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Ammonite Scale for the Volgian of Eastern Siberia and Its Paleontological Substantiation

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Abstract—The revision of available identifications of Volgian ammonites from the core of boreholes drilled in Western Siberia allowed for the refining of the list of genera and species established on its territory. The lack of reliable identifications of a series of taxa indicates an imperfectly substantiated subdivision of individual Volgian zones of the Subpolar Urals in Western Siberia. The Volgian zonal scale of Western Siberia is proposed to be put into correspondence with its actual paleontological substantiation. Although the scale leans upon the North Uralian one, it is less detailed as compared to the latter.

Key words: ammonites, Upper Jurassic, biostratigraphy, Western Siberia.

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INTRODUCTION

The zonal scale of the Volgian proposed in recent regional stratigraphic schemes of Western Siberia replicates the scale elaborated on the basis of natural exposures in the Subpolar Urals (*Resolution* …, 2004). It is impossible, however, to elaborate a zonal scale, similar in detail and substantiation, on the basis of materials from the core of boreholes drilled in Western Siberia. Although ammonites are rather abundant in Volgian deposits, they are preserved in the core to an extent that prevents the reliable identification of the species and sometimes the genus levels. Due to peculiar preservation and incomplete shells of the ammonites from the core, the set of criteria used for diagnosing genera and species is very limited. This entails the prevalence of identifications in the open nomenclature, a corresponding decline in the reliability of the substantiation of zonal units, and also affects the extent of the divisibility of the zonal scale for the whole Volgian Stage in Western Siberia. My analysis of identifications of Volgian ammonites, which were carried out for the last 30 years, as well as the revision of part of the taxa caused the necessity of refining the Volgian zonal scale for Western Siberia. The modifications are concerned with the abandonment of individual zonal units.

HISTORY OF THE ELABORATION OF THE AMMONITE ZONAL SCALE FOR THE VOLGIAN OF WESTERN SIBERIA

At present, the ammonite zonal scale for the Volgian of Western Siberia is completely derived from the Subpolar Urals where it was elaborated on the basis of a comprehensive study of the collections of ammonites in good preservation and rich in terms of taxonomy and abundance (Mikhailov, 1966; Zakharov and Mesezhnikov, 1974). The onset of deep drilling for oil and gas when the core was recovered with paleontological material made it possible to speak about the presence of the Upper Jurassic, including the Volgian, deposits on the territory of Western Siberia. Individual Volgian substages and zones were established there by the first single finds of ammonites in the core (Saks, 1961; Saks et al., 1963; *Stratigraphy* …, 1976). The fragmentary nature of the paleontological material, its fair preservation, as well as the lack of clear ideas on the connections between the West Siberian sea basin and the adjacent East European and East Siberian basins, all retarded the elaboration of the zonal scale for the Upper Jurassic of Western Siberia.

In the course of compiling stratigraphic schemes for the Jurassic of Western Siberia, the necessity arose for substantiating the stratigraphic volume of the formations and their fragments. In this connection, Mesezhnikov revised the identifications available at that time and reached the following conclusions (Mesezhnikov, 1983).

(1) There is only one piece of evidence for the presence of the lower Volgian rocks in the Bazhenov Formation (and its analogs) (*Pectinatites* from the borehole Yarainerskaya 3, depth 2930 m).

(2) The lower Volgian beds are not found in most of Western Siberia.

(3) There are grounds for the application of the middle Volgian zonal scale of the Urals to the Bazhenov Formation (the central part of Western Siberia).

Stages	Mesezhnikov, 1983	Mesezhnikov et al., 1984	Mesezhnikov, 1984	*Resolutions* .., 1991	*Resolution* ..., 2004
BOREAL BERRIASIAN	BERRIASIAN	Not given	Not given	*Hectoroceras kochi*	*Hectoroceras kochi*
		Praetollia		*Chetaites sibiricus* and *Praetollia maynci*	*Chetaites sibiricus*, *Praetollia maynci*
		Schulginites	?	Beds with *Subcraspedites maurynijensis* and *S. pulcher* / beds with *Schulginites* spp.	*maurynijensis*, *pulcher*
VOLGIAN	horizon with *Craspedites* ex gr. *mosquensis* and *C.* ex gr. *taimyrensis*	*Craspedites taimyrensis*	*C. taimyrensis*	*C. taimyrensis*	*C. taimyrensis*
	horizon with *Craspedites* ex gr. *okensis* and *C.* cf. *fragilis*	*Craspedites okensis*	*C. okensis*	*C. subditus* / *K. fulgens* / *Craspedites okensis*	C. subditus / K. fulgens / *C. okensis*
	?	*Epilaugeites vogulicus*	E. vogulicus	*E. vogulicus*	*E. vogulicus*
		Laugeites groenlandicus	*L. groenlandicus*	*L. groenlandicus*	*L. groenlandicus*
		?	?	Crendonites spp.	Crendonites spp.
	Dorsoplanites maximus	*D. maximus*	*D. maximus*	*Dorsoplanites maximus*	*D. maximus*
	?	*Dorsoplanites ilovaiskii*	*D. ilovaiskii*	*Dorsoplanites ilovaiskii*	*D. ilovaiskii*
	Pavlovia iatriensis	*Pavlovia iatriensis*	*Pavlovia iatriensis*	*Pavlovia iatriensis*	*Pavlovia iatriensis*
	?	*Pectinatites pectinatus*	*P. pectinatus*	*P. pectinatus*	*P. pectinatus*
			absent	*Subdichotomoceras subcrassum*	*S. subcrassum*
				Eosphinctoceras magnum	*E. magnum*

Fig. 1. Evolution of views on the zonal structure of the Volgian in Western Siberia.

(4) The middle Volgian *Pavlovia iatriensis* and *Dorsoplanites maximus* zones have been established in the central part of Western Siberia. Established in the upper Volgian were a lower horizon (with *Craspedites* ex gr. *okensis* (d'Orbigny), *Kachpurites* Spath, *Craspedites* sp. (cf. *C. fragilis* Trd.)) and an upper horizon (with *Craspedites* ex gr. *mosquensis* Geras., *Craspedites* ex gr. *taimyrensis* (Bodyl.)).

(5) Data are inadequate to distinguish the *Dorsoplanites* ilovaiskii, *Crendonites* spp., *Laugeites groenlandicus, Epilaugeites vogulicus* zones in Western Siberia.

