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The Berriasian of the European realm

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With 2 tables

ABSTRACT

In general stratigraphic scheme (table 1) the Tithonian is accepted as the uppermost Jurassic stage and the Berriasian as the lowermost Cretaceous unit. They correspond in the terms of absolute chronology to the interval between 144–131 m. y. B. P.; the Lower Berriasian boundary is dated as 137 m. y. B. P. During these ages there are identified 6 sedimentary cycles on the Russian Plain as the effect of alterating transgressions and regressions (29), which considerably influenced ecogenesis. Changes of cycles signified new phases of faunal phylogenesis. The intervals between sedimentary cycles had different duration.

KURZFASSUNG

Es wird ein Überblick über den heutigen Stand der biostratigraphischen Gliederung der Jura-Kreide-Grenze der subborealen Provinzen Europas mittels Ammoniten, Belemniten, *Buchia,* Foraminiferen und Tintinniden gegeben. Die Jura-Kreide-Grenze wird an die Oberkante *nikitini-, oppressum-, giganteus-* und *variabilis*-Zonen gelegt. Die Gorodischium Stufe (= Unter-Wolga) entspricht dem Tithon, die Kashpurium Stufe (= Ober-Wolga) den *grandis-* und *occitanica*-(pars)-Zonen des Berrias. Das Ober-Berrias wird als Äquivalent des Ryazan angesehen und entspricht den *boissieri-* und (?) Teilen der *occitanica*-Zonen.

In der anglo-grönländischen Provinz stimmt das Unter-Berrias mit der *subcraspedites*-Zone überein. Das Ober-Berrias wird dem Ryazan gleichgesetzt und umfaßt die *runctoni-, kochi-, icenii-, stenomphalus-,* und *albidum*-Zonen. Das Valanginium setzt mit dem ersten Auftreten von *Platylenticeras* und *Menjaites* ein.

INTRODUCTION

An up-to date account of the phylogenetic stages of ammonites, belemnites, *Buchia,* foraminifera and tintinnids at the Jurassic-Cretaceous boundary of the European Subboreal Provinces is given. The Upper Jurassic boundary is fixed at the top of *nikitini, oppressus, giganteus, variabilis* zones. The Gorodishchian stage is correlated with the Tithonian. The Kashpurian stage is synchronous with *grandis* and *occitanica* (pars) zones. The Upper Berriasian is established as equivalent to the Ryazanian stage and corresponds to *boissieri*-(?)*occitanica* (pars) zones. In the Anglo-Greenland Province the Lower Berriasian corresponds to the zone with *Subcraspedites;* the Upper Berriasian is distinguished as the Ryazanian stage composing *runctoni, kochi, icenii, stenomphalus, albidum* zones. The Valanginian begins with the first occurence of *Platylenticeras* and *Menjaites.*

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PALAEOBIOGEOGRAPHICAL ZONATION RECOMMENDED FOR THE BERRIASIAN

The European Subboreal Realm includes the Russian (without Prechernomorskaya depression), Polish, Anglo-Greenland Provinces, the latter being adjointed from the east by the North Siberian Province. The Russian Province is divided into the Pechora, Volga, Dneper-Donetsk and Precaspian subprovinces. The Volga subprovince includes Moscow bay. The Precaspian basin was connected with Mangyshlak Sea through the South Embian strait. The Submediterranean Province includes Mangyshlak, North Caucasian, Crimea-Carpathian (with Dobrudgian intercontinental bay), Middle Europian and South European subprovinces.

Subboreal seas were shallow. The depths up to 50 m occupied 50%, to 100 m – 20%, from 100 to 200 m – 15% of their total water surface; 5% was occupied by lagoons, fresh-water lakes and low accumulative plains. The continental Purbeck-type deposits are known in Dneper-Donetsk subprovince, in Dobrudgian depression, on Busginsk and Sarpinsk-Tengutinsk paleoplains in the west of Precaspian subprovince (30). Purbeck facies are known in the central part of Polish province (table 1). In terms of geochronology, their sedimentation lasted from one to four chrons, the deposits being formed in identical facial conditions. The Subboreal and Mediterra-

