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Biostratigraphic Scheme of the Carnian and Lower Norian in NE Russia. Paper 2. New Zonal Scales and Correlation

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New detailed zonal scales for the Carnian and Lower Norian in northeast Russia are suggested. On the basis of ammonoids, the following have been distinguished in the Lower Carnian: *Stolleyites tenuis* zone, beds with *Neosirenites aculeatus*, the zones "*Protrachyceras" omkutchanicum, Yanosirenites buralkitensis, Neoprotrachyceras seimkanense* and *Neosirenites armiger*; in the Upper Carnian, the zones *Yakutosirenites pentastichus, Sirenites yakutensis* and *Striatosirenites kedonensis*; in the Lower Norian, the zones *Striatosirenites kinasovi* and *Pinacoceras verchojanicum*. The last zone comprises beds with *Norosirenites nelgehensis* and beds with *N. obrucevi*. Nautiloids aided division of the Carnian into the zones *Proclydonautilus anianiensis*, *Cosmonautilus polaris* (with the subzones *Cosmonautilus polaris* and *Proclydonautilus goniatites*) and *Proclydonautilus pseudoseimkanensis*. In the Lower Norian the zone *Proclydonautilus seimkanensis* has been distinguished, which is divided into the subzones *P. spirolobus* and *P. seimkanensis*. A description of biostratons is offered, and correlation of ammonoid and nautiloid scales are given. Correlation was made of the Carnian and Lower Norian in NE Russia, Svalbard, Arctic Canada, British Columbia, and Eastern Alps. The position the Carnian-Norian boundary in NE Russia in the base of the *kinasovi* zone is substantiated by the presence of ammonoids in the zone *Striatosirenites kinasovi*, which are also common in the zone *Stikinoceras kerri* in British Columbia.

INTRODUCTION

The first biostratigraphic schemes of the Upper Triassic in northeast Russia developed by L.D.Kiparisova[20], I.I.Tuchkov [28-30], and Yu.N.Popov [25] distinguished beds with the ammonoids *Protrachyceras, Sirenites, Neosirenites, Striatosirenites* and the bivalve mollusks *Halobia* as a single sundivision (Table 1) first as a bed, then as a zone. Judging by its paleontological characteristics, this

Table 1 Division of Carnian and Lower Norian (according to different authors).

Kiparisova [20]	Tuchkov [28, 29]	Popov [25]	Archipov [1]	Archipov *et al.* [3,32]		Dagys *et al.* [15]		Bytschkov and Polubotko [13]	
Beds with *Sirenites* и *Halobia*	*Sirenites senticosus*	*Trachyceras aonoides*	*Pinaciceras regiforme*	*Pinacoceras verchojanicum*		*Pinacoceras verchojanicum*		*Pinacoceras verchojanicum*	
			Neosirenites irregularis	*Striatosirenites*		*Sirenites yakutensis*		*Sirenites yakutensis*	
				Sirenites hayesi		*Neosirenites pentastichus*		*Neosirenites pentastichus*	
			Protrachyceras	*Protrachyceras seimkanense*		*Protrachyceras seimkanense*		*Neoprotrachyceras seimkanense*	
				Protrachyceras omkutchanicum		*Protrachyceras omkutchanicum*		*Protrachyceras omkutchanicum*	
Ladinian	Ladinian	Ladinian	Ladinian	Ladinian	*Nathorstites gibbosus*	Ladinian	*Nathorstites tenuis*	Carnian	*Nathorstites tenuis*

biostraton corresponds to the Carnian stage and the lower zone of the Norian stage in the modern interpretation [13, 15]. Later, Yu.V. Archipov [1] suggested a more detailed stratigraphic scheme of this stratigraphic interval for the Yana River basin in eastern Yakutia including three ammonoid zones *Protrachyceras, Neosirenites irregularis* and *Pinacoceras regiforme*. In the early 70s, making allowance for data on the study of faunal sequences in the sections of the Omolon massif and northern Okhotsk region, YuV. Archipov, Yu.M. Bytschkov, and I.V. Polubotko [3, 11, 12, 32] generated a detailed zonal scheme for the Carnian and Lower Norian in NE Asia comprising five ammonoid zones. Along with the detailing of division, particularly of the Carnian stage, this scheme holds changes in the nomenclature of the upper zone and the Carnian-Norian boundary is lowered; the boundary coincides with the base of the *Pinacoceras verchojanicum* zone [11, 12]. Comparatively scanty data have been published for the last two decades specifying the Carnian-Lower Norian zonal scheme for NE Russia. A change of the index species for some zones [15] should be noted, and also the change of the position of the lower boundary of the Carnian stage [13] and a more detailed division of some intervals, and in particular, the distinguishing of beds with ammonoids in the *Neoprotrachyceras semkanense* [8] and *Sirenites yakutensis* [6] zones. Recently Yu.M. Bytschkov has described in his monograph [9] Late Triassic trachyceratids and syrenitids from the upper reaches of the Yana Okhotskaya River, specified their stratigraphic distribution in the section, and substantiated division of the *Neoprotrachyceras seimkanense* and *Yakutosirenites pentastichus* zones into beds with ammonoids.

Ye.S. Sobolev [26] first studied and described in his monograph nautiloids in NE Asia. A.S. Dagys and Ye.S. Sobolev [17, 39] introduced a zonal scale of the Triassic based on this group. Five biostratons as zones and subzones have been discriminated in the Carnian and Lower Norian basing on nautiloids.

In the last years we studied the principal sections of the Carnian stage and Lower Norian substage of the North Kharaulakh, Yana River basin, Omolon massif, and northern Priokhotye. Twelve ammonoid assemblages and six nautiloid assemblages [21] have been distinguished in the Carnian and Lower Norian, whose succession was traced in the studied territory and was used as a basis for the suggested new zonal scheme of the Carnian and Lower Norian in northeast Russia (Table 2).

A layer-by-layer description of the studied sections of the Carnian stage and Lower Norian substage in northeast Russia and their paleontological characteristics are offered in the work of A.G. Konstantinov and Ye.S. Sobolev [21].

Table 2 New biostratigraphic scheme for Carnian and Lower Norian in northeast Russia.