In 1984, Mesezhnikov together with his coauthors made an effort to generalize the material acquired by that time on the ammonites of Western Siberia (Mesezhnikov et al., 1984). Based on over 500 identifications of Upper Jurassic ammonites, the authors proposed a zonal scheme for the Callovian and Upper Jurassic of Western Siberia. The succession of Volgian zones almost completely repeated the scale for the Subpolar Urals where reference sections of the Volgian zones are located (Fig. 1). In this first zonal scheme, the *Crendonites* spp. Zone and beds with *Subcraspedites (S.?) maurynijensis* and *S. (Volgidiscus) pulcher*, which are present in the current stratigraphic scheme for the Upper Jurassic of Western Siberia (*Resolution* …, 2004), have not yet been found. Only the *Pectinatites pectinatus* Zone (Mesezhnikov et al., 1984) in the lower substage and beds with *Schulginites* in the uppermost upper Volgian have been distinguished.

By 1986, no analogs to the *Crendonites* spp., *Eosphinctoceras magnum*, and *Subdichotomoceras subcrassum* zones of the Northern Urals had been established in Western Siberia (*Bazhenov* …, 1986).

Later, three zones, the same as in the Subpolar Urals, were shown in the lower Volgian Substage in the stratigraphic scheme of the Jurassic deposits of Western Siberia (*Resolutions* …, 1991). The *Crendonites* spp. Zone was distinguished for the first time for the middle Volgian Substage. In the upper Volgian, along with beds with *Subcraspedites* (S.?) *maurynijensis* and *S. (Volgidiscus) pulcher*, beds with *Schulginites* spp. (Fig. 1) were distinguished, which are missing from the latest officially adopted regional stratigraphic schemes (*Resolution* …, 2004).

In 2000, the first (and the last) indication of on identification of the *Eosphinctoceras magnum* Mesezhn. from the core of BH Egur'yakha 22 was published,

which substantiated the presence of the Volgian lowermost zone in Western Siberia (Shurygin et al., 2000, p. 374). At present, the locality for this specimen is unknown. Furthermore, in publications, one may come across the identifications of *Subdichotomoceras* sp., *?Subdichotomoceras* sp., and *Ilowaiskya* ex gr. *sokolovi* (Ilov.), which are not confirmed by images and an exact reference to the section (Shurygin et al., 2000, p. 131).

Hence, when comparing time variant zonal scales of Western Siberia, it becomes evident that there are some intervals in them, the subdivision of which into zones is controversial and requires substantiation by the available paleontological material.

MATERIALS

I have analyzed 450 currently available finds of ammonites from the Volgian rocks of Western Siberia. Most of them (270) are published as lists of identifications and images (*Bazhenov* …, 1986; *Atlas* …, 1990; *Biostratigraphic* …, 1977; Braduchan et al., 1984). The identifications were made collectively at special colloquia in Tyumen (ZapSibNINI) and St. Petersburg (VNIGRI) and, thus, exhibit high reliability. I took the rest of the identifications from paleontological summaries to boreholes, which were carried out by specialists from INGG SD RAS, including myself, within the framework of cost accounting work in the 1990s and 2000s. A hundred specimens are included in my collection, part of which was mentioned previously in summaries to boreholes, and another part is represented by finds collected in recent years. I have summarized all 450 finds of Volgian ammonites of Western Siberia in a single databank which also comprises the site, borehole number, interval and sampling depth, stratigraphic range, and, if required, the published source.

RESULTS OF AMMONITE REVISION

The comparative analysis of diagnostic indicators for genera and species, which were used for identifying the taxa included in the databank allowed for inferring the extent of the reliability of the identifications of the Volgian ammonites known in Western Siberia.

The lower Volgian Stage in Western Siberia was confirmed by identifications of the only genus *Pectinatites*. Six finds of *Pectinatites* are known to date: two images are illustrated in (*Atlas* …, 1990, Plate 55, Figs. 1, 2), two finds are displayed in the list (*Biostratigraphic* …, 1977; Plate X), and two finds are available in my collection (Plate I, Fig. 1). A great number of *Pectinatites* species (*P. lideri* Mesezhn., *P. fedorovi* Mesezhn., etc.) has been described from the upper Volgian of the Subpolar Urals. None of them has been established in the core of the boreholes drilled in Western Siberia.

Ten ammonite genera are known in the middle Volgian of the Subpolar Urals. Seven of them have been established in Western Siberia: *Pavlovia, Strajevskya, Dorsoplanites, Laugeites, Taimyrosphinctes, Epilaugeites, Praechetaites, Craspedites* (Alifirov and Igol'nikov, 2007, *Atlas* …, 1990, and others).

Thirteen finds of the genus *Pavlovia* Ilov. are known in Western Siberia: two of them have been identified up to the genus level with a question mark, seven specimens have been established to the species level in the open nomenclature, and the rest of the specimens have been identified to the genus level. Seven specimens of the genus *Pavlovia* Ilov. from the core recovered in Western Siberia are described in (*Atlas* …, 1990; *Bazhenov* …, 1986). The following *Pavlovia* species: *P.* cf. *hypophantica* Ilov. em. Michlv., *P.* cf. *ponomarevi* Ilov. em. Michlv., and *P.* cf. *iatriensis* Ilov. em. Michlv. are known in the middle Volgian Substage of Western Siberia.

Multicostate forms of *P.* cf. *iatriensis* Ilov. em. Michlv. and rare-costate representatives of *P.* cf. *hypophantica* Ilov. em. Michlv. are more or less reliably

Plate I. Volgian ammonites of Western Siberia. Collection no. 983 housed in INGG SD RAS, Novosibirsk. All sizes are natural.

Fig. 1. *Pectinatites* spp., Sp. no. 983/41, BH North Danilovskaya 10009, int. 1736–1741 m (depth 1741 m), Tutleim Fm., lower Volgian, *Pectinatites pectinatus* Zone.

Fig. 2. *Dorsoplanites* sp. (*D.* cf. *maximus* Spath), Sp. no. 983/4, BH Druzhnaya 161, int. 2865–2875 m, Bazhenov Fm., upper Volgian.

Fig. 3. *Taimyrosphinctes* sp., Sp. no. 983/23, BH Var'eganskaya 114, int. 2503.6–2519.6 m (depth 2508.7 m), see Fig. 2 for formation and age.

Fig. 4. *Laugeites* ex gr. *groenlandicus* (Spath), Sp. no. 983/19, BH Severnaya Salymskaya 1183, int. 2862–2863 m, Bazhenov Fm., middle Volgian, beds with *Laugeites* ex gr. *groenlandicus* (Spath).