Systems	Stages	Substages	East European Platform (I): Zones			Northern Siberia (II): Stages	Northern Siberia (II): Zones		NW-Europe England - Greenland: Stages	NW-Europe England - Greenland: Zones		Submediterranean province, The Central European, Crimean, Carpathian subprovinces: Stages	Zones		
Lower Cretaceous	Valanginian		Pseudogarnieria undulatoplicatilis and Menjaites imperceptus			Valang.	Tollia tolli = Neotollia klimovskiensis and Menjaites spp. Zone		Valang.	Platylenticeras heteropleurum	Menjaites, Paratollia	Valang.	Kilianella roubaudiana		
										Tolypeceras marcousianum			Thurmanniceras pertransiens		
	Upper Berriasian	Upper Ryaz.	Surites (Bogoslovskia) simplex		Central Poland-Purbeckian	Berriasian (= Paksinian N-Sibiria)	Bojarkia payeri		Ryazanian=Upp.B. (p)	Peregrinoceras albidum	NW-Europe Wealden + Serpulit + Münder Mergel = Purbeckian England	Berriasian	Fauriella boissieri = Berriasella callisto and Picteticeras picteti Zones		
										Bojarkia stenomphalus					
			Surites spasskensis				Caseyiceras analogus			Surites (Lynnia) icenii					
		Lower Ryazanian	R. rjasanensis s.l.	Hectoroceras ex gr. kochi Subzone NE Platform; Riasanites rjasanensis s.str. Subzone SE Platform			Hectoroceras kochi			Hectoroceras kochi			Malbosiceras malbosi		
				R. maikopensis and Euthymiceras euthymi Subzone SE Platform				Chetaites sibiricus		Praetollia (Runctonia) runctoni					
								Chetaites chetae							
	Lower Berriasian	Kashpurian	Trautscholdiceras kaschpuricus & Craspedites nodiger	T. kaschpuricus and C. nodiger Subzone			Praechetaites	Taimyroceras taimyrense	Lower Berriasian (pars)	Subcraspedites (Volgidiscus) lamplughi			Dalmasiceras dalmasi Subzone		
				C. nodiger and Garniericeras subclypeiforme						Subcraspedites preplicomphalus			Tirnovella occitanica = Berriasella privasensis Zone		
			Craspedites subditus	C. subditus and G. catenulatum Subzone			C. okensis	Taimyroceras originalis		Subcraspedites (Swinnertonia) primitivus			Pseudosubplanites grandis = P. euxinus Zone		
				C. okensis Subzone				C. okensis							
			Kachpurites fulgens					Praechetaites exoticus							
Upper Jurassic	Upper Tithonian	Upper Gorodishchian					Epivirgatites vogulicus		Portlandian	Paracraspedites oppressus		Tithonian	Berriasella jacobi = B. chaperi Zone		
			Epivirgatites nikitini				Laugeites groenlandicus			Titanites giganteus			Delphinella delphinensis		
			Virgatites virgatus s.l.	V. rosonovi and V. virgatus Subzone			Dorsoplanites sachsi = Taimyrosphinctes excentricus			Glaucolithites gorei			Paraulacosphinctes transitorius	"Durangites"	Stramberg beds
				V. virgatus s. str. Subzone			Dorsoplanites maximus			Progalbanites albani					
			Dorsoplanites panderi & Zaraiskites scythicus	D. panderi and Z. zarajskensis Subzone			Dorsoplanites ilovaiskii		Upper Kimmeridgian	Virgatopavlovia fittoni			Pseudovirgatites scruposus	Micracanthoceras micracanthum	
										Pavlovia rotunda					
				Pavlovia pavlovi and Z. scythicus Subzone			Pavlovia latriensis			Pavlovia pallasioides			Zaraiskites ex gr. scythicus		
	Lower Tithonian	Lower Gorodishchian (Wetlianian Stage)	Ilowaiskya pseudoscythicus	I. pseudoscythicus Subzone			Pectinatites pectinatus = P. lideri Zone			Pectinatites pectinatus			Pseudovirgatites puschi, Ilowaiskya	ponti fallauxi	
													Pseudolissoceras bavaricum	semiforme	
													Danubisphinctes palatinum, Ilowaiskya spp.		Neochetoceras darwinii
				I. sokolovi Subzone			Subdichotomoceras subcrassum and Ilowaiskya spp.			Arkellites hudlestoni			Franconites vimineus		
													Usseliceras parvinodosum	Neochetoceras mucronatum	
										Virgatosphinctoides wheatleyensis			Dorsoplanitoides triplicatus		
										Virgatosphinctoides scitulus			Usseliceras tagmersheimense		
			Gravesia gravesiana = I. klimovi Zone (pars)				Gravesia gravesiana s.l. = Eosphinctoceras magnus Zone			Gravesia gravesiana and G. gigas; England: Pectinatites elegans and Gravesia spp. Zones			Gravesia gravesiana s.l. = Hybonoticeras hybonotum and Glochiceras lithographicum Zones		

Table 1. Correlation of the stratigraphic schemes of the European Subboreal and Submediterranean Jurassic-Cretaceous boundary beds.
Comp.: I: (1, 3, 8, 18, 19, 29, 30, 31, 32, 35), II: (3, 4, 9, 26, 28, 31, 32), III: (3, 5, 24, 26, 31, 33, 34), IV: (5, 21, 31, 32, 33, 34).

