INTRODUCTION

It would be no overstatement to say that future positioning of the Jurassic–Cretaceous boundary in Boreal sections depends on stratigraphic “fortune” of the upper Volgian Substage. It was exactly this unit proposed by Casey (1963) to be transferred from the Jurassic to the Cretaceous System. In his opinion, such a “shift” should solve the problem of Boreal–Tethyan correlation between the Tithonian and Volgian stages. This idea first gained no support of specialists. It appeared to be attractive nevertheless, and soon Kutek and Zeiss (1975) backed this proposal based on co-occurrence of Boreal and Subtethyan ammonites in the lower–middle Volgian boundary beds of Poland. During many years, Zeiss (1979, 2003) agitated for placing the lower boundary of the Cretaceous System at the base of the upper Volgian Substage (base of the Kachpurites fulgens Zone) in the Boreal realm instead of the eastern European platform have been found, is referred to the middle Volgian Substage. Newly found ammonites are figured. Two possible positions of the Jurassic–Cretaceous boundary in the Arctic region, i.e., at the lower and upper boundaries of the Chetae Zone at the top of the upper Volgian Substage, are discussed.

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Key words: Volgian Stage, upper Volgian Substage, ammonites, biostratigraphy, Jurassic–Cretaceous boundary, northern Siberia, Panboreal correlation.
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- **Taimyrspinhites ?sp.**
  - **Epivirgatites variabilis**
  - **Epilaugeites vogulicus**
    - **Laugeites sp. juv.**
    - **Laugeites sp. nov. aff. parvus** (= *L. parvus* in Kiselev & Rogov, 2005)
    - **Praechetaires exoticus**
    - **Praechetaires cf. bicostatus [M]**
    - **Laugeites sp.**
      - **?Praechetaires sp.**
      - **“Lytoceras” sp.**
    - **Pseudophylloceras cf. knoxvillense**
    - **Craspedites okensis**
    - **?Laugeites sp. (=Jeletzky, 1965, pl. VIII, f. 7)**

  *Craspedites canadensis*
  *Chetaites sp. (cf. chetae)*

  - *Praetollia despár*
  - *Praetollia maynci* 
  - *Chetaites sp. nov. [M]* 

  - *Chetaites sibiricus*
  - *Craspedites cf. canadensis*
  - *Praetollia contigua*

  - *Craspedites sp. ind.*
    - *Chetaites cf. sibiricus*
    - *Hectoroceras kochi*
    - *Boreiophylloceras sp.*
    - *Bochianites cf. glennensis*
    - **“Lytoceras” sp.**
    - *Praesurites sp. juv.*
THE UPPER VOLGIAN SUBSTAGE IN THE ARCTIC REGION

Ammonites of the Boreal family Craspeditidae (*Kachpurites, Craspedites, Subcraspedites, Volgidiscus, Schulginites, Garniericeras*) are of key significance for biostratigraphy of the upper Volgian Substage in the Arctic region. Based on succession of Craspeditidae species, the upper Volgian Substage is subdivided into zones and subzones. The substage top only is defined in northern Siberia by occurrence of *Chetaites chetae*, a representative of the family Dorsoplanitidae, while Craspeditidae were widespread in the Arctic region up to the Hauterivian.

First Craspeditidae from the Arctic region (Subpolar Urals, Tol’ya River) were probably described by Eichwald (1865–1868) as *Ammonites sagitta*, *A. septentrionalis (= Craspedites cf. okensis)*, and *A. catenulatus (= Shulginites cf. tolijensis)*. At the end of the 19th century, E.S. Fedorov collected here additional samples with ammonites. S.N. Nikitin, who studied his collection of Mesozoic fossils, identified among them *Oxynoticeras (= Shulginites) tolijensis* and suggested the late Volgian age of this taxon (Nikitin, 1884). V.I. Bodylevskii, who defined the upper Volgian Substage in the Tol’ya River basin and established the *Fulgens* Zone in Novaya Zemlya and Subpolar Urals, was first to determine *Craspedites okensis* and *Kachpurites* from the latter region (Bodylevskii and Kiparisova, 1940).

