The Jurassic-Cretaceous Boundary in the East European Platform

Die Jura/Kreide-Grenze der osteuropäischen Plattform

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Abstract: On the basis of new ammonite information and analysis of data from the literature, the Jurassic-Cretaceous boundary is drawn at the top of the *nikitini*, *oppressus* and *variabilis* Zones in the Boreal Realm of Eurasia, and at the top of the *jacobi* and *chaperi* Zones in the Tethys. Considerable regional hiatuses occur across the Jurassic-Cretaceous boundary; different palaeogeographic basins are characterized mostly by endemic faunas. This makes the correlation of the Boreal and the Tethyan stages and zones difficult. It is useful to distinguish provisional stages such as Ryazanian and Kashpurian. The Volgian Stage as previously defined can be subdivided into two substages: the Gorodishchian (= Lower Volgian) and the Kashpurian (= Upper Volgian). The former is synchronous with the Tithonian, the latter with the lower zones of the Berriasian. The Berriasian *boissieri* Zone is synchronous with the Ryazanian Stage, which is characterized by the endemic faunas such as *Surites* and *Riasanites*.

Kurzfassung: Auf der Grundlage neuer Ammonitenuntersuchungen und Literaturdaten wird die Jura/Kreide-Grenze im borealen Bereich Eurasiens mit dem Top der *nikitini*-, *oppressus*- und *variabilis*-Zonen und in der Tethys mit dem Top der *jacobi*- und *chaperi*-Zonen gezogen. Beträchtliche Sedimentationslücken bestehen an der Jura/Kreide-Grenze in verschiedensten Gebieten; für die unterschiedlichen paläogeographischen Provinzen sind meist endemische Faunen charakteristisch. Dies erschwert die Korrelation der borealen und tethydischen Stufen und Zonen. Daher bietet sich der Gebrauch von regionalen Stufen, wie z. B. das Ryazanium oder das Kashpurium an. Die Wolga-Stufe kann in zwei Unterstufen unterteilt werden: die Gorodishche- (= Untere Wolga-Stufe) und die Kashpur- (= Obere Wolga-Stufe) Unterstufe. Erstere ist zeitgleich mit dem Tithon, letztere mit den unteren Zonen des Berrias. Die *boissieri*-Zone des Berrias ist zeitgleich mit der Ryazanium-Stufe, die durch eine endemische Fauna mit *Surites* und *Riasanites* charakterisiert ist.

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Introduction

Discussion of where to set up the Jurassic-Cretaceous boundary has lasted for over a century. It has been concerned with the terminology of the stages, and their ranges and chronostratigraphic positions. The reasons why the boundary is still under discussion are the absence of an international standard for definition of stratigraphic units, and lack of knowledge of the ranges of stages already adopted. In order to establish a reliable stratigraphic scale, we have followed the rules recommended by Nikitin (1881) and Arkell (1956):

(1) The boundary of a stratigraphic unit should be drawn to correspond to that of the stratotype, taking the latter as a standard.

(2) The principle of priority in chronostratigraphy and terminology should be recognized.
(3) The boundaries of stratigraphic units should generally not be changed as a result of investigations of the history of organic evolution, but where necessary, should be re-defined under the international agreements.
(4) The base of a stratigraphic unit should be defined by the incoming of a new zonal species or substitutional faunal assemblage, but not by the disappearance of earlier forms.

Stratigraphy

We have constructed a general stratigraphic scheme (Table 1) for the Jurassic and the lower part of Cretaceous System, which can be used for a world-wide correlation of zones and stages. Following the priority principle, the upper and lower limits of a stage should not be changed. The number of zones and subzones within a stage can, however, be revised and increased as a consequence of further investigations, especially if the stratotype represents a marginal facies sequence with erosional breaks. In such cases type-sections should be established for the zones which are missing in the stratotype of a stage.

In the case of regional stages and zones, certain conventions must be adopted in order to correlate sections from different paleogeographical basins.

