zone, established on Spitzbergen by Ershova (Ershova and Pchelina, 1979), is characterized by the presence of *Dorsoplanites* ex gr. *maximus* Spath, *D. flavus* Spath, *D.* cf. *gracilis* Spath. This zone on Spitzbergen apparently includes an assemblage with *Dorsoplanites sachsi* Michlv. (pl. II, fig. 6) and *Praechetaites* sp. (pl. II, fig. 1), found only in the Myklegardfjellet Mountain section (see below). The zone is also established in an outcrop of the Festningen River (sections 2, 2a on Fig. 2), where it contains *Dorsoplanites* cf. *flavus* (pl. II, fig. 7), *D.* cf. *gracilis* (pl. II, fig. 5), *Glaucolithites* sp. (cf. *groenlandicus* (Spath) = *Pavlovia* aff. *kochi* in Ershova, 1983; pl. III, fig. 1–2). Unfortunately, in section 1 near the Festningen Cape no ammonites of this zone were found.

Composition. This zone is subdivided into two subzones. The lower subzone (*D. maximus*) is poorly represented in the sections studied. It is only present in isolated outcrops on the Festningen River. The upper part of this zone contains the *sachsi* Subzone and Biohorizon. In the Myklegardfjellet Mountain section, the level with these ammonites typifies the subsequent concretion level (Bed AC20) above the *erschovae* Biohorizon. However, the presence of *Dorsoplanites sachsi* Michlv., which in Yakutia are found in the same zone, overlying the *D. maximus* Zone, suggests that the lower part of the zone is absent in this section. It is proposed to consider the *D. sachsi* Zone of Yakutia as a subzone because its ammonite assemblage is closely similar to that of the *Maximus* Zone.

Correlation. This zone correlates with the *Dorsoplanites maximus* Zones of the Subpolar Urals, Taimyr, and Yakutia (including *D. sachsi* subzone) and the *Pseudapertum* Zone of East Greenland (based on the presence of *Glaucolithites* and *Dorsoplanites maximus*).

Remarks. Previously, Rogov and Zakharov (2007) suggested that on Spitzbergen, the level with *D. sachsi* occurs below the level of *D. maximus.* In this paper, ammonites, previously identified by the author as *D.* cf. *maximus*, are re-identified as *Taimyrosphinctes (T.) pavloviformis* Mesezhn., and level with this fauna is referred to the *Laugeites groenlandicus* Zone.

Boundary. The lower boundary of the zone is drawn based on the replacement of the assemblage dominated by small *Dorsoplanites*, such as *D. antiquus* Spath, *D. subovalis, D.* cf. *byrrangensis* Mesezhn. by the assemblage with larger *D.* ex gr. *maximus* Spath. *Dorsoplanites* is not found above the level of the *Maximus* Zone.

Crendonites anguinus Zone

Description. This zone was previously established by the author as the *Crendonites* Zone (Rogov, 2007; Rogov and Zakharov, 2007; 2009) based on a single occurrence of *Crendonites* in the section of the Festningen Cape. In this paper, this ammonite is re-identified as *C. anguinus* Spath (pl. VI, fig. 3), and the level of its occurrence is referred to the *Crendonites anguinus* Biohorizon (fauna 46 after Callomon and Birkelund, 1982). Apparently, *Crendonites* sp. (?) from the Spath's collection (also from the Festningen section) can be referred to this level.

Composition. In the *Anguinus* Zone, only the *Anguinus* Biohorizon is recognized on Spitzbergen.

Plate II

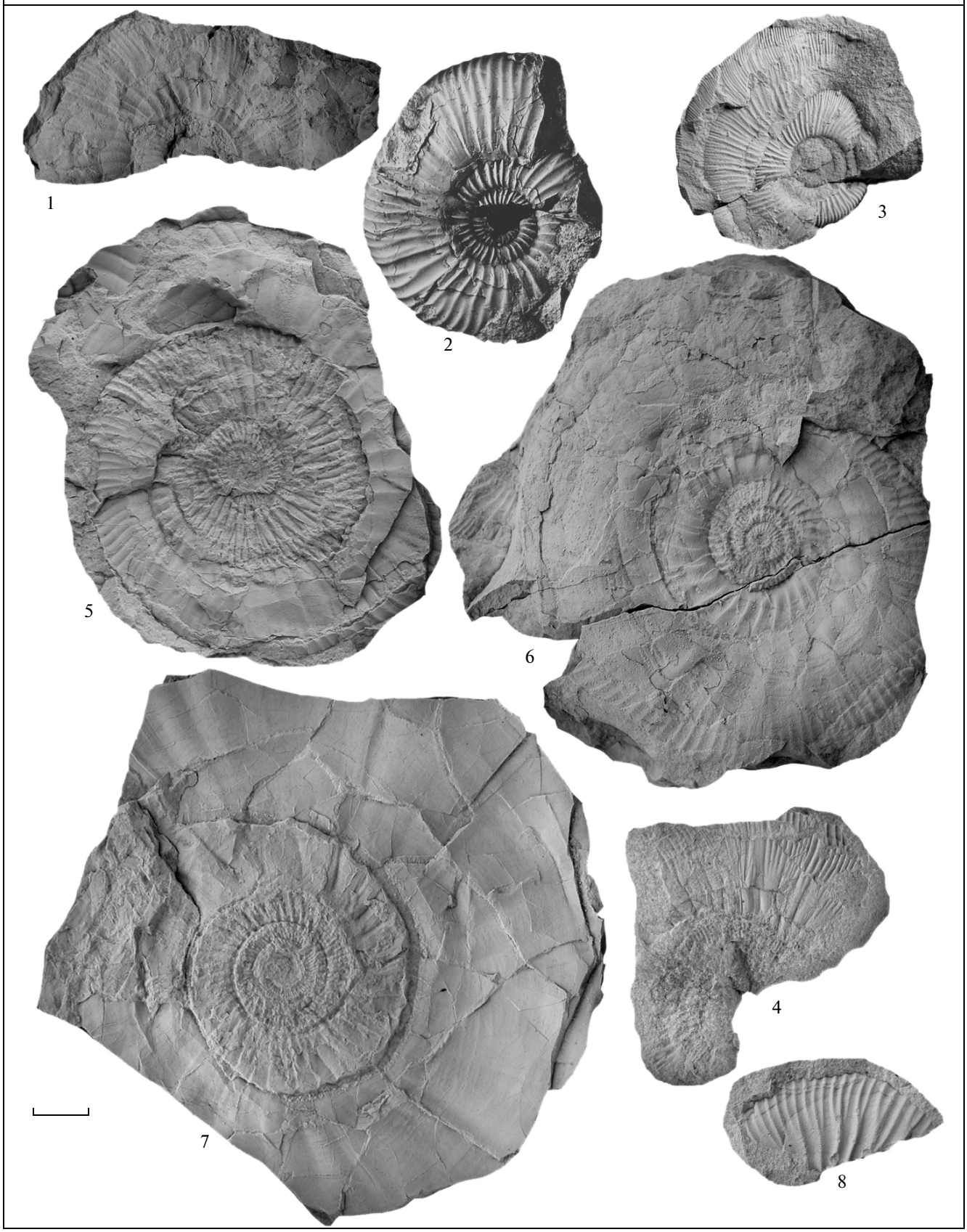


Plate II. Volgian ammonites of Spitzbergen and northern Siberia. (1) *Praechetaites* sp., SGM VH-20/94; Myklegardfjellet, section AC, Bed 20, middle Volgian, *Maximus* zone, *sachsi* Biohorizon; (2) *P. confusus* sp. nov., *Holotype* TsNIGR 32/9564. Kheta River, 6 km upstream of the mouth of Bukayi Creek, upper Volgian, *Okensis* Zone; (3) *P. tenuicostatus* (Shulgina), SGM VH-20/81, Levaya Boyarka River, Outcrop 23 of the reference section, not in situ; (4) *P. erschovi* sp. nov., *Holotype* SGM VH-20/91. Myklegardfjellet, section AC, Bed 22; middle Volgian, *Ilovaiskii* Zone, *erschovi* Biohorizon; (5) *Dorsplanites* cf. *gracilis* Spath, SGM VH-20/25; Festningen, section 2, Bed 12; middle Volgian, *Maximus* Zone; (6) *Dorsoplanites sachsi* Michlv., SGM VH-20/82, section AC, Bed 20; middle Volgian, Maximus Zone, *sachsi* Biohorizon; (7) *Dorsoplanites* cf. *flavus* Spath, SGM VH-20/30; Festningen, section 2, Bed 12; middle Volgian, *Maximus* Zone; (8) *Dorsoplanites subovalis* Mesezhn., SGM VH-20/74, Myklegardfjellet, section AC, Bed 22; middle Volgian, *Ilovaiskii* Zone, *erschovi* Biohorizon.

