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BERRIASIAN-VALANGINIAN (EARLY CRETACEOUS) SEAWAYS OF THE RUSSIAN PLATFORM BASIN AND THE PROBLEM OF BOREAL/TETHYAN CORRELATION

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Abstract: The Russian Platform (RP) is one of the key-regions for the correlation of the Boreal and Tethyan stratigraphic successions. Zoogeographical analysis of ammonite distribution in the RP and adjacent areas demonstrates the existence of relations between different basins and the opening/closure of sublatitudinal and submeridional sea-connections in the RP area. Two epochs in the development of the RP were recognized. The Berriasian–Barremian time shows a close relation of the RP Basin to the Boreal Realm. During Aptian–Albian times the region was affected mainly by the Tethys Ocean. It is supposed that the Upper Volgian corresponds to the Lower Berriasian. The similarity of the Western Siberia and the Peri-Caspian–Mangyshlak fauna allows us to propose for the first time an existence of a direct connection between those basins. Berriasian-Valanginian sea-connections of the RP Basin are discussed in this paper.

Key words: Lower Cretaceous, Boreal Realm, Tethyan Realm, Russian Platform, seaway, zoogeography, ammonites.

Introduction

This paper is based on long-term investigations of the Lower Cretaceous of the Russian Platform (RP) and adjacent areas (Crimea, North Caucasus, Peri-Caspian, Mangyshlak and the Tuarkyr–Kopet-Dagh region) and of its ammonite fauna. Even a brief observation of the ammonite distribution in this area demonstrates that the Lower Cretaceous Basin of the Russian Platform (Russian Sea — in literature) was the connecting area between the Tethys and Arctic (Boreal) seas. This fact was recognized a long time ago by Pavlow (1901) and Arkhangelsky (1923), who supposed the existence of meridional and latitudinal seaways through the Russian Platform. In accordance with the appearance of new stratigraphic data those reconstructions were modified and the sea-connections on the territory of the RP have been discussed in different works. One of the latest is that Sasonova (1971, 1977) and Sasonova & Sasonov (1967). The preliminary schemes about the configuration of the RP Basin data were published by the author (Baraboshkin 1997b).

The Russian Platform (RP) is a relatively stable block of the Earth crust. Its basement is heterogeneous and determines the position and the development of different troughs, depressions and syneclises during the Cretaceous (Milanovsky 1987). The RP responded to external stress conditions by changes in its relief and therefore in the shape of the existing sea basin and its paleogeography. The paleozoogeographical model and the model of RP seaways are proposed in the present paper.

Stratigraphy

Data for a stratigraphical scheme

Due to reinvestigation of the ammonite collections and outcrops (in the Moscow Syneclise, Simbirsk Syneclise, Riasan-Saratov Trough and Peri-Caspian Syneclise) and due to comparison with ammonite data from other regions, the following biostratigraphic scheme (for the central parts of the RP) is proposed (Fig. 1). The scheme was compiled after schemes of Gerasimov (1969) and Sasonova & Sasonov (1979) for Lower Berriasian (= Upper Volgian) and Valanginian, Mesezhnikov (1984) and Sasonova (1977) for Upper Berriasian. The proposed scheme, in general, is a combination of zones from both Boreal and Tethyan schemes, because of mixing of Boreal (prevailing) and Tethyan faunas in this region.

A similar scheme was published by Alekseev et al. (1993) and by Shulgina (1996) within the framework of the Interdepartmental Stratigraphic Commission of Russia. Both schemes differ from the scheme proposed here and excludes Upper Volgian as an equivalent of the Boreal Lower Berriasian. Some elements of the Lower Cretaceous biostratigraphy of the RP were included in the "Boreal Standard scheme", proposed by Zakharov et al. (1997).

Correlation

The author compiled the correlational scheme (Fig. 2) on the basis of the tentative analyses of the co-distribution of zonal indexes. As in recent cephalopods (Nessis 1985), the distribution of index ammonites was limited by (1) temperature, (2) basin bathymetry and configuration, (3) mode of life, (4) post mortem transportation. We can add some geological controlling factors: (5) selection during deposition, (6) selection during diagenesis, (7) the existence of redeposition or condensation, (8) the recent character of the exposures (or boreholes), and "subjective" factors. In spite of many limited factors, I consider that the primary factors (1–4) are the most important. One may conclude that in the places with optimal basin conditions ammonite species should be numerous and occupy this area for the longest time. It means that in the borders of ammonite index species areas, the frequency of the index spe-

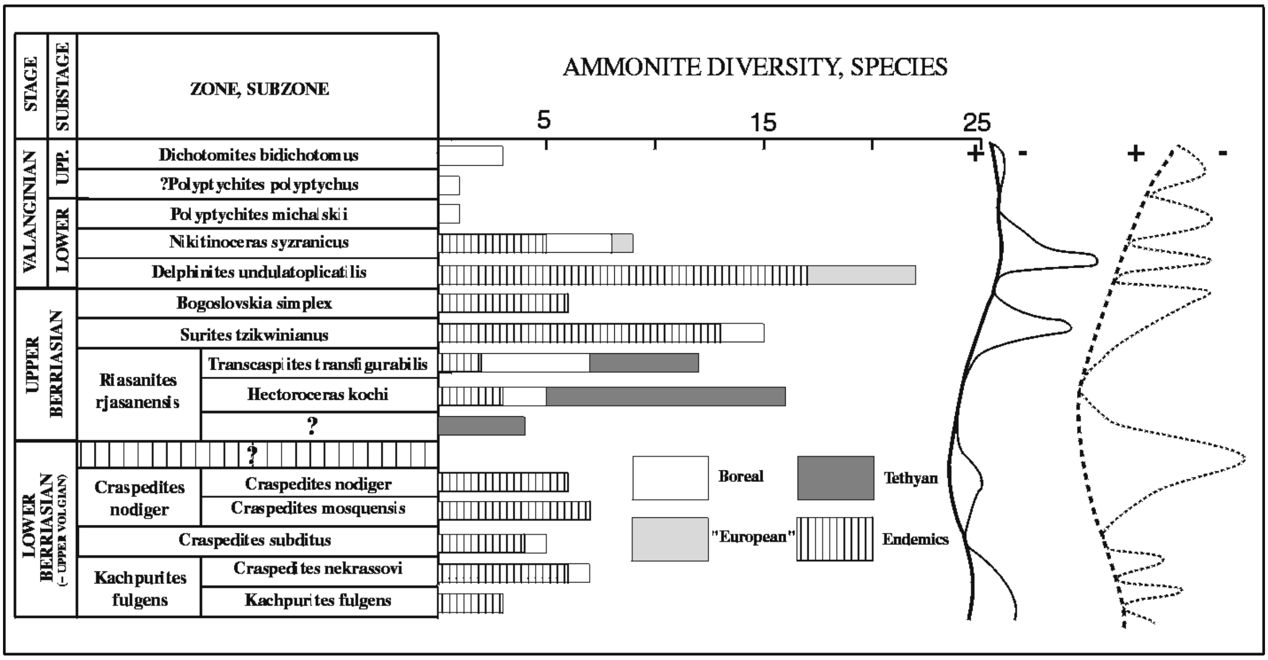

Fig. 1. The proposed ammonite biostratigraphic scheme for the Russian Platform, the ammonite diversity and the sea-level curves for the Berriasian and Valanginian. The solid sea-level curve is drawn after Haq et al. (1988) and adopted (scaled) to the zonal scheme. Dashed line is compiled by the author for the northern part of the Moscow Syneclise. Thick lines on the scheme are the 2nd-order fluctuations and fine lines are the 3rd-order fluctuations.

cies should be less than in the centre and it may co-occur with other index species. One of the most important factors is the water temperature, which causes some ammonites in one bed only (for example, *Hectoroceras* in the RP) or in a series of beds (*Hectoroceras* in Northern Siberia sections). It is obvious that in different regions index ammonites may occupy different stratigraphic intervals, that is they may have different ranges in different regions. Therefore, I propose to correlate zones not in the traditional way (correlation of zonal names in tables), but to look at them as at 3-dimensional zonal bodies on the basis of co-occurrence of zonal indexes in related regions (Fig. 2 and Fig. 3) in well-investigated sections.

Paleozoogeography

Terminology

The total fauna depends on climatic conditions. Therefore, the zonal subdivisions we used for biostratigraphical purposes are in fact of a paleozoogeographical nature. The author prefers the idea of the hierarchical system in paleozoogeography, as developed by Makridin (Makridin & Meyen 1988). He proposed to recognize subdivisions for different ecological types of organisms. It seems to the author, that if all groups of fossils will be included in this scheme (as they were traditionally), the "fine" data of short-term fauna area changes will be lost (one should keep in mind that our calculations are extrapolated on the geological time scale). This idea is well-illustrated in the work of Druzchitz & Smirnova (1979), who distinguish **different** subprovinces and regions for the **same time and area** by means of different groups of animals. A similar terminology was used by Saks et al. (1971, 1972) and his disciples, Druzchitz & Smirnova (1979), Rawson (1981, 1993, 1995), Hoedemaeker (1990) and others, for the global Early Cretaceous ammonite zoogeography with geographical labels.