The most complicated problem is the position of the Upper Jurassic and the Lower Cretaceous stages in the provisional and international stratigraphical schemes.

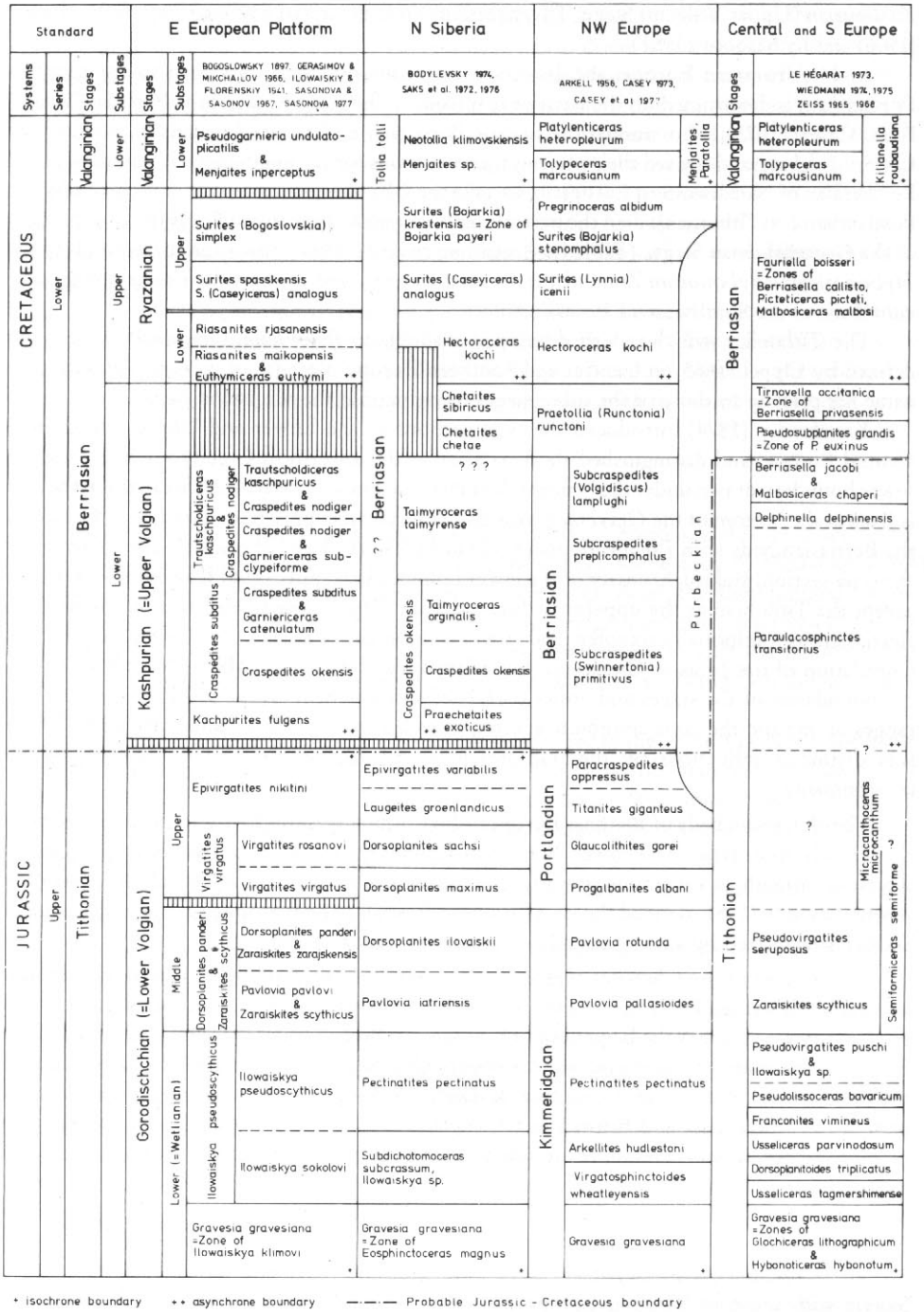
Gerasimov & Mikhailov (1966) proposed in the case of the Boreal paleogeographical Realm that the two previously adopted stages – the Lower Volgian and the Upper Volgian – be united into the one *Volgian* Stage, corresponding in their opinion to the "Volgian formation" established by Nikitin in 1881 for the whole sequence lying above the Oxfordian clays in the Volga basin. However, Nikitin introduced the name "Volgian formation" not for an independent stratigraphic unit but as a formal term, which he subdivided in his later paper (1884), into two stages, the Upper Volgian and the Lower Volgian. In 1886, Nikitin related these units to different facies, and excluded from the Lower Volgian the Kimmeridgian clays near the village of Gorodishche described by Pavlov (1886). Nikitin (1888) reported that the Upper Volgian is overlain by strata containing *Riasanites rjasanensis*.