Fig. 5. *Epilaugeites* cf. *vogulicus* (Ilov.), Sp. no. 983/18, BH Severnaya Salymskaya 1183, int. 2862–2863 m, Bazhenov Fm., middle Volgian, *Epilaugeites vogulicus* Zone.

Fig. 6. (a) *Craspedites* sp., Sp. no. 983/10a; (b) *Craspedites* ex gr. *taimyrensis* (Bodyl.), Sp. no. 983/10b, BH Pokachevskaya 7029, int. 2753–2767 m, Bazhenov Fm., upper Volgian.

Fig. 7. *Craspedites* ex gr. *taimyrensis* (Bodylevsky), Sp. no. 983/13, BH Pokachevskaya 7029, int. 2753–2767 m (depth 2762.6 m), Bazhenov Fm., upper Volgian.

Fig. 8. *Schulginites* cf. *pseudokochi* Mesezhnikov, Sp. no. 983/72, BH Khal'merpayutinskaya 2099, int. 3701.7–3695.4 m (depth 3696.8 m), Yanov Stan Fm., upper Volgian, beds with *Schulginites* cf. *pseudokochi*.

Plate I

Stage	Substage	Zones, subzones, beds		
VOLGIAN		Subpolar Urals, Western Siberia (*Resolution* …, 2004)	Western Siberia (Mesezhnikov et al., 1984)	Eastern Siberia (*Resolution* …, 2004)
	Upper	*S. (?) maurynijensis*, *S. (V.) pulcher*	*Schulginites*	*Chetaites chetae*
		Craspedites taimyrensis	*C. taimyrensis*	*Craspedites taimyrensis*
		C. subditus / *K. fulgens* — *Craspedites okensis*	*C. okensis*	*C. subditus* / *K. fulgens* — *Craspedites okensis*
	Middle	*Epilaugeites vogulicus*	*E. vogulicus*	*E. vogulicus* — *Epilaugeites vogulicus*
		Laugeites groenlandicus	*L. groenlandicus*	*L. groenlandicus*
		Crendonites spp.	?	*Taimyroshinctes excentricus*
		Dorsoplanites maximus	*D. maximus*	*Dorsoplanites maximus*
		Dorsoplanites ilovaiskii	*D. ilovaiskii*	*Dorsoplanites ilovaiskii*
		Pavlovia iatriensis	*P. iatriensis*	*Pavlovia iatriensis*
	Lower	*Pectinatites pectinatus*	*Pectinatites pectinatus*	*Pectinatites pectinatus*
		Subdichotomoceras subcrassum		*Subdichotomoceras subcrassum*
		Eosphinctoceras magnum		*Eosphinctoceras magnum*

Fig. 2. The zonal scale of the Volgian of Western Siberia proposed by Mesezhnikov together with coauthors in 1984 and its correlation with scales of adjacent territories.

The zonal subdivision and correlation of the middle Volgian of Eastern Siberia (the *Groenlandicus, Vogulicus, Variabilis* zones) need refinement. The latest data on this time interval were published in the paper of V.A. Zakharov and M.A. Rogov (2008).

recognized amidst the species of the genus *Pavlovia* on middle and later whorls. The rest of the species of the genus exhibit similar morphological characteristics and are hard to identify in the core. One specimen of the genus *Strajevskya* is known without the identification of the species. The genus *Strajevskya* in the core is not distinctive from the genus *Pavlovia* as well. To distinguish them, it is necessary to have a completely preserved specimen and diagnostic evidence of the genus: a wide or very wide umbilicus, dorso-planoid trifid, and quadrifid ribs unconnected with constrictions and branching from one point.

No identification of the genus *Crendonites* Buckman is available for Western Siberia, though, the *Crendonites* spp. Zone is distinguished in the middle Volgian of the zonal scale. Mesezhnikov established this zone in the Subpolar Urals and correlated it with the zone of the same name in eastern Greenland (Mesezhnikov, 1963). The Uralian *Crendonites* spp. Zone corresponds to the *Taimyrosphinctes excentricus* Zone of Eastern Siberia (Fig. 2).

The genera *Dorsoplanites*, *Laugeites, Epilaugeites, Taimyrosphinctes* belonging to the family Dorsoplanitidae are similar in morphology and often hard to distinguish in the core. That is why, taking into account the preservation of the material, I tried to find out those generic and specific indicators which could be used in the taxonomic classification of specimens from the core.

The main distinctive features of these genera (the cross section of whorls, the umbilical wall slope angle) described by Mesezhnikov (1972) are often not detectable in the core.

Based on the published data, I have selected two samplings involving specimens of ammonites with the diameter not exceeding 80 mm (the core diameter is 80–100 mm). The first sampling comprises 22 specimens of the genus *Taimyrosphinctes*, and the second sampling, 83 specimens of the genera *Laugeites* and *Dorsoplanites*. The umbilicus diameter turned out to average 29% of the shell diameter for the genus *Taimyrosphinctes* and 37% for the genera *Laugeites* and *Dorsoplanites* (Fig. 3). Mesezhnikov's data show that the umbilicus diameter for *Taimyrosphinctes excentricus* Mesezhn. and *T. trikraniformoides* Mesezhn. does not exceed 30% of the shell diameter if it varies from 40 to 80–90 mm (Mesezhnikov, 1972). By this parameter,

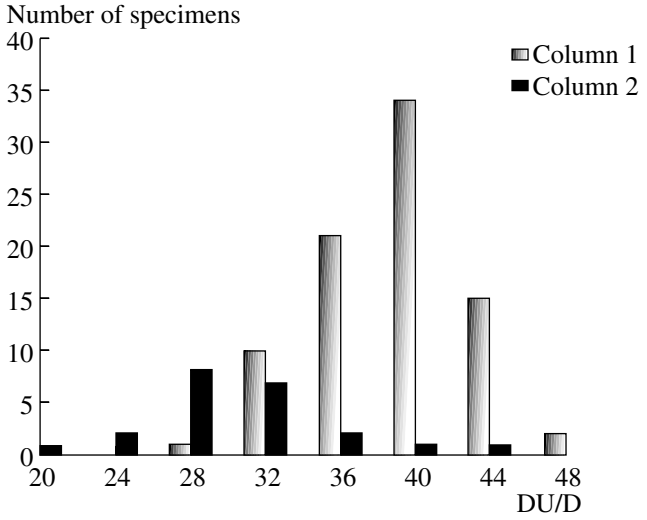

Fig. 3. Incidence of distribution for specimens of the genera *Laugeites* Spath, *Dorsoplanites* Semen. (column 1), and *Taimyrosphinctes* Mesezhn. (column 2) by the ratio of the umbilicus diameter (DU) to the shell diameter (D).