nean realms enjoyed different geological history and biocoenosis evolution. Only two stratigraphic levels of these realms may be considered as isochronous. These are the base of the Tithonian and Gorodischian stages and the base of the Valanginian. All other zones of the realms have a relative correlation. It casts doubt on the expedience to apply the Tethyan stratigrathic scheme to the Subboreal Realm. It seems much better to use provisional names of stages and zones instead. We follow Luppov's oppinion (22 p. 14) that the general stratigraphic scheme should be used not as a universal chart but only as a standart for correlation. Janshin has shown (22, p. 15) a provisional nature of the west European stages, their stratigraphic inter-connections being extremely intricate. Thus, the vicious circle is arisen: on the one hand, such an intricate character of the West European subdivisions prevents their usage by soviet geologists and on the other hand, the denial of an independant provisional scheme deprives geologists of an opportunity to make a stratigraphic scheme larger than regional. Janshin stresses the absurdity of such situation. According to Ruzentsev & Bogoslovskaja (27) the present state of knowledge does not permit universal correlation. We would like to point out that the 8th session of the Geological Congress (1900) has determined a stage as a unit of provisional significance. That congress recommended to name stages after geographical places from where they had been originally described. It was also mentioned at that congress that in different countries zones would not be coincident (12, p. 134). It is also remarkable that the name "Tithonian" has never been applied in geological practise to the Subboreal Realm and the Berriasian in the Anglo-Greenland Province is usually accepted as synchronous to the Ryazanian Stage of the Russian Province (table 1), composed of *runctoni, kochi, icenii, stenomphalus, albidum* zones (3, 25). Janshin has shown and explained (10) the absence of coeval global transgressions and regressions. According to Janshin they happened on the platforms at different times and were caused by development of the continental crust structures more then by eustatic fluctuations of the ocean level. Nikitin and Tchernishov (21) noted that from the evolutionary point of view a stratigraphic gap in one place must correspond to contineous sediments in the other. All these studies show, that coeval epicontinental basins of different paleogeographical realms were completely or partly isolated. The basins had different duration of existance, which averaged one – two phases, (i. e. 0,25–0,50 m. y. in absolute dating). Naidin et al. (17) had shown on the diagrams for each of Cretaceous age and phase the absence of coeval transgressions and regressions in different basins of the East European Platform. Conditions and rates of sedimentation were changed more them once during those periods. Transgressions controlled the lithological composition of sediments and spasmodic changes of faunal phylogenesis. Borisjak (2) stresses that any evolutional process is a result of interaction between organism and environment, the latter being a species – forming factor. Ruzhentsev pointed out that the incoming of new ammonite species coincided with the epochs of maximum transgressions and regressions. Changes of rhythms mark the zonal stratigraphic limits and changes of cycles correspond to the boundaries of stages and substages (27). In paleobasins of different provinces the boundaries slide, i. e. they can be fixed on different chronostratigraphic levels. Rich ammonite assemblages intensively developed in paleobasins with favourable hydrochemistry and oxygenous exchange while in basins with extreme conditions prevailed stunted or gigantic forms, whose evolution was accelerated or slackened; large taxons died out more rapidly and endemics had come into being. Discussion of which stage of the Boreal Realm is the Upper Jurassic and which one is the Lower Cretaceous has lasted for over a century. It has been concerned with the terminology of the boundary beds, their volume and synchronous zonal correlation. Three criteria exist for a chronostratigraphical subdivision: 1. incoming of new fauna; 2. its flourishing; 3. its extinction.

For the Russian Province Gerasimov and Michailov (8) have established the "Volgian stage" in the top of Jurassic strata by uniting mechanically the previously distinguished Lower Volgian and Upper Volgian stages. According to the constructed by this authors scheme of ammonites phylogenetic development during these ages, the critical points of the ammonites history response to the first criterion; they are known at the bases of *panderi, virgatus, fulgens, rjasanensis* zones. At these levels the evolution is interrupted by a revolutionary leap, followed by a qualitatively new phylogenetic phase. Thus, the scheme deprives its authors conclusions that it is expedient to unite the considered deposits into the one "Volgian stage". Pavlov (24, p. 37) considered the name "Volgian stage" as invalid. He had written "if do not reject completely this unsteady term confusing our literature so much, it is nessesary at least to add author's name and year, for example: Nikitin's Volgian stage of 1896 etc. Without it, it is impossible to understand what someone means while using names "Volgian deposits" or "Volgian stages". Nikitin pointed out (20, p. 277), that under the name "Lower and Upper Volgian stage" he always meant the terms of provisional significance; the Volgian deposits substitute in Russia the uppermost part of the Jurassic and the lowermost horizons of the Cretaceous period". Nikitin never used this name as an independant stratigraphic taxon. He supposed that the names "the Volgian deposits", "the Upper and Lower Volgian stage" as any other scientific terms should be used strictly in the sense attached to them by their author. Or, in case they fail to characterize distinctive groups of deposits, they should be excluded from usage. The boundaries between chronostratigraphic units should be drawn by the incoming of new faunas. This point is stressed in all papers by paleontologists-evolutionists, who support materialistic dialectics. Ivanova (9) supposed that the bases of organic kingdom history lay in coming of the new contrary to the extinction of the old, as the old could continue to exist for a long time but could not prevent the development of the new. Davitashvili (7) had shown that extinction is a prolongated and uneven evolutionary process. We may add that it is considerably influenced by cosmic factors (by changing its velocity).

Casey (3), Zeiss (34), Sasonova & Sasonov (31) and others had shown that the Tithonian and Berriasian correlation of the Mediterranean and Russian provinces is still far from certainty. Following Pavlov (24) and taking into consideration remarks by Nikitin (20) and other investigators, we concluded that the name "Volgian stage" was invalid. In our previous paper (31) we renounced this term and substituted "the Lower Volgian" into the Gorodishchian stage, accepting it as synchronous to the Tithonian and instead of "the Upper Volgian" we accepted the Kashpurian stage which corresponded to *grandis* zone and to lower part of *occitanica* (pars) zone of the Berrias. The Ryazanian stage is synchronous to *boissieri* and possibly to upper part of *occitanica* (pars) zones. On this evidence we determine the Kashpurian + Ryazanian stages as synchronous to the Tethyan Berrias. For the lectostratotype of the Ryazanian stage SASONOVA suggested (29, p. 11–12) a section near the village Chevkino at the River Oka, similiar to the outcrop (now destroyed by land-slide) which was described by BOGOSLOVSKY (1, p. 33–34) from near the village Tsikvino. A powerful transgression at the beginning of the Kashpurian marks a new Cretaceous period of faunal evolution, characterized by incoming of family and genus rank taxons.