Correlation. This zone correlates with the *Anguinus* Zone of East Greenland, with the *Crendonites* spp. Subpolar Urals, and based on the presence of small *Crendonites* with the *Galbanites okusensis* Zone of England. Recently Rogov and Zakharov (2009, pl. 1) suggested a partial correlation of the zone with the *bipliciformis* Biohorizon of the *Nikitini* Zone of the Russian Platform. A considerably similarity of *E. bipliciformis* and *Crendonites* and the absence of *Laugeites* in the *bipliciformis* Biohorizon suggests that this Biohorizon can be correlated with the *Anguinus* Zone (Table 1). This is supported by a considerable level of similarity between the Arctic *Epivirgatites* with the later *E. lahuseni* (see the species descriptions below).

Boundary. The lower boundary is marked by the entry of ammonites of the genus *Crendonites*, whereas the upper boundary is drawn based on the appearance of *Epivirgatites* and *Laugeites*.

Laugeites Groenlandicus Zone

Description. Ershova in (Ershova and Pchelina, 1979) was the first to recognize this zone in Spitzbergen based on the occurrences of *Laugeites* and *Epivirgatites*. In the same paper, Beds with *Virgatosphinctes tenuicostatus* were established at the base of the upper Volgian. The re-examination of Ershova's collections showed that the largest part of *Virgatosphinctes* should be re-identified as *Laugeites parvus* Donovan (see above), which are found in East Greenland in the upper part of the *L. groenlandicus* Zone. Apart from *Laugeites* and *Epivirgatites*, the *L. groenlandicus* Zone contains ammonite genera *Praechetaites* and *Taimyrosphinctes*.

Composition. The zone contains four assemblages (two in the section near the Festningen Cape and two in the Myklegardfjellet Mountain section), mutual geochronology of which is not entirely clear. The Myklegardfjellet Mountain section contains the assemblage with *Epivirgatites sokolovi* sp. nov. (pl. IV, fig. 1, pl. V, figs. 1–2), *Laugeites biplicatus* Mesezhn. (pl. IV, fig. 6), *Taimyrosphinctes* (*Udschasphinctes*) sp. (Rogov and Zakharov, 2009, fig. 4.2; pl. V, fig. 3). Upward in the section, it is replaced by assemblages with *Epivirgatites laevigatus* sp. nov. (pl. IV, figs. 2–4) and *Laugeites* sp. These assemblages are recognized as new biohorizons: *E. sokolovi* (stratotype—Bed AC8) and *E. laevigatus* (stratotype – Bed AC2 in the Myklegardfjellet Mountain section). Between these levels, Bed AC4 contained a large *Taimyrosphinctes* (*T.*) *pavloviformis* Mesezhn. (pl. V, fig. 4). Both these biohorizons, judjing from the presence of characteristic species of *Epivirgatites*, are also present in the section of Janusfjellet Mountain. Along with *E. laevigatus* sp. nov., this level also contained large *Taimyrosphinctes* (*T.*) sp. In the section of the Festningen Cape, equivalents of these Biohorizons were nor recognized, although the presence of the equivalents of the *sokolovi* Biohorizon can here be suggested from the occurrences of *Laugeites* cf. *biplicatus* (Sokolov and Bodylevsky, pl. IX, fig. 5). This section contains two supposedly higher successive assemblages. The lower of these contains mainly *Laugeites* ex gr. *groenlandicus* (Spath) (pl. VI, fig. 4) and *Praechetaites* sp. (pl. VII, fig. 5). Unfortunately, shells of *Laugeites* in this section are poorly preserved, and this interval is only tentatively recognized as Beds with *Laugeites* cf. *groenlandicus*. The upper assemblage, which is proposed to be considered as the *L. lambecki* Biohorizon (stratotype – interval 14.5–14.8 m above the base of Bed 1/131 of the Festningen section), contains *Laugeites parvus* Donovan (pl. VI, fig. 1) and *L. lambecki* (Ilov.) (pl. VI, fig. 7), and the less common *Praechetaites* sp. and *Taimyrosphinctes* sp.

Correlation. The *E. sokolovi* and *E. laevigatus* Biohorizons are correlated, based on the presence of *Epivirgatites* similar to *E. variabilis* Shulg., *Laugeites* and *Taimyrosphinctes*, with the lower part of the *Variabilis* Zone, whereas on the Russian Platform this level is approximately correlated with the lower part of the *E. lahuseni* Biohorizon. Apparently, these biohorizons correspond to the *groenlandicus* Biohorizon of East Greenland (fauna 47 of Callomon and Birkelund, 1982), its equivalents are also found in the Subpolar Urals. In the *groenlandicus* Biohorizon, occurrences of *Laugeites* are relatively uncommon, whereas occurrences of numerous *Crendonites* (Callomon and Birkelund, 1982) suggest that this biohorizon characterizes the basal part of the zone. The *L. lambecki* Biohorizon is established for the first time, but the existence of a separate assemblage of this age containing *L. parvus* and its position above the *L. groenlandicus* fauna have also been suggested (Callomon and Birkelund, 1982). The examination of the collections from Kuhn Island showed that this biohorizon can readily be recognized in East Greenland. In the sections of Kuhn Island it is recorded below the level with *Epilaugeites*. The distri-

Correlation of the scales of the Volgian of Spitzbergen, northern Siberia, Subpolar Urals, eastern Greenland, and Russian Platform (after Rogov and Zakharov, 2009, modified)

Russian Platform				Northern Siberia		Subpolar Urals		Eastern Greenland		Spitzbergen (this article)		Spitzbergen (Ershova, 1983)
Sub-stage	Zone	Subzone	Biohorizon	Zone, subzone		Zone, subzone		Zone, subzone	"Fauna" (biohorizon)	Zone, subzone	Biohorizon	Zone, beds
Upper Volgian		Beds with *Volgidiscus singularis*		*Chetaites chetae*		Chetaites chetae		Beds with *Chetaites chetae*				*Craspedites nodiger*
	Nodiger	Craspedites *milkovensis*		*Craspedites taimyrense*		Craspedites taimyrense		? Beds with *Sudcraspedites sowerbyi*		*Craspedites taimyrense*		
		Craspedites mosquensis										
	Subditus	*Craspedites subditus*		*Craspedites okensis*	*Craspedites originalis*	*Craspedites subditus*				*Craspedites okensis*		*Craspedites okensis*
	Fulgens	*Craspedites nekrassovi*			*Craspedites okensis*	*Kachpurites fulgens*						
		Kachpurites fulgens										
Middle Volgian	*Nikitini*	*Epivirgatites nikitini*	*Laugeites* sp. nov. 2	*Praechetaites exoticus*		?		Beds with *Praechetaites tenuicostatus*		*Praechetaites exoticus*		Beds with *Virgatosphinctes tenuicostatus*
			Laugeites sp. nov. 1					*"Epilaugeites vogulicus"*			*Laugeites* sp. nov.	
			Kachpurites sp. A	*Epivirgatites variabilis*		*E. vogulicus*		*Laugeites groenlandicus*	*L. lambecki*	*Laugeites groenlandicus*	*L. lambecki*	
			Nikitini									
		E. lahuseni	*Lahuseni*			*"Laugeites groenlandicus"*					b. w. *L.* cf. *groenlandicus*	*Laugeites groenlandicus*
											E. laevigatus	
									47. *L. groenlandicus*		*E. sokolovi*	
		E. bipliciformis	*Bipliciformis*	*Taimyrosphinctes excentricus*		*Crendonites* spp.		*Crendonites anguinus*	46. *C. anguinus*	*Crendonites anguinus*	*C. anguinus*	*Dorsoplanites maximus*
									45. *P.* aff. *subgorei*			
	Virg.	? *Crasp. ivanovi*		*Dorsoplanites maximus*		*Dorsoplanites maximus*		*Epipallasiceras pseudapertum*	44. *D. intermissus*	*Dorsopl. maximus*	*Dorsoplanites sachsi*	
		V. virgatus							43. *P. groenlandica*		*D. sachsi*	
		Virgatites gerassimovi							42. *E. pseudapertum*		*Dorsoplanites maximus*	
									41. *E. acutifurcatum*			
	Panderi	*Zaraiskites zarajskensis*	*Zarajskensis*	*Dorsoplanites ilovaiskii*		*Dorsoplanites ilovaiskii*		*Dorsoplanites gracilis*	38–40	*Dorsoplanites ilovaiskii*	*Pr. erschovae*	*Dorsoplanites panderi*
			Regularis					*Dorsoplanites liostracus*	36–37 *D. liostracus*, *D. gracilis*		*D. antiquus*	
		Zaraiskites scythicus	*Scythicus*	*Pavlovia iatriensis*		*Pavlovia iatriensis*	*S. strajewskii*	*Pavlovia communis*	34–35. *P. varioc.*, *P. communis*	*Pavlovia rugosa*		
								Pavlovia rugosa	33. *P. rugosa*			
			Quenstedti				*P. iatriensis*	*Pavlovia iatriensis*	32. *P. iatriensis*	?		
								Dorsoplanites primus	31. *D. primus*			
Lower Volgian	*Pseudosc.*	*"P." tenuicostatum*	*Puschi*	*"Pectinatites pectinatus"*		*"Pectinatites pectinatus"*		*Pectinatites pectinatus*	30. *Paravirgatites* sp. B	Beds with *Paravirgatites* sp.		Beds with *Subplanites* sp., *Pectinatites* (?) sp.
			Neoburgense						29. *Paravirgatites* sp. A			
									28. *P. eastlecottensis*			
		L. pseudoscythica							27. *P. groeniandicus*	?		
			"Franconites"	*Sphinctoceras subcrassum*		*Sphinctoceras subcrassum*		*Pect. hudlestoni*	26. *P.* cf. *abbreviatus*			
	Ilowaiskaya sokolovi		*Pavida*					*Pectinatites wheatleyensis*	25. *Sphinctoceras* sp.			
			Sokolovi									
	Ilowaiskaya klimovi		*Efimovi*									
			Steraspis	*Eosphinctoceras magnum*		*Eosphinctoceras magnum*		*Pectinatites elegans*	24. *P. elegans*			
			cf. *praecursor*									