The author proposes the following meaning for the paleozoogeographical terms for marine basins. **A realm** (or belt) is, in fact, analogous to a recent climatic zone. It includes very different paleogeographical situations (such as continental and marine), and it is therefore better to use it to determine climatic zones. **A province** is a part of a climatic realm determined by the domination of taxa of *family* range which are endemic. They could be named after a family. **A subprovince** is a part of a province determined by the domination of taxa of *subfamily* range. They could be named after a subfamily. **A region** is a part of a subprovince determined by the domination of taxa of *genera–subgenera* range. They could be named after genera (subgenera). **A district** is a part of a region determined by the domination of taxa of *species* range. They could be named after a species (or lower taxa). It seems to me that taxonomic names are probably better for terminology (it was developed for the Lower Cretaceous by Owen, see for example Owen 1996) than some of the geographical names.

Seaways and paleozoogeography of the Russian Platform in the Early Cretaceous

One of the main peculiarities of the Russian Platform (RP) sea in the Cretaceous is the existence of two systems of straits: (1) A sublatitudinal system, which connected the RP with the Polish Basin and with the Carpathians in the west and with Western Siberia in the east, and (2) a submeridional system, which connected the RP with the Tethys ocean in the south and with the Arctic sea in the north. Opening or closing of those seaways led to the prevalence of different successive faunas in the Early Cretaceous sea of the RP. The existence of these straits determined the penetration of Boreal ammonites into the Tethys area, but also of Tethyan ammonites into the Boreal area. The whole system was controlled by the tectonic activity of the RP and the eustatic changes of sea level.

There is no agreement among specialists either in the higher taxa systematics (families, subfamilies and higher), or in lower taxa systematics (genera and lower) of the ammonites discussed. For unification of terminology the author used the system of Wright et al. (1996) only for the higher taxa and tried to apply it to the various publications on the RP and neighbouring regions. The author disagrees with Wright and his colleagues in many points, especially in their attempt to synonymize many of the Lower Cretaceous ammonite genera, because it disagrees with stratigraphic data. The correct number of species is really hard to calculate (it needs an extended revision) and the author's idea of the reality of the taxa is reflected in Tables 1–4. The author's work resulted in the recognition of various paleozoogeographic regions and in the attempt to define seaways, which were a very important factor in water mass exchange and changes in the configuration of ammonite areas.

Some problems of the distribution of the Lower Cretaceous fauna of the RP and adjacent areas were observed by Sasonova (1971, 1977; Sasonova & Sasonov 1967, 1979), Saks et al. (1971, 1972), Shulgina (1974), Mesezhnikov et al. (1983). For the paleogeographical reconstructions I used palinspastic maps, polar projection, by Rowley & Lottes (1988), because this "mobile" pattern explains the faunal distribution much better than the "fixed" one of Saks et al. (1971, 1972).

The preliminary patterns of seaway changes and fluctuations of ammonite areas on the RP were illustrated by the author (Baraboshkin 1997b) and in this paper I will focus more tentatively on the Berriasian–Valanginian interval.

Early Berriasian

There is no uniform view on the subdivision of the Berriasian. Some authors do not like to subdivide it at all (Nikolov 1982; Luppov et al. 1988), others try to divide it into 3 substages (Hoedemaeker at al. 1995). The author prefers the scheme, proposed by Sakharov (1984) for the North Caucasus, where the lithostratigraphic subdivision coincides with the biostratigraphic subdivision based on ammonites. This point is also shared by Sasonova & Sasonov (1979), Sei & Kalacheva (1997), Zeiss (1979), Casey et al. (1977). Two subdivisions in the Berriasian are more useful for the RP and adjacent areas, where Lower Berriasian (= Upper Volgian) sections are characterized by a Boreal fauna whereas the Upper Berriasian succession contains a Tethyan as well as a Boreal fauna.

According to the publication of Casey (1973), Sasonova & Sasonov (1979), Jeletzky (1984), Hoedemaeker (1987), Sei & Kalacheva (1997), the Upper Volgian should be correlated with the Lower Berriasian if we accept the boundary of the Durangites spp./Berriasella jacobi Zones as the Jurassic/Cretaceous boundary. A very similar idea was proposed by Zeiss (1979), but he drew the boundary at the base of the Subditus Zone. It seems that the idea of Casey (1973), Sasonova & Sasonov (1979) and Sei & Kalacheva (1997) is more reasonable if we analyse the sea-connections of the RP and adjacent areas. The same idea was reflected in the correlation scheme of the International Jurassic-Cretaceous Working Group (Zakharov et al. 1996). In the sections along the middle Volga River (mainly Kashpir region), where the sedimentary record of Lower Berriasian (= Upper Volgian)-Upper Berriasian (= Ryazanian) transition is complete enough, one can see that there are 4 major sedimentary events: at the top of the Dorsoplanites panderi Zone, at the top of the Epivirgatites nikitini Zone (Middle Volgian), at the top of the Surites tzikwinianus Zone (Upper Berriasian) and at the top of the Lower Valanginian. The Upper Volgian-Berriasian sedimentary style (sandstones with phosphorites) is the same. The extension of the hiatus between Upper Volgian (= Boreal Lower Berriasian) and Upper Berriasian (= Ryazanain) is estimated to be one ammonite zone or even less according to Casey et al. (1977), Mesezhnikov (1979b), Mesezhnikov (1984), Sei & Kalacheva (1997), and author's data (Fig. 2). The range of that hiatus was correlated with the Occitanica Zone by Hoedemaeker (1987) i.e. with the Middle Berriasian (Hoedemaeker et al. 1995).

We have modified the zonal scheme of the Upper Volgian and divided the Kashpurites fulgens Zone into 2 subzones: Kashpurites fulgens s.s. and Craspedites nekrassovi (Figs. 1, 2). The type section for this subdivision is located on the right bank of the Volga River, Kashpir Town (Syzran region), near to the boat station. The section and the distribution of fossils in it were described in detail by Gerasimov (1969, p. 26). The Kashpurites fulgens Subzone corresponds to beds 6–8 and the Craspedites nekrassovi Subzone to bed 5 of Gerasimov. The main peculiarity of the new Craspedites nekrassovi Subzone is the appearance of the first representatives of *Craspedites*, including the index species and the widely distributed *Craspedites okensis*.

One of the key regions for clarifying the situation with the RP Lower Berriasian is the Polish Furrow (Marek 1967–1969, 1983; Raczyńska 1967), where in the Kujawy area (Northern Poland) it is possible to recognize traces of Tethyan Lower Berriasian covering a Middle Volgian Succession with *Zarajskites* and *Virgatites* and a Wealden Succession. Marek recognized 2 ammonite levels (Marek et al. 1989; Marek & Shulgina 1996): the *Riasanites, Himalayites* and *Picteticeras* beds at the base and *Surites, Euthymiceras* and *Neocosmoceras* beds at the top, which he proposed to be equivalent to the Ryazanian horizon of the RP. Marek changed his list of ammonite names 3 times at least (Marek 1967–1969; Dembovska & Marek 1979; Marek et al. 1989 — with a revision of his finds). According to his last publication on this topic (Marek & Shulgina 1996), the lower ammonite assemblage should be correlated with the Tethyan Tirnovella occitanica Zone and with the Boreal Hectoroceras kochi Zone and with a part of the Fauriella boissieri Zone. I think that the Boreal correlation was not correct, because *Hectoroceras* occurred with *Riasanites* in the RP area, therefore, they cannot

