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ANISIAN-LADINIAN BOUNDARY IN BOREAL REGION BASED ON AMMONOIDEA

BY

V. V. ARKADIEV and M. N. VAVILOV

With 2 plates, 19 figures and 2 tables in the text



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Zusammenfassung

Beschrieben werden die Ammonoideen der Anis-Ladin-Randablagerungen vom NE der UdSSR, die den Arten *Longobardites*, *Indigirites*, *Eutomoceras*, *Frechites*, *Monophyllites*, *Arctoptychites* angehören.

Untersucht wird die Morphologie der Schalen von *Longobardites*, *Indigirites* in Queranschliffen sowie die stratigraphische Verteilung dieser Arten. Angegeben wird auch die ontogenetische Entwicklung der Lobenlinie. Eingehend wird die Lage der Grenze zwischen Anis und Ladin in den Borealgebieten betrachtet. Eine neue Möglichkeit der Grenzziehung zwischen Anis und Ladin wird angegeben.

Schlüsselwörter: Ammonoidea — Trias — UdSSR — Biostratigraphie — Ontogenese.

Summary

The paper describes Ammonoidea from the Anisian-Ladinian boundary deposits in the North-East of the USSR, belonging to *Longobardites*, *Indigirites*, *Eutomoceras*, *Frechites*, *Monophyllites*, *Arctoptychites*.

The morphology of shells belonging to *Longobardites* and *Indigirites* is studied in polished sections, stratigraphic distribution of these genera is analyzed and data on the ontogeny of their lobe line development are given. The location of the boundary between the Anisian and Ladinian stages in Boreal region is discussed in detail and a new version of its establishment is suggested.

Key words: Ammonoidea — Triassic — USSR — ontogeny — biostratigraphy.

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Introduction

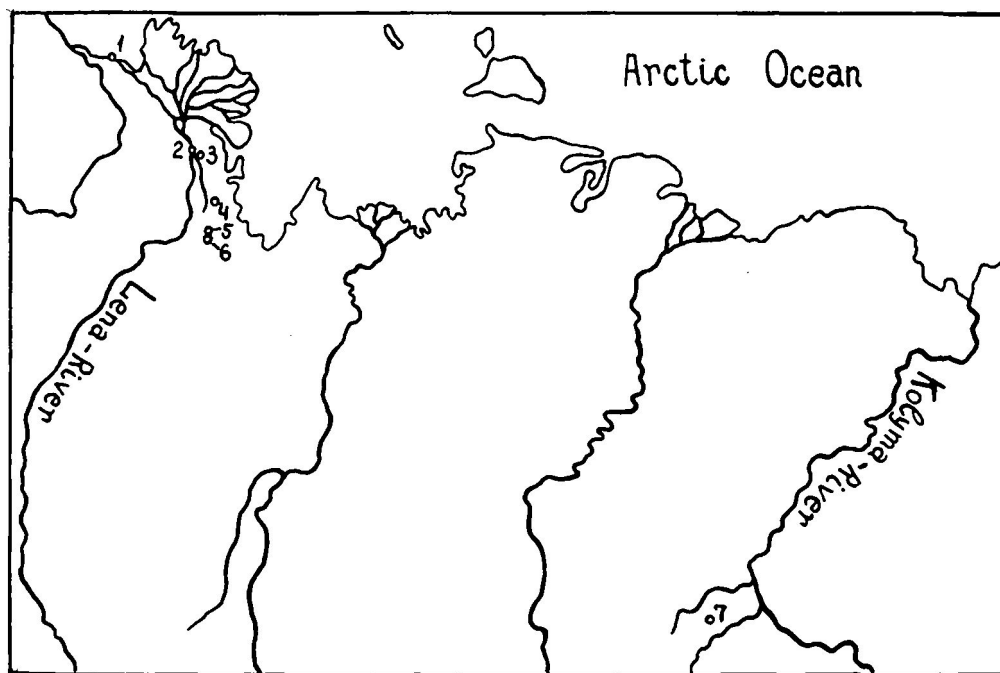
At present biostratigraphy of Anisian and Ladinian stages of the Boreal Region differs greatly from each other in the degree of distinctness. The biostratigraphy of the Ladinian stage and especially that of its lower substage is the least detailed one. This can be explained not only by the rarity and relative monotony of the ammonoidea composition but also by the lack of representative geological sections and, above all, by ambiguous treatment of genus and species to which different groups of ammonoidea belong.