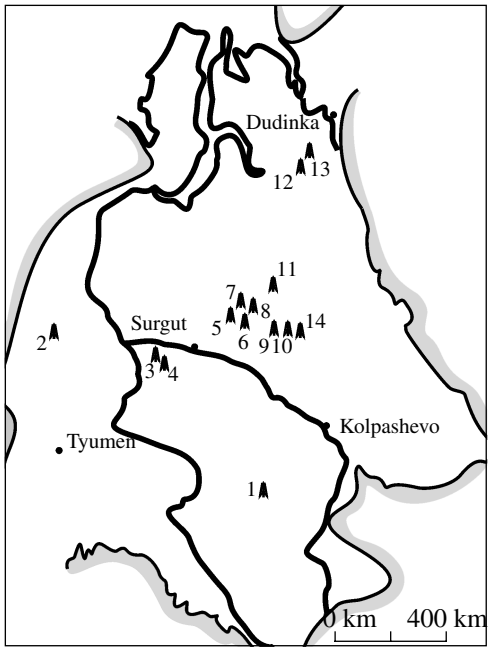

Fig. 4. Location of boreholes with ammonite finds (Western Siberia).
(1) East Moiseevskaya 3; (2) North Danilovskaya 100009; (3) North Salymskaya 1183; (4) Salymskaya 1; (5) Pokachevskaya 7029; (6) Potochnaya 22; (7) Druzhnaya 161; (8) Egur'yakhskaya 22; (9) Var'eganskaya 114; (10) Enitorskaya 971; (11) Yarainerskaya 3; (12) Khal'merpayutinskaya 2099; (13) Suzunskaya 15; (14) Kolikeganskaya 148.

most of the specimens of the genera *Laugeites* Spath and *Dorsoplanites* Semen. fall within the interval of 36–40% (Fig. 3). In other words, the umbilicus diameter, which is often assessed on shells recovered from the core, may serve as a reliable indicator in the generic identification of *Dorsoplanites*. It should be noted that the genus *Taimyrosphinctes* comprises evolute species, of which DU/D makes up 33–50% at the shell diameter 60–90 mm that is characteristic of the majority of the species of the genera *Dorsoplanites* and *Laugeites*. In particular, *T. nudus* Mesezhn., *T. pavloviformis* Mesezhn., and *T. evolutus* Mesezhn belong to them. The genus *Dorsoplanites* also comprises species (*D. panderiformis* Michlv., *D. sibiriakovi* Ilov. em. Michlv., *D. subpanderi* Spath) with DU/D about 30% which is characteristic of *T. excentricus* Mesezhn., *T. pachycostatus* Mesezhn., and *T. udschensis* (Schulgina).

The comparison of the ornamentation in the genera *Dorsoplanites* and *Taimyrosphinctes* with the shell diameter of 40–80 mm, most often encountered in the core, showed that from 30 to 40 umbilical ribs can be counted per whorl in these genera, whereas forms of the genus *Laugeites* exhibit more than 41 umbilical ribs per whorl.

Hence, when identifying ammonites, forms with a narrow, moderately narrow umbilicus (DU/D 20–29%) and a coarse (*Dorsoplanites*-like) ornamentation should be attributed to the genus *Taimyrosphinctes*.

As the studies showed, using a combination of indicators (rib thickness, umbilicus width) the genera *Laugeites, Dorsoplanites*, and *Taimyrosphinctes* can be rather reliably distinguished even in the core. In the known previous lists of ammonite identifications for Western Siberia, the genus *Taimyrosphinctes* was not mentioned. Amidst the looked-through Volgian ammonites of Western Siberia, up to now there has been revealed only one specimen of *Taimyrosphinctes* sp. in the author's collection. This is the first find of *Taimyrosphinctes* in the core recovered from boreholes in Western Siberia (BH Var'eganskaya 114, Plate I, Fig. 3; Fig. 4). The ratio of the umbilicus diameter of this specimen to the shell diameter (46 mm) equals 26%, the bifurcation coefficient is 2.2 (44/20), and the general view of ornamentation resembles that typical of *Dorsoplanites*.

The genus *Laugeites* Spath has been described in detail both in the Russian and foreign literature (Spath, 1936a, 1936b; *Treatise* …, 1957; Khimshiashvili et al., 1958; Donovan, 1964; Mikhailov, 1966; Zakharov and Mesezhnikov, 1974; Ivanov, 1979; Mitta, 1993). These descriptions yielded common morphological features of the genus *Laugeites* Spath: a medium and large shell, flattened or of a medium thickness. Earlier whorls are of the oval cross section and later whorls, of the rounded–rectangular cross section.

Characteristic of the genus *Laugeites* are a thin, copious ribbing on the early whorls and a smoothing ribbing on later whorls. Mesezhnikov also reported a posterolateral branching of the secondary ribs as a

Table 1. Comparison of diagnostic characteristics (cross section and ornamentation) of middle Volgian genera *Laugeites* Spath, *Dorsoplanites* Semen., *Taimyrosphinctes* Mesezhn. (based on published data)

Genera / Characteristics	*Laugeites*	*Dorsoplanites*	*Taimyrosphinctes*
Cross section	Oval early whorls, rounded–rectangular later whorls	Oval	Subrectangular at all stages of growth
Ornamentation	Copious, thin, bifid and trifid, with a secondary rib slanting backward in the flank upper part. Some species have a siphuncle bend	Sharp, often elevated in the perumbilical part, with a forward bend on the ventral side	Sometimes, a bend of the secondary rib is observed like in *Laugeites*; no elevation of primary ribs is observed like in *Dorsoplanites*. Ornamentation is coarser than in *Laugeites*

generic characteristic (Zakharov and Mesezhnikov, 1974). Though, the species of the genus *Laugeites* described by Mesezhnikov exhibit both the posterolateral and forked branching (virgatotome appearance in triple bundles). Mesezhnikov regarded the rib slanting in the upper part of the flanks along with the thin ornamentation as one of the dissimilarities of the genus *Laugeites* (and *Epilaugeites*) from close genera *Dorsoplanites* and *Taimyrosphinctes*. The shape of the shell cross section is another distinctive feature of the mentioned ammonite genera (Table 1).