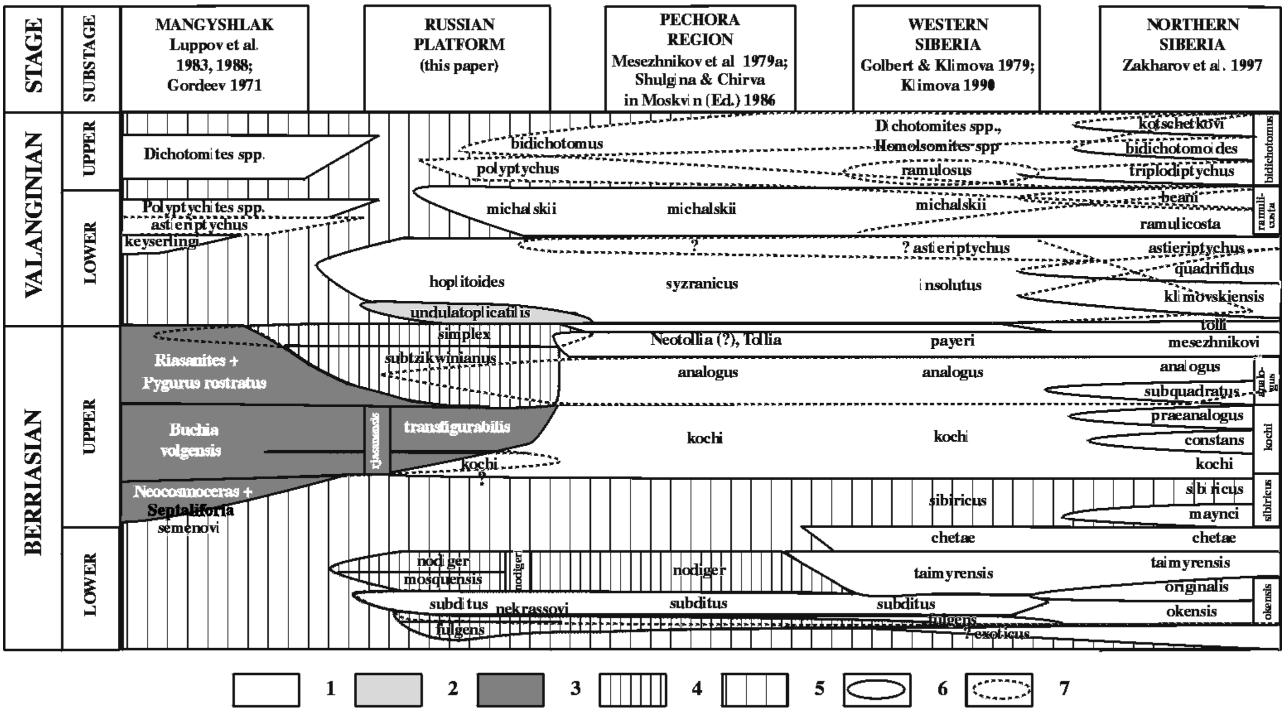

Fig. 2. Correlation of zonal index species ranges in Northern Siberia, Western Siberia, Pechora region, Russian Platform and Mangyshlak. ***Legend:*** 1 — Boreal zonal index species ranges; 2 — "European" zonal index ammonite ranges; 3 — Tethyan zonal index species ranges; 4 — Endemic zonal index species ranges; 5 — Absence of sediments; 6 — Limits of zonal index ammonite ranges; 7 — Supposed limits and crossing of index species ranges.

be Early Berriasian (see Fig. 2) in age. The genus "*Riasanites*" from Kujawy differs from the true *Riasanites* in the absence of a ventral groove, the existence of a connection between the angled secondary ribs and the high position of the point of virgation. Sasonova (1977) thought that they are "not typical *Riasanites rjasanensis*" (p. 33) and similar to *Riasanites maikopensis* from the North Caucasus.

If we look at the composition of the ammonite assemblage for the Lower Berriasian (Table 1), we can determine the following provinces in the region allied to the RP area.

A. **Perisphinctid-Polyptychitid Province.** It is characterized by the prevalence of Craspeditinae: *Craspedites, Taimyroceras, Subcraspedites, Chetaites* with rare representatives of Perisphinctidae: *Praechetaites* (Sasonova & Sasonov 1979, = *Virgatosphinctes* sensu Shulgina) and *(?)Kossmatia* with extremely rare Phylloceratidae: *Phylloceras(?)*. The Province includes Western Siberia (with Polar Ural Mts.), Northern Siberia and Spitzbergen Islands. It was named North-Siberian Subprovince of Arctic Province by Saks et al. (1971–1972) and Shulgina (1974).

B. **Polyptychitid Province** is characterized by the total prevalence of Craspeditinae: *Craspedites, Subcraspedites*. The Province includes Russian Platform and Pechora area in the north and was referred to as the East-European Province by Saks et al. (1971, 1972) and Shulgina (1974). Within this area it is possible to differentiate a **Platylenticeratinid Subprovince** (RP & Pechora Basins and eastern slope of the Ural Mts.) and a related **Craspeditinid Subprovince** (England). The Platylenticeratinid Subprovince contains endemic Platylenticeratinae: *Garniericeras* and Craspeditinae: *Kachpurites* (typical for the RP and very rare in Pechora Basin and in the east of Western Siberia). The Craspeditinid Subprovince (England) is characterized by endemic Craspeditinae: *Subcraspedites (S.), S. (Swinnertonia), S. (Volgidiscus).* Both provinces could be placed in the Boreal climatic realm.

C. **Neocomitid Province** contains representatives of Berriasellinae (Neocomitidae): *Pseudosubplanites, Retowskiceras, Dalmasiceras?, Tirnovella, Mazenoticeras*, etc. Some rare ammonites from the Perisphinctid-Polyptychitid Province, may occur, but this is problematic. The Province belongs to the northern part of Tethyan climatic realm and covers the territory of Central Poland.

D. **Olcostephanid-Neocomitid Province** contains mainly representatives of Berriasellinae: *Pseudosubplanites, Retowskiceras, Dalmasiceras, Tirnovella, Mazenoticeras, Subalpinites*, etc. quite frequent Olcostephanidae (Spiticeratinae: *Spiticeras*) and rare representatives of Neocomitinae (*Jabronella*). The Province belongs to the Tethyan climatic realm and includes the Carpathians, Crimea and North Caucasus.

On the basis of ammonite zoogeography one may suppose that the RP Basin had free connection with the Boreal Realm during the Early Berriasian (= Late Volgian). The only northern seaway reflected on the basin reconstructions by Sasonova (1971, 1977; Sasonova & Sasonov 1967) and Saks et al. (1972, 1972). In 1977 Sasonova proposed an additional reconstruction for Occitanica Chron (p. 30) with a northward spread into the central part of the RP Basin of *Malbosiceras malbosi* and *Tirnovella* sp. (samples in the collection of Sasonova, she never illustrated them) from the Neocomitid Province. I think that the reconstruction was not correct, be-

Table 1: Distribution of Lower Berriasian (= Upper Volgian) ammonite genera and subgenera. ***Explanations:*** The data were taken from works of Aristov & Ivanov 1971; Casey et al. 1977; Dembovska & Marek 1979; Gerasimov 1969, 1986; Golbert & Klimova 1979; Gordeev 1971; Klimova 1982, 1990; Kutek & Marcinowski 1996; Kvantaliani & Sakharov 1986; Luppov et al. 1983, 1988; Marek 1967; Mesezhnikov et al. 1979a,b; Sakharov 1984; Saks et al. 1972; Sasonova 1971, 1977; Sei & Kalacheva 1997; Zakharov & Mesezhnikov 1974 and completed by the author's data. "?" marks problematic determination of the genus. "+" indicate presence of genus without species name and figure. Numbers indicate the number of the species illustrated in publications and mentioned in the lists.

	Polish Basin	Spitzbergen Basin	North Siberia Basin	Western Siberia Basin (+Polar Urals)	Pechora Basin	Moscow Basin	Ulianovsk -Saratov Basin	Peri-Caspian Basin	Mangyshlak Basin	North Caucasus Basin
Phylloceratidae										
Phylloceras s.l.			1?							
Perisphinctidae										
Dorsoplanitinae										
Chetaites			1	1						
Paracraspedites						1?				
Virgatosphinctinae										
Praechetaites		1?	3?	1?						
Polyptychitidae										
Platylenticeratinae										
Garniericeras			1?	1?	+	3	3	+		
Craspeditinae										
Taimyroceras		1	3	1						
Craspedites		3	3	3	3	16	15	1?		
Kachpurites				2	2	2	2	1?		
Subcraspedites	1?		1	2			1?			
Volgidiscus				1						
Pseudocraspedites			4							
Neocomitidae										
Berriasellinae										
Dalmasiceras	1?									1(3?)
Delphinella										1
Fauriella										2(4?)
Malbosiceras	1?									1?
Mazenoticeras										2
Pseudosubplanites	2?									2?
Retowskiceras	1?									1
Tirnovella	1?									2(1?)
Neocomitinae										
Jabronella										2
Olcostephanidae										
Spiticeratinae										
Spiticeras										2(3?)

cause nobody mentioned Early Berriasian Tethyan ammonite finds from the RP. The absolute domination of a Boreal ammonite fauna in the Lower Berriasian of the RP also excludes connections with the Polish Furrow Basin. Therefore, the Russian sea was connected with the other regions only through the Pechora Basin. In the previous model the author supposes the existence of a Timan highland as an island chain (Baraboshkin 1997b). Recently, I accepted the idea of Gramberg & Ronkina (1983), that the Timan region developed as a submerged high from the Late Jurassic. The Baltic Shield was probably a highland during the Cretaceous.