THE MAIN STAGES OF FAUNAL EVOLUTIONS

1. AMMONITES

Phylogenetic study of the ammonites which existed at the Jurassic-Cretaceous junction in the Subboreal Realm allow us to destinguish 6 stages of their development.

The first stage begins in the Early Gorodishchian (Vetljanka) age. It is characterized by incoming and flourishing of Pseudovirgatitinae, represented by genus *Ilowaiskya* and its branches *Pseudovirgatites, Subplanites, Pectinatites* etc. which are known during the Early Tithonian in the Middle and South European Subprovinces. The second stage is recognized in the late Gorodishchian, when Virgatitinae *(Ilowaiskya* descendants) phylogenetic lineage *Zaraiskites - Virgatites - Epivirgatites* and *Paracraspedites* dominates. The latter genus we consider as a lateral branch of genus *Epivirgatites* which existed in the norhtern part of the Boreal Province but was absent in the Russian sea. Development of species of *Epivirgatites* differed from normal to gigantism, assymetric type of ribbing and sutures on left and right sides of ammonites. This indicates the extreme life-conditions which brought the whole subfamily of Virgatitinae to extinction.

During the second stage *Dorsoplanites, Pavlovia, Strajevskya, Lomonossovella* etc. of Dorsoplanitinae developed in the Russian Province and such branches of Dorsoplanitinae as *Crendonites, Behemoth* and others, existed in the Anglo-Greenland basin. Dorsoplanitinae extinguished at the end of the second stage. Regression of the Russian and Polish seas begins at the end of *virgatus* phase and reaches a climax at the end of *nikitini* phase. Representatives of Dorsoplanitinae are known as rareties in the Subboreal Realm during the third and fourth stages. They are represented in North Siberia by phylogenetic lineage *Praechetaites-Chetaites* and in the Russian and Anglo-Greenland basins by the lineage of *Pronjaites – Externiceras – Peregrinoceras.*

The third stage corresponds to the Kashpurian age. A leap in ammonites phylogenesis at its beginning is marked by incoming of *Kachpurites – Garniericeras – Craspedites – Trautscholdiceras,* unknown in the Tethyan Realm. The two latter genera correspond to the vicarious genus *Subcraspedites* of the Anglo-Greenland basin and are substituted by *Taimyroceras* in North Siberia. Phylogenetic branch *Kachpurites, Garniericeras, Hectoroceras* s. lato is very distinctly recognized. *Hectoroceras* s. lato is characteristic of the fourth stage when it spreads through all the North Siberian and Anglo-Greenland basins. Typical ribbing of *kochi* s. str. is seen for the first time on the adults of *Garniericeras* which inhabited Moscow basin of the Russian sea at the end of the Kashpurian age. To the same phylogenetic lineage belong the Early Valanginian *Pseudogarnieria* and *Platylenticeras.* By the end of the third stage species of *Trautscholdiceras* obtain ugly assymetric shells and sutures, indicating their dying phase. These species do not occur in the North Siberian and Anglo-Greenland Provinces.

The fourth stage corresponds to the Early Ryazanian. During this time Submediterranean *Riasanites, Euthymiceras, Neocosmoceras, Subsurites, Prorjasanites* migrated from the North Caucasian to the Russian sea through the Mangyshlak and South Embian seaway. At the same time endemic species of the Suritidae genera *Borealites* s. lato and *Subsurites* spp. have been generated. *Riasanites* s. lato is not known nothward of the village Lojno (on the River Kama) latitude. Representatives of this genus exist neither in the Anglo-Greenland and North Siberian Provinces, nor in Pechora subprovince. During *rjasanensis* phase *Hectoroceras kochi* s. lato was developing in these basins. At the end of *rjasanensis* phase *H.* ex gr. *kochi* migrated southward till down the latitude of Ryazan (32, p. 77). There, near the village Kostino, *rjasanensis* zone has a later chronostratigraphic level in its upper part (table 2). For the north-eastern part of the Russian Province it is expedient to establish that level as the upper subzone of the *rjasanensis* zone (table 1). The water temperature strongly influenced faunal migration during the Ryazanian age. The temperature in the sublittoral zone of ferruginous oolitization (near Pehorka on river Menja) was about 30° C and in the Pechora and North Siberian seas did not exceed 7° C (32, p. 101). Fluctuations of the temperature influenced the strength of assamblages, the speed and possibilities of their migration.

The fifth stage corresponds to the Late Ryazanian phase. The water temperature within the Subboreal Provinces in this stage did not exceed 8–10° C and fluctuations were very small. This stage begun with a biological eruption which resulted in flourishing of Suritidae family, comprising 12 genera and 60 species. Suritidae migrated through the Brest strait to the Polish basin, where they coexisted together with Submediterranean berriasellids (15). During this stage Suritidae predominated in the whole Boreal Realm.