In the early 1920s, *Craspedites* were found in Spitsbergen by Spath (1921), although examination of that ammonite collection stored at the Natural History Museum of London showed that his identification was erroneous. Subsequently, Spath himself (1924) considered the *Craspedites* forms he described as the Cretaceous (infra-Valanginian) ammonites. Later on, *Craspedites* from this area were described and figured by Frebold (1930) and Ershova (1969).

Bodylevskii (1936) was next to report on *Craspedites* from Novaya Zemlya. He described also the new genus Taimyroceras from the upper Volgian sediments of northern Siberia (Bodylevskii, 1956), although now it is considered as a subgenus of the genus *Craspedites*. Subsequently *Taimyroceras* was discovered in the Yenisei Depression (Bodylevskii and Shul’gina, 1958). First data on occurrence of this genus in the upper Volgian sediments of the Khatanga Depression and Nordvik Peninsula appeared at that time as well (Saks et al., 1959). Then a complete succession of biostratigraphic ammonite units of the upper Volgian was established in northern East Siberia (Saks et al., 1965; Basov et al., 1970; Zakharov et al., 1983; Shul’gina, 1985; and others). Spath (1936) reported first on the upper Volgian Craspeditidae and *Subcraspedites* from eastern Greenland, and later on they were found here on the north (Peary Land, Häkansson et al., 1981). In the early 1960s, Craspeditidae were found in Arctic Canada (Jeletzky, 1965) and slightly later in northeastern Russia (Parakvetov, 1970). The upper Volgian *Craspedites* occur also beyond the Arctic region: they are frequently dominate among fossils in Boreal areas of Europe (East European platform, the North Sea, eastern England).

The upper Volgian Dorsoplanitidae are distributed mostly in Arctic regions. An exception is the genus *Chetaites* occurring also in the East European platform. This ammonoid group studied insufficiently is of prime importance for defining boundaries of the upper Volgian Substage.

THE VOLGIAN STAGE SCOPE ACCORDING TO NEW AMMONITES FOUND IN THE CAPE URDYUK-KHAYA (NORDVIK PENINSULA)

In the Nordvik Peninsula, the Volgian Stage is represented by part of the middle and complete upper Volgian sub stages. We found new evidence for occurrence of an equivalent of the middle Volgian *Taimyroshpinctes* (*Taimyroshpinctes*) *excentricus* Zone in this area and for correspondence of the *Pruechetaites* *exoticus* Zone to the middle Volgian Substage.

In the Cape Urdyuk-Khaya, many fossils were found in talus and should be used for solving stratigraphic problems with a great caution. Nevertheless, ammonites found previously facilitate recognition of a complete succession of the upper middle Volgian to lower Valanginian zones (Zakharov et al., 1983; Bogomolov, 1989; and others). The fossils (largely, ammonites and belemnites) were sampled with the reference to particular marker beds (levels 1A–C, 2B–D in the section) and simultaneous correlation with previously defined beds (Zakharov et al., 1983).

The lower Volgian ammonites have not been found in the Nordvik section so far. All the middle Volgian forms of stratigraphic significance, except for rare specimens, were sampled from talus. Some of them suggest occurrence of sediments underlying the *Variabilis* Zone that was previously assumed based on occurrence of *Dorsoplanites* sp. (Zakharov et al., 1983). We found also several small ammonites, which can be referred to *Taimyroshpinctes* (*Udshashpinctes*) sp. (Plate II, fig. 4) based on peculiar ornamentation (very frequent ribs slightly inclined anteriorly and

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**Fig. 1.** The Jurassic–Cretaceous boundary section of the Nordvik Peninsula (Cape Urdyuk-Khaya), stratigraphy after Zakharov et al. (1983) and Zakharov and Rogov (2006); all the ammonites, except for designated by asterisk, are found by authors; marker horizons 1A–C and 2B–D (field observations by Rogov) and bed numbers after Zakharov et al. (1983) are designated in columns marked by one and two asterisks respectively: (1) dark gray argillite-like clay; (2) phosphate–carbonate concretions; (3) bed enriched in glauconite.