In the Early Berriasian the basin temperature conditions of the RP sea were different from the Arctic sea. Therefore, many endemic species in this basin: *Kachpurites, Garniericeras* and various endemic species of *Craspedites* (Gerasimov 1969). "*Garniericeras*" described from Siberia by Shulgina (in Ronkina et al. 1969) and Mesezhnikov et al. (1983), differ significantly from the real *Garniericeras* in being more similar to *Subcraspedites (Volgidiscus)*, which occurs in England (Casey et al. 1977). Some of these *Craspedites* forms were found in the Pechora Basin and the Polar Ural Mts. The southward expansion of the Craspeditinae also occurred during that time. In particular, *Craspedites okensis* penetrated into the RP Basin during the second half of the Fulgens Chron.

The southern margin of the RP Basin was located in the Peri-Caspian region. This is supported by the finds of *Craspedites okensis* and *Kachpurites* cf. *subfulgens(?)* in the Koi-Kara–Kainar River area (Sokolova 1939; Vakhrameev 1952). Those "far south" finds of fragments of *Kachpurites* sp. indet. (Braduchan et al. 1986: p. 104, pl. XVI: figs. 1, 2) from the Salyma River area in Western Siberia give us a possibility to presume the existence of a shallow seaway between the RP and the Western Siberia Basin. The analysis of the paleogeographical data (Surkov 1995) shows that the south-west marginal facies of the "Bazhenov" Basin (in the direction of Ekaterinburg city, Middle Ural Mts.) are missing (eroded) and fine clayey and bituminous facies are located in the western part of this basin. In the RP Basin in its present configuration the same clayey facies are located only in the Peri-Caspian region (Sasonova 1977), whereas the other area to the north-west is covered by shallow-water sandy facies. So, it is very probable that a seaway connected Western Siberia with the RP Basin in the Early Berriasian and that *Kachpurites* used this for the eastward expansion of it area. The existence of this strait is recognized for the first time in the Berriasian–Hauterivian. It probably functioned also during the Late Jurassic. It seems that the RP Basin was the shallow shelf of the West Siberian sea. This idea was discussed first by A.G. Olferiev (PGO "Centrgeologia", personal communication) as one of the alternative possibilities to explain the peculiarities of the RP paleogeography.

The distribution of *Praechetaites* in the Perisphinctid-Polyptychitid Province provides additional data on the direction of water mass movement. The earliest finds of *Praechetaites* gr. *tenuicostatus* are mentioned from the Epivirgatites variabilis Zone of North Siberia (Saks et al. 1976), where they occurred up to the Chetaites chetae Zone (Upper Volgian). The same species was found in the Polar Ural Mts. (Golbert & Klimova 1979) in the Chetaites chetae Zone and in the Spitzbergen Islands (Ershova 1983) from the same level (but without *Chetaites*). This shows that *Praechetaites* migrated from the Pacific Ocean (or North-Eastern Tethys, but not from the Atlantic (!) as was supposed by Saks et al. (1971, 1972) and invaded the North Siberian Basin in the latest Jurassic.

Late Berriasian

The late Berriasian is characterized by shallow marine to continental conditions in the RP Basin. Specialists agree that the "Ryazanian Horizon" of Bogoslowsky (1897) should be referred to as Upper Berriasian. I accept in general the biostratigraphic scheme by Mesezhnikov et al. (1979) for Upper Berriasian, but I think that Tzikwinianus Zone could be overbuilded by Simplex Zone of Sasonova (1977). I cannot agree with the opinion of Mesezhnikov (Mesezhnikov et al. 1979; Mesezhnikov 1984) that *Surites simplex* should be referred to *Nikitinoceras* and therefore to the base of the Valanginian. I also think that the Zone of *Riasanites rjasanensis* and *Garniericeras subclypeiforme* of Mesezhnikov (1984) could not be accepted at the moment, because of the debatable position of finds of *Garniericeras*: are they reworked or not? On the other hand, I agree with the existence of a level in the base of the Rjasanensis Zone, which contains different *Riasanites*. It is possible that the level one may correlate with the Sibiricus Zone (or a part of it) of the Boreal scheme.

In the Late Berriasian we recognize the following provinces in the region allied to the RP area (Table 2).

A. **The Perisphinctid-Polyptychitid Province** is characterized by the dominance of Tolliinae (*Bojarkia, Praetollia, Tollia, Surites, Peregrinoceras*, etc.) and Craspeditinae (*Hectoroceras*) and rare *Chetaites* (Perisphinctidae). The Province includes Western Siberia (with the Polar Ural Mts.), Arctic Siberia, the Spitzbergen Islands and Greenland. It was called the North-Siberian Province by Saks et al. (1971, 1972), Shulgina (1974) or Siberian/North American Region by Rawson (1981). The finding of *Riasanites* in the Spitzbergen Islands (Zhirmunsky 1927) is very questionable, because this genus is not even known from the Pechora Basin. The distribution of *Riasanites* towards the north was limited by the water temperatures.

B. **The Polyptychitid Province** is characterized by the prevalence of Tolliinae (*Runctonia, Borealites, Paratollia, Surites, Peregrinoceras*, etc.) and Craspeditinae (*Hectoroceras*). England is the only region within this Province.

C. **The Neocomitid-Polyptychitid Province** contains representatives of Tolliinae (*Surites, Caseyiceras, Borealites, Peregrinoceras, Externiceras, Subcraspedites,* etc.), rare Craspeditinae (*Hectoroceras*) and Berriasellinae (*Riasanites, Euthymiceras, Transcaspiites*) and the first Polyptychitinae (*Subpolyptychites*). The only find of *Chetaites* (Perisphinctidae) was also mentioned from this Province (Sasonova 1977). The Province includes the Russian Platform, Poland, Mangyshlak. It was divided by Saks et al. (1971, 1972) and Shulgina (1974) into 2 Subprovinces (Polish and East-European) which seems very unnatural, because both basins contain the same ammonite families.

D. **The Olcostephanid-Neocomitid Province** mainly contains representatives of Berriasellinae (*Euthymiceras, Neocosmoceras, Riasanites, Fauriella, Picteticeras, Transcaspiites*, etc.), quite frequent Olcostephanidae (*Spiticeras*), rare Himalayitinae (*Himalayites*) and Neocomitinae (*Jabronella*). The Province forms part of the Tethyan climatic realm and includes the Carpathians, the Crimea and the North Caucasus. According to Rawson (1981) the last two should still be included in the Neocomitid-Polyptychitid Province (i.e. his European Province for the Berriasian–Early Barremian), but this disagrees with the family distribution data at least for Berriasian–Lower Hauterivian.

The early Late Berriasian is characterized by the expansion of Tethyan ammonites towards the north. This occurred along 2 routes (Fig. 2). One seaway connected the Polish Basin with the Crimea–Carpathians area. Sasonova (1971, 1977) supposed that there was no direct connection between the RP Basin and the Polish Basin, because of the difference in faunas (in contrast to the ideas of Marek 1967–1969). The Polish "Ryazanian" fauna differs significantly from the original Ryazanian of the RP (see above). The other seaway passed through Mangyshlak, where the neocomitid diversity is rather high (Table 2): *Neocosmoceras, Euthymiceras, Riasanites*, other Berriasellids and Boreal *Surites*. Luppov et al. (1988) supposed an Early Berriasian age for the basal part of this succession. A comparison with the North Caucasus ammonite succession (Sakharov 1984; Sei & Kalacheva 1997) indicates, however, a Late Berriasian age for the Mangyshlak ammonite assemblage. It should be noted that the first species of *Riasanites* (*R.* cf. *swistowianus, R.* ex gr. *subrjasanensis*) were found together with *Neocosmoceras* and *Transcaspiites* in this area ("Lone of *Neocosmoceras* and *Septaliphoria semenovi*": Luppov et al. 1988). This makes the distribution of the later two genera the same as in the North Caucasus the so-called "lower *Riasanites*" level (Sei & Kalacheva 1997). In this case, it would probably be better to refer to "the upper *Riasanites*" level as the *Tauricoceras* level (Kvantaliani & Lysenko 1979) and correlated with the "upper *Riasanites*" level from Mangyshlak (*Riasanites rjasanensis* (p. 130, pl. XVII: figs. 4, 6); *R.* sp. nov. ex gr. *rjasanensis* (p. 132, pl. XVII: fig. 7, Luppov et al. 1988). The Boreal ammonites *Surites* cf. *spasskensis* and *S. kozakowianus* were mentioned from the basal part of the Upper

Table 2: Distribution of Upper Berriasian ammonite genera and subgenera. Explanations see Table 1.