Clearly, the cross section shape should not be used in ammonite identification. On the other hand, the ornamentation is well preserved, and this characteristic is one of the main features for the identification of genera from the family Dorsoplanitidae in the core. Thin (filamentary), dense, bi-, tri-, quadrifid ribs with posterolateral and forked branching are typical of the *Laugeites*.

The genus *Laugeites* is rarely identified in the core to the species level. Only one specimen *L.* cf. *borealis* Mesezhn., eight identifications of *L.* cf. *stschurovskii* (Nikitin), and one specimen of the index species from the middle Volgian *L.* cf. *groenlandicus* Zone (all in the open nomenclature) have been established in it. Only one of the above-listed species is depicted in (*Atlas* …, 1990, Plate 59, Fig. 1). Along with *L. groenlandicus* (Spath), similar characteristics (number of umbilical, bifid and trifid ribs, as well as ribbing coefficient) are peculiar to species *L. lambecki* (Ilovaisky), *L. biplicatus* Mesezhnikov, and *L. stschurovskii* (Nikitin), which are united in the group *L.* ex gr. *groenlandicus* (Plate I, Fig. 4), whereas species *L. borealis* Mesezhn. and *L. planus* Mesezhn. make up the group *L.* ex gr. *borealis*.

Unlike ammonites of the group *L.* ex gr. *groenlandicus*, ammonites of the group *L.* ex gr. *borealis* have quadrifid ribs. Species of the group *L.* ex gr. *groenlandicus* have bifid and trifid ribs on medium whorls and differ (at the shell diameter up to 80 mm) in the early or later appearance of trifid ribs, and their number compared to bifid ribs. Actually, it is only the affinity of the *Laugeites* specimen to one of the mentioned groups that can be established in the core.

The study of published materials and my own collection shows that the establishing of the species affinity for *Laugeites* Spath in the core is troublesome. This is confirmed by the small number of identifications of *Laugeites* to the species level (10 out of 52 specimens known to the author).

The genus *Epilaugeites* Mesezhn. is morphologically very close to the genus *Laugeites* Spath and differs from it in that the "lobe line is less dissected and approaches the suture at the right angle; the ventral lobe I_1 is undivided", as well as in the absence of substantial changes in ornamentation on body whorls of mature specimens of *Epilaugeites* (Zakharov and Mesezhnikov, 1974). As the lobe line on ammonites in the core is, as a rule, unobservable, and the body whorl is not necessarily preserved, then, on the basis of these characteristics, the genus *Laugeites* is undistinguishable from the genus *Epilaugeites*.

Nevertheless, the species characteristics of *E. vogulicus* (Ilov.) (strictly biplicated ornamentation up to a shell diameter of 70 mm, ribs slanting orad, forked or posterolateral branching of ribs, rare single or inserted ribs at the end of the last whorl) allow for differentiating it from species of the genus *Laugeites*. Irrespective of the species affinity, this species is easy to recognize in the core, and I studied it by specimens, images of which have already been published, as well as specimens from my own collection (Plate I, Fig. 5).

The genus *Epilaugeites* was mentioned nine times in identification lists. Two specimens are depicted in (*Atlas* …, 1990, Plate 59, Figs. 6, 7). The genus *Laugeites* is represented by 52 identifications. The data show that in most cases, ammonites with copious and thin ornamentation and a wide umbilicus were identified as *Laugeites*.

The genus *Praechetaites* identified previously as *Virgatosphinctes* is often encountered in the Volgian deposits of Western Siberia. Seventeen specimens of the genus are known, ten of which are depicted in (*Atlas* …, 1990, Plate 61, Figs. 1–10). These ammonites are noteworthy for their very dense chaotic and thin ribbing with a high (about 4) ribbing coefficient. The species identification of *Praechetaites* involves great difficulties. I know only

two cases of *Praechetaites* identification to the species level (*Atlas* …, 1990, Plate 61, Fig. 1, and my specimen).

The genus *Craspedites* is represented by hundreds of specimens in the databank I have compiled. Most of them were identified to the genus level (*Craspedites* sp. ind.). The species identification of *Craspedites* is rather rare. *Craspedites* from the core are most often identified with *C. taimyrensis* (Bodylevsky) and *C. mosquensis* Schulgina (non Gerasimov) species. Only one specimen of *Craspedites* ex gr. *okensis* (d'Orbigny) is available. The characteristics of the species *C. okensis* (d'Orb.) are as follow: a smoothing of ornamentation at the shell diameter of about 25 mm, which begins at the lower part of the flank; disappearance of ornamentation to a diameter of 60 mm and sometimes earlier (Shul'gina, 1969, Plate XXVII, Fig. 2); ribs sometimes retained on the ventral side are hardly detectable. Judging from the *C.* ex gr. *okensis* (d'Orb.) (*D* = 60 mm) image, the specimen has ribs reaching the umbilical edge (*Bazhenov* …, 1986, Plate XVI, Fig. 5). As noted in the cited work, the specimen is similar to the group of specimens of the *C. okensis* (d'Orb.) species depicted in (Gerasimov, 1969, Plate XXI, Figs. 1–8). The nature of the ornamentation does not allow me to attribute the studied specimen to the *C. okensis* (d'Orb.) species. Often encountered in the core of boreholes drilled in Western Siberia are representatives of *Craspedites* which are identified as *Craspedites* ex gr. *mosquensis* Schulgina (non Gerasimov) (*Bazhenov* …, 1986, p. 104, Plate XVI, Figs. 6–8; *Atlas* …, 1990, Plate 63, Fig. 2). I assign these forms to a new species and propose to name it *Craspedites schulginae* sp. n., after N.I. Shul'gina. I attribute to this species the specimen *Craspedites* sp. found in BH Khal'merpayutinskaya 2099 along with the Volgian *Buchia* assemblage and microfauna (Alifirov and Igol'nikov, 2007, Plate I, Fig. 9).

The upper Volgian genus *Kachpurites* Spath is established in Western Siberia in boreholes Salymskaya 1, Salymskaya 130, Pokachevskaya 7029 (*?Kachpurites* sp. ind. – 4 specimens, Fig. 4), and Enitorskaya 971 (*Kachpurites* sp. ind. – 1 specimen). Images of only two specimens of this genus are known from BH Salymskaya 130 (*Bazhenov* …, 1986, Plate XVI, Figs. 1, 2; *Atlas* …, 1990, Plate 62, Figs. 1, 2).