<table>
<tr><th>Stage</th><th>Substage</th><th colspan="2">Zones and beds distinguished by ammonoids</th><th colspan="2">Zones and subzones distinguished by nautiloids</th></tr>
<tr><td rowspan="3">Norian</td><td rowspan="3">Lower</td><td rowspan="2">Pinaciceras verchojanicum</td><td>Beds with Norosirenites obrucevi</td><td rowspan="3">Proclydonautilus seimkanensis</td><td rowspan="2">Proclydonautilus seimkanensis</td></tr>
<tr><td>Beds with Norosirenites nelgehensis</td></tr>
<tr><td colspan="2">Striatosirenites kinasovi</td><td>Proclydonautilus spirolobus</td></tr>
<tr><td rowspan="10">Carnian</td><td rowspan="3">Upper</td><td colspan="2">Striatosirenites kedonensis</td><td colspan="2" rowspan="2">Proclydonautilus pseudoseimkanensis</td></tr>
<tr><td colspan="2">Sirenites yakutensis</td></tr>
<tr><td colspan="2">Neosirenites pentastichus</td><td rowspan="6">Cosmonautilus polaris</td><td rowspan="5">Proclydonautilus goniatites</td></tr>
<tr><td rowspan="6">Lower</td><td colspan="2">Neosirenites armiger</td></tr>
<tr><td colspan="2">Neoprotrachyceras seimkanense</td></tr>
<tr><td colspan="2">Yanosirenites buralkitensis</td></tr>
<tr><td colspan="2">Beds with Neosirenites aculeatus</td></tr>
<tr><td colspan="2">"Protrachyceras" omkutchanicum</td><td>Cosmonautilus polaris</td></tr>
<tr><td colspan="2">Stolleyites tenuis</td><td colspan="2" rowspan="2">Proclydonautilus anianiensis</td></tr>
<tr><td>Ladinian</td><td>Upper</td><td colspan="2">Nathorstites lindstroemi</td></tr>
</table>

This paper deals with the problems of nomenclature related only to the change of the zones volume and the discrimination of new subdivisions, since they have been examined fairly well for most ammonoid and nautiloid zones [15, 17, 39].

ZONAL SCALE BASED ON AMMONOIDS

Carnian stage

Lower substage

Stolleyites tenuis zone

Index species. *Stolleyites tenuis* (Stolley) (=*Nathorstites tenuis*: [40], p. 116, Table 9, Figs 3, 4); Svalbard Archipelago.

Stratigraphy and paleontological characteristics. The lower boundary is delineated basing on the first appearance of the index species. *Stolleyites tenuis, S. gibbosus* and *Arctophyllites taimyrensis* are distributed through the whole zone. Finds of the *Stolleyites* sp., which has a narrow, smooth shell at the earliest stages of development, are confined to the upper part of the zone.

Distribution. Northern Priokhotye, Yana Okhotskaya River basin, Pravaya Vtoraya Sentyabrskaya River (exp. C-5, interval 35.5-40 m from the base of bed 1, beds 2-4 and lower 34 m from the base of bed 5), Zhakan Creek (exp. C-6, interval 26-43 m from the base of bed 1, bed 2); Omolon massif, Dzhugadzhak River (exp. 103, beds 2, 3); Middle reaches of Kolyma River, Kotelnyi Island; Svalbard Archipelago.

"Protrachycera" omkutchanicum zone

Index species. "*Protrachyceras" omkutchanicum* Bytschkov (= *Protrachyceras omkutchanicum*: [6], p. 35, Table 1, Fig. 1); Omolon massif, Omkuchan River.

Stratigraphy and paleontological characteristics. The lower boundary is drawn basing on the appearance of the index species. Ammonoids are rare in the zone. The zone is characterized by the following trachyceratids that appeared first in northeast Russia: "*Protrachyceras" omkutchanicum* and "*P*". aff. *omkutchanicum,* having a more evolute shell. *Atctophyllites taimyrensis*, which arrived from the *tenuis* zone, are frequent.

Distribution. Northern Priokhotye, Yana Okhotskaya River basin, Pravaya Vtoraya Sentyabrskaya River (exp. C-5, interval 34-132 m from the base of bed 5); Omolon massif, Dzhugadzhak River (exp. 103, beds 4, 5), Omkuchan River (exp. 101, bed 1); upper and middle reaches of Kolyma River; lower reaches of Yana River; Kharaulakh Range, Darky River (exp. 52, beds 3, 4); lower reaches of Lena River, Taas-Aryy Island, Kengdei River basin, Olkhovyi Creek.

Beds with *Neosirenites aculeatus*

Index species. *Neosirenites aculeatus* Bytschkov: [10], p. 127, Table 37, Fig. 10; northern Priokhotye, Yana Okhotskaya River basin, Zhakan Creek.

Typal locality. Northern Priokhotye, Yana Okhotskaya River basin, Vtoraya Sentyabrskaya (exp. C-5, interval 24-26 m from the base of bed 6; exp. C-10, interval 19-30.5 m from the base of bed 1; exp. C-2, interval 0-20.5 m from the base of bed 1), Zhakan Creek (exp. C-12, interval 4-21 m from the base of bed 1).

Nomenclature. A subdivision under such a name is distinguished first and volumetrically corresponds to beds with *Neosirenites pseudopentastichus*, distinguished in the lower part of the *Neoprotrachyceras seimkanense* zone by Yu.M. Bytschkov [8]. This biostraton was recognized only in the northern Priokhotye and therefore is reckoned as a bed.

Stratigraphy and paleontological characteristics. The lower boundary is delineated basing on the appearance of the index species. Most characteristic and abundant is the species *Neosirenites aculeatus*. *Neosirenites pseudopentastichus* occurs, apparently, only in the upper part of the recognized beds. Less frequent are finds of *Arctophyllites okhotensis* and *Proarcestes* sp. ind.

Distribution. Northern Priokhotye, and Yana Okhotskaya River basin (typal locality). Data on the presence of forms close to the index species in the sections of the Carnian stage in the Kharaulakh Range [16] require verification.

Yanosirenites buralkitensis zone

Index species. *Yanosirenites buralkitensis* (Popow) (= *Striatosirenites buralkitensis*: [25], p. 88, Table 21, Fig. 5); northern Priokhotye, and the upper reaches of the Yana Okhotskaya River.

Typal locality. Northern Priokhotye, Yana Okhotskaya River basin, and Vtoraya Sentybrskaya River (exp. C-5, interval 42-63 m from the base of bed 6; exp. C-10, interval 30.5-37 m from the base of bed 1; exp. C-2, interval 20.5-34.5 m from the base of bed 1), Zhakan Creek (exp. C-12, interval 21-30.5 m from the base of bed 1).

Nomenclature. This subdivision was first discriminated by Yu.M. Bytschkov [8] as beds with *Yanosirenites buralkitensis* in the middle part of the *Neoprotrachyceras seimkanense* zone and was known in a single locality — in the northern Priokhotye in the Vtoraya Sentyabrskaya River basin. Since the beds holding *Yanosirenites buralkitensis* were identified in the same stratigraphic position (below the beds with *Neoptotrachyceras seimkanense*) in the Adycha River basin, they are first ranked in this paper as zones.

Stratigraphy and paleontological characteristics. The lower boundary is drawn basing on the appearance of the index species. The ammonoid assemblage of the zone comprises *Yanosirenites buralkitensis* and *Y. seimkanensis*. *Neosirenites pseudopentastichus*, arriving from the subjacent beds, are very rare in the lowermost strata of the zone.

Distribution. Northern Priokhotye, Yana Okhotskaya River basin (typal locality), Viliga River, where the *Yanosirenites seimkanensis* was encountered [15]; Adycha River basin, Derbeke River basin (generalized section at exp. 6231, 6232, 6238 and 7003, interval 12-58 m from the base of bed 1).