	Polish Basin	Spitzbergen Basin	North Siberia Basin	Western Siberia Basin (+Polar Urals)	Pechora Basin	Moscow Basin	Ulianovsk-Saratov Basin	Peri-Caspian Basin	Mangyshlak Basin	North Caucasus Basin
Neocomitidae										
Berriasellinae										
Argentiniceras (?)			1							
Prorjasanites						2			+?	+?
Riasanites	?	1?				4	3	1?	6	6(4?)
Berriasella									1	1
Blanfordiceras										2?
Euthymiceras	1								1	1?
Fauriella	1									
Gechiceras										3
Neocosmoceras	2								4	2(2?)
Malbosiceras									2?	1?
Mazenoticeras									1	1
Picteticeras	1									3
Tauricoceras										1?
Tirnovella										1?
Transcaspiites									3	2(3?)
Neocomitinae										
Jabronella									1	1
Subalpinites									3	1
Himalayitinae										
Himalayites									1?	1?
Perisphinctidae										
Dorsoplanitinae										
Chetaites			1	2		1				
Polyptychitidae										
Craspeditinae										
Hectoroceras				3	1	1				
Tolliinae										
Surites	3	1	4	2	3	10	10	+	4	?
Externiceras	1?					2	2	1		
Bogoslovskia					+	2	2	+		
Caseyiceras					2	3	3	+		
Chandomirovia					+	1	1	1		
Pronjaites	1?				+	2	2	+		
Pseudocraspedites					1					
Praesurites				1						
Ronkinites				1						
Schulginites				3						
Peregrinoceras		1		1	2					
Praetolia	1?	1		2			1?			
Bojarkia		1	3	3	1					
Borealites	1?	1	1	5	1					
Tollia	1?	1		1	1					
Polyptychitinae										
Subpolyptychites							1			
Olcostephanidae										
Spiticeratinae										
Spiticeras										6(3?)

Berriasian of Mangyshlak (Luppov et al. 1988). This considerably differs from the situation in the central part of RP, where these species of *Surites* appear above the beds with the first *Riasanites, Transcaspiites* and *Euthymiceras* (Sasonova 1977; Mesezhnikov et al. 1979b). Taking in account that both samples were not collected by the authors themselves and that most finds of *Surites* (*in situ*) are known from higher levels than those with the FO of *Riasanites, Transcaspiites* and *Euthymiceras,* we may suppose that the given age by Luppov et al. (1988) was provisional. Then we must conclude that Lons (= local Zones) of "*Buchia volgensis*" and "*Riasanites* and *Pygurus rostratus*" correlates with the Surites tzikwinianus Zone and with upper part of the Riasanites rjasanensis Zone of the RP (according to Mesezhnikov 1984). Only *Surites* sp. indet. was mentioned in list from the Neocosmoceras and Septaliphoria semenovi Lone from Dzharmysh section (Luppov et al. 1988, p. 25, not illustrated). If it is a true *Surites*, we may expect the opening of a **direct** sea-connection with the West Siberian Basin and an accelerated penetration of *Surites* into the Peri-Caspian and Mangyshlak areas. In the central parts of the RP, the first *Surites* appears together with *Riasanites*, above the base of Rjasanensis Zone and *Hectoroceras* level (Mesezhnikov 1984), i.e. much higher than in the Mangyshlak. In that case *Surites* could appear there even earlier than in the RP. The other reason for this suggestion is the comparison of the paleogeography of the RP (Sasonova 1977) and Western Siberia (Sarkisian & Protzvetalova 1968). If mainly clayey sedimentation took place in the north-western part of Western Siberia, it was mainly sandy sedimentation in the RP (with some exceptions in the Peri-Caspian region). Nevertheless, an island chain instead of the Ural Mts. must have existed as a natural border separating different paleozoogeographical provinces.

Neocosmoceras is not known from the centre of the RP, so the basal part of the Upper Berriasian does not exist here (see also Sasonova & Sasonov 1979) and the Tethyan transgression reached this region only later. Analogues of the Siberian Chetaites chetae Zone (the Uppermost Volgian according to Siberian scheme: Zakharov et al. 1997) are probably missing in the RP. I agree with Casey (1973) and Sasonova (1977, not Sasonova & Sasonov 1979) that a part of Riasanites rjasanensis Zone of RP probably correlates with a part of the Chetaites sibiricus Zone (Siberian scheme). Fortunately, rare finds of *Hectoroceras* sp. juv. (Mesezhnikov et al. 1979a) in the Pechora region and *Hectoroceras* sp. indet and *H.* cf. *kochi* (Casey et al. 1977; Mesezhnikov et al. 1979b) near Riasan and the author's finds in the Moscow region mark the beginning of a Boreal fauna expansion through the meridional strait. In this time the RP–Polish Basin connection did not exist (possibly it opened later). The Boreal influence became more powerful at the end of the Berriasian, when *Surites, Peregrinoceras, Borealites*, etc. reached the central parts of RP, Peri-Caspian and Mangyshlak. Some of the Boreal ammonites possibly penetrated into the North Caucasus Basin. One find of *Surites* cf. *pechorensis* was reported by Sakharov (Sakharov & Frolova-Bagreeva 1973, p. 130) from Gizeldon River (North Osetia). It was found in an assemblage with *Riasanites subrjasanensis, "Paracraspedites"* sp. and "*Berriasella*" aff. *broussei*. Unfortunately, those finds are very problematic, because in the special publication on the Boreal invasions into the Northern Caucasus by Sakharov (1993) he did not mention this *Surites*. Nevertheless, a restricted connection is possible because of the presence of *Buchia* there (Sakharov 1993).

The existence of a Late Berriasian sublatitudinal seaway in the RP was proposed by Sasonova (Sasonova & Sasonov 1967; Sasonova 1971, 1977). She supposed that the connection between RP and Polish Basin did not appear earlier than the Surites spasskensis Chron. It is supported by finds of *Surites* and rare *(?)Externiceras* (the typical form for the RP) in Central Poland (Marek 1967, 1968, 1983; Raczyńska 1967). It is possible, however, that the Boreal faunas coming from the North Sea (some of the English suritids, described by Casey (1973) are similar to those of the RP area: Casey et al. 1977). Anyway, this strait should have opened not long before the Berriasian/Valanginian boundary, because it was the only way by which *Delphinites* (= *Pseudogarnieria*), *Proleopoldia* and *Platylenticeras* could have migrated from Western Europe to the east.

Early Valanginian

The Early Valanginian was characterized by a decreasing of the ammonite diversity in the investigated area. Shallow marine to continental conditions existed over the RP and the southern connection was closed or was extremely restricted. The Valanginian is one of the known good levels for correlation. There is only a problem with the definition of the base of the Valanginian in the RP region: the position of the Bogoslovskia simplex Zone. Sasonova (1971, 1977; Sasonova & Sasonov 1979) prefers to put it in the top of the Berriasian succession and I agree.

The following ammonite provinces could be recognized for the Early Valanginian (see Table 3):

A. **The Polyptychitid Province** is characterized by the dominance of Tolliinae: *Neotollia, Nikitinoceras* (= *Temnoptychites*), *Tollia,* etc. and various Polyptychitinae: *Amundoptychites, Astieriptychites, Euryptychites, Polyptychites*, etc. The Province includes Western Siberia (with the Polar Ural Mts.), Arctic Siberia, the Spitzbergen Islands, Greenland and England. It was recognized as the Arctic Region by Saks et al. (1971, 1972) and Shulgina (1974) (or the Siberian/North American Region by Rawson (1981)) with 3 Provinces: the Pechora-Greenland, North Siberian and Chukotka-Canadian Provinces. The RP was recognized by Saks et al. and Shulgina as a separate East-European Province within the Boreal-Atlantic Region. It coincides in principle with our definitions: the RP should be separated as **Platylenticeratinid-Polyptychitinid-Tolliinid Subprovince**, because of the dominance of Tolliinae, the presence of relatively rare Polyptychitinae and rare Platylenticeratinae: *Delphinites, Platylenticeras* and *Proleopoldia,* which passed through Polish Basin to the east. The other part of the Province should be determined as **Polyptychitinid-Tolliinid Subprovince.**

B. **The Neocomitid-Polyptychitid Province** is characterized by an assemblage of rare Platylenticeratinae (*Platylenticeras*), Tolliinae (*Nikitinoceras*), Polyptychitinae (*Astieriptychites, Euryptychites, Polyptychites*) and relatively rare Neocomitidae (*Thurmanniceras, Karakaschiceras*). Two Subprovinces could be distinguished in the Province: **The Neocomitinid-Polyptychitinid-Tolliinid Subprovince** (Mangyshlak area and Peri-Caspian) and **the Neocomitinid-Platylenticeratinid-Polyptychitinid Subprovince** (Poland, Germany, England).