The lectostratotype of the Volgian Stage near the village of Gorodishche, introduced by Gerasimov & Mikhailov (1966), is incomplete: part of the section was eroded during the Late Valanginian transgression, and the deposits of the *Trautscholdiceras kaschpuricus* and *Craspedites nodiger* Zones, the upper part of *Craspedites subditus* Zone, and the whole range of the Ryazanian and Lower Valanginian are absent. This section is therefore not a reliable lectostratotype for the whole range of Volgian deposits.

The Upper Volgian may correspond in age to the lower part of the Berriasian (Zeiss 1974). As pointed out by Nikitin & Chernishov (1889), one can observe a distinctive faunal difference between the Lower and Upper Volgian Stages in the Russian Plain. Nikitin (1888) considered them to be the transitional stages between the Jurassic and the Cretaceous.

In view of the above facts, it seems more reasonable at the present level of knowledge to adopt for the East European Platform the two traditionally-used provisional sub-units: the Lower Volgian and the Upper Volgian, but with the geographical names of their lectostratotypes – the Gorodishchian and the Kashpurian Stages respectively. This subdivision coincides with breaks in lithology and ammonite evolution. The section near Gorodishche can be recommended as a lectostratotype of the *Gorodishchian* (Lower Volgian) Stage, and the outcrop

Table 1. Correlation of the Jurassic-Cretaceous boundary beds in the Boreal and Tethyan Realms.



Read instead of MIKCHAILOV – MIKHAILOV; Gorodischchian – Gorodishchian; Pregrinoceras – Peregrinoceras; F. boisseri – F. boissieri; T. orginalis – T. originalis.

near the village of Kashpur (on the right bank of the Volga southward of Syzran) for the *Kashpurian* (Upper Volgian) Stage. These sections were described by Gerasimov & Mikhailov (1966) and by Sasonov (1951).

In Northwestern Europe, the Jurassic-Cretaceous boundary, assigned to the topmost *Portlandian,* is determined on the basis of ostracods in the middle part of the Purbeck (Weald) Beds. Casey (1973), who studied the marine Berriasian and Upper Portlandian beds of the Eastern England and revised their zonation, gave reasons for raising the upper boundary of the Portlandian of Northwestern Europe. If we take the *Gravesia gravesiana* Zone as the base of the Portlandian (= Tithonian), then the base of the Portlandian appears isochronous with the base of the Gorodishchian Stages (Table 1). According to Zeiss (1968), this zone corresponds to the *Hybonoticeras hybonotum* Zone of the Central Europe, and to the *Glochiceras lithographicum* Zone of the Southwestern Frankenalb.

The *Tithonian,* which is well developed throughout the whole Tethyan Province, was defined by Oppel (1865) in Central and Southern Europe. Because of its early definition, its name has priority to those of the other stages recognized at the top of the Jurassic.