Neoprotrachyceras seimkanense zone

Index species. *Neoprotrachyceras seimkanense* (Bytschkov) (= *Protrachyceras seimkanense*: [6], p. 36, Table 1, Fig. 2); northern Priokhotye, and Yana Okhotskaya Rive basin.

Typal locality. Northern Priokhotye, Yana Okhotskaya River basin, Vtoraya Sentybrskaya River (exp. C-5, interval 63-80 m from the base of bed 6), Pravyi Zhakan Creek [9].

Nomenclature. Ammonoid distribution in the section of the typal locality in the *Neoprotrachyceras seimkanense* zone allowed Yu.M. Bytschkov [8], basing on epiboles of separate species, to distinguish beds with *Neosirenites pseudopentastichus* in the lowermost strata of the zone; beds with *Yanosirenites buralkitensis* in the middle part, and beds with *Neoprotrachyceras seimkanense* in the upper part of the zone. Since the index species of the zone appears in the upper part of the middle beds and occurs abundantly in the upper layers [9, p.10], the *Neoprotrachyceras seimkanense* zone is identified in this paper as a smaller-size division and corresponds to the uppermost strata of beds with *Yanosirenites buralkitensis* and to beds with *Neoprotrachyceras seimkanense* [8, 9].

Stratigraphy and paleontological characteristics. The lower boundary is drawn basing on the appearance presence of the index species. The zone is characterized by a meager ammonoid assemblage, and besides the index species, rare *Yanosirenites buralkitensis* и *Y. semkanensis* are encountered in the lowermost strata of the zone, and *Proarcestes* sp. are also noted [9].

Distribution. Northern Priokhotye, Yana Okhotskaya River basin (typal locality); Omolon massif, Omkuchan River (exp. 101, interval 0-9 m from the base of bed 2); middle reaches of Kolyma River, Zyryanka River, Adycha River basin, Derbeke River (generalized section at exp. 6231, 6232, 6238 and 7003, interval 58-104 m from the base of bed 2); lower reaches of Yana River, Kharaulakh Range, Darky River (exp. 52, interval 7.2-9 m from the base of bed 5, bed 6).

Neosirenites armiger zone

Index species. *Neosirenites armiger* (Vozin) (= *Sirenites armiger*: [14], p. 88, Table 15, Fig. 9); Nelgese River basin, Silir River.

Typal locality. Northern Priokhotye, Yana Okhotskaya River basin, Vtoraya Sentyabrskaya River (exp. C-2, interval 34.5-71 m from the base of bed 1, bed 2).

Nomenclature. A zone with such a name is distinguished first, it corresponds to the lower part of the *Neosirenites pentastichus* zone [15]. Synonyms are beds with *Yakutosirenites ochotensis* in the northern Priokhotye [9] in the lower part of the *Yakutosirenites pentastichus* zone. The replacement of the index species is explained by the fact that *Yakutosirenites ochotensis* (Alabusheva) is a junior synonym of *Neosirenites armiger* (Vozin).

Stratigraphy and paleontological characteristics. The lower boundary is drawn basing on the appearance of the index species. The zone is noted for the first appearance of the genus *Sirenites* - S. *ovinus* and *S. zhakanensis* in northeast Russia. *Neosirenites* sp., *Proarcestes afanasijevi*, *P.* sp. and the species *Arctophyllites okhotensis*, arriving from beds holding *Neosirenites aculeatus*, are also encountered.

Distribution. Northeastern Priokhotye, Yana Okhotskaya River basin (typal locality); Omolon massif, Omkuchan River (exp. 101, interval 9-11.5 m from the base of bed 2); Adycha River basin, Derbeke River (generalized section at exposures 6231, 6232, 6238 and 7003, interval 104-116 m from the base of bed 2, beds 3, 4, and interval 0-44.5 m from the base of bed 5); Yana River basin; Kharaulakh Range, Darky River (exp. 52, interval 3.5-5.6 m from the base of bed 7, interval 0-5 m from the base of bed 8); Kotelnyi Island, Tikhaya River.

Upper substage

Yakutosirenites pentastichus zone

Index species. *Yakutosirenites pentastichus* (Vozin) (= *Sirenites pentastichus*: [14], p. 86, Table 15, Fig. 5-8); Derbeke River basin, Bagryanyi Creek.

Typal locality. Northern Priokhotye, Yana Okhotskaya River basin, Vtoraya Sentyabrskaya River (exp. C-2, bed 3,exp. C-3, beds 4, 5, 6).

Nomenclature. Recently [9] the *pentastichus* zone in the typal locality was divided into beds with *Yakutosirenites ochotensis* and beds with *Sirenites serotinus*. The revision of the stratotype of the zone showed that the index species is confined to the upper part of the zone and is not encountered in the lower part, which is characterized by the most illustrative ammonoid species *Neosirenites armiger* (Vozin). Therefore, the *pentastichus* zone, distinguished in this paper, corresponds to the upper part of the zone under the same name in the former scheme or to beds with *Sirenites serotinus* [9].

Stratigraphy and paleontological characteristics. The lower boundary is delineated on the basis of the index species appearance. Ammonoids in the zone are represented by *Yakutosirenites pentastichus*, *Y.* ex gr. *pentastichus*,

Sirenites serotinus, Neosirenites irregularis, Arctophyllites okhotensis, Proarcestes verchojanicus, P. afanasijevi, P. gaytani. In the upper part of the zone rare *Striatosirenites* ex gr. *solonis* and *S.* ex gr. *Striatofalcatus* are encountered.

Distribution. Northern Priokhotye, Yana Okhotskaya River basin (typal locality), Viliga River; upper reaches of Kolyma River; Adycha River basin, Derbeke River (generalized section at exp. 6231, 6232, 6238 and 7003, interval 44.5-50 m from the base of bed 5); lower reaches of Yana River; Kharaulakh Range, Darky River (exp. 52, interval 5-8 m from the base of bed 8, beds 9, 10, interval 0-10.5 m from the base of bed 11); Kotelnyi Island, Tikhaya River. Equivalents of the zone are probably present in the western and eastern Verkhoyansk region, and in Chukotka, where finds of the ammonoids *Neosirenites irregularis* and *Sirenites hayesi* are known [15].

Sirenites yakutensis zone

Index species. *Sirenites yakutensis* Kiparisova: [19], p.6,Table 1, Fig.1; Kolyma River basin, right bank of Bokhapchi River, near the mouth of Bolshoi Mandychan River.

Stratigraphy and paleontological characteristics. The lower boundary is drawn basing on the presence of the index species. The most frequent in the zone are *Sirenites yakutensis, S.* ex gr. *yakutensis, Neosirenites irregularis.* In the northern Priokhotye the deposits of the zone show numerous *Proarcestes verchojanicus, Arctophyllites okhotensis* and *A.* sp. There are solitary finds of *Striatosirenites* ex gr. *solonis, Paratrachyceras* sp. and *Arctoarpadites costatus. Striatosirenites* sp. is known only in the upper part of the zone.