According to the existing system of stratigraphic zoning (DAGYS et al. 1979, VAVILOV 1983, "Geostratigraphical scale" 1984) the Ladinian stage of North-eastern Asia is subdivided into the following zones: *Longobardites oleshkoii* (lower substage), *Arctoptychites omolojensis*, *Indigirites krugi* and *Nathorstites mcconnelli* (upper substage). The lower boundary of Ladinian stage in North-eastern Asia, as well as in all the Boreal region, is established on the basis of the disappearance of upper anisian Beyrichitidae and the appearance of few, mainly endemic, representatives of *Longobardites*, *Arctogymnites* and *Monophyllites*. An accurate determination of the boundary between the Anisian and Ladinian stages, the establishment of the Lower Ladinian substage capacity and its correlation depend greatly upon the revision of the ammonoidea inherent in the substage, mainly upon representatives of the family Longobarditidae.

We have described the most important ammonoidea of the boundary interval of Anisian-Ladinian section, i. e. *Frechites*, *Longobardites* and *Indigirites*, and, above all, some rare species of Middle Triassic ammonoidea that are important for the biostratigraphic development and correlation. The samples were collected from sections of Middle Triassic deposits of the northern part of Middle Siberia (Text-fig. 1).

The most significant section of Middle Triassic was described by the authors in 1984 in the Kharaulakh Range, North Yakutia, along the Nyakutchan River, the Darky right tributary (Text-fig. 19). This section includes a siltstone member, 13 m thick, containing numerous concretions with ammonoidea of presumably Ladinian age. This member occurs some 94 m above *Arctohungarites* and *Czekanowskites* layers of Middle Anisian substage. No Upper Anisian ammonoidea were discovered in this section but in a section in the upper reaches of the Darky, some 3 km away from the Nyakutchan, *Frechites nevadanus* (MOJSISOVICS) and *F. darkyensis* VAVILOV & ARKADIEV dating the *nevadanus* zone of Upper Anisian substage were collected from the layers underlying a similar member. The siltstone member (13 m thick) of the Nyakutchan section contains mainly *Longobardites* represented by a great number of specimens collected at an interval of 1—2 m throughout the section. Besides *Longobardites*, *Arctogymnites spectori* ARCHIPOV are

also present occurring generally at an interval of 0—7 m from the foot of the member. Also present are *Tsvetkovites dolioliformis* VAVILOV & KORCHINSKAJA and *Monophyllites bytschkovi* VAVILOV found within 7—8 m from the foot and *Monophyllites* ex gr. *wengensis* KLIPST. that occurs throughout the member. *Arctoptychites euglyphus* (MOJSISOVICS) was found in the talus.



Text-fig. 1. Location of fragments of the Ammonoidea studied: 1 — the shore of Olenek Bay, Laptevs Sea, Stannakh-Khocho settlement, 2 — Taas-Ary island, 3 — the river Adgirhai, 4 — Artiste-Agatyn-Yurege Creek, 5 — the river Nyakutchan, 6 — the river Darky, 7 — the river Olguya.

Characteristic ammonoidea association represented only by *Longobardites*, *Arctogymnites* and *Monophyllites*, lacking completely such typical Late Anisian forms as *Frechites* and *Gymnotoceras*, makes it possible to relate the lower layers of the member (0—6 m) to the *Longobardites oleshkoi* zone of the existing zonal system ("Geostratigraphical scale", 1984). The finding of *Arctoptychites euglyphus* (MOJSISOVICS) in the talus possibly indicates higher levels of the Ladinian stage (*omolojensis* zone) to which the upper part of the member might belong.