C. **The Neocomitid Province** contains representatives of the Neocomitidae: *Kilianella* and *Busnardoites.* The Province includes the North Caucasus Basin and belongs to the Tethyan Realm.

D. **The Olcostephanid-Neocomitid Province** contains representatives of the Neocomitidae (*Kilianella, Thurmanniceras, Busnardoites,* etc.), and Olcostephanidae (*Olcostephanus, Spiticeras*, etc.). The Province belongs to the Tethyan Realm and includes the recent territory of southern Europe, Crimea (Baraboshkin 1997a) and extends further to the south-east.

A sublatitudinal strait connecting the Polish Basin with the RP existed at the beginning of the Early Valanginian. This is confirmed by the distribution of the Platylenticeratinae; *Platylenticeras* and possibly *Proleopoldia* moved from Europe through the Polish Basin to the RP Basin. The direction of this faunal expansion was probably opposite to that in the Late the Berriasian. According to Saks et al. (1971) the provisional direction of the faunal movement was the same as in the Berriasian, but this would conflict with the higher diversity of representatives of the Platylenticeratinae in Western Europe (mainly Germany) and their presence in Greenland. Moreover, finds of the Platylenticeratinae are not known from the Siberian-Pechora area. As to the derivation of *Platylenticeras*, it

Table 3: Distribution of Lower Valanginian ammonite genera and subgenera. Explanations see Table 1.

	Polish Basin	Spitzbergen Basin	North Siberia Basin	Western Siberia Basin (+Polar Urals)	Pechora Basin	Moscow Basin	Ulianovsk-Saratov Basin	Peri-Caspian Basin	Mangyshlak Basin	North Caucasus Basin
Lytoceratidae										
"Lytoceras"			1?							
Phylloceratidae										
"Phylloceras			1?							
Neocomitidae										
Endemoceratinae										
Karakaschiceras	4							1?		
Neocomitinae										
Busnardoites										2
Kilianella										1
Thurmanniceras								1	1	1?
Polyptychitidae										
Tolliinae										
Nikitinoceras	+?	2	12	7	4	4	1	3	1	
Bogoslovskia					+	+	+	+		
Costamenjaites				1?	+	1	4			
Stchirowskiceras			+		+	4	4			
Luppoviceras						1				
Suridiscus						2				
Menjaites			+	1?	1	6	6			
Tollia			1	1	1			1?		
Neotollia			5	4	1?					
Neocraspedites				1						
Thorsteinssonoceras			1							
Subtemnoptychites			2	1?						
Bodylevskites			2	1?						
Russanovia		2		2						
Platylenticeratinae										
Platylenticeras	2					1		+		
Delphinites						3				
Proleopoldia						3				
Tolypeceras		+								
Polyptychitinae										
Polyptychites	3		7	7	2	2		2	6	
Euryptychites		2	3	1		1	1		1	
Astieriptychites		4	2	1		1			1	
Subpolyptychites							3			
Amundoptychites			3	1						
Siberites			2	1						
Siberiptychites			1	1						
Primitiviptychites			1							
Virgatoptychites			2							

seems that this genus penetrated the RP not because of the "northward spread" of the sea (Rawson 1993), but because of the opening of the latitudinal connection.

The other seaway joined the Arctic sea with the central part of the Russian Platform. The fauna moved through the Pechora Basin and the diversity of *Nikitinoceras* there is very similar to that in the centre of the RP. In the Pechora area (Izhma River) typically Siberian *Tollia* and *Neotollia* are common, whereas many of the endemic ammonites (*Stchirowskiceras, Suridiscus, Luppoviceras, Costamenjaites*, etc.) were spread over the RP Basin (Sasonova 1971, 1977). It indicates a one-way exchange with Western Siberia. It seems that most specimens of *Polyptychites* in the RP were found in phosphorite conglomerates, they were interpreted as redeposited and mixed with in situ *Nikitinoceras*.

The diversity of *Polyptychites* in the Mangyshlak area (Luppov et al. 1988) and the frequency of *Euryptychites, Astieriptychites* and *Nikitinoceras* in the Peri-Caspian region (Aktubinsk region, author's data) are much higher than in the RP (Table 3). Moreover, there are some finds of *Tollia* sp. in the Aktyubinsk region (Moskvin 1986, p. 67). This implies the presence of a seaway joining Western Siberia and the south-eastern part of the RP. According to paleogeographical data (Sarkisian & Protzvetalova 1968) this seaway should be shallower and narrower.

The RP Basin had a very limited sea-connection with the North Caucasus Basin and only Tethyan ammonites (*Kilianella, Busnardoites*) are known from the latter region (Sakharov 1984, 1993; Kvantaliani & Sakharov 1986). Very rare *Thurmanniceras(?)* and *Karakaschiceras(?)* are mentioned from the Mangyshlak–Peri-Caspian area (Moskvin 1986).

A movement of Boreal ammonites during the Early Valanginian has been recognized in Western Europe. A new seaway could have opened through Northern France (?) or Germany (as was supposed by Rawson 1995), because a rich ammonite assemblage with *Platylenticeras* and *Polyptychites* is known from southern France (Thieuloy 1973; Kemper et al. 1981; Rawson 1981) as well as in Germany (Kemper 1961). In the Polish Lowland (Marek & Raczyńska 1973) and in the Carpathians (Michalík 1995) *Platylenticeras* is not so frequent.

Late Valanginian

Late Valanginian sediments in the RP Basin are only locally preserved in the northern part of the Moscow Syneclise and in the Peri-Caspian area and contain very rare *Dichotomites bidichotomus* and *Polyptychites petschorensis* (Sasonova 1958).

The following ammonite provinces could be defined in the studied area during the Late Valanginian (Table 4).

A. **The Polyptychitid Province** is characterized by the domination of the Polyptychitinae: *Dichotomites, Polyptychites, Homolsomites* and by rare Tolliinae: *Neocraspedites.* The Province embraces Western and Arctic Siberia, the Spitzbergen Islands and RP. It could be subdivided into **the Tolliinid-Polyptychitinid Subprovince** (Siberia, Polar Ural Mts., Pechora Basin), because of the presence of Tolliinae and **the Polyptychitinid Subprovince s.s.** (Russian Platform except Peri-Caspian).

B. **The Neocomitid-Polyptychitid Province** is characterized by an assemblage of the Polyptychitinae (*Dichotomites, Polyptychites, Homolsomites*), rare Tolliinae (*Neocraspedites*), and Neocomitidae (*Neohoploceras, Karakaschiceras*). Probably, very rare Olcostephanidae (*Valanginites?*) also occur there (Mangyshlak: Luppov et al. 1988). The Province includes only the Mangyshlak–Peri-Caspian area.

C. **The Polyptychitid-Olcostephanid-Neocomitid Province** contains mainly representatives of the Neocomitidae (*Karakaschiceras, Teschenites, Neocomites*); Olcostephanidae (*Valanginites, Olcostephanus, Saynoceras*) and quite rare Polyptychitinae (*Dichotomites, Polyptychites, Prodichotomites*). The Province covers the Polish Basin and the North Caucasus Basin.

D. **The Olcostephanid-Neocomitid Province** contains representatives of the Neocomitidae: *Karakaschiceras, Teschenites, Neocomites, Luppovella*; Olcostephanidae: *Valanginites, Olcostephanus, Saynoceras.* The presence of the Polyptychitinae (*Dichotomites, Polyptychites*) is questionable. The Province covers the North Caucasus Basin, southern Europe and the Crimea (Baraboshkin 1997a).

Representatives of Bochianitidae (*Bochianites, Protoleptoceras*) could occur as a rare occasional element either in the Polyptychitid Province and in the Polyptychitid-Olcostephanid-Neocomitid Province. It betrays the existence of a direct Boreal–Tethyan connection.

An important seaway connected the RP Basin with the Arctic sea through the Pechora Basin. It is confirmed by the similarity of the ammonite assemblages in these basins, but there were a few more Boreal elements in the Pechora – Polar Ural Mts. region than in the RP (see Table 4). The highest sea-level position was determined for the Polar Ural Mts.–Western Siberia in the Late Valanginian (Golbert & Klimova 1979) and resulted in a free penetration of ammonite faunas through this seaway. In spite of the co-occurrence of *Dichotomites* and *Homolsomites* in Western Siberia (Klimova 1990), it seems that in the RP (Yaroslavl region: Shulgina et al. 1979) both genera appear to be reworked in phosphorite conglomerates.

The seaway between the Polish Basin and the RP was closed. This is confirmed by the presence of a Tethyan fauna in the Polish furrow (Marek & Raczyńska 1973; Kutek & Marcinowski 1996; Kutek et al.1989) and its absence in the Russian Platform. The other argument is the general paleogeo-

Table 4: Distribution of Upper Valanginian ammonite genera and subgenera. Explanations see Table 1.