bution of *Epilaugeites* on the Russian Platform, in East Greenland and in the Subpolar Urals suggest that the ranges of the *Groenlandicus* and *Vogulicus* in East Greenland and the Subpolar Urals could be different (Table 1). In the sections of the Russian Platform, positively identified *Epilaugeites* are known only from the *lahuseni* Biohorizon. The place of origin and distribution of this species are not known, and it can be suggested that the *lambecki* Biohorizon can also correlate with part of the *lahuseni* Biohorizon and can partly correlate with the *nikitini* Biohorizon (Table 1). Judging from the presence of *L. lambecki* (Ilov.) in the sections the Subpolar Urals in the lower reaches of the Lena River, this biohorizon can later be recognized in these regions, although currently there is no data from these sections for a finer subdivision of the *L. groenlandicus* Zone.

Boundary. The lower boundary is recognized based on the presence of *Laugeites* and *Epivirgatites*; the upper boundary is drawn based on the disappearance of *L. parvus* and *L. lambecki*, which are replaced by late *Laugeites* with smooth whorls (Zakharov and Rogov, 2008, pl. I, fig. 8, pl. II, fig. 7), and by the predominance of *Praechetaites*.

Exoticus Zone

Description. The *Praechetaites exoticus* Zone was proposed on Spitzbergen to replace Beds with "*Virgatosphinctes*" *tenuicostatus* previously recognized here by Ershova (Rogov and Zakharov, 2009). Beds with "*Virgatosphinctes*" *tenuicostatus* were established by Ershova and Pchelina (1979) based on the presence of the typical ammonitic assemblage but without indicating the type section and level. They partly correlate with the *L. lambecki* Biohorizon of the *Groenlandicus* Zone, because most "*Virgatosphinctes*" in Ershova's collection from Spitzbergen (all ammonites, figured by Ershova and Pchelina (1979) and by Ershova (1983, pl. XXV, figs. 1, 3, 4)) are re-identified by the present author as *L. parvus*, which is characteristic of the *lambecki* Biohorizon. The basal part of the *Exoticus* Zone of Spitzbergen also contains *Laugeites* from the *L. lambecki* group, but, in contrast to the specimens from the *lambecki* Biohorizon they have a narrower umbilicus, more pronounced constrictions and earlier disappearing ornamentation in the mid-flank (Pl. VI, fig. 6). Like in the of the Nordvik Peninsula (Zakharov and Rogov, 2008), apart from the *Praechetaites* there also found relatively uncommon *Laugeites* sp. nov., some of which show a prolonged stage with whorls lacking ornamentation (pl. VII, fig. 7). Although species of *Praechetaites* found in this zone are found in Siberia from older rocks (*P. tenuicostatus*) or younger beds (*P. tenuicostatus* and *P. exoticus*), the *Exoticus* Zone is readily recognized as an interval between the appearance of the late *Laugeites* together with large *Praechetaites* ex gr. *exoticus* and the first appearance of the ammonite genus *Craspedites*. On Spitzbergen, like in the section of the Norvik Peninsula this zone contains rare *Taimyrosphinctes* (*Udschasphinctes*) sp. (pl. VII, fig. 6), and phylloceratids *Euphylloceras* cf. *knoxvillense* (Stanton) (pl. IV, fig. 7), similar to ammonites, found at the base of the upper Volgian of the Nordvik Peninsula.

Composition. The basal part of the *Exoticus* Zone in the Festningen section contain a level with *Laugeites* aff. *lambecki* (Ilov.) emend Michlv. (pl. VI, fig. 6), and large *Laugeites* sp. nov. (pl. VII, fig. 7), similar to *Laugeites* with early disappearing ornamentation known from *Nikitini* Zone of the Russian Platform and the *Exoticus* Zone of northern Siberia. Unfortunately, poor preservation of *Laugeites* sp. nov. does not allow their positive identification with ammonites (index taxa of the *Laugeites* sp. nov 1 and *Laugeites* sp. nov. 2 Biohorizon in Pl. 1), found in the upper part of the *Nikitini* Zone of the Russian Platform. Similar ammonites are also known from East Greenland (Donovan, 1964, pl. IV, figs. 1, 2) and the *Exoticus* Zone of northern Siberia (Zakharov and Rogov, 2008, pl. I, fig. 8). This interval can tentatively be recognized as the *Laugeites* sp. nov. Biohorizon, but ammonites from the *Exoticus* Zone, should certainly be studied more extensively.

Correlation. The correlation of the *P. exoticus* Zone with the Volgian successions may be based on the presence of characteristic species of the genus *Laugeites* through the sections of the Russian Platform (Rogov and Zakharov, 2009). The zone corresponds to the upper part of the *E. nikitini* Subzone of the *E. nikitini* Zone of the Russian Platform and to the *Subcraspedites preplicomphalus* and partly *S. plicomphalus* zones of England and North Sea. Judging from the succession of ammonites, recognized by the present author based on the collections of ammonites from East Greenland (Kuhn Island), the lower part of the zone should partly correspond to the *Epilaugeites vogulicus* Zone. In Greenland, *Epilaugeites* appear above the *L. lambecki* Biohorizon, and the assemblage with *Epilaugeites* is followed by Beds with *Praechetaites tenuicostatus*. Unfortunately, the absence of *Craspedites* in the sections of East Greenland does not allow the recognition of the position of Beds with *Praechetaites tenuicostatus*, but it can be suggested that it corresponds there to the boundary between the middle and upper Volgian Substages. The correspondence of the *Vogulicus* Zone with the *Exoticus* Zone is not entirely clear. In the Nordvik section, the first *Epilaugeites* enter in the upper part of the *Variabilis* Zone (Zakharov and Rogov, 2008). In East Greenland, a level *c Epilaugeites* is above the *lambecki* Biohorizon, in the interval, which in Spitzbergen apparently corresponds to the lower part of the *Exoticus* Zone. Most likely the level of appearance of *Epilaugeites* varies in different regions. In addition, *Epilaugeites*, occurring in East Greenland, differ in the considerably larger shells from specimens of other regions (e.g., Surlyk, 1978, pls. 2, 3).

Plate III

Plate III. Volgian ammonites of Spitzbergen.

(1, 2) *Glaucolithites* sp.; Festningen; middle Volgian, *Maximus* (?)zone: (1) SGM VH-20/3, (la) SGM VH-20/47, section 2a, Bed 4; (2) NHM C26976, precise locality and level unknown; (3) *Kachpurites* sp., SGM VH-20/112; Festningen, section 1, 32.5 m above the base of Bed 131, upper Volgian, *Okensis* Zone.

Boundary. The lower boundary is drawn based on the replacement of *Laugeites lambecki* and *L. parvus* by more weakly ornamented *Laugeites*, and on the appearance of *Praechetaites* ex gr. *exoticus*. The upper boundary is recognized based on the appearance of the first *Craspedites* ex gr. *okensis* (d'Orb.). Unfortunately, both in the examined sections of Spitzbergen and in the sections known from the literature, the interval below the first *Craspedites* contains no ammonites.

Upper Volgian

Okensis Zone

Description. This zone is established in Spitzbergen by Ershova (1969) based on the occurrence of *Craspedites*[7] (*C.*) *okensis* (d'Orb.), *C.* (*C.*) aff. *fragilis* (Trd.), and characteristic assemblage of bivalves collected in the coquinas on Myklegardfjellet Mountain. Such coquinas overfilled by bivalvian shells and to a lesser extent by ammonites, are found in the upper Volgian of different regions of Spitzbergen (they are also known from Junusfjellet). Coquinas form lenses and on Myklegardfjellet Monntain in several meters from the AD section are replaced by sideritic nodules, almost lacking fossils. In the Festningen section, a small ammonite was found along with *Craspedites* (*C.*) *okensis* (d'Orb.) which can be tentatively identified as *Kachpurites* sp. (pl. III, fig. 3).

Composition. In the Myklegardfjellet Mountain section, the *Okensis* Zone contained two successive levels characterized by different morphotypes of *Craspedites* (*C.*) *okensis* (A and B) – lower level with more strongly evolute shells (pl. VII, fig. 2) and the upper level with more strongly involute shells (Rogov and Guzhikov, 2009) (pl. VII, fig. 3). The presence of shells with more or less wide umbilicus and earlier and later disappearing ribs in the sample of *C.* (*C.*) *okensis* (d'Orb.) from Spitzbergen was mentioned Ershova (1969). It is not yet clear how consistent is the succession of morphotypes of *C. okensis* found on Myklegardfjellet Mountain. The section on the Festningen Cape contains an earlier morphotype *C. okensis* (pl. VII, fig. 1), similar *Craspedites* were collected V.A. Basov on Janusfjellet Mountain.