Some *Indigirites krugi* POPOV and *Arctoptychites euglyphus* (MOJSISOVICS) were found 11,5 m above the top of this member in a lenticular parting of a conglomerate consisting of clay rock pebbles, wood fragments and redeposited concretions. This level appears to be considered the basis of the *Indigirites krugi* zone. The upper 30 m of the section are characterized only by *Indigirites krugi* POPOV and *I. neraensis* POPOV which are then replaced by *Nathorstites mcconnelli* WHITEAVES. The total thickness of the Ladinian deposits characterized by ammonoidea in the Nyakutchan section amounts to 78 m.

On the basis of the ammonoidea specimens collected from the Nyakutchan section and other sections of Middle Triassic in the north of Middle Siberia (Text-fig. 16—19) it was possible to trace changes in individual *Longobardites* species in a section from bottom to top and to compare the data obtained with materials from other locations. The ammonoidea collection which served as the basis for the present study is kept by the museum of the Leningrad Mining Institute under numbers 310 and 321, and by the museum of the All-Union Petroleum Research and Geological Prospecting Institute under number 831.

The authors used the following terms when describing ammonoidea lobe line and dimensions of shells: V — ventral, L — lateral, I — inner lateral, D — dorsal, U (numbered) — umbilical, A (numbered) — adventitious lobe; D — diameter of shell, H — height of whorl, W — width of shell, D_u — diameter of umbilicus.

This study was made at the Department of Historical Geology and Paleontology of the Leningrad Mining Institute and at the All-Union Petroleum Research and Geological Prospecting Institute. The paper was reviewed by M. V. KORTCHINSKAYA (Oceanology Research Institute) and A. N. OLEYNIKOV (All-Union Geological Institute). Photographs were taken by B. S. POGREBOV (Leningrad State University). The paper was translated into English by M. M. KUDRYAVTSEVA.

Systematic descriptions

Order Ceratitida HYATT 1884

Suborder Ceratitina HYATT 1884

Family Longobarditidae SPATH 1951

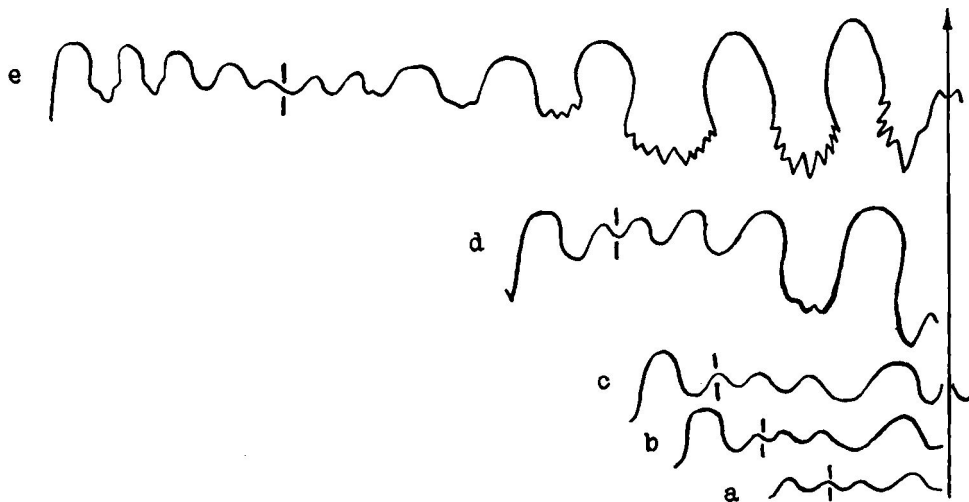
Subfamily Longobarditinae SPATH 1951

Genus *Longobardites* MOJSISOVICS 1882

Type species: *Longobardites breguzzanus* MOJSISOVICS 1882

Longobardites sp.