The sixth stage begins from the Early Valanginian. It is characterized by a broad development of *Platylenticeras* subfamily which migrated from the Middle European basin through Northern Europe and the Brest strait into the Russian Sea. *Menjaites, Costamenjaites* and other representants of Suritidae family occur in the Russian Sea and Tollinae *(Neotollia, Tollia* and *Praetollia)* are known from North Sibirian Province. Distribution of ammonites reflects an intermittent character of their development. Evolutional stages coincide with changes of sedimentary cycles and correspond to the stratigraphic units of stage and substage.

2. BELEMNITES

Zonal distribution (table 2) is based on V. N. SACHS interpretations of the belemnites, obtained during our mutual sampling from the outcrops near villages Chevkino, Nikitino, Pehorka. *Lagonibelus* s. str. and *Pachyteuthis* died out during *virgatus* and *nikitini* phases at the end of the Gorodishchian age. Relict *Pachyteuthis (Simobelus)* s. str. occur in the North Siberian basin up till the *analogus* zone. Subgenus *Mikrobelus* of *Acroteuthis* takes the supremacy in the Kashpurian Russian Sea and at the same time first *Acroteuthis* s. str. and *Acroteuthis (Boreioteuthis)* make their appearance. Du-

Stages	Pekhorka on Menja river typesection (Sasonova, 1977)	Mosolovo on Neplozhe river	Tchevkino on Oka. Lectostratotype of the Ryazanian Stage	Kashpur on Volga. Lectostratotype of the Kashpurian Stage (Sasonova and Sasonov, 1967)	SE-Transcaspia (domes: Koj-Kora, Zhdali erc.) and Usturt
Valanginian	(hatched)	Zone: *Polyptychites keyserlingi* and *P. michalskii*. Fauna: *Nikitinoceras triptychiformis, Buchia keyserlingi, B. inflata* etc.		Zone: *Polyptychites keyserlingi* and *P. michalskii*. Fauna: *P. clarkei, Buchia inflata*	Zone: *Polyptychites keyserlingi* and *P. michalskii*. Fauna: *P. michalskii, P. clarkei, Buchia inflata, B. keyserlingi*
Valanginian	Zone: *Nikitinoceras hoplitoides*. Fauna: *N. hoplitoides, N. grandiosus, N. triptychiformis, N. syzranicus, N. ribkinianus, Menjaites glaber, Costamenjaites lgovensis, Buchia inflata, B. keyserlingi, B. tolmatschewi* etc. (Beds 9–8)		(Beds 8–6)	Zone: *Nikitinoceras hoplitoides*. Fauna: *N. syzranicus, N. ribkinianus, Buchia inflata, B. keyserlingi, B. tolmatschewi* (Bed 33)	Zone: *Nikitinoceras hoploides*. Fauna: *N. hoplitoides, N. syzranicus, N. ribkinianus, Buchia keyserlingi, B. tolmatschewi*
Valanginian	Zone: *Pseudogarnieria undulatoplicatilis*. Fauna: *Proleopoldia kurmichensis, Platylenticeras geverilianum, Menjaites imperceptus, Luppoviceras validum, Buchia inflata, B. crassa, B. uncitoides, Acroteuthis (Acroteuthis) lateralis, A. (Boreioteuthis) explarata, A. (B.) hauthali* etc. (Bed 7)		*Menjaites glaber, Buchia solida, B. crassicollis*	*Menjaites imperceptus, Pseudogarnieria* spp. etc. (Upper part of bed 32)	In the domes-roofs the deposits are missed or reworked; Fauna: *Surites* spp., *Buchia terebratuloides, Trigonia* spp.
Ryazanian	Zone: *Surites (Bogoslovskia) simplex*. Fauna: *Surites abalicus, S. (Bogoslovskia) pseudostenomphala, Stchirowskiceras tumefactum, Buchia terebratuloides, B. trigonoides, B. uncitoides, B. surensis* etc. (Bed 6)		Yields no fauna	*Surites* spp., *S. (Bogoslovskia) simplex* (Lower part of bed 32)	
Ryazanian	Zone: *Surites spasskensis*. Fauna: *Surites spasskensis, S. poreckoensis, S. kazakowianus, S. tzikwinianus, Borealites suprasubditus, Chandomirovia ilekensis, Peregrinoceras pressulum, P. subpressulum, Externiceras solovaticum, E. mostjae, Caseyiceras casey, C. dorsorotundus, C. analogus, Buchia unschensis, B. uncitoides, B. terebratuloides, B. volgensis, B. syzranensis, Acroteuthis (Microbelus) russiensis, A. (Acrotheuthis) lateralis, A. (Boreioteuthis) hauthali. Buchia* are in shelly hash. At the base occur redeposited: *Riasanites* spp., *Euthymiceras* spp. etc. (Beds 5–3)		(Beds 5–3)	(Bed 31)	Zone: *Surites spasskensis*. Fauna: *S. spasskensis, S. pechorensis, Chandomirovia ilekensis, Externiceras* spp., *Buchia terebratuloides*
Ryazanian — *Riasanites rjasanensis* s.l.	(hatched)	? Subzone: *?Hectoroceras* ex gr. *kochi*	(hatched)	? Subzone: *Riasanites* spp., *Malbosiceras micheicus* etc. (Beds 30–29)	Zone: *Riasanites rjasanensis* and *Euthymiceras transfigurabilis*. Fauna: *Malbosiceras malbosi, E. transfigurabilis, Negreliceras negreli, Dalmasiceras* aff. *dalmasi, Prorjasanites vnigni, Buchia volgensis, Calpionellopsis simplex, Tintinnopsella carpathica, Trigonia* spp., *Tauricoceras* spp.
Ryazanian — *Riasanites rjasanensis* s.l.	Subzone: *Riasanites rjasanensis*. Fauna: *R. rjasanensis* s. str., *R. swistowianus, Pronjaites plumatum, Pronjaites bidevexus, Borealites suprasubditus, Buchia volgensis, Acroteuthis (Microbelus) russiensis, A. (M.) mosquensis* etc. (Bed 2)	*Neocosmoceras* spp., *Euthymiceras transfigurabilis, Prorjasanites vnigni, Trigonia scapha* etc.	(Bed 2)	(Beds 28–27)	
Ryazanian — *Riasanites rjasanensis* s.l.	(hatched)	Subzone: *Riasanites maikopensis* and *Euthymiceras euthymi*. Fauna: *R. maikopensis* s.l., *Neocosmoceras* aff. *perarmatum, Prorjasanites vnigni, Euthymiceras euthymi, Malbosiceras* spp., *Trigonia* spp., *Buchia* spp.	(Bed 2)	(Bed 26)	Zone: *Riasanites maikopensis* and *Euthymiceras euthymi*. Fauna: *E. euthymi, Neocosmoceras* spp., *Malbosiceras* spp., *Calpionellopsis simplex*
Kashpurian Stage	Gorodischian Stage: *Dorsoplanites panderi* and *Zaraiskites scythicus* Zone (Bed 1)	Upper Oxfordian Stage: *Amoeboceras alternans* s.l. Zone	(Bed 1)	*Trautscholdiceras kaschpurites* and *Craspedites nodiger* Zone — Subzone: *Trautscholdiceras kaschpuricus* and *Craspedites nodiger*. Fauna: *T. kuznetzowi, T. milkovensis, C. nodiger, Subcraspedites* spp., *Garniericeras subclipeiforme. ?G. tolijense, Buchia volgensis, B. terebratuloides, B. unschensis, Acroteuthis (Microbelus) russiensis, A. (M.) mosquensis* (Bed 25)	South Embe. In the domes-roofs the deposits are thin or absent completely. Fauna: *Craspedites nodiger, Buchia volgensis, Calpionella alpina, Tintinnopsella carpatica* — Usturt. Shachpachtian horizon Shallow-water carbonaceous deposits, 215m thick. The middle layers yield: *Craspedites* spp., *Buchia* spp., *Trigonia* spp., *Tintinnopsella carpathica, Calpionella alpina, C. elliptica*
Kashpurian Stage				*Trautscholdiceras kaschpurites* and *Craspedites nodiger* Zone — Subzone: *Craspedites nodiger* and *Garniericeras subclipeiforme*. Fauna: *C. nodiger, C. mosquensis* etc. (Bed 24)	
Kashpurian Stage				*Craspedites subditus* Zone — Subzone: *Craspedites subditus* and *Garniericeras subclipeiforme*. Fauna: *G. catenulatum, G. interjectum, Buchia terebratuloides, B. volgensis, A. (M.) mosquensis* (Bed 23)	
Kashpurian Stage				*Craspedites subditus* Zone — Subzone: *Craspedites okensis*. Fauna: *C. okensis Garniericeras nov.*, etc. (Bed22)	
Kashpurian Stage			Zone: *Kachpurites fulgens*. Fauna: *K. fulgens, K. subfulgens, Craspedites nekrassovi, C. fragilis, C. krylovi, Buchia volgensis, Acroteuthis (M.) mosquensis*	(Bed 21)	*Kachpurites fulgens, Craspedites krylovi, Buchia volgensis, Acroteuthis (M.) mosquensis*
			Upper Jurassic, Gorodischchian Stage = Tithonian Stage		