Correlation. The *Okensis* Zone is the most widely distributed zone of the Volgian Stage, recognized from Spitzbergen to northern Siberia. In the Russian Platform, this zone corresponds to the *Kachpurites fulgens* and *Craspedites subditus* zones.

Boundary. The lower boundary is established based on the appearance of *Craspedites* (*C.*) ex gr. *okensis* (d'Orb), the upper boundary is drawn based on the entry of *Craspedites* (*Taimyroceras*).

Taimyrense Zone

Description. This stratigraphic unit was for the first time established in Spitzbergen by Ershova (1969) as the *Craspedites nodiger* Zone based on the presence of *Craspedites* (*C.*) cf. *mosquensis* Geras. and *C.* (*C.*) ex gr. *nodiger* (Eichw.). This zone also typically contains *Craspedites* (*Taimyroceras*) spp., including *C.* (*T.*) *taimyrense* (Bodyl), *C.* (*T.*) *agardensis* Erschova (pl. VII, fig. 4), *C.* (?*T.*) cf. *canadensis* Jeletz. (pl. VII, fig. 8). The name of the zone is proposed to be replaced by *Taimyrense* (Rogov and Zakharov, 2007; Rogov and Zakharov, 2009) because species of *Craspedites*, similar to shells from the *Nodiger* Zone of the Russian Platform, are rare here, and its assemblage is more similar to that of the *Craspedites* (*Taimyroceras*) *taimyrense* Zone of northern Siberia.

Boundary. The lower boundary is recognized based on the *Craspedites* (*Taimyroceras*) spp. and later species of *Craspedites* s.s. The upper boundary is drawn tentatively, because the ammonites that characterize the terminal Volgian *Chetaites chetae* Zone in Siberia are not yet recognized in Spitzbergen. In the Myklegardfjellet Mountain section, the base of the Myklegardfjellet Beds can be accepted as the upper boundary of the zone.

SYSTEMATIC PALEONTOLOGY

ORDER AMMONITIDA

SUBORDER PERISPHINCTINA BESNOSOV ET MIKHAILOVA, 1983

Family Dorsoplanitidae Arkell, 1950

Genus *Praechetaites* Sasonova et Sasonov, 1979 emend. Rogov, herein

Virgatosphinctes (pars): Schulgina, 1967, p. 135.
Berriasella (pars): Schulgina, 1967, p. 150.
Aulacosphinctes (pars): Schulgina, 1967, p. 148.
Praechetaites: Sasonova et Sasonov, 1979, p. 493.

[7] The generic name *Craspedites* Pavlov, 1892 is a junior homonym of *Craspedites* Allman, 1872 (Hydrozoa = *Craspedonites* Haeckel, 1865). However the latter name has not been used in the literature from 1899 and can be declared *nomen oblitum* under Article 23.9.2 of the International Code of Zoological Nomenclature, whereas the generic name *Craspedites* Pavlov (and the family Craspeditidae) is widely used and should be conserved. The junior homonym (*Craspedites* Pavlov) is used as a valid name in publications dedicated to Boreal ammonites for over a century and is mentioned in more than 25 works by more than 10 anthors for the last 50 years.

Plate IV

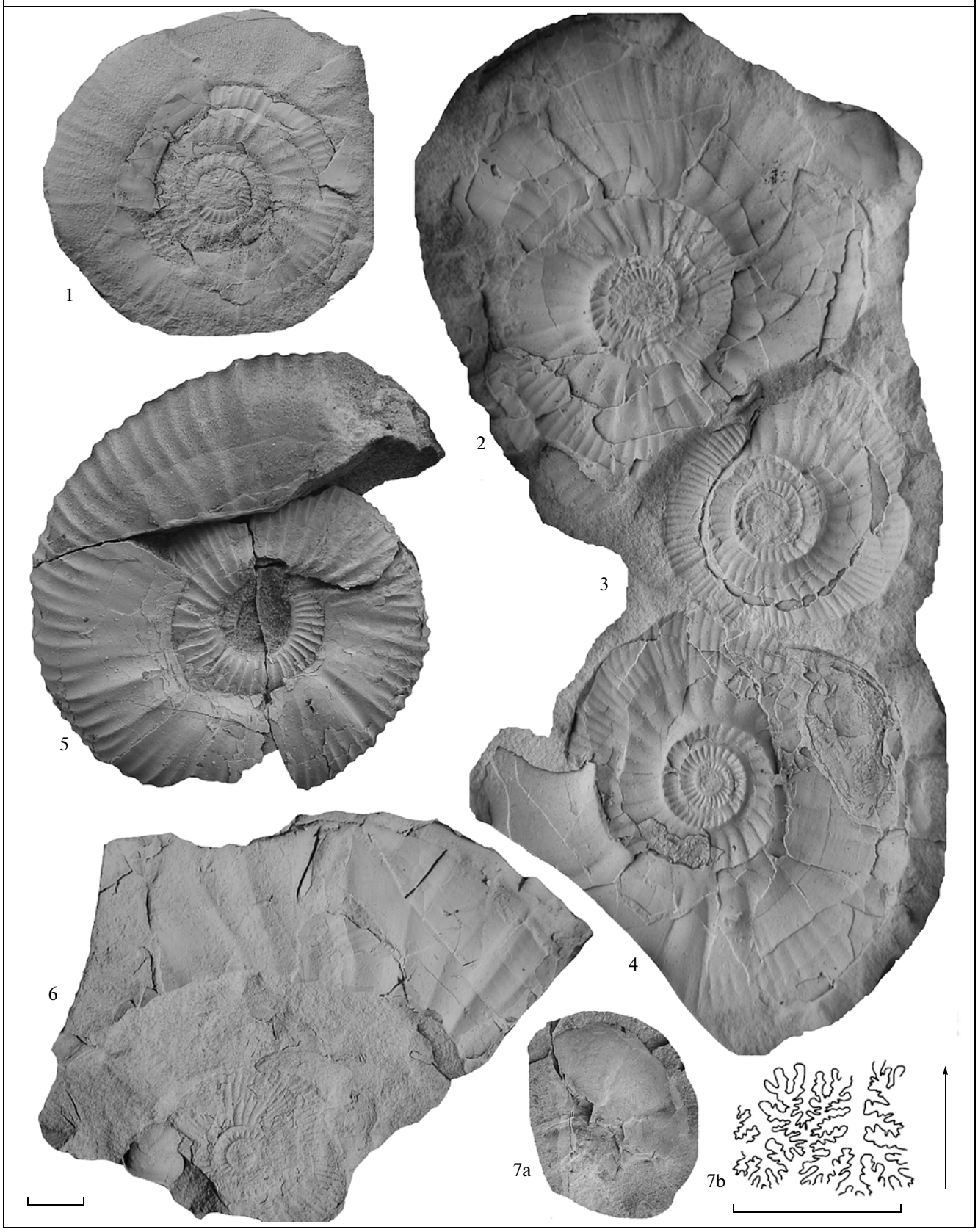


Plate IV. Middle Volgian ammonites of Spitzbergen and northern Siberia. (1) *Epivirgatites sokolovi* sp. nov., SGM VH-20/16, Myklegardfjellet, section AC, Bed 8; middle Volgian, *Groenlandicus* Zone, Biohorizon *sokolovi*; (2–4) *Epivirgatites laevigatus* sp. nov., Myklegardfjellet, section AC, Bed 2; middle Volgian, *Groenlandicus* Zone, Biohorizon *laevigatus*: (2) *Holotype* SGM VH-20/13a, (3) SGM VH-20/13b, (4) SGM VH-20/13c; (5) *Epivirgatites variabilis* Schulgina, SGM VH-20/4, Levaya Boyarka River, Outcrop 23 of the reference section, Bed 10 (= section 2, Bed 1); middle Volgian, *Variabilis* Zone; (6) *Laugeites biplicatus* Mesezhn., SGM VH-20/88, Myklegardfjellet, section AC, Bed 8; middle Volgian, *Groenlandicus* Zone, *sokolovi* Biohorizon; (7a, 7b) *Euphylloceras* cf. *knoxvillense* (Stanton), SGM VH-20/11; Festningen, section 2, Bed 3; middle Volgian, *Exoticus* Zone.

Type species. *Virgatosphinctes exoticus* Schulgina, 1967, middle Volgian *Exoticus* Zone – upper Volgian *Taimyrense* zone of northern Siberia.