The index species of the upper Volgian *Craspedites taimyrensis* Zone is represented by four specimens identified in the binary nomenclature. The rest of the six identifications are given in open nomenclature, *Craspedites* ex gr. *taimyrensis* (Bodyl.) (Plate I, Figs. 6, 7; *Atlas* …, 1990, Plate 62, Figs. 3–7).

Two specimens of upper Volgian *?Subcraspedites* sp. ind. (*Bazhenov*…, 1986, Plate XXI, Fig. 11; Alifirov and Igol'nikov, 2007, Plate I, Fig. 5) and two specimens of *?Subcraspedites (Volgidiscus)* sp. ind. (*Bazhenov* …, 1986, Plate XVI, Fig. 3, 4) are known in Western Siberia. I doubt the validity of attributing the latter to the subgenus *S. (Volgidiscus)* because of their preservation. No images and reference to the section are given for *Subcraspedites (Subcraspedites)* sp. cf. *turbinae* Klim. and *Subcraspedites (Volgidiscus)* sp. (Shurygin et al., 2000, p. 132; Meledina and Aleinikov, 2003). The specimen *Craspedites* sp. (cf. *C. fragilis* (Trd.)) recovered from a depth of 2649.3 m in BH Potochnaya 22 was reidentified as *?Subcraspedites* sp. ind (*Bazhenov* …, 1986, Plate XXI, Fig. 11).

The upper Volgian–Ryazanian genus *Schulginites* was represented by several finds in Western Siberia. Later, the specimen *?Schulginites* sp. ind. from BH Vostochno-Moiseevskaya 3 (*Bazhenov* …, 1986, Plate XXVIII, Fig. 3) was reidentified as *Hectoroceras (?Schulginites)* sp. ind. (*Atlas* …, 1990, Plate 68, Fig. 3). Two incomplete cores of *S.* aff. *pseudokochi* Mesezhn. (*Bazhenov* …, 1986, Plate XXVIII, Figs. 1, 2) were reidentified as *Praetollina* sp. ind. cf. *P. maynci* Spath (*Atlas* …, 1990, Plate 68, Figs. 1, 2). As of now, the only specimen of the genus *Schulginites*, namely, *Schulginites* cf. *pseudokochi* Mesezhn. is known from upper Volgian deposits of Western Siberia (Plate I, Fig. 8; Alifirov and Igol'nikov, 2007). It should be noted that publications have been issued in recent years, in which the genus *Schulginites* is regarded as a subgenus of the genus *Hectoroceras* or as its synonym (*Treatise* …, 1996; Mitta, 2004, 2005, 2007). Following Mesezhnikov and N.I. Shul'gina, as well as A.E. Igol'nikov, and others (Mesezhnikov et al., 1983; Igol'nikov, 2008, and others), I support the idea of the self-dependence of the genus *Schulginites*.

The genus *Chetaites* is also one of the genera characterizing the boundary horizons of the Jurassic and Cretaceous in Western Siberia. The only find of it (*Chetaites* sp. ind.) is known from the BH Suzunskaya 15 in the northeastern part of Western Siberia (*Atlas* …, 1990, Plate 61, Fig. 11).

Hence, the results of the revision of Volgian ammonites in Western Siberia show that their generic composition is less diverse compared to the Subpolar Urals. The lower Volgian Substage in the Subpolar Urals is characterized by five genera versus one genus in Western Siberia. The generic diversity of the middle Volgian and upper Volgian in Western Siberia is similar to that in the Subpolar Urals (Table 2). However, the composition of the Volgian ammonites in Western Siberia is much poorer than in the Subpolar Urals. The unsatisfactory preservation of some West Siberian specimens casts doubt upon the reliability of their identifications and renders low the substantiation of individual biostratigraphic units of the zonal scale.

STRATIGRAPHIC CONCLUSIONS

The lower Volgian Substage. For lack of the only specimen of *Eosphinctoceras magnum* Mesezhn. and reliable identifications of *Subdischotomoceras*, I believe that distinguishing the two lower Volgian *Eosphicto-*

Table 2. Comparison of the generic diversity of Volgian ammonites from Western Siberia (Atlas ..., 1990, and others) and the Subpolar Urals (Zakharov and Mesezhnikov, 1974; Mesezhnikov, 1984)

Stage	Substage	Ammonite genera	Subpolar Urals	Western Siberia
Volgian	Upper	Chetaites	+	+
		Subcraspedites	+	+
		Schulginites	+	+
		Praechetaites	+	+
		Craspedites	+	+
		Kachpurites	+	+
		Garniericeras	+	–
	Middle	Craspedites	–	+
		Epilaugeites	+	+
		Laugeites	+	+
		Praechetaites	–	+
		Taimyrosphinctes	+	+
		Crendonites	+	–
		Dorsoplanites	+	+
		Strajevskya	+	+
		Lydistratites	+	–
		Pavlovia	+	+
	Lower	Pectinatites	+	+
		Subdichotomoceras	+	–
		Eosphinctoceras	+	–
		Gravesia	+	–
		Paravirgatites	+	–
		Ilowaiskya	+?	–

Note: According to M.A. Rogov's data, Siberian representatives of *Ilowaiskya*, from the Subpolar Urals included, belong to the genus *Pectinatites* (Rogov, 2007).

ceras magnum and *Subdichotomoceras subcrassum* zones to be groundless at present.

The problem of the lower Volgian Substage's completeness on the territory of Western Siberia is debatable. Mesezhnikov inferred that only the upper part (the *P. pectinatus* Zone) of the lower Volgian deposits occurs in Western Siberia (Mesezhnikov, 1983; Braduchan et al., 1984). The inference was based on finds of the genus *Pectinatites* in the core of boreholes. In recent years, data on the distribution of this genus in the Subpolar Urals over the whole of the lower Volgian have emerged (Rogov, 2007). Hence, West Siberian *Pectinatites* identified to the genus level indicate only the presence of the lower Volgian as a whole (Fig. 5).