Kovalevsky (1874) introduced the type sections of the Lower and Upper Tithonian in Central Europe, and distinguished the Berriasian as the lowermost Cretaceous stage, with its lower boundary drawn under the "ciment de la Porte de France" beds. The base of the Tithonian is fixed at the bottom of the *Gravesia gravesiana* Zone and its upper boundary lies at the base of the Berriasian beds with *Pseudosubplanites grandis.* On the basis of priority, completeness of the type section, and isochroneity of the lower boundaries (Oppel 1865; Kovalevsky 1874), we accept the Tithonian as the uppermost Jurassic Stage. The Lower Cretaceous begins with the Berriasian, as traditionally accepted, and as was recommended at the Lyon Colloquium in 1963. Correlation of the Jurassic-Cretaceous boundary beds is shown in Table 1. Asynchroneity of the boundaries of the stages and zones correlated in the scheme is the result of the different ranges of one and the same ammonite species, as well as of the rate of faunal migration (which was distinctly influenced by the transgressions and regressions, and by changes in the environment).

The *Berriasian* beds of the East European Platform correspond only to the upper zone of the French stratotype. The lower Berriasian boundary of the East European platform is therefore difficult to determine. Because the two bottom zones of the French Berriasian are absent, Sasonov (1951) defined the East European Berriasian beds as the provisional Ryazanian Stage, characterized by a peculiar endemic *Riasanites* fauna.

Correlation of the *Chetaites chetae* and *Ch. sibiricus* Zones of North Siberia still remains uncertain. Saks *et al.* (1972) have regarded the *Chetaites chetae* Zone as the topmost Jurassic and the *Ch. sibiricus* level as the beginning of Cretaceous. Bodylevsky (1974) treated the *H. kochi* Zone together with the *Ch. sibiricus* and probably *Ch. chetae* Zones as the Siberian equivalent of the *R. rjasanensis* Zone. If we accept Bodylevsky's (1974) opinion, then we might wonder what part of the Siberian section below the *Ch. chetae* Zone can be correlated with the Tethyan *grandis* and *occitanica* Zones. One can suggest that these zones correspond to a missing interval which is recognized in some parts of Northern Siberia between the *kochi* and *taimyrense* Zones, but the absence of such a gap in the Central part of Western Siberia makes this speculation questionable.

In the opinion of Saks & Janshin (1977), the correlation of the Berriasian beds of Northern Siberia with those of Western Europe, the East-European Platform and the Tethys is still unsatisfactory. These authors proposed that the Berriasian beds of Northern Siberia should be

distinguished as a new provisional *Packsian* Stage, though they did not specify either its range or the Lower boundary. We suggest that this boundary be drawn on the basis of the appearance of ?*Virgatosphinctes* at the base of the *Craspedites okensis* Zone, where a local hiatus is reported (Saks *et al.* 1976). In the past, this zone was assigned to the Jurassic on the basis of the presence of species referred to ?*Virgatosphinctes* from the Himalayan Tithonian. Further investigations have shown, however, that pronounced differences exist between the Himalayan and Siberian forms on the one hand, and the genus *Virgatosphinctes* on the other, in terms of suture line, whorl-section and ornamentation (the ribbing is distinctively inclined in the Himalayan specimens). Thus the Siberian ?*Virgatosphinctes could be recognized as a new genus, Praechetaites* n. gen. (type species: *V. exoticus* Schulgina, 1976), which is the forerunner of the genus *Chetaites.*

The genus *Praechetaites* n. gen. is typical of the Boreal Lower Cretaceous and the beds containing these ammonites can probably be correlated with the two lower Berriasian Zones of the Tethys. The need for the provisional Packsian Stage in Northern Siberia is then eliminated, and the Berriasian may be established as a worldwide stage with the above-mentioned range.

The Jurassic System

Gorodishchian Stage. The *Gravesia gravesiana* Zone at the bottom of this stage lies directly above the Kimmeridgian beds containing *Exogyra virgula.* Gerasimov & Mikhailov (1966) distinguished it as the *Ilowaiskya klimovi* and *Gravesia* sp. Zone, but they pointed out that *I. klimovi* also occurs together with *E. virgula* in Kimmeridgian deposits, described by them as bed 3. It seems more reasonable to separate deposits containing *E. virgula* and *I. klimovi* from those including only the representatives of *G. gravesiana,* and to distinguish the latter as an independent *gravesiana* Zone.