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diverging in two or three branches less commonly) and shape of their shells (high-oval cross section of whorls with flattened ventral side, stepwise umbilicus, and abrupt uncoiling). An impression of such a form was found 0.3 m below Bed 2D. In distinction from all the known representatives of the genus (Mesezhnikov, 1972, 1984b), the found form exhibits a very early uncoiling and slightly rounded cross section. Although remains of Taimyrspinctes occur in the Subpolar Urals (Zakharov and others, 1983), the species are quite different. All of them except Laugeites with ornamentation of ribs in the ontogenesis, ornamentation preserved on the body chamber), these Laugeites forms (Plate II, fig. 3) are identical to L. planus described by Mesezhnikov from the Subpolar Urals (Zakharov and Mesenzhnikov, 1974), where this species characterizes basal part of the Groenlandicus Zone. The Laugeites forms found stratigraphically above the last occurrence of Epivirgatites are quite different. All of them, except for a single pyritized mold (Plate II, fig. 6) and ammonite from a concretion, are represented by deformed impressions suitable only for examination of ornamentation details. It is also remarkable that Laugeites with early disappearing ornamentation (Plate I, figs. 3, 8) was found along with Praechetaites, which has in contrast the body chamber with distinct biplicate ribs (= Virgatosphinctes bicostatus, Zakharov et al., 1983, Plate II, fig. 1), in the Exoticus Zone (its position and correlation are discussed below). These Praechetaites forms should probably be attributed to a new species since they are represented, in contrast to the type series of P. bicostatus, by macroconchs with substantially smoothed ornamentation on early whorls. Laugeites forms from the interval in question are similar to ammonites from the Nikitini Zone of the Gorodishchi section, where they co-occur with early Kachpurites. We identified these forms with L. parvus (Kiselev and Rogov, 2005). Their comparison with L. parvus from Greenland and Taimyr (Donvan, 1964; Mesezhnikov, 1984b) shows that, despite some features in common, ammonites from Taimyr and Middle Volga region are significantly larger in size and ribbing on their shells disappears earlier and rapidly. Moreover, it seems that two morphotypes have different stratigraphic positions, since some specimens from the L. parvus type series originate from the Crendonites anguinus Zone (Fauna 46b, Birkeland et al., 1984), while the others are from the Groenlandicus Zone, i.e., they are a fortiori older than ammonites of the Vogulicus Zone. A specimen of Laugeites found in talus shows even earlier disappearance of ornamentation (Plate II, fig. 7; Fig. 2, C). This specimen is similar to Laugeites sp. nov. known from uppermost layers of the Nikitini Zone of the East European platform (Kiselev and Rogov, 2005). Several small Praechetaites exoticus (Plate II, fig. 1) and Praechetaites cf. exoticus with more evolve coiling (Plate I, fig. 5) have been also found close to the designated level. Specimens of P. tenuicosatus (Shulg.) sampled from the talus (Plate I, figs. 2, 6) are most likely confined to a close stratigraphic level.

Ammonite with unusually rough ribs (Plate I, fig. 1) found in a concretion from talus originates most likely from the Exoticus Zone or basal part of the Okensis Zone. In its ornamentation, this specimen certainly differs from Epivirgatites, Epilaugeites, Laugeites, and Praechetaites species. Having course, sharp, widely spaced ribs with a high bifurcation point, it resembles some Lomonossovelia forms being most close to the genus Glottopychinites from England (Buckman, 1909–1930, Plates CDIII, DCCXVII; Subcraspedites sp. in: Gerasimov, 1969, Plate XXX, fig. 3) that is characteristic of the middle–upper Volgian boundary beds (Casey, 1973; Kiselev and Rogov, 2005).

Basal part of the Okensis Zone yielded a small ammonite shell ornamented with ribs in lower part of lateral side only (Plate I, fig. 7). According to this feature, it resembles a form from uppermost part of the

Plate I. Volganian ammonites from the Nordvik Peninsula. All the specimens pictured in plates I and II are stored at the Vernadsky Geological Museum (Moscow), Collection no. 00. Hereinafter, scale bar is 1 cm.