Diagnosis. Shells from small to large. Two groups of species are recognized within the genus differing in the final shell diameter and can be considered as micro- and macroconchs. Although dorsoplanitids had dimorphs differing primarily in size and (to a lesser extent) ornamentation, the relationships of the two groups of species are not clear (dimorphism or parallel existence of two lineages). Species with shells reaching 5–7 cm in diameter – *P. tenuicostatus* (Schulgina), *P. confusus* Rogov, sp. nov., *P. subtenuicostatus* (Mesezhn.), *P. erschovae* Rogov, sp. nov., *P. bicostatus* (Shulg.), *?P. arcticus* (Schulgina) are somewhat more widely geographically and stratigraphically ranged than large shells, which are not found below the *Exoticus* Zone, but this can be related to poor knowledge of the Volgian of the Arctic. The second group of species includes *P. exoticus* (Schulgina), *P. rudicostatus* (Schulgina), *P. borealis* (Schulgina), ?*P. tripartitus* (Schulgina), as well as a unusual *Prechetaites,* apparently belonging to a new species figured as *Virgatosphinctes bicostatus* (Zakharov et al., 1983, pl. II, fig. 1). Ammonites from this group reach 30 cm and over in diameter. The umbilicus is moderately wide (usually within the range of 28-35% of the shell diameter). The whorl cross-section from compressed to medium wide (30–40% of the shell diameter), highly oval, often with a tapering venter. The shell is the widest in the lower third of the flank. The ornamentation of the inner whorls comprise distinct, sharp bifurcate and trifurcate, slightly prorsiradiate ribs.With age the frequency of ribs and branching coefficient increase reaching 5–7, and virgatotome ribs appear. The branching often becomes irregular, sometimes with numerous intercalating ribs, beginning at different levels. Changes in the ribbing in different species occur at a noticeably different diameters. In addition, in *P. rudicostatus* (Schulgina) ribs on the outer whorls do not become more frequent, although branching ratio increases, and in *P. bicostatus* (Schulgina) and *P. confusus* sp. nov. the ornamentation does not change. The ribs run across the venter with a small curvature orad. In large *Praechetaites* the ornamentation on outer whorls become weaker remaining only in the umbilical zone and near the venter, it sometimes completely disappears. Constrictions are present occasionally; they are primarily typical of *P. bicostatus* (Schulgina). The suture examined by Schulgina (1967) is typical of dorsoplanitids.

Comparison. By their frequent ribs with the rib ratio increasing with growth, *Praechetaites* are similar to *Laugeites*, from which they differ in the narrower umbilicus, more irregular branching and a higher branching ratio of the outer whorls. In shell shape, the most similar to *Praechetaites* are specimens of *Laugeites* aff. *lambecki* (Ilov.), found in the lower part of *Exoticus* Zone of Spitzbergen (Pl. VI, fig. 6). These *Laugeites* are distinguished from *Praechetaites* by more rapidly disappearing ornamentation in the mid-flank and by the presence of numerous constrictions. This genus differs from *Taimyrosphinctes* (which is similar to *Praechetaites* in the narrow umbilicus), in a different cross-section (highly oval or oxyconic, rather than semirectangular), in the absence of a noticeable uncoiling of the shell and in the ontogenetic changes of ornamentation, observed in most species. Specimens of *Taimyrosphinctes* usually do not show weakening of the ornamentation on the terminal body chamber.

Remarks. Sasonova and Sasonov (1979) did not publish a description of their new genus *Praechetaites* and did not indicate its composition. They only published a comparison of the type species of the genus *Virgatosphinctes* with "*V.*" *exoticus*, the typical species of "Siberian *Virgatosphinctes*", which they designated as the type species of their new genus *Praechetaites*. Schulgina (1967, p. 138) when describing *Virgatosphinctes* noted that the general shell shape and sutural outline of this genus are similar to those of *Chetaites*, although *Virgatosphinctes* are differing from the latter in the shape of the whorl cross-section and the presence of multifurcate rib fascicles in the outer whorls. This suggests (already suggested by Sasonov) that *Praechetaites* as a likely ancestor of *Chetaites*. Ammonites from the Volgian of northern Siberia, assigned by Schulgina (1967) to the genus *Berriasella*, are also assigned by the present author to *Prechetaites*. Small ammonites from this group (*P. confusus* Rogov, sp. nov.) are very similar to *P. tenuicostatus* differing from this species only by the lack of the ontogenetic changes in ornamentation. They retain the juvenile type of ribbing until the end of the terminal body chamber. Large "*Berriasella*" (*P. borealis* (Schulgina)) in the shell shape and the character of ornamentation do not differ from the typical *Praechetaites*. The ammonite described by Schulgina (1967) as *Aulacosphinctes tripartitus* is similar to *Praechetaites* in the shell shape and general character of ornamentation. The groove present on the venter interrupting the ribs clearly distinguishes this taxon from most Volgian

Plate V

Plate V. Middle Volgian ammonites of Spitzbergen.

(1, 2) *Epivirgatites sokolovi* sp. nov., Myklegardfjellet, section AC, Bed 8; Middle Volgian, *Groenlandicus* Zone, *sokolovi* Biohorizon: (1) SGM VH-20/27; (2) holotype SGM VH-20/2; (3) *Taimyrosphinctes (Udschasphinctes)* sp., SGM VH-20/54, the same level; (4) *Taimyrosphinctes* (*T.*) *pavlovifbrmis* Mesezhn., SGM VH-20/20, Myklegardfjellet, section AC, Bed 4. Middle Volgian, *Groenlandicus* Zone (field photograph).

boreal ammonites, except for the lower Volgian *Pectinatites aulacophorus* Buckman (Buckman, 1909–1930, pl. CCCLXXXI, figs. 1–3). Perhaps the appearance of the groove on the shell of the Siberian *"Aulacosphinctes"* (known from one shell only) is a product of illness or injury. Such grooves can continue in ammonites throughout several whorls retaining its position and expression (see examples in Hölder, 1977; Larson, 2007). This hypothesis is supported by the fact that a slight change in the depth and position of the groove in the Siberian *"Aulacosphinctes"* is clearly observed in one of the photographs published by Schulgina (1967, pl. XIII, fig. 1d). In this case, this ammonite can be referred to the genus *Praechetaites* despite the relatively wide whorl cross-section. The form originally described as *Craspedites ? arcticus* (Schulgina, 1969, p. 151, pl. XXXIII, figs. 3–4) and later referred to *Subcraspedites* (Mesezhnikov et al., 1983; Schulgina, 1985) also probably belongs to *Praechetaites*. The suture line is unknown in this species, but in the shell shape and ornamentation it is very similar to other microconchs of *Praechetaites*. Apparently, *Praechetaites* evolved from *Dorsoplanites* possibly related to *D. ilovaiskii* (Mesezhn.), showing a sharp increase in the branching ratio on the outer whorls or finely ornamented shells such as *D. subovalis* Mesezhn.

Composition. *?Praechetaites arcticus* (Schulgina), upper Volgian *Okensis* Zone, *Originalis* Subzone of northern Siberia; *P. bicostatus* (Schulgina), middle Volgian *Variabilis* Zone– *Exoticus* Zone (and possibly upper Volgian *Okensis* Zone) of northern Siberia; *P. borealis* (Schulgina) upper Volgian *Okensis* Zone and Subzone of northern Siberia; *P. confusus* Rogov, sp. nov., upper Volgian *Okensis* Zone and Subzone of northern Siberia; *P. erschovae* Rogov, sp. nov., middle Volgian *Ilovaiskii* Zone of Spitzbergen and ? Western Siberia; *P. exoticus* (Schulgina), middle Volgian *Exoticus* Zone – upper Volgian *Taimyrense* Zone of northern Siberia and Spitzbergen; *P. tenuicostatus* (Schulgina), middle Volgian *Variabilis* Zone – upper Volgian *Chetae* Zone of northern Siberia, *Exoticus* Zone and its equivalents in the upper part of the middle Volgian of East Greenland, Spitzbergen and Western Siberia (in the latter region the exact locality is unknown); *?P. tripartitus* (Schulgina), middle Volgian *?Exoticus* Zone – upper Volgian *Okensis* Zone of northern Siberia; *P. subtenuicostatus* (Mesezhn.), middle Volgian *Maximus* Zone – upper Volgian *Okensis* Zone of northern Siberia.

***Praechetaites erschovae* Rogov, sp. nov.**

Plate II, fig. 4

cf. *Dorsoplanites* cf. *ilovaiskii*: Vyachkileva et al., 1990, pl. 56, figs. 7, 10, 12, 13.

cf. Dorsoplanitidae gen. et sp. ind: Braduchan et al., 1986, pl. IV, fig. 1.

Etymology. After E.S. Ershova, a key person in the development of the stage and zonal scales of the Jurassic and Lower Cretaceous of Spitzbergen.

Holotype. No. SGM VH-20/91. Vernadsky State Geological Museum, Russian Academy of Sciences, Myklegardfjellet Mountain, section AC, Bed 22; middle Volgian *Ilovaiskyi* Zone, *erschovae* Biohorizon, figured: pl. II, fig. 4.

Description. Shells are small. All specimens examined are strongly compressed and incomplete, hence the shell shape is not very clear. The ornamentation of the inner whorls is poorly preserved showing only dense and thin bifurcate and trifurcate subrectiradiate ribs (about 25 per half-whorl). At a shell diameter of about 4–5 cm the character of ornamentation changes sharply. The rib ratio increases to 5–6, numerous intercalating ribs appear originating at various levels of the flank. The density of the primary ribs is somewhat reduced. Towards the aperture the ribs become thinner. No suture was observed.