Distribution. Northern Priokhotye, Yana Okhotskaya River basin, Vtoraya Sentyabrskaya River (exp. C-3, beds 7, 8, 9); upper reaches of Kolyma River, Adycha River basin, Derbeke River (generalized section at exp. 6231, 6232, 6238 and 7003, interval 50-52 m from the base of bed 5, beds 6-8, interval 0-3 m from the base of bed 9), Nelgese River (exp. 6240, beds 1-4); lower reaches of Yana River; Kharaulakh Range, Darky River (exp. 52, interval 10.5-12 m from the base of bed 11). The age equivalents are probably present in the eastern Verkhoyansk region, Omulyovka uplift, Omolon massif. (Omkuchan River – exp. 101, interval 29-33 m from the base of bed 2), and in Chukotka [15], where finds of *Neosirenites irregularis* and other ammonoids characteristic of the zone are known.

Striatosirenites kedonensis zone

Index species. *Striatosirenites kedonensis* Bytschkov: [6] p. 37, Table on p. 36, Fig. 4; Omolon massif, Omkuchan River.

Typal locality. Omolon massif, Omkuchan River (exp. 101, interval 11.5-12 m from the base of bed 3, interval 0-6 m from the base of bed 4).

Nomenclature. This zone is distinguished for the first time, and it corresponds to beds with *Striatosirenites kedonensis* in the Omolon massif [6].

Stratigraphy and paleontological characteristics. The lower boundary is drawn on the basis of the index species appearance. Besides *Striatosirenites kedonensis*, *Arctophyllites okhotensis* and *Proarcestes verchojanicus* were identified.

Distribution. Northern Priokhotye, Yana Okhotskaya River basin, Vtoraya Sentyabrskaya (exp. C-3, bed 10); Omolon massif (typal locality); Viliga River [15]; Adycha River basin, Nelgese River (exp. 6240, bed 5).

Norian stage

Lower substage

Striatosirenites kinasovi zone

Index species. *Striatosirenites kinasovi* Bytschkov: [10], p. 130, Table 43, Fig. 4; Omolon massif, Omkuchan River.

Typal locality. Omolon massif, Omkuchan River (exp. 101, interval 6-42 m from the base of bed 4).

Nomenclature. This zone has been distinguished for the first time; it corresponds to beds with *Striatosirenites kinasovi* in the Omolon massif [6].

Stratigraphy and paleontological characteristics. The lower boundary is drawn basing on the appearance of the index species. The zone is characterized by the presence of *Striatosirenites kinasovi, S.* aff. *kinasovi, Pterosirenites auritus, Pinacoceras regiforme* and *Arctophyllites popovi*.

Distribution. Northern Priokhotye, Yana Okhotskaya River basin, Vtoraya Sentyabrskaya River (exp. C-9, interval 6-20.5 m from the base of bed 1); Omolon massif (typal locality); Adycha River basin, Derbeke River (generalized section at exp. 6231, 6232, 6238 and 7003, interval 5-25 m from the base of bed 10); Kharaulakh Range, Darky River (exp. 52, bed 12). The age equivalents of the zone are present in Kotelnyi Island, where C.Diener [34] described the species *Pinacoceras regiforme,* which is part of the zone assemblage.

Pinacoceras verchojanicum zone

Index species. *Pinacoceras verchojanicum* Archipov: [2], p. 250, Table 16, Fig. 1, 2; Baky River basin, Tirekhtyakh Creek.

Nomenclature. In the stratotype of the zone on the Vtoraya Sentyabrskaya River [15] and in the parastratotype on the Nizkogornyi Creek [9] in the basin of the Yana Okhotskaya River the lower beds do not hold the index species or are entirely ammonoid-free. In this connection, there is no ground to assign these beds to the *Pinacoceras verchojanicum* zone, the more so to distinguish a subzone under the same name in the lower part of the latter.

Therefore, the *Pinacoceras verchojanicum* zone in this paper is defined as volumetrically smaller, since the lower beds belonging to the *Striatosirenites kinasovi* (?) have been excluded from its composition. Possibly, beds with *Pterosirenites* aff. a*uritus* (?), distinguished by [9] in the lower part of the *verchojanicum* zone on the Nizkogornyi Creek also belong to the *kinasovi* zone.

Stratigraphy and paleontological characteristics. Species of the genus *Norosirenites* are most characteristic of the zone: *N. obrucevi* (= *N. kiparisovae*) and *N. nelgehensis*. *Pinacoceras verchojanicum* is rare and appears in the stratotype at the higher levels than *Norosirenites nelgehensis*; in this connection the lower boundary of the zone is conventionally (before additional data on other sections are obtained) is drawn basing on the appearance of the last species. The assemblage of the zone includes also *Yanotrachyceras ulynense, Arcestes* ex gr. *colonus*, and *Wangoceras* (?) sp., which can be encountered in the uppermost strata of the zone [7].

Ammonoid distribution in the stratotype makes it possible to distinguish beds with *Norosirenites nelgehensis* and beds with *Norosirenites obrucevi* in the zone. Despite the wide extension of the zone within northeast Russia, it is impossible to trace equivalents of the discriminated beds in other regions, since the literature [15] cites, as a rule, lists of ammonoids for the whole zone.

Distribution. Northern Priokhotye, Yana Okhotskaya River basin (exp. C-9, interval 20.5 m from the base of the roof of bed 1); Kotelnyi Island, Tikhaya River, Adycha River basin, lower reaches of Yana River; Kharaulakh Range, Ebetiem and Beris Rivers.

Beds with *Norosirenites nelgehensis*

Index species. *Norosirenites nelgehensis* (Archipov) (= *Sirenites nelgehensis*:[2], p. 245, Table 15, Fig. 4, Adycha River basin, Nelgese River.

Typal locality. Northern Priokhotye, Yana Okhotskaya River basin, Vtoraya Sentyabrskaya River (exp. C-9, interval 20.5-265 m from the base of bed 1).

Nomenclature. The subdivision has been identified for the first time, recognized in a single locality and thus is ranked as beds.

Stratigraphy and paleontological characteristics. The lower boundary is drawn basing on the appearance of the index species. Besides abundant *Norosirenites nelgehensis*, the ammonoid assemblage in the beds holds less frequent *Yanotrachyceras ulynense, Pinacoceras verchojanicum*, and *Arcestes* ex gr. *colonus*

Distribution. Northern Priokhotie (typal locality).

Beds with *Norosirenites obrucevi*

Index species. *Norosirenites obrucevi* (Bajarunas) (= *Sirenites obrucevi*: [5], p. 40, Table 1, Fig. 5-9); Indigirka River basin, Bayagap-Yuryakh River.

Typal locality. Northern Priokhotye, Yana Okhotskaya River basin, Vtoraya Sentyabrskaya River (exp. C-9, interval 265 m from the base - the roof of bed 1).

Nomenclature. This subdivision has been identified for the first time; recognized in a single locality, and therefore it is ranked as beds.