(1) Glottopychinites sp., MK959, talus of Outcrop 33, middle Volganian Substage; (2, 6) Praechetaites tenuicosatus (Shulg.), talus of Outcrop 33, middle Volganian Substage, Exoticus Zone; (2) MK1033, (6) MK1032; (3) Laugeites cf. parvus Donovan, MK994, Outcrop 33, 2C155; middle Volganian Substage, Exoticus Zone; (4) Epivirgatites variabilis Shulg., middle Volganian Substage, Variabilis Zone, MK1028, talus of Outcrop 33; (5) Praechetaites cf. exoticus (Shulg.) [m]; middle Volganian Substage, ?Exoticus Zone; (3) MK1004, Outcrop 32, 1A1990; (7) Praechetaites sp., MK1148, Outcrop32, 1A1947; middle Volganian Substage, Exoticus Zone; (8) Laugeites aff. parvus Donovan (= parvus in Kiselev and Rogov, 2005) [M], MK1081, Outcrop 33, 2C1123; middle Volganian Substage, Exoticus Zone.
middle Volgian Substage of Canada, which was determined as *Laugites* sp. (Jeletzky, 1965, p. 23, Plate VIII, fig. 7). On the other hand, the early disappearance of ribbing is characteristic also of some *Prachetaites* (Shul’gina, 1967, Plates I–III) and *Subcraspedites* species (Abbink et al., 2001, Figs. 4B, 4E). We identified this specimen as *Prachetaites* sp.

Many new ammonites have been found in lower part of the Ryazanian Stage lower part. We managed to prove occurrence of *Practoilla* at the stage base. Approximately 3 m higher in the section, we collected predominantly *Chetaites* and *Practoilla* species (Plate II, figs. 2, 8, 9). In the first genus, we distinguished two forms each likely belonging to new species. One of them is represented by a half of very large shell with widely spaced ribs (Plate II, fig. 9). According to this feature, this form sharply differs from ammonites of the *Chetaites sibiricus* type series that includes only microconchs with the largest shell diameter less than 8 cm (Shul’gina, 1962). In addition, we found small *Craspedites* forms near the *Sibiricus–Kochi* boundary, which are similar to ammonites described earlier from Bed 23 of the Exposure 33 (Zakharov et al., 1983, Plate IV, figs. 5–7) and differ from typical representatives of the *sibiricus* species owing to earlier appearance of tripartite ribs with splitting rib bunches (Plate II, fig. 8).

Despite the convincing evidence of last decades that *Craspedites* occur in basal layers of the Ryazanian Stage (Zakharov et al., 1983; Mesezhnikov, 1984a; Shul’gina, 1985), these ammonites were never described and figured. We found a well-preserved *Craspedites* specimen very similar to *C. canadiensis*. In addition, we found small *Chetaites* forms near the *Sibiricus–Kochi* boundary, which are similar to ammonites described earlier from Bed 23 of the Exposure 33 (Zakharov et al., 1983, Plate IV, figs. 5–7) and differ from typical representatives of the *sibiricus* species owing to earlier appearance of tripartite ribs with splitting rib bunches (Plate II, fig. 8).

An unusual ammonite assemblage and first *Hectoroceras* discovered in basal part of the *Kochi* Zone. Like the assemblage from the *Exoticus–Okenis* boundary layers, this one includes lytoceratids and phylloceratids (Rogov, 2004). In addition, a small ammonite resembling *Bochianites glemensis* Anderson from California is a component of this assemblage. This may be an indication of direct connections between the Arctic and Pacific oceans that were previously assumed for the Valanginian time (Saks et al., 1984). Another very important record is a small *Praesurites* found stratigraphically above the occurrence level of *Hectoroceras kochi* (Plate II, fig. 10). Until recently, it was thought that representatives of this genus are characteristic of the concurrent *Sibiricus* (Subpolar Urals) and *Runcitori* (England) zones (Casey et al., 1988). Mita (2005) assumed the same age for *Praesurites* forms from the Ryazanian Stage of the East European platform too. Later on, he reported on co-occurrence of this and *Hectoroceras* genera (Mita, 2007). Shul’gina (1985) mentioned *Surites nikitini* (= *Praesurites*) from the *Kochi* and *Analogus* zones of northern Siberia.