I. sokolovi and *I. pseudoscythica* Zones are recognized in the stratotype of the Wetlianian Stage along the bank of the Berdianka river and in the Gorodishchian section. Ilowaisky & Florensky (1941) accepted these zones as the provisional Wetlianian Stage. Deposits of Wetlianian Age are widely spread throughout the basin of the Middle and Lower Volga, in Poland and in Western Europe.

The *Dorsoplanites panderi* and *Zaraiskites scythicus* Zones appears to be present throughout the whole East European Platform.

The *Virgatites virgatus* Zone is subdivided into two subzones: a lower *V. virgatus* Subzone and an upper *V. rosanovi* Subzone.

The *Epivirgatites nikitini* Zone is identified only in the Povolzhie, Upper Kama and Pechora basins. It contains representatives of *Titanites* sp. and *Paracraspedites* sp. which migrated from Northwestern Europe. These genera constitute a faunal assemblage which can be correlated with the Tithonian and Portlandian genera of Western Europe. The genus *Epivirgatites* was widely distributed throughout the Boreal Province, where it comprised numerous substitutional species characterized by different ranges in various basins.

The Cretaceous System

Kashpurian Stage. This stage is divided into three zones: the lower *Kashpurites fulgens* Zone, the middle *Craspedites subditus* Zone with *C. okensis* and *C. subditus-Garniericeras catenulatum* Subzones, and the upper *Trautscholdiceras kaschpuricus* and *Craspedites nodiger*

Zone. The upper zone also consists of two subzones: the lower *Garniericeras subclypeiforme* (= *Craspedites mosquensis)* Subzone, and the upper *Trautscholdiceras kaschpuricus* and *Craspedites nodiger* Subzone.

The numerous specific representatives of the genus *Trautscholdiceras* inhabited the central part of the Russian sea. There is no evidence of their presence in the Canadian and North Siberian basins.

On the Russian Plain, the *K. fulgens* Zone contains rare, poorly preserved ?*Subcraspedites* sp. at its base. Considering that *Subcraspedites* is a typical Cretaceous genus, it is possible that the Jurassic-Cretaceous boundary occurs at the base of the *fulgens* Zone. At present, it is difficult to correlate the Kashpurian Stage with the contemporaneous deposits of Western Europe.

Berriasian Stage. This stage is subdivided into three zones in the Tethys: the lower *Pseudosubplanites grandis* Zone, the middle *Tirnovella occitanica* Zone and the upper *Fauriella boissieri* Zone.

At the beginning of the Berriasian, the East European Platform was part of the Eurasian continent. No deposits of the *grandis* Zone or the lower part of the *occitanica* Zone are known from the platform. Inclusion of the Kashpurian Stage or its upper part in the Berriasian has been suggested before (Casey 1973; Casey *et al.* 1977; Zeiss 1965, 1968). However, we consider the Kashpurian Stage as an independent stratigraphic unit with its particular assemblage of Boreal ammonites.

At the end of the *occitanica* time, the transgression penetrated from the North Caucasus basin through the Trans-Caspian basin to the central part of the Pre-Caspian depression and the Middle Povolzhie.

It is generally accepted that on the East European Platform, the *boissieri* Zone and the upper portion of the *occitanica* Zone are correlated with the Ryasanian Stage. This stage is divided into three zones: the lower *Riasanites rjasanensis* Zone, the middle *Surites spasskensis* Zone and the upper *Surites* (*Bogoslovskya*) *simplex* Zone. The Ryasanian Stage transgressively overlaps the stratigraphic succession from the Kashpurian down to the crystalline basement at the Northern slope of the Voronezh anticline. It is difficult to determine the duration of the break but the distinctive change in faunal content across it indicates that it was of considerable length. This break is also found in Western Siberia. The *rjasanensis* Zone is subdivided into two subzones. The lower *Riasanites maikopensis* Subzone consists of beds with *Euthymiceras* sp., *Neocosmoceras* sp., and *Fauriella* cf. *latecostata*. This fauna also occurs in the upper part of *occitanica* Zone.