Table 2. Correlation of the Kashpurian, Ryazanian (= ? Berriasian) and the Lower Valanginian zones of the Russian Plain. Belemnites are classified by V. N. SACHS.

ring *rjasanensis* and *spasskensis* phases *Microbelus* and *Acroteuthis* s. str. are widely distributed, the latter genus completely substituting *Microbelus* during the *simplex* phase at the end of the Ryazanian age. At Spitsbergen, the Tethyan relict genus *Pseudohibolites* is described from the lower part of the Ryazanian stage. No members of this genus are recognized in the synchronous beds of the North Siberian and Russian Provinces. *Acroteuthis (Microbelus) russiensis, A. (M.) mosquensis, A. (Acroteuthis) lateralis* which are characteristic of the Kashpurian stage, have been also reported from *rjasanensis* and *spasskensis* zones of the Ryazanian stage. According to PINKNE & RAWSON (32, p. 43) *A. (A.) lateralis* and *A. (A.) sublateralis* in the North Western Europe are characteristic of the Berrias. The basal beds of the *undulatoplicatilis* zone at Pehorka (River Menja) jield numerous *A. (A.) lateralis, A. (M.) mosquensis,* well known from the Kashpurian stage of the Russian Province, also found (32) in the Berriasian beds of North Siberia. Now, on the evidence of the belemnites distribution, the Jurassic period lasted till the end of the Gorodishchian age and was followed by the Early Cretaceous period which came to its climax at the end of the Ryazanian age. Some relict species survived into the Lower Valanginian.