	Polish Basin	Spitzbergen Basin	North Siberia Basin	Western Siberia Basin (+Polar Urals)	Pechora Basin	Moscow Basin	Ulianovsk-Saratov Basin	Peri-Caspian Basin	Mangyshlak Basin	North Caucasus Basin
Polyptychitidae										
Tolliinae										
Neocraspedites	2?	3	2	1				1	1	1?
Polyptychitinae										
Dichotomites	6		3	1	3	2	1	1?	5	1?
Polyptychites	3	2	17	1	2	1	1	1?	1	1?
Prodichotomites	1?	1	2?	2				+?		
Homolsomites				1	1?			1?		
Olcostephanidae										
Olcostephaninae										
Olcostephanus	1									3
Rogersites	1									
Saynoceras	1									2
Valanginites	2								1?	2
Neocomitidae										
Endemoceratinae										
Karakaschiceras	2								1?	2
Neohoploceras	1								1	
Neocomitinae										
Luppovella										1
Neocomites	1?									1
Teschenites	1									
Sarasinella	1									
Bochianitidae										
Bochianitinae										
Bochianites	1		1							
Protoleptoceras										1
Haploceratidae										
Neolissoceras										1

graphical situation in the Russian Platform (excluding the Peri-Caspian region): the development of a shallow-water sandy facies with rare faunal remains in the northern part (Sasonova 1958; Moskvin 1986), which are missing in the central part of the RP.

The other region with Upper Valanginian sediments is the Peri-Caspian region, where they are developed in a sandy facies (salt dome sections) and in a silty-clayey facies (between salt domes). The ammonite fauna is typically Boreal: *Dichotomites, Polyptychites* (Moskvin 1986; Sasonova & Sasonov 1967, and author's data) and rare *Neocraspedites* (author's data from the Aktubinsk region). The co-occurrence of *Dichotomites* with the earliest *Homolsomites*: *H. petschorensis* (Moskvin 1986) is important, for it makes the situation almost identical to Western Siberia (Klimova 1990), the Spitzbergen Islands (Ershova 1983) and probably Poland (Marek 1968). This co-occurrence as well as the paleogeographical data from Western Siberia (Sarkisian & Protzvetalova 1968) confirm the existence of a sea-connection between Western Siberia and the Peri-Caspian region. The central part of the strait was located in the Middle Ural Mts. A seaway was opened further to the south towards Mangyshlak, where a Boreal ammonite fauna is dominant (Luppov et al. 1983). Very rare Upper Valanginian ammonites from the Tethys: *Neohoploceras(?)* (Gordeev 1971), *Valanginites(?)*: Luppov et al. (1983) are also known from this region.

The furthest finds of Boreal ammonites (*Dichotomites bidichotomus, Neocraspedites grotriani, Polyptychites euryptychoides*) together with North Tethyan *Acanthodiscus* and *Leopoldia* are known from the North Caucasus and were mentioned in the paper of Egoyan & Tkachuk (1965). Unfortunately, those ammonites were not illustrated and it is impossible to find out what they really are. The work of the author during a long time in the North Caucasus did not reveal new finds of these Boreal Upper Valanginian ammonites.

The expansion of the Boreal fauna was significant in the Late Valanginian, probably even more significant than in the Early Valanginian, because Boreal ammonites penetrated into the northern margins of the Tethys not only in the regions of Poland–Mangyshlak, but also in France, where *Dichotomites* and *Neocraspedites* were found (Thieuloy 1973; Kemper et al. 1981).

Sea-level changes

It is hard to reconstruct the sea-level changes on the basis of a few sections in the RP because of numerous unconformities and stratigraphical problems. A compilation of the data from the northern part of the Moscow Syneclise provided material to draw a provisional sea-level curve (Fig. 1). The comparison of this curve with the "global" curve (Haq et al. 1988) shows that its trend is close to the fluctuations for the Lower Berriasian–mid-Valanginian. It is strongly confirmed by ammonite diversity. The trend of the 2nd order curve starts to be opposite to the ammonite diversity for the Michalskii–Bidichotomus zones. This irregularity can be explained as being caused by tectonic movements: the uplift of the northern part of the RP and the attendant shallowing of the sea (Fig. 3). These data are in contradiction to Rawson's (1993, 1995) idea on the late Early Valanginian and mid-Valanginian sea-level rise. But Rawson's idea fits in well with sea-level rise in the southern part of the RP (Peri-Caspian–Mangyshlak area), because of the opening of the seaway to Western Siberia through the Urals. The 3rd-order curve contains more peaks than the "global" curve because of the very shallow marine conditions of the RP. Sea-level drops were have appeared around most of the zonal boundaries.

An other logical conclusion can be reached when one compares the rate of endemism with the third-order sea-level changes (Fig. 1). Endemism rises during shallowing of the sea. Shallowing leads to the appearance of geographical barriers, which makes the exchange of marine fauna difficult. The rate of endemism was very high during the Fulgens and Nodiger chrons in the Early Berriasian, and the Simplex Chron in the Late Berriasian. In the second half of the Fulgens Chron a part of the West-Siberian Craspeditidae (Craspedites okensis, for example) penetrated into the RP Basin and mixed with the endemics there. The endemism increased during the Subtzikwinianus and Undulatoplicatilis Chron and decreased during the Rjasanensis Chron when Tethyan and Boreal faunas mixed in the RP Basin. The late Early-Late Valanginian faunas had no endemic ammonites at all because of the absence of isolation of the RP Basin.

Recently, sea-level curves for the Jurassic–Cretaceous of the RP were produced by Sahagian et al. (1996). Previous works of the group of Sahagian have already been criticized by me (Naidin & Baraboshkin 1994), but some of their mistakes were repeated again in their last work. I still cannot understand the reason for incorporating the data from Siberia (why not Arctic Canada or Greenland?!) in the Valanginian curve for the RP. It does not help to understand the complex geological history of the RP and does not reflect the real eustatic changes in the marine basin of the RP. Therefore, there is no reason to discuss the Valanginian part of this curve as the curve for the RP. The Upper Volgian-Berriasian part (i.e. Berriasian part according to this paper) of the sea-level curve of Sahagian et al. (1996) coincides in major features with our data (with the exception of absence of the Simplex Zone in their stratigraphic frame).

Discussion

According to the proposed model we can conclude the following.

1. The shape of the RP Basin has changed during the Berriasian and Valanginian ages. There were 4 seaways functioning in the RP Basin during that time (not 3 as was supposed before): (1) the Byelorussia Strait connecting the Polish Furrow and the RP; (2) the Caspian Strait connecting the RP with Mangyshlak area; (3) the Pechorian Strait connecting the RP with the the Arctic basin and (4) the Mid-Uralian Strait connecting the RP–Peri-Caspian region with Western Siberia. The latter is recognized here for the first time. It was located probably in a gap through the Middle Ural Mts. (Ekaterinburg region), where the distance between the RP and Western is very short. From the latest Jurassic to the Valanginian, the Ural Mts. developed as an island chain or partially submerged