Stratigraphy and paleontological characteristics. The lower boundary is drawn basing on the index species appearance. The ammonoid assemblage in the beds comprises *Norosirenites obrucevi, Pinacoceras verchojanicum* and with reference to data of Yu.M. Bytschkov [7], *Wangoceras* (?) sp.

Distribution. Northern Priokhotye (typal locality).

ZONAL SCHEME BASED ON NAUTILOIDS

Upper Ladinian-Lower Carnian substages

Proclydonautilus anianiensis zone

Index species. *Proclydonautilus anianiensis* (Shimansky) (= *Gryponautilus anianiensis*: [31], p. 38, Table. 2, Fig. 6); eastern Taimyr, Cape Tsvetkov.

Stratigraphy and paleontological characteristics. The lower boundary is drawn basing on the index species appearance. Widely distributed *Cenoceras boreale* and less frequent *Proclydonautilus okhotensis* appear in the upper part of the zone (corresponding to the *Stolleyites tenuis* ammonid zone), representatives of the genus *Sibyllonautilus* are sporadic.

The zone corresponds to the terminal Ladinian ammonoid zone *Nathorstites lindstroemi* and the Lower Carnian *Stolleyites tenuis* zone.

Distribution. Northern Priokhotye, Yana Okhotskaya River basin, Pravaya Vtoraya Sentybrskaya River (exp. C-5 beds 2-4, interval 0-8 from the base of bed 5), Zhakan Creek (exp. C-6,beds 1, 2); Omolon massif, Dzhugadzhak River (exp. 103, beds 1-3); northern Taimyr, Cape Tsvetkov.

Lower-Upper Carnian substages

Cosmonautilus polaris zone

Index species. *Cosmonautilus polaris* Sobolev: [26], p. 104, Table 39, Fig.1; eastern Taimyr, Cape Tsvetkov.

Stratigraphy and paleontological characteristics. The lower boundary is drawn basing on the index species appearance. Species of the preceding zone, *Proclydonautilus anianiensis* и *P. okhotensis*, disaooear. In the lower part of the zone still common are *Cenoceras boreale*, overpassing from the *anianiensis*

zone, and also rare representatives of the genus *Sibyllonautilus*. In the upper part clidonautilids with a reticular sculpture appear – the *Proclydonautilus goniatites* and the first species of the genus *Germanonautilus*.

The zone corresponds to nearly the whole Lower Carnian (except the interval that is equal to the ammonoid zone *Stolleyites tenuis*) and the base of the Upper Carnian. The upper boundary is defined basing on the disappearance of the genus *Cosmonautilus*, *Proclydonautilus goniatites* species, and other characteristic species, and is drawn inside the Upper Carnian ammonoid zone *Yakutosirenites pentastichus*. The considered zone is subdivided into two subzones: *Cosmonautilus polaris* and *Proclydonautilus goniatites* basing on the confinement of the species *P. goniatites* to its upper part.

Distribution. Northern Priokhotye, Omolon massif, upper reaches of Kolyma River, Yana River basin, Adycha River basin, Kharaulakh Range, and eastern Taimyr. Apparently, we can assign to the zone Upper Triassic deposits in the Zyryanka River basin (Omulyovka uplift), holding representatives of the genus *Cosmonautilus* [24].

Cosmonautilus polaris subzone

Index species is indicated in the description of the zone.

Stratigraphy and paleontological characteristics. The lower boundary is characterized in the description of the zone. Besides the index species, the subzone is characterized by *Cenoceras boreale* and rare species of the genus *Sibyllonautilus*.

The subzone corresponds to the ammonoid zone "*Protrachyceras*" *omkutchanicum*.

Distribution. Upper reaches of Kolyma River, watershed of the Pervyi and Vtoroi Munuken Rivers; Omolon massif, Dzhugadzhak River (exp. 103, beds 4, 5), Omkuchan River (exp. 101, bed 1), Kegali River; Yana River basin, Baky River, Tirekhtyakh Creek; Kharaulakh Range, Darky River (exp. 52, beds 3, 4); lower reaches of Lena River, Kengdei River basin, Olkhovyi Creek; eastern Taimyr, Cape Tsvetkov.

Proclydonautilus goniatites subzone

Index species. *Proclydonautilus goniatites* (Hauer) (= *Nautilus goniatites*: [36], p. 4, Table 1, Fig. 9-11); Eastern Alps, Rashberg.

Stratigraphy and paleontological characteristics. The lower boundary is drawn on the basis of appearance of the index species and disappearance of representatives of the genera *Cenoceras* и *Sibyllonautilus*. *Cosmonautilus polaris* is widely distributed through the whole interval of the subzone. The upper part of the subzone is characterized by the presence of *C.* aff. *polaris*, and also species of the genus *Germanonautilus*: *G.* sp. nov., *G.* aff. *popowi*, *G. popowi* and *G. sibiricus*.

Volumetrically, the subzone is equal to the stratigraphic interval equaling ammonoid beds with *Neosirenites aculeatus*, to the zones *Yanosirenites buralkitensis, Neoprotrachyceras seimkanense, Neosirenites armiger* of the Lower Carnian and the lower part of the zone *Yakutosirenites pentastichus* of the Upper Carnian.

Distribution. Northern Priokhotye, Yana Okhotskaya River basin, Vtoraya Sentybrskaya River (exp. C-5, beds 6; exp. C-10, bed. 1; exp. C-2, beds 1, 2, interval 0-50.5 m from the base of bed 3), Zhakan Creek (exp. C-12, bed 1); Omolon massif, Omkuchan River (exp. 101, interval 0-12.5 m from the base of bed 2); Omulyovka uplift, Zyryanka River; Adycha River basin, Derbeke River (generalized section at exp. 6231, 6232, 6238 and 7003, beds 2-4); Kharaulakh Range, Darky River (exp.52, beds 7,8). The liable presence of analogs of the subzone in the Eastern Alps can indicate finds of the species *Proclydonautilus goniatites* along with ammonoids from the *Trachyceras aonoides* subzone [38].

Upper Carnian substage

Proclydonautilus pseudoseimkanensis zone

Index species. *Proclydonautilus pseudoseimkanensis* Sobolev: [26], p. 102, Table 42, Fig. 2; Adycha River basin, Nelgese River.

Stratigraphy and paleontological characteristics. The lower boundary is drawn basing on the appearance of the index species. Besides, the zone is characterized by *Proclydonautilus sinekensis* and *P.* aff. *sinekensis*. Of wide distribution there are species of the genus *Germanonautilus*, that appeared in the upper part of the *polaris* zone: *G. sibiricus* and *G. popowi*.

The zone corresponds to the upper part of the ammonoid zone *Yakutosirenites pentastichus*, *Sirenites yakutensis* and *Striatosirenites kedonensis* zones of the Upper Carnian.