**ZONATION AND PANBOREAL CORRELATION**

**VOLGIAN STAGE**

**Middle Volgian Substage**

*Taimyrosphinctes excentricus* Zone (Mesezhnikov in Saks, 1976)

The zone, which is conditionally defined in the section of the Cape Urduyk-Khayaa based on finds of *Taimyrosphinctes* (Udschaspincthes) sp. and *Dorsoplanites* sp., likely corresponds to the upper part of Bed 7 in the Exposure 33 (Zakharov et al., 1983). Species characteristic of this zone occur also in underlying (*Dorsoplanites*) and overlying (*Taimyrosphinctes, Prachetaites*) strata. Thus, the zone lacking *Laugites* and *Epivirgatites* forms is above the *Maximus* Zone, which is correlated with the *Pseudoapertum* Zone of Greenland based on occurrence of *D. maximus* and *D. gracilis* (Callomon and Birkeland, 1982).

*Epivirgatites variabilis* Zone (Saks et al., 1968)

The zone is reliably recognized based on index species found in beds 7–9, Exposure 33. Although the early *Laugites* have not been found in these beds, it is admissible to think that specimens sampled from talus originate from lower part of the *Variabilis* Zone. In the East European platform, ammonites close to *E. variabilis* are known from the *Nikitini s.l.* Zone (Ivanov et al., 1987, p. 56, Plate 5, fig. 1: Kiselev et al., 2003, Plate 33, figs. 1, 5, 6). In the *lahuseni* faunal horizon of the Gorodische section, “*Paracraspedites*” sp. Occur in association with ammonites resembling *E. variabilis* (Kiselev and Rogov, 2005). Judging from the fact that late *Laugites* occur in the *Exoticus* Zone of the section under consideration, it is reasonable to assume that stratigraphic range of *E. variabilis* in the East European platform corresponds to upper part of this unit in Siberia. The *Variabilis* Zone top corresponds approximately to boundary between the *lahuseni* and *nikitini* faunal horizons in the stratotype.

**Plate II.** Volgian and Ryazanian ammonites from the Nordvik Peninsula.

(1) *Prachetaites exoticus* (Shulg.), MK1778, Outcrop 33, 2C 135; middle Volgian Substage, *Exoticus* Zone; (2) *Practoilla contigua* Spath., MK1069, Outcrop 32, 1A 200; Ryazanian Stage, *Sibiricus* Zone; (3) *Laugites planus* Mes., MK1022, Outcrop 32, talus, middle Volgian Substage; (4) *Taimyrosphinctes* (Udschaspincthes) sp., MK1030, Outcrop 32, talus; (5) *Epivirgatites variabilis* Shulg., middle Volgian Substage, *Variabilis* Zone, MK 1114, 2B 170; (6) *Laugites* sp. juv., MK1093, Outcrop 33, 2C 110; middle Volgian Substage, *Exoticus* Zone; (7) *Laugites* sp. nov. (=cf. *parvus* in Kiselev and Rogov, 2005), Outcrop 32, talus; (8a, 8b) *Chetaites* cf. *sibiricus* Shulg., MK1146, Outcrop 32, 1C 10, *Sibiricus* Zone; (9) *Chetaites aff. sibiricus* Shulg., [M], MK1009, Outcrop 32, 1A 50; Ryazanian Stage, *Sibiricus* Zone; (10) *Praesurites* sp., MK1018, Outcrop 32, 1C 30, *Kochi* Zone.
"Despite the fact that basal part of the upper Volgian or uppermost part of the Craspedites okensis Zone of the Subpolar Urals, although its equivalents are not established there so far. The Exoticus Zone corresponds to the Praechetaites tenicostatus Beds in Greenland and Spitsbergen (Surlyk, 1978; Ershova, 1983), and this is confirmed by field observations in Spitsbergen (Rogov, 2007).