Form and sculpture: Earlier volutions, judging by transverse polished sections of two poorly preserved specimens (Text-fig. 17, a, b), are semi-involute with wide rounded ventral and bulging lateral sides. In the middle of the fourth (?) whorl a keel appears on the ventral side, which on further whorls acquires the appearance of a bulging formation bounded by furrows. On the fifth (?) whorl an umbilicus closure occurs, whorl height increases sharply, lateral sides flatten. A 5-whorl shell is smooth, with almost closed umbilicus and flattened lateral sides. Convex keel on the ventral side turns into an ordinary slight tapering.



Text-fig. 2. Ontogenetic development of lobe line in *Longobardites* sp., all the stages were drawn from specimen N 1/321: a — with H = 0,42 mm (1,3 whorl) (x 22,5), b — with H = 0,60 mm (2,2 whorls) (x 22,5), c — with H = 0,95 mm (2,5 whorls) (x 22,5), d — with H = 1,6 mm (3,3 whorls) (x 21), e — with H = 14 mm (sixth whorl) (x 6). The shore of Olenek Bay, Laptev's Sea, Stannakh-Khocho settlement, anisian stage, *kharaulakhensis* zone.

Lobe line: At the beginning of the 2nd whorl (Text-fig. 2, a) the line is a five-lobed one — VLU¹: ID. At the beginning of the 3rd whorl (Text-fig. 2, b) it is a six-lobed line. At the basis of the ventral lobe a tubercle starts to appear. Lobe U² is near the suture. In the middle of the third whorl (Text-fig. 2, c) the ventral lobe is distinctly bifid. At the beginning of the fourth whorl (Text-fig. 2, d) crenulation is observed at the basis of the lateral lobe, lobe U³ is located on the suture, the dorsal lobe is bifid. On the sixth whorl (Text-fig. 2, e) the line is thirteen-lobed, suture

saddles being slightly phylloid and lobes crenulate at the basis. The suture line formula is $(V_1V_1)LU^1U^2U^4U^6U^8:U^9:U^7U^5U^3I(D_1D_1)$.

Notes: The species described differs from all the other known *Longobardites* species in that its lobe line is simpler, characterized by slightly phylloid saddles and crenulation only at the basis of lobes. It would seem appropriate to distinguish this species as a new one on the basis of this feature but due to poor preservation of the material we did not do it.

Geological and geographic range: Anisian stage, *kbaraulakhensis*-zone, North-East of the USSR.
Material: 5 specimens (NN 1—5/321).

Longobardites nevadanus HYATT & SMITH 1905

Plate 1, figs. 2—4

- 1905 *Longobardites nevadanus* HYATT & SMITH, p. 132, pl. 25, figs. 13—16 (holotype), 17—18.
1966 *Longobardites (Intornites) nevadanus* — ASSERETO, p. 963, pl. 69, figs. 5, 7; pl. 70, figs. 1, 3, 4, 6.
1969 *Longobardites nevadanus* — MCLEARN, p. 31, pl. VI, figs. 1—7, 13.
1974 *Longobardites oleshkoi* — ARKHIPOV, p. 239, pl. XI, figs. 1, 2.
1976 *Longobardites taimyrensis* — BYCHKOV, p. 97, pl. 19, fig. 34, text-fig. 10k.
1976 *Longobardites arkagalensis* — BYCHKOV, p. 98, pl. 26, fig. 5, text-fig. 10l.
1982 *Intornites nevadanus* — SILBERLING & NICHOLS, pl. 21, figs. 1—18, text-fig. 32.
1984 *Longobardites nevadanus* — ALEKSEYEV, ARKADIEV & VAVILOV, p. 55, fig. 2.

Holotype: HYATT & SMITH 1905, pl. 25, figs. 13—16, MCZ 3902.

Type locality: Nevada, New Pass range.

Type level: Middle triassic, anisian, *shoshonensis* zone.

Form and sculpture: The first three whorls form semi-involute, almost spheroidal shell with wide rounded ventral side and convex lateral ones (Text-fig. 18, b). The width of whorls exceeds their height. The first whorl is smooth, on the second one small tubercles appear on the near-umbilical part of the shell (6 tubercles per half a whorl), which are retained on the third whorl.