Comparison. This species is distinguished from *P. tenuicostatum* (Schulgina) (pl. II, fig. 3) and *P. subtenuicostatum* (Mesezhn.), to which it is similar in size and general character of ornamentation, by widely spaced primaries on outer whorls. It is distinguished from *Praechetaites* sp., found in the overlying *sachsi* Biohorizon (pl. II, fig. 1), in the somewhat more widely spaced ornamentation on the inner whorls and the fewer trifurcate ribs.

Remarks. Ammonites very similar to *P. erschovae*, have been found in a borehole core in the Middle Volgian of Western Siberia (see synonymy list above). The absence of the final stage of ornamentation, showing the appearance of numerous intercalating ribs clearly observed in *P. ershovae*, allows them to be identified only tentatively.

Material. Five specimens (SGM VH-20/91, 20/92, 20/93, and two specimens without numbers) from Bed AC22 of Myklegardfjellet Mountain section, *Ilovaiskii* Zone, Middle Volgian *erschovae* Biohorizon.

Plate VI

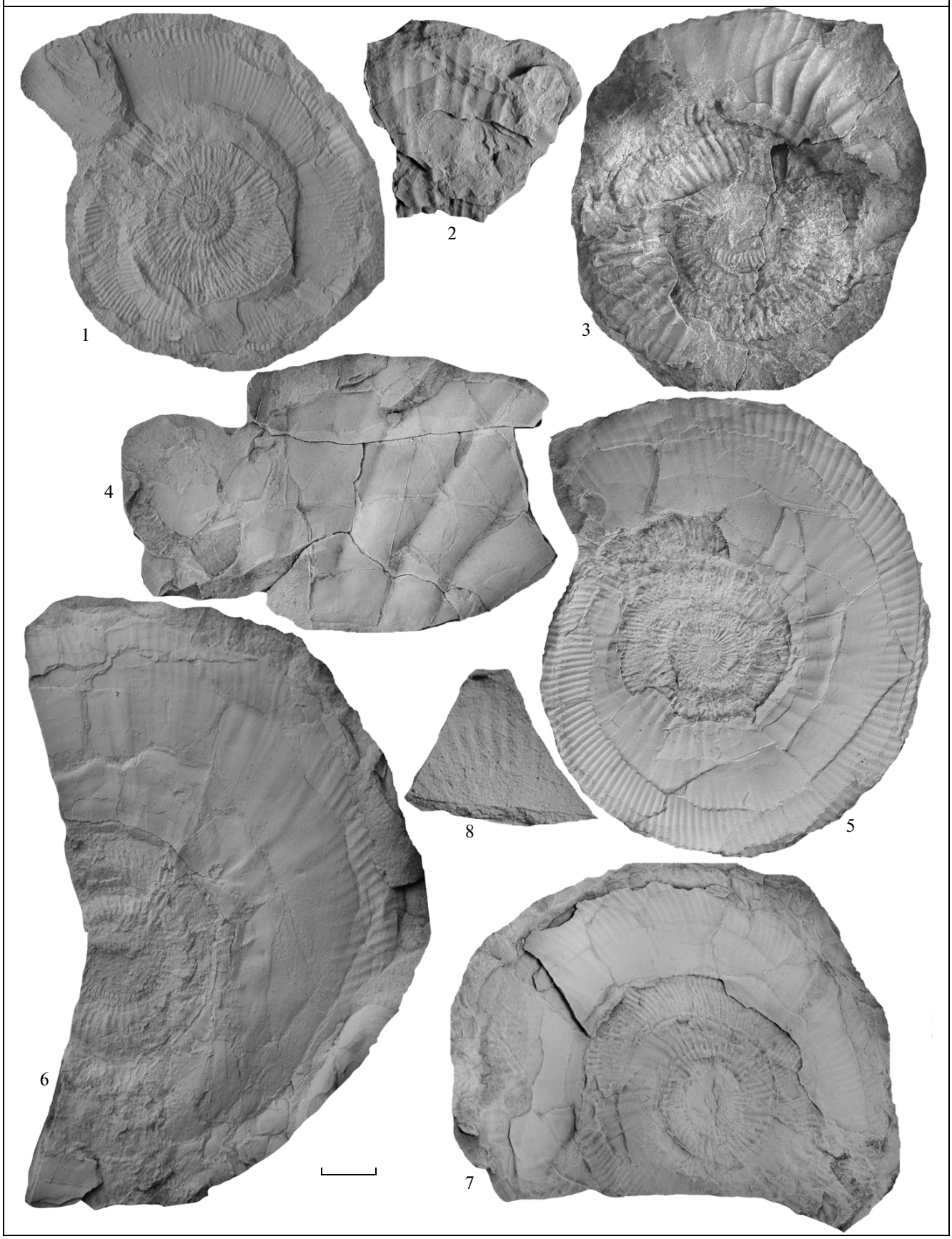


Plate VI. Middle-upper Volgian ammonites of Spitzbergen.

(1) *Laugeites parvus* Donovan, SGM VH-20/61; Festningen, section 2, Bed 8; middle Volgian, *Groenlandicus* Zone, *lambecki* Biohorizon; (2) *Praechetaites* sp., SGM VH-20/118; Festningen, section 1, 20.7 m above the base of Bed 131; middle Volgian, *Exoticus* Zone; (3) *Crendonites anguinus* Spath, SGM VH-20/29; Festningen, section 1, 9.5 m above the base of Bed 131; middle Volgian, *Anguinus* Zone, *anguinus* Biohorizon; (4) *Laugeites* cf. *groenlandicus* Spath, SGM VH-20/97; Festningen, section 1, 13.5 m above the base of Bed 131; middle Volgian, *Groenlandicus* Zone, beds with *Laugeites* cf. *groenlandicus;* (5) *Praechetaites exoticus* (Schulgina), SGM VH-20/55; Festningen, section 2, Bed 5; middle Volgian, *Exoticus* Zone; (6) *Laugeites* aff. *lambecki* (Ilov.) emend. Michlv., SGM VH-20/64; Festningen, section 2, Bed 5; middle Volgian, *Exoticus* Zone; (7) *Laugeites lambecki* (Ilov.) emend. Michlv., specimen lost; Festningen, section 1, 14.5 m above the base of Bed 131; (8) *?Boreiophylloceras* sp. ind. SGM VH-20/33; Festningen, section 1, 32.5 m above the base of Bed 131; upper Volgian, *Okensis* Zone.

Praechetaites confusus Rogov, sp. nov.

Plate 2, fig. 2

Berriasella aff. *richteri*: Schulgina, 1967, p. 151, pl. XIV, figs. 1, 2.

Etymology. From the Latin *confusus* – (confusing).

Holotype. No. 32/9564. TsNIGR Museum, figured in: Schulgina, 1967, pl. XIV, fig. 2, refigured here, pl. II, fig. 2; River Kheta (Khatanga Basin, northern Siberia), 6 kms upstream of the mouth of Bukatyi Creek, *Okensis* Zone, upper Volgian.

Description. Shells are small. The *umbilicus* is moderately wide (34–35% of shell diameter). The whorl cross-section is high oval. At a diameter of 0.5 cm (Schulgina, 1967, pl. XIV, fig. 2b–2d), the ornamentation is composed of sharp, simple and bifurcate ribs with low furcation point (18 per half-whorl). Later in ontogeny, the subrectiradiate, slightly prorsiradiate bifurcate ribs (~20 per half-whorl) with a bifurcation point in the upper third of the flank, and few (1–2 per half-whorl) trifurcate ribs, with a furcation point either in the lower or in the upper third flank, usually appear on the body chamber. Intercalating ribs and a few constrictions (3–4 per whorl) may be present accompanied by simple or trifurcate ribs.

Comparison. This species is similar to *P. bicostatus* (Schulgina) in the predominance of bifurcate ribs but is distinguished by the more widely spaced ornamentation and less pronounced constrictions. This species differs from other species of *Praechetaites* in the absence of virgatotome ribs at all ontogenetic stages. In the character of ornamentation *P. confusus* sp. nov. resembles young *P. tenuicostatus* (Schulgina), but *P. confusus* lacks the change of ornamentation in ontogeny.

Remarks. Schulgina (1967) assigned these ammonites to *Berriasella*, considering them to be very similar to *Berriasella richteri* (Oppel).[8] In *Berriasella* s.s., the ribbing on the venter is discontinued, and only singular and bifurcate ribs are present (Arkadiev and Bogdanova, 2004), and microconchs have lappets. All these characters readily distinguish specimens of *Berriasella* from the species described. The shape of the aperture is not known in microconchs of *Richterella* (Cecca, 1986), but these ammonites are sharply different from *P. confusus* sp. nov. in their very fine secondaries, forming a noticeable ventral curvature towards the aperture, while constrictions are absent. The stratigraphic position and geographical distribution of these ammonites are also different. *Richterella* is found in the middle Tithonian *Semiforme* and *Fallauxi* Zones, which correspond with the upper part of the lower Volgian Substage and the basal part of the middle Volgian (Rogov, 2004), and are present only in the north-western regions of Neotethys, from Iran to North Africa and southeastern France (Cecca, 1999). *P. confusus* is restricted to the upper Volgian *Okensis* Zone, which corresponds to the uppermost part of the upper Tithonian (Houša et al., 2007), and is unknown outside northern Siberia.