Upper Volgian Substage

Craspedites okensis Zone (Saks et al., 1965, emend Baraboshkin, 2004)

We did not obtain new data on correlation of the Okensis Zone, its position in the Nordvik section, and possibility to subdivide it into subzones were. Basal layers of the zone bear Pseudophyllloceras knoxvillense also known from Alaska and California. A close stratigraphic level yielded Praechetaites sp. very similar to Laugeites? sp. indet. from Canada (Jeletzky, 1965),

1 These are species Buchia tenuicolis close to upper Volgian B. piochi and B. fisheriana first occurring in the Maximus Zone (Zakharov, 1981). Judging from lists of fauna, they were identified as the upper Volgian B. terebratuloides and B. lahuseni (Saks and Sanin, 1976).

2 When discussing migration routes of the late Volgian ammonites, Baraboshkin (2004) assumed that C. okensis migrated very quickly eastward from the East European platform and almost synchronously appeared in the regions under consideration.
where it occurs also in the upper part of the middle Volgian Substage, was not discussed.

*Craspedites taimyrensis* Zone (Shul’gina in Saks et al., 1963)

No ammonite taxa characteristic of this zone were found in the study section. It was long believed that the zone is an equivalent of the *Nodiger* Zone in the East European platform. According to alternative assumption, its lower subzone only corresponds to the *Taimyrensis* Zone (Mesezhnikov et al., 1983; Baraboshkin, 2004). In our opinion, the variant by Shul’gina (1985) is more correct for the following reasons. First, *Craspedites psedonodiger* occurs in both the *Taimyrensis* Zone of the Khatanga River basin and the *Nodiger* Zone of Kachpir (Shul’gina, 1969). Our observations showed that this species is confined in the latter area to a narrow interval within the upper *Nodiger* Subzone. Second, in layers above the *Nodiger* Zone (*Volgidiscus singularis* Beds), Kiselev (2003) found ammonites, which are close to *Volgidiscus* from the *Subcraspedites mauryeniensis* Beds of the Subpolar Urals (Casey et al., 1988).

*Chetaites chetae* Zone (Shul’gina in Saks et al., 1963)

Stratigraphic position the *Chetae* Zone was topic of discussions because of transitional morphology of ammonites occurring in this unit. Based on distribution of the upper Volgian *Craspedites (Taimyroceras)* and “*Vrgatosphinctes*”, this zone was attributed to the upper Volgian Substage (Saks et al., 1968, 1969; Shul’gina, 1969). Bodylevskii (1974) and then Sazonova and Sazonov (1979b) argued that both *Chetaites* zones are the Cretaceous in age. Considering ammonite assemblages from the *Chetae* and *Sibiricus* zones, it is difficult to find unambiguous solution with due account for currently known distribution of ammonites. In the *Sibiricus* Zone, ammonites attributed to the genus *Craspedites* have been found recently in association with *Praetollia* forms of the Lower Cretaceous. Characteristic of both zones are widespread genera *Volgidicus* and *Praetollia*, which provide a reliable Panboreal correlation.

**RYAZANIAN STAGE (BOREAL BERRIASIAN)**

*Chetaites sibiricus* Zone (Shul’gina in: Saks et al., 1963) = *Praetollia maynci* Zone (Surlyk, 1978)

Owing to previous detailed sampling (Shul’gina, 1972; Zakharov et al., 1983), boundaries and characteristic ammonite species of the zone are well known. We collected additional *Chetaites* and *Praetollia* specimens and refined stratigraphic range of the latest *Craspedites* forms. It is remarkable that *Craspedites* forms from the zone are very close to counterparts from the upper Volgian (Plate II, figs. 3, 5).

Although the zone is subdivided in two subzones in many sections of the Panboreal Supererealm (Alekseev, 1984; Casey et al., 1983), this is impossible so far in the Nordvik section. Moreover, the main criterion used for subdivision (absence of *Praetollia* in the upper subzone) is questionably valid. At any rate, the section studied (Zakharov et al., 1983) and sections of eastern Greenland (Surlyk et al., 1973) contain joint records of *Praetollia* and *Hectoroceras* forms. Based on ammonites found in the Nordvik section, it is possible to
Correlation of middle Volgian-Ryazanian sediments from different areas of the Panboreal Superrealm

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Note. The Tithonian–Berriasian boundary based on paleomagnetic data (Housa et al., 2007); (2, 3) two possible positions of the boundary between the Volgian Stage and Boreal Berriasian intervals directly correlative based on ammonites.