Distribution. Northern Priokhotye, Yana Okhotskaya River basin, Vtoraya Sentyabrskaya River (exp. C-2, interval 52.5-74 m from the base of bed; exp. C-3, beds 4-11); upper reaches of Kolyma River, Kulu River basin, Sineke River; Omolon massif, Omkuchan River (exp. 101, interval 12.5-33 m from the base of bed 2, bed 3, interval 0-4 m from the base of bed 4), Kedon River; Omulyovka uplift, Zyryanka River; Adycha River, Derbeke River (generalized section at exposures 6231, 6232, 6238 and 7003, beds 5-8), Nelgese River (exp. 6240, beds 1-5); Yana River basin, Baky River, Tirekhtyakh Creek; Kharaulakh Range, Darky River (exp. 52, beds 10-11); Kotelnyi Island, Pryamaya River.

Lower Norian substage

Proclydonautilus seimkanensis zone

Index species. *Proclydonautilus seimkanensis* Bytschkov: [10], p. 90, Table 53, Fig. 1; northern Priokhotye, Yana Okhotskaya River basin, Seimkan River, Nizkogornyi Creek.

Typal locality. Northern Priokhotye, Yana Okhotskaya River basin, Vtoraya Sentyabrskaya River (exp. C-9, bed. 1).

Nomenclature. The zone was identified by A.S. Dagys and Ye.S. Sobolev [17]. The volume of the zone is expanded at the expense of beds with *Proclydonautilus spirolobus* included into it. Earlier these deposits were correlated with the *Proclydonautilus pseudoseimkanensis* zone. The conducted investigations showed that the species *Proclydonautilus spirolobus* occurs above the level with nautiloids of the *pseudoseimkanensis* zone and in association with the first rare representatives of the species *Proclydonautilus seimkanensis*.

Stratigraphy and paleontological characteristics. The lower boundary of the zone coincides with the Carnian-Norian boundary. It is drawn by the appearance of the index species and disappearance of such species as *Proclydonautilus pseudoseimkanensis, P. sinekensis, P.* aff. *sinekensis, Germanonautilus sibiricus*. Besides, *Proclydonautilus spirolobus* appears in the base of the zone. The species *Germanonautilus popowi,* which passed from the subjacent zone, is often encountered through the whole interval of the zone. The upper boundary of the zone is defined by the boundary of disappearance of *G. popowi* and by appearance of typical representatives of the Middle and Late Norian nautiloids – genera *Yakutionautilus* and *Siberionautilus* of the Siberionautilidae family, etc.

The zone corresponds to the whole Lower Norian. With reference to *Proclydonautilus spirolobus* confinement to the lower part of the interval, the examined zone can be subdivided into two subzones: *Proclydonautilus spirolobus* and *P. seimkanensis*.

Distribution. Southern Priokhotye, Okhotsk massif, northern Priokhotye, Omolon massif, middle reaches of Kolyma River, upper reaches of Indigirka River, Adycha River basin, Yana River basin, Kharaulakh Range, Kotelnyi Island.

Proclydonautilus spirolobus zone

Index species. *Proclydonautilus spirolobus (Dittmar)* (= *Nautilus spirolobus*: [35], p. 352, Table 13, Figs 1, 2), Eastern Alps, Rossmoos.

Typal locality. Northern Priokhotye, Yana Okhotskaya River basin, Vtoraya Sentyabrskaya River (exp. C-9, interval 0-11 m from the base of bed 1).

Nomenclature. This subzone has been identified for the first time.

Stratigraphy and paleontological characteristics. The characteristics of the lower boundary are given in the description of the zone. Besides the index species, fairly rare representatives of the species *Proclydonautilus seimkanensis* and the frequent species *Germanonautilus popowi* are encountered in the interval of the subzone.

The subzone corresponds to the ammonoid zone *Striatosirenites kinasovi.*

Distribution. Okhotsk massif, Ulbeya River; northern Priokhotye (typal locality); Omolon massif, Omkuchan River (exp. 101, interval 6-42 m from the base of bed 4), upper reaches of Gizhiga River, Irbychan River; middle reaches of Kolyma River; Adycha River basin, Debeke River (generalized section at exposures 6231, 6232, 6238 and 7003, interval 3-30 m from the base of bed 9, bed 10); Dulgalakh River basin, Echiy River; Kotelnyi Island, Tikhaya River. Besides, the species *Proclydonautilus spirolobus* is known in the Norian (Lacilian, Sevatian) deposits in the Eastern Alps [38].

Proclydonautilus seimkanensis subzone

Indexspecies is indicated in the description of the zone.

Typal locality. Northern Priokhotye, Yana Okhotskaya River basin, Vtoraya Sentyabrskaya River (exp. C-9, interval 20.5-302 m from the base of bed 1).

Nomenclature. This subzone has been distinguished for the first time.

Stratigraphy and paleontological characteristics. At the lower boundary *Proclydonautilus spirolobus* disappears, and the subzone is characterized by *P. seimkanensis* and *Germanonautilus popowi.*

The subzone corresponds to the *Pinacoceras verchojanicum* ammonoid zone.

Distribution. Southern Priokhotye, coast of Tungur Bay, mouth of Sebash River; northern Priokhotye, Yana Okhotskaya River basin, Vtoraya Sentyabrskaya River (typal locality), Seimkan River, Nizkogornyi Creek; upper reaches of Indigirka River, Elege; Adycha River basin, Borulakh River, Sular Creek; Yana River basin, Sartang River; Baky River, Tirekhtyakh Creek; Kharaulakh Range, Ebitiem River; Kotelnyi Island, Tikhaya River. Analogs of the subzone are apparently present in the Svalbard Archipelago (Nadezhda Island, Lingefjellet), where *Proclydonautilus* ex gr. *seimkanensis* and *Germanonautilus* sp. were described [27].

CORRELATION

1.Boreal regions. Biostratigraphic schemes for the Carnian and Lower Norian of the eastern and western parts of the Boreal realm are not comparable in terms of details. The zonal scale of the Carnian stage and Lower Norian substage in NE Russia, comprising 12 biostratons based on ammonoids and 6 biostratons based on nautilods, is the most complete and detailed as compared with schemes for other Boreal regions.

In the Svalbard Archipelago in the Upper Triassic, represented mainly by coastal-marine and continental facies, ammonoids occur at two stratigraphic levels: in the Lower Carnian in the *Stolleyites tenuis* zone, and in the Lower Norian – in beds with *Pterosirenites* [22, 23, 33, 44]. Basing on the common species *Stollyites tenuis* (Stolley), *S. gibbosus* (Stolley) and *Arctophyllites taimyrensis* (Popow), the *Stolleyites tenuis* zone is equivalent to the *Stolleyites tenuis* zone in NE Russia (Table 3). Beds with "*Pterosirenites*" [23] contain the ammonoids "*Pterosirenites*" (=*Norosirenites*) *nelgehensis* (Archipov) and и "*P.*" (=*N.*) *obrucevi* forma *nabeshi* McLearn, and are reliably correlated with beds holding *Norosirenites nelgehensis* and beds with *Norosirenites obrucevi* – the sum total volume of the zone *Pinacoceras verchojanicum*. This correlation is fully confirmed by distribution of nautiloids, since in the Svalbard beds with "*Pterosirenites*" the finds of *Proclydonautilus* ex gr. *seimkanensis* and *Germanonautilus* sp. [27] are known, which are indicative of possible presence in this region of analogs of the Siberian subzone *Proclydonautilus seimkanensis*. Beds with *Lima, Myophoria* and *Pleurophorus*, discriminated in the interval between the *tenuis* zone and beds with *"Pterosirenites"*, probably, correspond stratigraphically to the rest of the Carnian and the lowermost strata of the Lower Norian in NE Russia – to the *Striatosirenites kinasovi* zone.