The assemblage of ammonites of the Upper *Riasanites rjasanensis* s. str. Subzone includes *Hectoroceras kochi,* an emigrant from the Boreal Realm. *Surites spasskensis* or similiar species have not been found either in this subzone or in the coeval *kochi* Zone of Northern Siberia.

The *Surites spasskensis* Zone is characterized by a large number of species of *Surites, Peregrinoceras, Externiceras,* and other genera. At the bottom of this zone, redeposited phosphoritized *Riasanensis* sp. occasionally occur, but they are absent higher in the section. Near the village of Pekhorka, the composition of the faunal assemblage of this zone changes. Numerous *Surites poreckoensis, S. pechorensis, Bogoslovskia pseudostenomphala* and *Chandomirovia ilekensis* appear, together with rare *Surites spasskensis, S. kozakowianus, Caseyiceras caseyi* and *Peregrinoceras bellum.*

Gerasimov (1969) renamed the *spasskensis* Zone as the *S. tzikwinianus* Zone, considering it to be coeval with the *Tollia stenomphala* Zone. The latter had been established by Pavlov (1907)

at the base of the Valanginian, and was confirmed by Sasonov (1951). Pavlov and Sasonov did not report the presence of the species *S. spasskensis* and *S. tzikwinianus* in the *stenomphala* Zone. Applying the priority principle, and noting that Gerasimov (1969) did not define the range of this zone, we consider it more reasonable to retain the name *Surites spasskensis* for the middle zone of the Ryasanian Stage, and not to introduce a new name that would also contradict article IX.6 of the Stratigraphic Code of the USSR (1977).

The *Surites (Bogoslovskia) simplex* Zone occurs in the Menja basin and in the Pechora depression. It contains the following assemblage: *Surites* (*Bogoslovskia*) *pseudostenomphala, S.*(*B.*) *simplex, Stchirowskiceras (St.) principale, St. (St.) vylkoi, St.(St.) tumefactum, Stchirowskiceras (Suridiscus) subprincipale,* and *St. (S.) mischukoviense.* Detailed investigations have shown that typical Valanginian elements are absent from this zone, and thus it may be treated as an independent upper zone of the Berriasian, underlying beds containing Platylenticeratinae, and resting upon the *spasskensis* Zone. It is correlated with the *Surites (Bojarkia) stenomphala* and *Peregrinoceras albidum* Zone of Eastern England.

Valanginian Stage. The Berriasian-Valanginian boundary is marked by the appearence of Platylenticeratinae and numerous *Menjaites, Stchirowskiceras* and *Costamenjaites.* The *Pseudogarnieria undulatoplicatilis* Zone is correlated with the *Tollia tolli Zone* or the *Neotollia klimovskiensis* Zone of Northern Siberia. This correlation is based on the presence of identical assemblages of ammonites in these zones: *Stchirowskiceras (St.) vylkoi, St. (St.) tumefactum, Virgatoptychites trifurcatus* and *Menjaites* sp.. Bodylevsky (1974) has reported *Platylenticeras* cf. *gevrili* from boulders at Pankova Zemlja in Northern Siberia. Casey *et al.* (1977) have described *Pseudogarnieria* cf. *kurmyschensis* from beds with *Paratollia* in Eastern England, and typical *Menjaites* sp. from bed "D" of the English Speeton Clays. These facts indicate that ammonites can be used for zonal correlation in the Boreal Realm. The Platylenticeratinae Zone of Central and Northwestern Europe is correlated with the *Kilianella roubaudiana* Zone, or, according to Wiedmann (1975) with the *Thurmanniceras thurmanni* Zone of the standard sequence.

Systematic Palaeontology

Genus *Praechetaites* n. gen.

Type species: *Virgatosphinctes exoticus* Schulgina, 1967, t. IV, f. 1.