Central areas of the East European Platform (Mitta, 1993, 2007; Baraboshkin 2004; Kiselev and Rogov, 2005, with modifications)
Northern Siberia (Mesezhnikov, 1984; Casey et al., Zakharov and Rogov, 2006)
Subpolar Urals (Mesezhnikov, 1984; Casey et al., 1988)
Eastern Greenland (Surlyk et al., 1973; Callomon and Birkelund, 1982; Birkelund et al., 1984), with additions
define both the Sibiricus and Maynci zones of equal stratigraphic ranges.

Hectoroceras kochi Zone (Spath, 1952)

The Kochi Zone is recognized only in basal part (approximately 0.5 m) of the section. Small Praesurites form was found here in addition to Hectoroceras and some other stratigraphically insignificant ammonites (Bochianites, Boreiophylloceras, “Lytoceras”). Despite small size, the form is readily attributable to the genus.

JUASSIC–CRETACEOUS BOUNDARY IN ARCTIC REGIONS

In northern Siberia, the Jurassic–Cretaceous boundary is traditionally defined between the Chetaites che- tae and Chetaites sibiricus zones (Saks et al., 1963, 1965). In the East European platform, the type region of the Volgian Stage, the Nodiger Zone was long consid- ered as the uppermost zonal unit of the Volgian Stage. It has been shown recently, however, that the last zone is overlain by sediments containing Volgidiscus (Kiselev, 2003) and Chetaites probably (Mitta, 2005). According to magnetostratigraphic data, the base of the Tethyan Berriasian (= the Jacobi Zone base) corre- sponds in the Nordvik section to the level inside the upper Volgian Taemyrense Zone, while the boundary between the Chetae and Sibiricus zones is inside the Jacobi Zone (Houša et al., 2007). In turn, the Taemyrense Zone is correlative in its whole range with the Nodiger Zone (Shul‘gina, 1985).

One of two levels, either the base or top of the Chetae Zone may represent the Jurassic–Cretaceous boundary in Arctic regions. Each of the levels has its advantages. In the case of the boundary defining in the Tethyan Realm at the base of the Jacobi Zone, we would see both levels slightly above it, though within one zone of the Tethyan ammonoid and calpionellid zonations.

The Chetae Zone base is closer to the Jurassic–Cretaceous boundary in the Tethyan Realm and very close to its traditional position in the East European platform, the type region of the Volgian and Ryazanian stages.

The level of the Chetae Zone top has other advan- tages. First, the zone top corresponding to the first occurrence level of Praetollia distributed throughout Arctic regions is of a high correlation potential. Sec- ond, the Sibiricus zone base is at the level of iridium anomaly well recognizable in Arctic sections from the Barents shelf to northern Siberia (Zakharov et al., 1993; Dyvpike et al., 2006).

CONCLUSIONS

Section of the Nordvik Peninsula spans the com- plete succession of Jurassic–Cretaceous boundary zones from the uppermost middle Volgian to the Boreal Berriasian. Ammonites occurring in the section have wide geographic and narrow stratigraphic ranges and enable direct correlation of the studied succession with concurrent successions in other Arctic areas and bound- ary zones of the Panboreal Superrealm in general.

The Exoticus Zone containing ammonite taxa char- acteristic of the Nikitini Zone upper part in the East European platform is attributed to the middle Volgian Substage. Pelagic ammonoids (primarily, phyllocer- atids) occurring in the middle–upper Volgian boundary strata and in basal layers of the Kochi Zone offer opportunity to consider these levels as event markers charac- terizing a brief episode of enhanced connections between the Arctic and Pacific oceans.

Like their equivalents in the Subpoaral Urals and East European platform, the middle and upper Volgian substages in the Nordvik Peninsula are lacking significant hiatuses recognizable by biostratigraphic methods. This is evident from occurrence of the same or close ammonoid assemblages throughout spacious regions, which were remarkably successive in terms of phylog- eny during the middle–late Volgian time.

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Reviewers D.N. Kiselev and V.V. Mitta

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