3. BIVALVES *(BUCHIA)*

Buchia are of prominant importance for chronostratigraphy though ontogenetic and phylogenetic conservatism of shells and the absence of non-arbitrary criteria for classification of species and subspecies make *Buchia* taxonomy subjective and reduce its stratigraphic usefulness. One of the obstacles in taking *Buchia* for zonation is a strong controll of their morphology by environment. The most favourable condition for intensive development of *Buchia* were provided by sublittoral areas with sandy-glauconite floor. Glauconite strongly influenced the abundance of population and the size of individuals. Glauconite sands contain 20 times more *Buchia* shells than the sands without glauconite or with small amount. During *spasskensis* phase a bend of *Buchia* shell-hash (0,20–0,22 m thick) was formed in the western part of the Russian sea. It is exposed near Kashpur, Nikitino, Chevkino. Mass *Buchia* burials are reported from Canada, Alaska, South-East of the USSR. Enormous extinction of this genus is marked throughout the vast territory of the Boreal Realm during *spasskensis* and *simplex* phases and at the beginning of the Valanginian. In spite of all the difficulties with *Buchia*, it is possible to distinguish on the Jurassic-Cretaceous junction 3 stages of their phylogenetic development; each answers to subgeneric level in evolution and to an age in geochronology.

The first stage covers the Gorodishchian age. It is characterized by Jurassic *Buchia russiensis, mosquensis, piochii* and others. The second stage corresponds to the Kashpurian and Ryazanian ages. It is characterized by *B. surensis, terebratuloides, volgensis, uncitoides.* The third stage begins in the Valanginian with flourishing of species like *B. inflata, keyserlingi, crassa* and others. Record (32, p. 127) of *Buchia inflata* from the Berriasian seems speculative. None of the Jurassic *Buchia* species occur in the Kashpurian-Ryazanian beds and no Cretaceous *Buchia* have ever been reported from the Gorodishchian deposits. Characteristics of the Valanginian *Buchia* are narrow, swelled shells with coarse, sharply advanced, wrinkled growth ribs. The Jurassic shells are flat, with thin, narrow, sometimes filiform ribs.

4. FORAMINIFERA

According to DAIN & KUZNETSOVA (6, table 2) at the end of *panderi* zone 83 foraminifera species became extinct, of which 62 species were endemic forms of *panderi* zone and the rest are from the Gorodishchian stage. In both, *panderi* and *virgatus* zones, occur 17 common species, 13 species are endemics of *virgatus* zone and 8 species are endemics of *nikitini* zone. Deposits of *virgatus, nikitini* zones and of the Kashpurian stage jield 8 common species.

Hence, the boundary of a substage rank (in terms of foraminiferal stratigraphy), may be fixed at the bottom of *panderi* zone, the latter being characterized by an abundance of new species. Regression between *panderi* and *virgatus* phases was short. Transgression in the beginning of *virgatus* phase had strongly changed a geochemistry of the new basin. The end of the Gorodishchian age is marked by mass extinction of *Ammobaculites, Orbignynoides, Mironovella, Lenticulina, Pseudolamarckina* and numerous species of *Saracenaria, Astacolus* (13, fig. 3). In the Kashpurian deposits *Saracenaria* is represented by 3 species, *Astacolus* by 2 species, *Marginulina* by 5 species (one of which is new), *Lenticulina* by 1 new species. Three foraminiferal zones has been established (13, p. 56) for the "Upper Volgian" stage. A new zonal genus *Placopsilina* is introduced for the lower zone; the latter also jields *Lenticulina münsteri, Marginulina embaensis, M. polyhymnius, Lagena hispida.* The middle zone (corresponding to *subditus* zone) is characterized by abundance of *Lenticulina hoplitiformis, L. uralica, Astacolus aquilonicus, Saracenaria alfa, Marginulina impropria, M. pseudolinearis, Dentalina delta, Ramulina nodosarioides.* Characteristics of the upper zone are *Lenticulina münsteri, L. nuda, Marginulina robusta.*

KUZNETSOVA described (13, p. 25) foraminiferal assemblage of the Upper Volgian deposits of the Pechora Subprovince and marked the presence of Arctic species as a factor which significantly distinguished this assemblage from the one of the Volgian Subprovince. KUZNETSOVA regards the development of foraminifers in stratigraphic interval *Kachpurites fulgens* – *Chetaites sibiricus* as a single stage. It is marked by incoming of new Cretaceous forms of a genus rank: *Placopsilina, Arenoturrispirillina.* New species *Saracenaria visa, S. valanginiana, Marginulina transmutata, M. impropria* were derived from the previously existed genera and steadily lasted through the Early Cretaceous.

KUZNETSOVA stressed that the elements of new Cretaceous fauna are distinctly seen in the Kashpurian foraminiferal paleobiocoenosis. In the Upper Volgian deposits of the central part of the Precaspian Subprovince with *Craspedites* spp., *Acroteuthis mosquensis, Buchia terebratuloides* MJATLIUK (16, p. 86) (with a reference to PROKOPENKO) identified a foraminiferal assemblage which on the evidence of its composition should be attributed, partly or completely, to the basal Berriasian. This brief review shows that a large new foraminiferal complex appears during the Kashpurian. Hence the Jurassic-Cretaceous boundary may be fixed at the bottom of the Kashpurian stage.