Remarks: Uhlig (1910) described the genus *Virgatosphinctes* from the Upper Kimmeridgian-Tithonian of the Himalayas (type species: *V. broilii* Uhlig 1910). *V. broilii,* at a diameter of 110 mm, is moderately evolute, with rounded to slightly compressed whorls. Dense, elevated ventral ribs with slight forward inclination are interrupted by several deep grooves. The ribs trifurcate at mid-flank, forming bundles of the virgatotome type. One or two intercalatories are separated from the primary bundles. Ribbing is defined up to diameters of 110–120 mm. The suture-line is strongly ascending, the lobes long and narrow. The first lateral lobe ends with a sharp peak and has the same length as the ventral lobe. Schulgina (1967) has described species from the *Craspedites okensis* and *Taimyroceras taimyrense* Zone of the Northern Siberia, and referred them to the genus *Virgatosphinctes.* The species *exoticus* was chosen as the type species of these Siberian ammonites. The holotype is 110 mm in diameter, moderately involute (umbilicus is 33 % of the diameter). The whorl height is 35 % of the diameter. The whorl section is oval and more elongated in the younger whorls. No grooves interrupt the ribs; this is the

notable difference between *V. exoticus* and the ammonites described by Uhlig. Ventral ribs are well defined up to 50 mm diameter; above this, they gradually disappear and the shell becomes smooth at 70 mm diameter. In the suture line, the lateral lobe is considerably shorter than the ventral one; beyond the lateral lobe the suture line sharply bends to an angle of 45° with the umbilical edge. These characteristics show that ammonites of the *exoticus* group cannot be attributed to the genus *Virgatosphinctes*. They are instead treated as a new genus *Praechetaites*. This genus is restricted to the lower beds of the Berriasian of Northern Siberia, here referred to the lower Cretaceous.

Conclusions

Investigations of the development of ammonites in the marine environment of the East European Platform during the Jurassic-Cretaceous transitional period allow us to distinguish 6 phases in their evolution.

The first phase – Early Gorodishchian (Wetlianian) – is characterized by the genus *Ilowaiskya*, with representatives of *Pseudovirgatites* and *Subplanites* known from the Middle European basins.

The second phase occurs in the Middle and Late Gorodishchian when there existed such descendants of *Ilowaiskya* as *Zaraiskites, Virgatites* and *Epivirgatites*, and the related genera *Paracraspedites* and *Lomonossovella*.

The third phase occurs in the Kashpurian, when a sharp biological explosion altered the development of ammonites, and resulted in the appearance of forms previously unknown either in the Tethys or in the Middle European seas (e.g. the families Craspeditidae and Garniericeratidae, and the genus *Kachpurites* endemic to the Russian sea). All these forms died out at the end of Kashpurian Age, except rare *?Subcraspedites* sp., which has been reported from the bottom of the *K. fulgens* Zone of Kashpurian Stage.

The fourth phase begins with a transgression during which *Riasanites, Neocomites, Euthymiceras*, etc. entered the Russian sea from the North Caucasus basin.

The fifth phase is defined by the flourishing of the family Suritidae (12 genera, 60 species), the first forms of which appeared in the *rjasanensis* Zone. These are the typical Lower Cretaceous ammonites (Sasonova 1977). They quickly spread throughout the Boreal Realm, including the Canadian and Greenland basins. They passed through the Brestian Strait to the Polish and Middle European seas, while in the Tethyan the Berriasellidae continued as the dominant group.

The forth and the fifth phases occur in the Ryasanian Stage, which is known throughout the Boreal Realm. The Upper Ryasanian boundary is isochronous with the Upper Berriasian boundary. In Northern Siberia, the Berriasian probably includes beds ranging from the top of the *Epivirgatites variabilis* Zone to the bottom of the Valanginian.

The sixth phase is defined by the appearance of *Platylenticeras* at the beginning of the Valanginian: the assemblage still includes the members of the family Suritidae: *Menjaites, Paratollia* and *Tollia*.

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