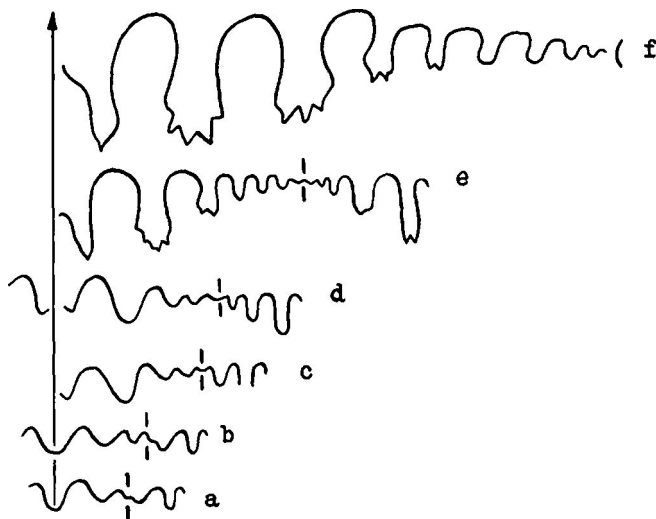
Change in the shell shape occurs in the end of the fourth whorl, when the whorl height starts increasing and equals its width, the lateral sides gradually flattening and ventral side tapering. On the fourth whorl near-umbilical tubercles disappear. On the fifth whorl the lateral sides become still more flattened with simultaneous sharp increase in the whorl height. The ventral side is tectiform, strongly tapering. Very slight crescentiform folds are developed on lateral sides in the near-umbilical part of the shell, their convex side being turned to the aperture. With the fifth whorl the shell becomes more involute. An adult shell (6 whorls) is disk-shaped, with almost closed umbilicus (its closure occurs), with flat and smooth lateral sides showing only some evidence of growth and a halberd-shaped ventral side.

Lobe line: At the end of the 1st — beginning of the 2nd whorl (Text-fig. 3, a) the line is 5-lobed: $VLU^1:ID$. Lobe U^1 is observed on the outer side of the shell on the dorsal side of saddle L/I. The ventral lobe is complete, most deep. At the end of the 2nd whorl (Text-fig. 3, b) lobe U^2 originates on the suture of the dorsal side of saddle U^1/I . The basis of the ventral lobe becomes flattened. By the middle of the 3rd whorl lobe U^2 is shifted to the outer side (Text-fig. 3, c), lobe U^3 originates on the suture. Lateral lobe becomes the deepest one, the ventral lobe is divided into two branches by a low median saddle. At the end of the 3rd whorl the line is eight-lobed (Text-fig. 3, d). Lobe U^3 passes to the inner side, lobe U^4 becomes visible near the suture on the outer side of the shell. Ventral lobe is bifid, dorsal lobe is complete, very narrow and deep. The line formula is $(V_1V_1)LU^1U^2U^4:U^3ID$. On the fourth whorl rapid and considerable complication of the line takes place — 4 new lobes originate within one whorl. At the end of the 4th — beginning of the 5th whorl the line becomes 12-lobed (Text-fig. 3, e, its formula is $(V_1V_1)LU^1U^2U^4U^6U^8:U^7U^5U^3I(D_1D_1)$). At the basis of lobe L crenulation is observed, dorsal lobe becomes bifid. At the end of the fifth whorl with $H = 8,5$ mm the outer section of the line contains no less than 12 lobes (Text-fig. 3, f). The main lobes are indented at the basis, the saddles are high, phylloid. Lobes and saddles decrease regularly towards the suture. The lobe line formula is $(V_1V_1)LU^1U^2U^4U^6U^8U^{10}U^{12} \dots \dots U^{11}U^9U^7U^5U^3I(D_1D_1)$.