5. TINTINNIDS

Tintinnids are known in the Crimea-Carpathian, North Caucasian (32, p. 171), South-Embian and Mangyshlak Subprovinces. They are abundant in the middle calcareous beds of the Shachpachtinsk horizon at Usturt. We distinguish the three following tintinnid complexes which characterize different stratigraphic levels.

a) The Tithonian complex includes numerous *Crassicolaria intermedia*, *Crassicolaria* spp. This is described from limestones with *Malbosiceras chaperi* and *Berriasella jacobi* in the outcrops along the coastal section near Pheodosia, Crimea. Rare samples of *Crassicolaria* spp. occur together with *Ilowaiskya* spp. in the Opoka sandstones at the Khan-Mountain. Further to the north tintinnids have not been reported.

b) The Lower Berriasian (Kashpurian) complex includes numerous *Calpionella alpina*, *C. elliptica*, *Tintinnopsella carpatica*. It is characteristic of the basal part of Stavchinsk formation, Precarpathian depression and of the middle calcareous beds of Shachpachtian horizon.

c) The Upper Berriasian (Lower Ryazanian) complex is composed of *Calpionella oblonga*, *C. simplex*, *Tintinnopsella* ex gr. *carpatica*, *T. longa*. It is distinguished in the lower beds with *Riasanites rjasanensis* on River Aminovka, North Caucasus, also in the platy limestones with *Fauriella boissieri* of the Pheodosia section, Cremia and in the top of Stavchinsk formation, Precarpathian depression. Rare representatives occur in the Koj-Kora and Zhdaly domes together with *Riasanites* spp. Geographical distribution of tintinnids depends on climatic condition. Tintinnids allow correlation of the Russian Province beds characterized by *Riasanites* s. lato with the deposits of the Berriasian *boissieri* zone.

Remarks on the paper by Mesezhnikov et al (32, p. 71–80):

Concerning the Berriasian outcrops on the River Oka near the villages Kuzminskoje and Kostino, the authors of this paper made a point of co-occurence in situ of *Riasanites* and *Garnierіceras*. Kuzminskoye section was originally described by Bogoslovsky (1, p. 26). There, he distinguished the beds with *rjasanensis* as independant ones, underlain by sandstones with *subclypeiforme*. Such a pattern of faunal distribution was marked by Bogoslovky also in the other sections. Pavlov (23) described the only section near Konstantinovo (2 km to the north of Kuzminskoye) where sandstone with *rjasanensis* and *subclypeiforme* (underlying the Quarternary sands) is followed by sands with *fulgens*. Marking an account of intensive studies, Zonov wrote (35) that one could not agree with Pavlov in attributing even the lower part of band with *rjasanensis* to the same stage as the beds with *Garnierіceras*. Zonov had pointed out that he "... made this conclusion in spite of the fact that the beds with *Garnierіceras* and those with *Riasanites* occur near Kuzminskoye most closely to each other; there, they partly suffered redeposition and formed a single condensed band". According to Zonov a new marine transgression on the Russian Plain, incoming and flourishing previously completely strange *Riasanites*, is also a significant fact for distinguishing these beds from those with *Garnierіceras*. The authors of the paper (32, p. 71–80) mention phoshatized ammonites as observed in situ and reject the fact of redeposition of these ammonites, though all the previous studies mark the occurrence of reworked ammonites in the bottoms of *rjasanensis*, *spasskensis* and the Lower Valanginian. Redeposited ammonited are black, glossy, rounded (P_2O_5 content exceeding 20%). Fossils in situ are in sandy-clay preservation with less than 12% of P_2O_5.

CONCLUSIONS

1. The Tithonian is established as the European Upper Jurassic stage in terms of a standard for correlation. The Berriasian is regarded as the lower stage of the Cretaceous system. In the Russian Province the Tithonian is synchronous to the Gorodishchian stage. The stratigraphic subdivision and correlation of the latter with other provisional stratigraphic schemes is given in table 1.

2. The base of the Tithonian and Gorodishchian is isochronous. In all the Subboreal Provinces the upper boundaries of these stages are marked by breaks in sedimentation of different duration, which have been caused by powerful, though not simultaneous transgressions and regressions. These boundaries are asynchronous.

3. In numerous outcrops at the Russian Plain, including those near Kostino, Kuzminskoye, Chevkino, Kashpur, *Riasanites* and *Garnierіceras* never occur together in situ.

4. The Berriasian in the Anglo-Greenland Province begins with the beds yielding *Subcraspedites* spp. and includes the Ryazanian stage. A stratigraphic scheme of the Kashpurian and Ryazanian stages and their proposed correlation with the Berriasian zones of the Submediterranean Realm is given in table 1. Lectostratotype and type-sections of the Ryazanian stage for the Russian Province are given in table 2.

5. The Pucksian stage of North Siberia is represented by a complete succession with underlying Jurassic deposits. It can be used as a type-section for correlation with the Berriasian.

6. Changes of faunal assemblages clearly mark the Lower Valanginian boundary in the Subboreal Realm. It can be used as a regional marking horizon for inter-regional correlation.

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