The similarity of *P. confusus* sp. nov. with inner whorls of *P. tenuicostatus* (Schulgina) allows the hypothesis that the new species could have evolved from *P. tenuicostatus* through paedemorphosis.

Material. Specimens 32/9564. 33/9564 (TsNIGR Museum), collection by N.I. Schulgina, Kheta River, 6 km upstream of the mouth of Bukatyi Creek; Upper Volgian, *Okensis* Zone.

Genus *Epivirgatites* Spath, 1924

Epivirgatites sokolovi Bodylevsky in Rogov, sp. nov

Plate IV, fig. 1, pl. V, figs. 1–2

Virgatosphinctes sp.: Sokolov, 1912, p. 10, pl. I, fig. 6.

Perisphinctes sp. A: Sokolov and Bodylevsky, 1931, p. 90, pl. IX, fig. 3.

Etymology. After D.N. Sokolov (as suggested by V.I. Bodylevsky in an unpublished manuscript).

Holotype. No. SGM VH-20/2. Vernadsky State Geological Museum, Russian Academy of Sciences, Myklegardfjellet Mountain, section AC, Bed 8; Middle Volgian, *Groenlandicus* Zone, *sokolovi* Biohorizon, figured: pl. V, fig. 2.

Description. The shells are medium-sized (up to ~9 cm in diameter). The *umbilicus* is from moderately wide to wide. The ornamentation of the inner whorls is composed by pronounced medium-thick bifurcate ribs. Beginning from a diameter of ca. 4 cm there appear many trifurcate ribs dominating the last whorl. In some specimens the branching ratio increases to 4–5. The

[8] At present these ammonites are assigned to the genus *Richterella* Avram, 1975. This name is a junior homonym of *Richterella* Hessler, 1965 (*trilobites*) and should be replaced.

Plate VII

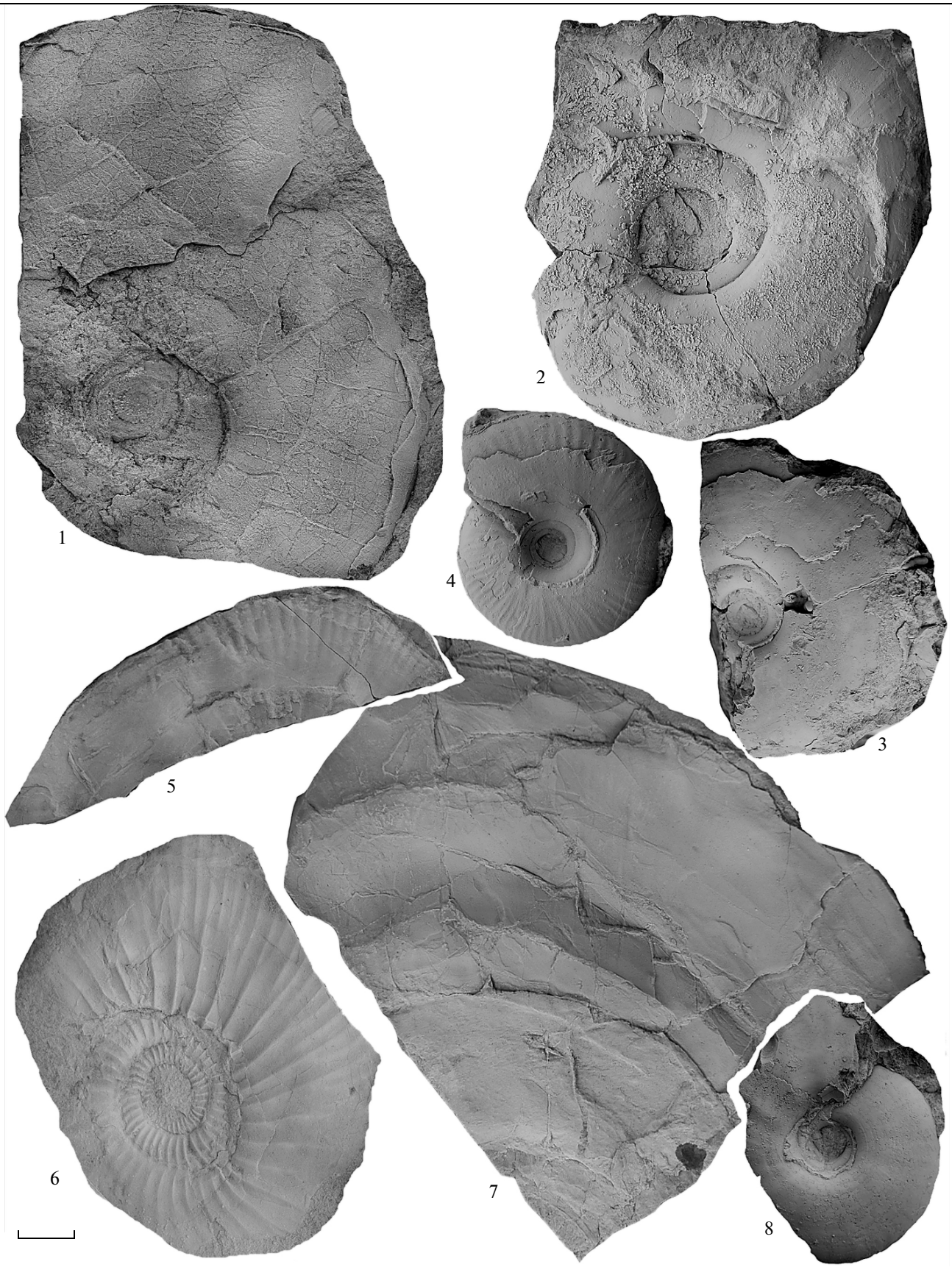


Plate VII. Middle and upper Volgian ammonites of Spitzbergen

(1, 2) *Craspedites (C.) okensis* (d'Orb.) morphotype A; upper Volgian, *Okensis* Zone: (1) SGM VH-20/73; Festningen, section 1, 32.5 m above the base of Bed 131, (2) SGM VH-20/78, Myklegardfjellet, section AD, Bed 26; (3) *Craspedites (C.) okensis* (d'Orb.) morphotype B, SGM VH-20/70; Myklegardfjellet, section AD, Bed 28, upper Volgian, *Okensis* Zone; (4) *Craspedites* (Taimyroceras) *agardensis* Erschova, SGM VH-20/71, Myklegardfjellet, section AD, Bed 30, upper Volgian, zone Taimyrense; (5) *Praechetaites* sp., SGM VH-20/39; Festningen, section 1, 12.5 above the base of Bed 131; middle Volgian, *Groenlandicus* Zone; (6) *Taimyrosphinctes* (*Udschasphinctes*) sp., SGM VH-20/79; Festningen, section 2, Bed 4. middle Volgian, *Exoticus* Zone; (7) *Laugeites* sp. nov., SGM VH-20/80; Festningen, section 1, 14.5-14.8 m above the base of Bed 131; middle Volgian, *Exoticus* Zone; (8) *Craspedites (C.) canadensis* Jeletz., SGM VH-20/72; Myklegardfjellet, section AD, Bed 30; upper Volgian, *Taimyrense* Zone.

ribbing becomes somewhat smoother toward the terminal body chamber but do not disappear completely. Usually, relatively wide ribs are present near the aperture. Primary ribs remain pronounced, whereas the secondary ribs can become thinner. Constrictions may be present. The aperture is simple.

Suture (Sokolov and Bodylevsky, 1931, Pl. IX, fig. 3) has a typical dorsoplanitid outline.

Dimensions in mm and ratios in %:[9]

Specimen no. or source	*D*	*d*	*h*	*r*/2	*rr*	*d*/*D*	*h*/*D*
Sokolov, 1912, pl. I, fig. 6			16	19	2		
Sokolov and Bodylevsky, 1931, pl. IX, fig. 3	45	18.7	16.8	15	2.46	41	37.3
Sokolov, Bodylevsky, 1931, pl. IX, fig. 3	37.7	15.7	12.8	17	2.35	41	33.9
SGM VH-20/16	57	23.5	19.2	~12	3	41	33.6
SGM VH-20/16	45	18	~15	14	2.57	4	33.3
SGM VH-20/17	86.5	33.4	27			38	31.2
SGM VH-20/17	63	24.6	23	13		39	36.5
SGM VH-20/54	85	37	28			43	32.9
SGM VH-20/14	81.5	34.5	25.5	13		42.3	31.2
SGM VH-20/14	73	29.6	24.3	12		40.5	33.2
SGM VH-20/19	62	24.4	21	12		39.3	33.8
SGM VH-20/19	53	19	18	14	3.2	35.8	33.9

Variability. The variability is mainly expressed in the differences in the rib ratio and degree of pronunciation of the ribs on the outer whorls.

Comparison. The species described resembles some specimens of *E. variabilis*, in some of which ribs become smoother toward the aperture (pl. IV, fig. 5), but such specimens are quite rare among *E. variabilis*.