In Arctic Canada ammonoids are rare in the Carnian and have not been identified in the Lower Norian. Beds in the upper part of the lower schist band, Blaa-Mountain Formation, holding "*Discophyllites*" (=*Arctophyllites*) cf. *taimyrensis* Popow and *Halobia* cf. *zitteli* Lindstroem [41, 42], are correlated with the Siberian zones *Stolleyites tenuis* and *Protrachyceras omkutchanicum*, which are characterized by the species *Arctophyllites taimyrensis* (Popow). The *Sirenites nanseni* zone, identified in Arctic Canada in the Hat, Ellesmere, and Axel Heiberg islands, in a typal locality in British Columbia, contains *Sirenites ovinus* Tozer in association with the index species [43]. *Sirenites ovinus* Tozer was detected in the *Neosirenites armiger* zone, which allows us to correlate this zone with the *Sirenites nanseni* zone. The species *Yakutosirenites pentastichus* (Vozin) and *Sirenites serotinus* Tozer have been described [43] in the beds with *Jovites borealis*. In the subjacent layers with *Arctosirenites canadensis* the forms (*Arctosirenites southeri* Tozer) are present, which are close to some thinly sculptured specimens of *Yakutosirenites pentastichus* (Voz.). Hence the *Yakutosirenites pentastichus* zone in NE Russia corresponds to beds with *Arctosirenites canadensis* and *Jovites borealis* from Arctic Canada. Undoubtedly, judging by finds of the species *Sirenites yakutensis* Kipar. in the Ellesmere, there also equivalents of the Siberian zone *Sirenites yakutensis* in this region. E.T. Tozer [43] assigns this level to beds with c *Jovites borealis*, However, this interpretation is hardly enough substantiated, since *Sirenites yakutensis* Kipar. was detected in asingle locality beyond the bounds of the assemblage

Table 3 Correlation of Carnian and Lower Norian deposits.

<table>
<tr><th rowspan="2">Stage</th><th rowspan="2">Substage</th><th colspan="4">Northeast Russia</th><th rowspan="2">Svalbard</th><th rowspan="2">Arctic Canada</th><th rowspan="2">British Columbia</th><th rowspan="2">Eastern Alps</th></tr>
<tr><th colspan="3">Zones and beds distinguished by ammonoids</th><th>Zones and subzones distinguished by nautiloids</th></tr>
<tr><td rowspan="7">Norian</td><td rowspan="2">Middle</td><td colspan="3">Bomonotis scutiformis</td><td rowspan="3">Yakutionautilus kavalerovae</td><td rowspan="3"></td><td>Beds with Himavatites</td><td>Himavatites columbianus</td><td>Himavatites columbianus</td></tr>
<tr><td rowspan="3">Lower</td><td colspan="3" rowspan="2">Otapiria ussuriensis</td><td rowspan="5">Beds with Meleagrinella antiqua</td><td>Drepanites rutherfordi</td><td>Cyrtopleurites bicrenatus</td></tr>
<tr><td>Juvavites magnus</td><td>Juvavites magnus</td></tr>
<tr><td rowspan="2">Pinaco-ceras verchojanicum</td><td>Beds with N. obrucevi</td><td rowspan="2">Proclydo-nautilus seimka-nensis</td><td rowspan="2">P. seim-kanensis</td><td rowspan="2">Beds with "Pterosirenites"</td><td>Malayites dawsoni</td><td>Malayites paulckei</td></tr>
<tr><td>Beds with N. nelgehensis</td><td>Stikinoceras kerri</td><td>Guembelites jandianus</td></tr>
<tr><td colspan="3">Striatosirenites kinasovi</td><td>P. spirolobus</td><td></td><td>Klamathites macrolobatus</td><td>Anatropites spinosus</td></tr>
<tr><td></td><td>Upper</td><td colspan="2">Striatosirenites kedonensis</td><td colspan="2" rowspan="2">Proclydonautilus pseudoseimkanensis</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="2">Sirenites yakutensis</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Carnian	Upper	*Yakutosirenites pentastichus*	*Proclydonautilus pseudoseimkanensis*			Beds with *Jovites borealis* Beds with *Arctosirenites canadensis*	*Ttopites welleri*	*Ttopites subbulatus*	
			Cosmo-nautilus polaris	*Proclydo-nautilus goniatites*			*Tropites dilleri*	*Tropites dilleri*	
	Lower	*Neosirenites armiger*				*Sirenites nanseni*	*Sirenites nanseni*	*Austrotrachyceras austriacum*	
		Neoprotrachyceras seimkanense					*Austrotrachyce-ras obesum*		
		Yanosirenites buralkitensis					*Trachyceras desatoyense*	*Trachyce-ras aonoides*	*T. aonoides*
		Beds with *Neosirenites aculeatus*							
		"*Protrachyceras*" *omkutchanicum*		*C. polaris*		Beds with "*Discophyllites*" cf. *taimyrensis*			*T. aon*
		Stolleyites tenuis	*Proclydonautilus anianiensis*		*Stolleyites tenuis*				
Ladinian	Upper	*Nathorstites lindstroemi*			*Nathorstites lindstroemi*	Beds with *Nathorstites*	*Frankites sutherlandi*	*Frankites regoledanus*	

with other ammonoids, about 800 m higher in the section of *Sirenites nanseni* Tozer finds and thus the relation between this level and the beds with *Jovites borealis* is unknown. No analogs of the Carnian *Striatosirenites kedonensis* zone and the Norian *Striatosirenites kinasovi, Pinacoceras verchojanicum* and *Otapiria ussuriensis* are known in Arctic Canada.

2. Tethyan regions. Correlation of biostratigraphic schemes for the Carnian stage and Lower Norian substage of different regions of the Boreal and Tethyan paleobiogeographic realms is attended with substantial difficulties due to a high degree of endemism of high-latitude ammonoids and absence in the Boreal regions, with rare exceptions, a number of taxons (genera *Trachyceras, Austrotrachyceras, Tropites, Anatropites*, etc.), whose sequence was the basis of the standard scale for the Carnian and Lower Norian of the Tethyan realm. A bridge between the Carnian and Norian schemes of different biochores is sections in British Columbia and partly in Arctic Canada, whose ammonoid assemblages show the presence of both Tethyan and Boreal elements.