The middle Volgian Substage. The distinguishing of middle Volgian *Pavlovia* iatriensis, *Dorsoplanites ilovaiskii*, and *Dorsoplanites maximus* zones in Western Siberia is corroborated by a sufficient amount of reliable identifications of index species as well as attendant species. The *Pavlovia iatriensis* Zone is characterized by species *P.* cf. *iatriensis* Ilov. em Michlv., *P.* cf. *hypophantica* Ilov. em Michlv., *Dorsoplanites* cf. *antiquus* Spath, *D.* cf. *crassus* Spath. Abundant finds of the index species is typical of the *Dorsoplanites ilovaiskii* Zone. Characteristic of the *Dorsoplanites* Zone are the following species: *D.* ex gr. *maximus* Spath, *D.* cf. *transitorius* Spath, *D. tricostatus* Michlv., *D.* cf. *sibiriakovi* Ilov. em Michlv., *D.* cf. *crassus* Spath, *D.* cf. *subdorsoplanus* Mesezhn., *D.* cf. *dainae* Mesezhn., *D.* cf. *flavus* Spath, and *Pavlovia* cf. *ponomarevi* Ilov. em Michlv.

The *Crendonites* spp. Zone in Western Siberia is not confirmed by finds of *Crendonites* Buckman ammonites and should be excluded from stratigraphic schemes. Up to the present time, there have been no grounds to replace this biostratigraphic unit by its East Siberian analog, the *Taimyrosphinctes excentricus* Zone. The range of the vertical distribution of the genus *Taimyrosphinctes* Mesezhn. is not quite clear. The stratigraphic interval characterized by this genus was determined as the sum of the *D. maximus* and *D. sachsi* zones of Eastern Siberia (Mesezhnikov, 1972, p. 121). Later, the *Taimyrosphinctes excentricus* Zone synchronous to the *Dorsoplanites sachsi* Zone (the Lena River's lower reaches) was distinguished in the middle Volgian of the central Taimyr Peninsula (the Dyabakatara River) (*Stratigraphy* …, 1976; Bidzhiev and Mikhailov, 1966). Until recently, the genus *Taimyrosphinctes* Mesezhn. has not been reported in the overlying middle Volgian *Laugeites groenlandicus, Epivirgatites variabilis, Praechetaites exoticus* zones of Eastern Siberia. According to the latest data, the genus *Taimyrosphinctes* sp. was found in the *Variabilis* Zone on the Nordvik Peninsula (Zakharov and Rogov, 2008). In the Subpolar Urals, the genus is known in the *Epilaugeites volgulicus* Zone, but it has not been found above and below the zone (Mesezhnikov, 1984). When giving the paleontological characteristics of stratigraphic units of the zones, Mesezhnikov did not mention the genus *Taimyrosphinctes* in the upper Volgian *okensis* Zone as well, though, when describing the Volgian section in the Kheta River basin he mentioned the find of *T. (T.)* cf. *trikraniformoides* Mesezhn. in the *Craspedites okensis* Zone (the *Praechetaites exoticus* Subzone) (Mesezhnikov, 1984, p. 54). When describing the *Taimyrosphinctes pachycostatus* Mesezhn. species, its stratigraphic interval was determined as the middle Volgian *T. excentricus* Zone, ?Berriasian *Chetaites sibiricus* Zone (Mesezhnikov, 1984, p. 143). Though, it is shown in the same work (p.65, Fig. 27) that the *T. pachycostatus* Mesezhn. species is distributed in middle Volgian *Dorsoplanites maximus* and *Taimyrosphinctes excentricus* zones.

Hence, the genus *Taimyrosphinctes* is typical of the middle Volgian *D. maximus* and *T. excentricus* zones in

Stage	Substage	Zones, subzones, beds	
		Subpolar Urals, Western Siberia (*Resolution* … 2004)	Western Siberia (proposed version)
Boreal Berriasian		*Hectoroceras kochi*	*Hectoroceras kochi*
		Chetaites sibiricus *Praetollia maynci*	*Chetaites sibiricus* *Praetollia maynci*
VOLGIAN	Upper	*S. (?) maurynijensis, S. (V.) pulcher*	beds with *Schulginites* cf. *pseudokochi* Mesezhn.
		Craspedites taimyrensis	*Craspedites taimyrensis*
		Craspedites okensis	*Craspedites okensis*
	Middle	*Epilaugeites vogulicus*	*Epilaugeites vogulicus*
		Laugeites groenlandicus	beds with *Laugeites* ex gr. *groenlandicus* (Spath)
		Crendonites spp.	
		Dorsoplanites maximus	*Dorsoplanites maximus*
		Dorsoplanites ilovaiskii	*Dorsoplanites ilovaiskii*
		Pavlovia iatriensis	*Pavlovia iatriensis*
	Lower	*Pectinatites pectinatus*	beds with *Pectinatites*
		Subdichotomoceras subcrassum	
		Eosphinctoceras magnum	

Fig. 5. Suggested zonal subdivision of the Volgian for Western Siberia and its correlation with zones of the Subpolar Urals.

Eastern Siberia, whereas in the Subpolar Urals it is established only in the *E. vogulicus* Zone. Indications that *Taimyrosphinctes* Mesezhn. was found in the upper Volgian and especially Ryazanian deposits of Siberia are likely to need verification. The stratigraphic interval in its full volume, which the find of *Taimyrosphinctes* sp. in Western Siberia may point to, corresponds to several middle Volgian zones and not just the *Taimyrosphinctes excentricus* Zone.

The genus *Laugeites* is widespread in the Subpolar Urals mainly in the *L. groenlandicus* Zone and is rarely found in middle Volgian *Crendonites* spp. and *Epilaugeites vogulicus* zones. Therefore, finds of the genus in Western Siberia may indicate the affiliation of host deposits instantaneously to three Volgian zones.

In the middle Volgian of Western Siberia, I propose to unite the *Crendonites* spp. and *Laugeites groenlandicus* zones into one biostratigraphic unit (Fig. 5). As the genus *Laugeites* is most often identified in this interval, the genus is proposed to be named as beds with *Laugeites* ex gr. *groenlandicus* (Spath). Ammonites of the *L.* ex gr. *borealis* group are encountered in this biostratigraphic unit along with species of the *L.* ex gr. *groenlandicus* group.

The *Epilaugeites vogulicus* Zone in Western Siberia is established by the *E. vogulicus* Ilov. species that is well recognized in the core.