Remarks. One specimen examined (SGM VH-20/19, Janusfjellet Mountain, Site 48), came from V.A. Basov who indicated that the specimen was collected loosely under the beds with *Paravirgatites* sp. (Pl. I, fig. 1). Apparently, in one of these cases the was shown erroneously. *Ammonites*, referred by Frebold to *Perisphinctes* cf. *panderi* (Frebold, 1930, Pl. X, figs. 2–6, pl. XI, fig. 1), apparently, belong to one of the *Epivirgatites* species described in this paper. At the same time, small size and questionable stratigraphic position do not exclude the possibility that these can be *Dorsoplanites* from the *D. ilovaiskii* Mesezhn. group. The Myklegardfjellet section together with *Epivirgatites* contained an ammonite assigned to *Taimyrosphinctes* (pl. V, fig. 3), similar to the species under description in the small shell size and high rib ratio. However, in this ammonite, unlike in *Epivirgatites*, the ornamentation of the body chamber does not become weaker, but became stronger. In addition, the rib branching in this ammonite is different: primary ribs in the upper flank remain more pronounced than secondary ribs, whereas the branching is mainly posterolateral.

Occurrence. Middle Volgian, *Groenlandicus* Zone, *sokolovi* Biohorizon, Spitzbergen and Andøya Islands (Lofoten Islands).

Material. 7 specimens, of which siz are from Myklegardfjellet Mountain, section AC, Bed 8 (SGM VH-20/2, 20/14, 20/16, 20/17, 20/54, specimen without number), and one (SGM VH-20/19) from Janusfjellet Mountain, Outcrop 48, talus of Beds 29–30, coll. by V.A. Basov (1988); middle Volgian, *Groenlandicus* Zone, *sokolovi* Biohorizon.

Epivirgatites laevigatus Rogov, sp. nov.

Plate IV, figs. 2–4

Dorsoplanites cf. *tricostatus:* Vyachkileva et al., 1990, pl. 58, fig. 2 (only).

Etymology. From the Latin *laevigatum* (smooth).

Holotype. No SGM VH-20/13a, Vernadsky State Geological Museum, Russian Academy of Sciences, Myklegardfjellet Mountain, section AC, Bed 2; middle Volgian, *Groenlandicus* Zone, *laevigatus* Biohorizon, figured: Pl. IV, fig. 4.

Description. The shell is small and medium-sized (not exceeding 7–8 cm in diameter). The umbilicus is moderately wide, although cannot be measured precisely. The ornamentation of the inner whorls consists of densely spaced bifurcate ribs. At a diameter of 3–4 cm

[9] All specimens are distorted, hence the dimensions of the shells are distorted as well. At the same time, the degrees of distortion in *E. sokolovi* and *E. laevigatus* are similar, and these dimensions are given primarily for comparison of these species *D*—shell diameter, *d*—umbilicus diameter, *h*—whorl height, *r*/2—the number of primaries per half-whorl, *rr*—rib ratio.

(sometimes earlier), the character of ornamentation changes. The density of primary ribs decreases by approximately a third, but the rib ratio increased considerably (up to 3–6). At the same time, ornamentation gradually becomes smoother, while the secondary ribs becomes less rigidly connected with the primaries. The body chamber possesses only irregular, very thin ribs. Constrictions may be present (including the near apertural region). The aperture is simple, the shell becomes uncoiled towards the aperture. No suture was observed.

Dimensions in mm and ratios in%:

Specimen no. or source	*D*	*d*	*h*	*r*/2	*rr*	*d*/*D*	*h*/*D*
Vyachkileva et al., 1990, pl. 58, fig. 2			18.8	14	2.64		
SGM VH-20/13a	61	24.7	20	13		40	32
SGM VH-20/13a			15.5	15			
SGM VH-20/13b	41	15	17	17	2.64	36	41
SGM VH-20/13b	34	13	10	17	2.5	38	29
SGM VH-20/13c	58	22	21.5			38	37
SGM VH-20/13c			16	14	4.5		
SGM VH-20/31	62	22	22	14	3.42	35	35
SGM VH-20/31	54	18	18	14	3.2	33	33
SGM VH-20/31	46	16	15.2	17	2.76	34	33
SGM VH-20/15			21	13	3.07		

Variability. The duration of the stage of predominance of bifurcate ribs varies, as well we in the degree of smoothening of ornamentation.

Comparison. *Epivirgatites* specimens from Bed AC8 (*E. sokolovi* sp. nov.) are similar to *E. laevigatus*, from which they are distinguished by more evolute whorls, coarser and more widely spaced ribs with a lower rib ratio, and by pronounced ribs remaining up to the end of the body chamber. Some *E. variabilis* are similar to this species in having thin closely spaced ribs (Schulgina, 1969, pl. XXIII, fig. 1), but such specimens are relatively rare among *E. variabilis.* The Arctic species of *Epivirgatites* (*E. laevigatus, E. sokolovi, E. variabilis*) differ from the species from the Russian Platform in the weaker ornamentation, which decreases towards the body chamber in some specimens (*E. variabilis*) or in most specimens (*E. laevigatus, E. sokolovi*). The Arctic representatives show most differences with *E. bipliciformis*, the earliest species of the genus *Epivirgatites* from the Russian Platform with distinctly bifurcate ribs.

Remarks. The high rib ratio of *E. laevigatus* is similar to *Subcraspedites* (*Swinnertonia*), from which they are distinguished in the less pronounced primary ribs on the body chamber and coarser ornamentation of the inner whorls. In addition, although no suture was observed in our specimens, its outline in the similar species *E. sokolovi* (Sokolov and Bodylevsky, 1931, pl. IX, fig. 3) is very much different from that in *Subcraspedites*, which has a *Craspedites*-type suture.

Occurrence. Middle Volgian, *Groenlandicus* Zone, *laevigatus* Biohorizon of Spitzbergen and ? western Siberia.

Material. 7 specimens, of which five are from Myklegardfjellet Mountain, section AC, Bed 2 (SGM VH-20/13a–c, 20/31 and one unnumbered specimen), and two from Janusfjellet, coll. by V.A. Basov (1988), SGM VH-20/18 – Outcrop 50, Bed 14; SGM VH-20/15 – Outcrop 50, Bed 13; middle Volgian, *Groenlandicus* Zone, *laevigatus* Biohorizon.

ORDER PHYLLOCERATIDA ARKELL, 1950

Family Holcophylloceratidae Druzczic, 1956

Subfamily Pseudophylloceratinae Besnossow, 1957

Genus *Euphylloceras* Druzczic, 1953

Euphylloceras cf. *knoxvillense* (Stanton, 1896)

(Plate IV, fig. 7)

Remarks. Phylloceratida are one of the most poorly studied ammonites in the boreal Upper Jurassic, their descriptions and figures are almost non-existent in the literature. *E. knoxvillense* known from northern California, South Alaska, Far East and northern Siberia (Nordvik), is one of the species suggesting the connections between the Pacific and Arctic oceans at the end of the Jurassic and in the very beginning of the Cretaceous. *Euphylloceras*, like all Pseudophylloceratinae, show prorsiradiate quickly disappearing constrictions on the mould of the inner whorls. In the outer whorls, the ornamentation in *Euphylloceras* consists only of dense ribs. Only one specimen of *Euphylloceras* is so far found in Spitzbergen.

Comparison. *E. knoxvillense* (Stanton) resembles the Barremian *E. sablyense* (Karakasch) by pronounced constrictions, differing in a different type of ornamentation of outher whorls. In *E. sablyense* the entire shell is covered by thin, weakly curved ribs, whereas in *E. knoxvillense* numerous wide ribs are present only in the upper flank. *?Boreiophylloceras* sp. ind. (Pl. VI, fig. 8), similar to *E. knoxvillense* by the presence of ribs in the upper flank, differing by the wider ribs, which do not reach the venter.

Material. No. SGM VH-20/11 Vernadsky State Geological Museum, Russian Academy of Sciences Bed 3, section 2 on the Festningen River, *Exoticus* Zone, Middle Volgian.

CONCLUSIONS

These studies allowed refinement of the subdivision of the Volgian of Spitzbergen, especially in the stratigraphy of the middle Volgian with seven 7 zones and 10 Biohorizons established. The succession of the Volgian ammonites of Spitzbergen is the most similar to those of East Greenland, northern Siberia, and the

Subpolar Urals, suggesting the position of this region on the pathway of ammonite immigration from the western sector of the Arctic to the eastern sector. At the same time, the similarities of the species composition of the ammonite faunas of Spitzbergen with those of East Taimyr and northern Siberia suggest a wide distribution of in the Arctic at the Middle—Late Volgian transition such genera as *Taimyrosphinctes*, *Craspedites*, *Laugeites*, and other. The Central Russian sea apparently did not influence the Volgian ammonite associations of Spitzbergen, and a few common elements (*Kachpurites* and some *Craspedites*) belong to widely ranging Arctic taxa. Unfortunately, many Volgian localities of Spitzbergen remain insufficiently studied, and the scheme of the infrazonal subdivision proposed in this paper requires verification in other regions.

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