The problems of correlation of the Upper Triassic deposits in NE Russia and elsewhere in the world have been dealt with in a number of publications [13, 15,18,37, and others]. The revision of the sections – stratotypes of ammonoid zones of the Carnian and Lower Norian in northeast Russia, the specification of ammonoid stratigraphic distribution, and publication of the fundamental monograph on ammonoid faunas of the Triassic in Canada [43] make it possible to make some corrections in the previous correlation constructions.

The genus *Stolleyites*, detected recently in British Columbia in the lower part of the *Trachyceras desatoyense* zone [43], which according to L.Krystyn [37] is correlated with the standard zone *Trachyceras aonoides* in Eastern Alps by its species *Trachyceras desatoyense* Johnston being close to the species *T.* aon (Munster) and by the presence of *Trachyceras aonoides* Mojsisovics. However, it follows from the analysis of ammonoid distribution in the sections of specific deposits cited by E.T. Tozer [43] that *Stolleyites* had its origin in British Columbia at a stratigraphically lower level than *Trachyceras desatoyense* Johnston., *Coroceras nasutum* Mojsisovics and *Badiotites scapulatus* Tozer. In this connection it is a matter of debate to include the *Stolleyites tenuis* zone in Siberia and Svalbard into the Carnian stage and to delineate the Ladinian-Carnian boundary in the base of this zone. The discussion of this issue is beyond the scope of this paper, and the *Stolleyites tenuis* zone is conventionally correlated with the lowermost strata of the *Trachyceras desatoyense* zone and the lower part of the *Trachyceras aon* subzone, *Trachyceras aonoides* zone.

By its position in the section, the "*Protrachyceras" omkutchanicum* zone is higher than the *Stolleyites tenuis* zone, and possibly corresponds to the rest of the *Trachyceras aon* subzone. Data on halobiids distribution do not contradict

this correlation either: according to I.V. Polubotko [13], the species *Halobia talajaensis* Polubotko from the *omkutchanicum* zone is close to *Halobia fluxa* Mojs., which appeared in the *aon* subzone [37]. Finds of nautiloids of the *Proclydonautilus goniatites* species in NE Russia and in the Eastern Alps allow a supposition of a probable synchronism, at least of the lower boundaries of the Siberian nautiloid *Proclydonautilus goniatites* subzone and Alpine limestone holding *P. goniatites*. Since the first *P. goniatites* in northeast Russia were encountered in association with ammonoids of the *Neosirenites aculeatus* species, and in the Alps this species has been described in the limestone with *Trachyceras aonoides* [38], then the synchronism of the lower boundaries of Siberian ammonoid beds with *Neosirenites aculeatus* and the Alpine ammonoid *Trachyceras aonoides* subzone is confirmed.

The lower boundary of the *Neoprotrachyceras seimkanense* zone coincides with the base of the Alpine zone *Austrotrachyceras austriacum* and the Canadian zone *Austrotrachyceras obesum*, whose synchronism is emphasized by the appearance of the genera *Austrotrachyceras* and *Neoprotrachyceras*. In the overlying zone *Neosirenites armiger* in northeast Russia the species *Sirenites ovinus* Tozer was encountered, characteristic of the *Sirenites nanseni* zone in British Columbia [43]; this supports correlation of the zones *armiger* and *nanseni*. Hence, the *Neoprotrachyceras seimkanense* zone corresponds to the *Austrotrachyceras obesum* zone. In turn, the *obesum* zone, according to L. Krystyn [37], corresponds to the *Austrotrachyceras austriacum* lower subzone from the zone under the same name in the Alps; and the *nanseni* zone, to the *Sirenites* upper subzone.

It was shown above that the *Yakutosirenites pentastichus* zone is correlated with the beds holding *Arctosirenites canadensis* and the beds with *Jovites borealis* in Arctic Canada. These beds are correlated [43] with the *Tropites welleri* zone in British Columbia, so the *pentastichus* zone is correlated with the *welleri* zone and with its equivalent in the Alps — the *Tropites subbulatus* standard zone. However, judging by the absence of discernible traces of a hiatus in the sections in northeast Russia between the zones *armiger* and *pentastichus* and the morphological closeness of ammonoids from these zones, the *pentastichus* zone can include also age analogs of the lower zone of the Upper Carnian - *Tropites dilleri* zone, but this correlation is measurably coventional.

The *Striatosirenites kinasovi* zone is reliably correlated with the lower subzone of the *Stikinoceras kerri* zone in British Columbia, in whose base the lower boundary of the Norian stage is drawn. Common in these subdivisions are the species *Pterosirenites auritus* Tozer and *Pinacoceras regiforme* Diener. To the latter species, which opposite to *P. verchojanicum* Archipov has a smooth shell and a less complex sutura, most likely belongs *Pinacoceras* sp. indet., described by E.T. Tozer in the lower subzone of the *Stikinoceras kerri*

zone [43, p. 131, Table 110, Fig. 4]. The probable synchronism of the *Striatosirenites kinasovi* zone if only with part of the *Guembelites jandianus* Alpine zone is also indicated by finds of nautiloids, common in both zones,- *Proclydonautilus spirolobus* (Dittmar).

Beds with *Norosirenites obrucevi* from the *Pinacoceras verchojanicum* zone are correlated with the lower subzone from the *Malayites dawsoni* zone in British Columbia by the presence of the genus *Wangoceras* and closeness, if not identity, of the Canadian species *Norosirenites krystyni* Tozer with the Siberian *N. obrucevi* (Bajarunas).

Correlation of the zones *Yanosirenites buralkitensis*, *Sirenites yakutensis, Striatosirenites kedonensis*, and also beds with *Norosirenites nelgehensis*, characterized by endemic fauna of ammonoids, is accomplished basing on their stratigraphic position.

The *Otapiria ussuriensis* zone, which recently [13, 16, 18] has entirely been assigned to the Middle Norian, comprises several different-age ammonoid assemblages allowing its correlation with the upper, larger part of the *Malayites dawsoni* zone, *Juvavites magnus, Drepanites ruthefordi* zones, and two lower subzones of the *Himavatites columbianus* zone in British Columbia. For example, a find of *Malayites* ex gr. *parcus* McLearn in the *ussuriensis* zone of the Yana River basin [2] is suggestive of the presence of correlatives of the *dawsoni* zone; and the presence in the upper part of the *ussuriensis* zone of *Dittmaritoides guembeli* Archipov et Vavilov [4], similar to *Pleurodistichites stotti* Tozer, indicates the presence of correlatives of the lower subzone of the *columbianus* zone. Though at present there are no data on ammonoids both in northeast Russia and in other Boreal regions about the presence of correlatives of the Canadian *Juvavites magnus* and *Drepanites rutherfordi* zones, and it is obvious that the boundary between the Lower and Middle Norian substages must run inside the *Otapiria ussuriensis* zone.

The zonal scales for the Lower and Middle Norian in British Columbia and in the Alpine region are readily correlated with one another due to great similarities of ammonoids at a genus level.

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