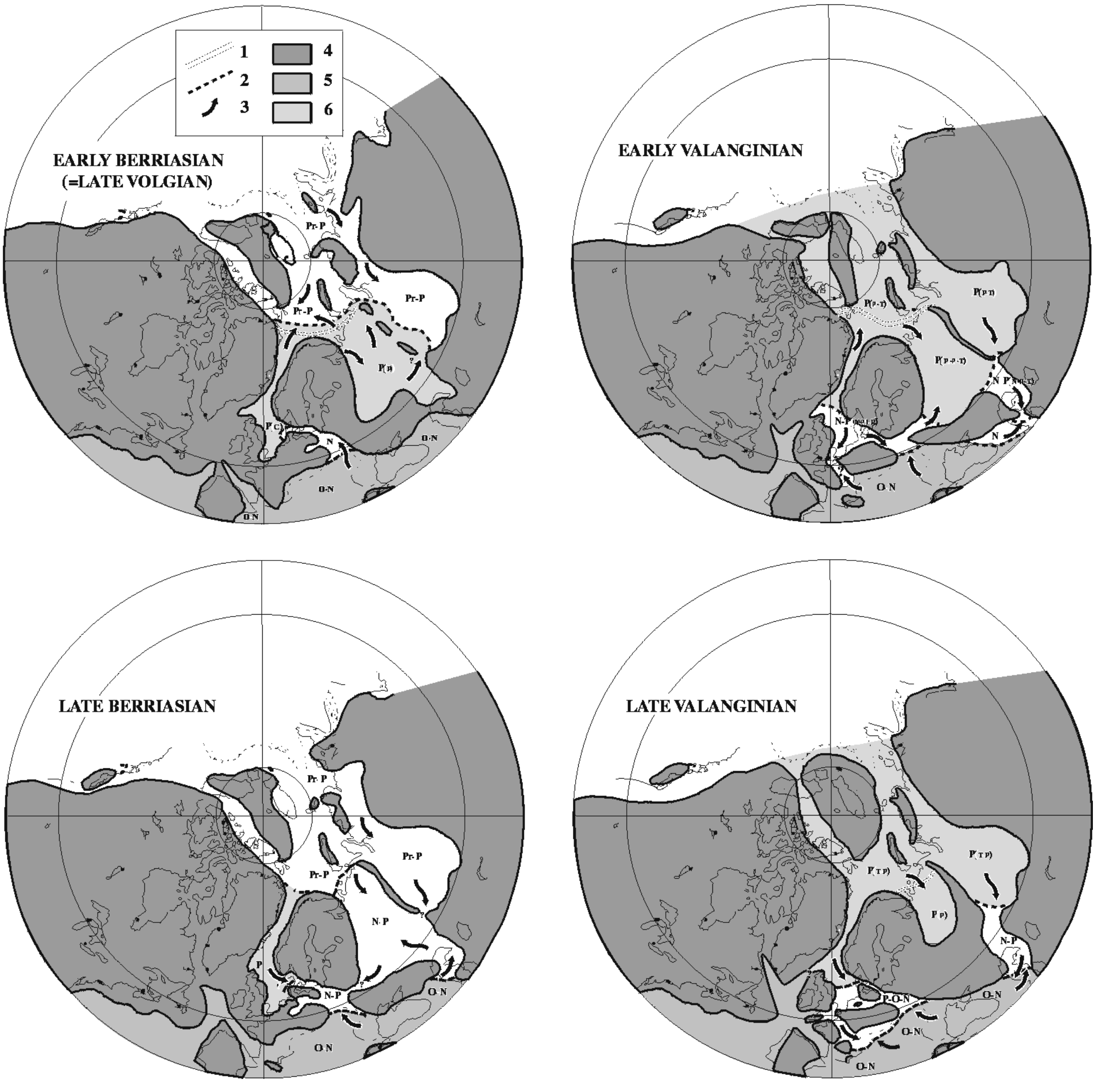

Fig. 3. Berriasian-Valanginian seaways of the Russian Platform Basin and ammonite paleozoogeography of the RP and surrounding area. 1 — Paleozoogeographical Subprovince boundaries; 2 — Paleozoogeographical Province boundaries; 3 — direction of fauna area expansion; 4 — land and areas of continental deposition; 5 — Olcostephanid-Neocomitid Province; 6 — Polyptychitid Province. The outlines of continents after Rowley & Lottes (1988), contours of the land margins after Casey (1973), Saks et al. (1971, 1972), Rawson (1973), Jeletzky (1973), Kemper (1973), Sasonova (1977), Marek (1983), Marek & Raczyńska (1973), Kemper et al. (1981), Ziegler (1990), Prozorovsky (1991) and author's own data. **Early Berriasian** Provinces: **Pr-P** — Perisphinctid-Polyptychitid Province; **P** — Polyptychitid Province: **P(C)** — Craspeditinid Subprovince; **P(P)** — Platylenticeratinid Subprovince; **N** — Neocomitid Province; **O-N** — Olcostephanid-Neocomitid Province; **N-P** — Neocomitidm-Polyptychitid Province. **Late Berriasian** Provinces: **Pr-P** — Perisphinctid-Polyptychitid Province; **P** — Polyptychitid Province; **N-P** — Neocomitid-Polyptychitid Province; **O-N** — Olcostephanid-Neocomitid Province. **Early Valanginian** Provinces: **P** — Polyptychitid Province: **P(Pl-P-T)** — Platylenticeratinid-Polyptychitinid-Tolliinid Subprovince; **P(P-T)** — Polyptychitinid-Tolliinid Subprovince; **N-P** — Neocomitid-Polyptychitid Province: **P(N-P-T)** — Neocomitinid-Polyptychitinid-Tolliinid Subprovince, **P(N-Pl-P)** — Neocomitinid-Platylenticeratinid-Polyptychitinid Subprovince; **N** — Neocomitid Province; **O-N** — Olcostephanid-Neocomitid Province. **Late Valanginian** Provinces: **P** — Polyptychitid Province: **P(T-P)** — Tolliinid-Polyptychitinid Subprovince; **P(P)** — Polyptychitinid Subprovince; **N-P** — Neocomitid-Province; **P-O-N** — Polyptychitid-Olcostephanid-Neocomitid Province; **O-N** — Olcostephanid-Neocomitid Province.

area. The northern part of the Ural Mts. became uplifted in the early Late Berriasian and submerged in the Valanginian (Golbert & Klimova 1979). The submergence happened as a result of Western Siberia immersion: the connection of Western Siberia with the Peri-Caspian–Mangyshlak area became wider, but the connection with the RP Basin reduced.

2. The contours of the RP Basin changed. During the Early Berriasian (= Late Volgian) there was a fauna exchange

with Western Siberia and the Arctic sea only; this time is characterized by the absolute dominance of a Boreal fauna and a high rate of endemism (Fig. 1). The sea-connections of the RP Basin with the Tethys and with the Polish Basin opened during the Latest Berriasian and existed until the late Early Valanginian. In the Late Valanginian the RP Basin was again separated from the Tethys and had only a connection with the Arctic sea. It became even more isolated than during the Early Berriasian and its size was much smaller. This is the reason why no endemic ammonites are known from the Upper Valanginian of the RP. It should be noted that the direct seaway between the young Atlantic Ocean and the Arctic sea did not exist during the Berriasian. It probably appeared in the Late Valanginian (Rawson 1973, 1995), but this fact needs additional investigations. The Valanginian phylloceratids and lytoceratids on Traill Island could also be of Pacific origin. It is difficult to suppose the presence of the "warm Atlantic stream" (Saks et al. 1971, 1972), especially during Valanginian, when Boreal ammonites migrated southward in the Tethys. Therefore, I think that the term "Boreal-Atlantic" Province (Saks et al. 1971, 1972; Shulgina 1974) is not a very good choice. I also think that taxonomic names for different paleozoogeographical subdivisions are preferable to the above geographic names.

3. It is obvious that the presence and configuration of seaways was responsible for the ammonite distribution, but water temperature was also important. For example, the RP Basin had a free connection with both the Tethys and the Arctic sea in the Late Berriasian, but *Riasanites*, which has Tethyan roots, did not move far to the north. At the same time *Surites*, a Boreal genus, did not move far to the south (the furthest region is probably the North Caucasus). I think that changes in the distance from the temperature optimum were, in fact, the reason of Rawson's (1973) "mass migrations" and "facultative migrations" of ammonites, which he tries to explain by sea connections. In my opinion it is not correct to apply the term "migration" to changes of ammonite areas, because it really reflects mass movements of water (and not changes in ammonite mode environments). So, several natural factors formed the limits of the provinces. They were, in general, correctly interpreted by previous investigators (Saks et al. 1971, 1972, etc.). It is easy to see that these limits do not coincide with the latitude lines on palinspastic reconstructions (Fig. 3) and especially with their recent position (compare with reconstructions of Saks et al.). The situation could be explained by the coincidence of several factors: (1) the ammonite mode of life; (2) the existence of warm/cool paleocurrents or (3) the precision of the palinspastic and paleogeographic reconstructions.

4. One can see now, after this integrated analysis, **where** and in **what stratigraphic interval** we can try to solve the problem of the Boreal/Tethyan correlation. For the Early Berriasian: it is the Polish Furrow, Alaska and Far East. For the Late Berriasian it is Mangyshlak, the Polish Furrow and Far East. For the Early Valanginian it is again Mangyshlak, the Polish Furrow–northern Europe and the Far East. For the Late Valanginian it is northern Europe and the Far East. The problem was solved in particular by Kemper et al. (1981), and by Luppov et al. (1983, 1988), but it should be done in the other regions in the future.

Conclusions

The investigation of the Lower Cretaceous of the RP provides interesting data in many stratigraphical, paleozoogeographical and paleogeographical aspects; it had a strong relationship with the surrounding regions. The most important factors of the development of the RP during the Early Cretaceous were intracratonic tectonic movements and sea-level fluctuations. Tectonic movements controlled the opening of the seaways and basin configuration and the sea-level fluctuations determined the expansion/restriction of the ammonite areas. Both factors control the rate of endemism of the RP: if the basin became extended, but partially isolated, the endemism level was high. The endemism became low during the opening of the seaways and completely disappeared during the shortening of the basin. On the other hand, when the seaways were maximally open, the opportunities for Tethyan/Boreal correlation were also maximal. There were two such well-correlatable horizons for the Berriasian–Valanginian interval: the Rjasanensis–Kochi zones in the Upper Berriasian and the Undulatoplicatilis Zone in the Lower Valanginian.

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