The genus *Praechetaites* is known in Western Siberia from the middle Volgian *Dorsoplanites maximus* Zone to the upper Volgian *Craspedites okensis* Zone. In the Subpolar Urals (the Yany-Man'ya River), representatives of the genus *Praechetaites* are encountered in the upper Volgian *Chetaites chetae* Zone (Gol'bert et al., 1972). In Western Siberia, the genus characterizes both middle and upper Volgian deposits. For instance, in BH Enitorskaya 971, the *Praechetaites* cf. *tenuicostatus* (Schulg.) species (depth 2650.1 m) was found below *Kachpurites* sp. (depth 2647.2 m), characteristic of the upper Volgian base. In BH Kolikeganskaya 148, three finds of *Praechetaites* sp. within the interval of 2379.4–2377.02 m were encountered higher than the find of the upper Volgian *Craspedites* ex gr. *taimyrensis* (Bodyl.) (depth 2381.3 m). In a series of boreholes, *Praechetaites* specimens were found in one and the same interval with *Laugeites*. The long interval of the

existence of the *P.* ex gr. *tenuicostatus* (Schulg.) does not allow this species to be used for detailed stratigraphic reconstructions. On the Nordvik Peninsula, part of the Volgian section, where representatives of *Praechetaites* are the most abundant, is distinguished as the *Exoticus* Zone (Zakharov and Rogov, 2008). The *Exoticus* Zone in Western Siberia is not yet distinguishable.

The upper Volgian Substage in Western Siberia begins with the *Craspedites okensis* Zone with *Kachpurites fulgens* and *C. subditus* subzones. The zone in Western Siberia is not corroborated by finds of index species, but its presence is evidenced by *Kachpurites* Spath and *Craspedites taimyrensis* (Bodyl.), by the appearance of which the lower and upper boundaries respectively are drawn for the zone. Finds of ammonites close to *Craspedites originalis* Schulgina also indicate the presence of the *C. okensis* Zone in Western Siberia.

The *Craspedites taimyrensis* Zone in Western Siberia is reliably substantiated by the index species often found in the core.

The upper stratigraphic subsector in the zonal scale of the Volga layer of Western Siberia are beds with *Subcraspedites* (S.?) *maurynijensis* and *S.* (Volgidiscus) pulcher, which Mesezhnikov correlated with the *S. (V.) lamplughi* Zone of eastern England (Mesezhnikov et al., 1983). The *S.* (S.?) *maurynijensis* Mesezhn. et Alekseev species was described from Volgian deposits exposed on the Mauryn'ya River right bank (Subpolar Urals). At the beginning of the description, the species' stratigraphic position was indicated as Berriasian, the base of the *Chetaites sibiricus* Zone (Mesezhnikov et al., 1983, p. 113), and at the end of the description, as the top of the upper Volgian (Mesezhnikov et al., 1983, p. 114). Mesezhnikov believed the *S.* (S.?) *maurynijensis* Mesezhn. et Alekseev species to belong to the *S. (S.?) claxbyensis* Spath group, but the stratigraphic position of the species is unknown precisely (the *preplicomphalus* Zone–the Boreal Berriasian base). Found along with *S. (S.?) maurynijensis* were ammonites *Schulginites tolijense* (Nik.) and *S. pseudokochi* Mesezhn., which are widespread in the upper Volgian above the *Craspedites taimyrensis* Zone right up to the lowermost parts of the Berriasian *Hectoroceras kochi* Zone.

The *B.* (V.) *pulcher* Casey, Mesezhn., Schulg. species was described on the basis of the only specimen from BH 255 (depth 213.6 m) drilled in the Vol'ya River basin (Subpolar Urals). The stratigraphic range of the species was established as the upper Volgian (?upper part) (Casey et al., 1977, p. 29), though, the authors did not rule out its Early Cretaceous age (Casey et al., 1977, p. 28). In 1983, Mesezhnikov established the stratigraphic range for *S.* (V.) *pulcher* Casey, Mesezhn., Schulg. as either an independent interval of the section between the *Craspedites taimyrensis* Zone and beds with *S.* (S.?) *maurynijensis* and *Schulginites tolijense, S. pseudokochi* or at the level of the latter. The boundary between the Volgian and Boreal Berriasian in the Subpolar Urals (the Mauryn'ya River) is drawn by the appearance of ammonites *Praetollia Spath at the base of the Chetaites sibiricus* Zone.

Hence, beds with *Subcraspedites* (S.?) *maurynijensis* and *S. (Volgidiscus) pulcher* species of the Volgian in the Subpolar Urals have not been distinguished in the natural section. The *S. (V.) pulcher* Casey, Mesezhn., Schulg. species has not been found along with or in succession with any of the upper Volgian ammonites. The stratigraphic interval, which *S. (S.?) maurynijensis* Mesezhn. et Alekseev and *S. (V.) pulcher* Casey, Mesezhn., Schulg. species characterizes, has not been clearly established. At present, it can be adopted as the uppermost upper Volgian–Boreal Berriasian base.

During the field season of 2007 in the Subpolar Urals (the Mauryn'ya River, exposure 54), one specimen of *S. (S.?) maurynijensis* Mesezhn et Alekseev (and one specimen from talus) and two specimens of *Schulginites* cf. *tolijense* (Nik.) were found below the level of the appearance of ammonites *Praetollia* Spath. The *S. (V.) pulcher* Casey, Mesezhn., Schulg. species has not been found (Alifirov et al., 2008).

Mesezhnikov wrote in his last works that in Western Siberia the stratigraphic interval above the *C. taimyrensis* Zone and below the level of the appearance of ammonites *Praetollia*, i. e., the analog of the *Chetaites chetae* Zone, has not been established (Mesezhnikov, 1984, p.76; *Bazhenov*…, 1986, p. 44). According to my findings, no paleontological data have appeared since that time for distinguishing in the uppermost upper Volgian of Western Siberia the biostratigraphic unit in the rank of a zone or beds with *S. maurynijensis, S. pulcher*, except for the find of ammonite *Schulginites* cf. *pseudokochi* Mesezhn.

Beds with *Subcraspedites (S.?) maurynijensis* and *S. (Volgidiscus) pulcher* are proposed to be changed by beds with *Schulginites* cf. *pseudokochi* Mesezhn. (Fig. 5). The upper boundary of this biostratigraphic unit, i. e., the boundary between the Jurassic and Cretaceous, is drawn by the appearance of *Praetollia* (Fig. 5).

Hence, the use of the Volgian detailed zonal scale of the Subpolar Urals for the whole territory of Western Siberia can be regarded as not sufficiently substantiated yet. The proposed coarser subdivision of the Volgian in Western Siberia objectively reflects the peculiarities of the distribution and possibilities of identification of ammonite genera and species from the core of the boreholes. The absence of ammonite genera characterizing some zones of the Volgian, as well as problems with their identification indicate the necessity to use for Volgian deposits of Western Siberia a less detailed zonal scale than the scale adopted in the current scheme (*Resolution* …, 2004).

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