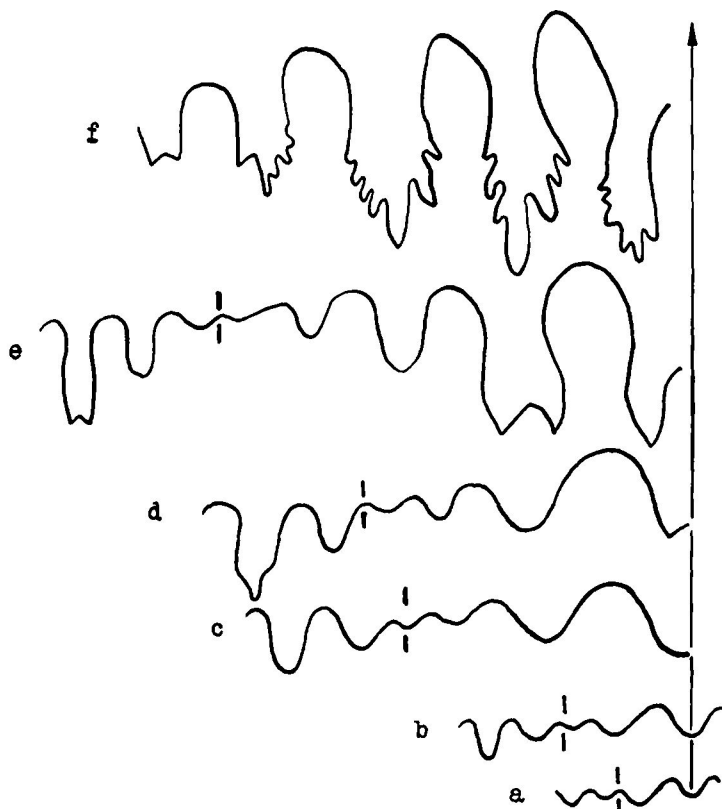
Ontogenetic development of lobe line and shell morphology of *Longobardites* from the "*oleshkoi*" zone has been studied on two specimens N 15/321 and N 17/321 belonging to the same stratigraphic interval from the Nyakutchan

section (Text-fig. 4, 5, 6). Specimen N 17/321 is by the form of earlier volutions a transitional one between *Longobardites* and *Indigirites* and was identified by us as *Longobardites* ex gr. *nevadanus* HYATT & SMITH (Text-fig. 19, b).

Specimen N 15/321, 8,5 mm in diameter was identified by us as *Longobardites nevadanus* HYATT & SMITH.

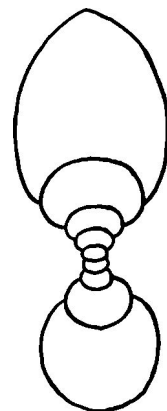


Text-fig. 3. Ontogenetic development of lobe line in *Longobardites nevadanus* HYATT & SMITH, all the stages were drawn from specimen N 10/321: a — end of first — beginning of second whorl (x 21), b — end of second whorl (x 15), c — middle of third whorl (x 10), d — end of third whorl (x 10), e — with H = 3,7 mm (end of fourth — beginning of fifth whorl) (x 8), f — with H = 8,5 mm (end of fifth whorl) (x 8). Kharaulakh Range, Kengdey Basin, Artiste-Agatyn-Yurege Creek, Anisian Stage, *nevadanus* zone.



Text-fig. 4. Ontogenetic development of lobe line in *Longobardites nevadanus* HYATT & SMITH, all the stages were drawn from specimen N 15/321: a — beginning of first whorl (x 31), b — beginning of second whorl (x 31), c — beginning of third whorl (x 31), d — end of third whorl (x 31), e — with H = 3,8 mm (middle of fourth whorl) (x 15), f — with H = 13 (?) mm (fifth whorl) (x 7,5). Kharaulakh Range, Nyakutchan River, "oleshkoï" zone.

Form and sculpture: (Text-fig. 5): Within the first three whorls the shell is semi-involute, almost spheroidal with broadly orbicular ventral side and convex lateral ones. On the fourth whorl the height of the whorl exceeds its width, ventral side is tapering and by the end of the whorl becomes tectiform. With 4 whorls the shell is involute with slightly convex lateral and tapering ventral sides. There is no true convex keel on the ventral side. At all stages of development the shell is smooth without any noticeable sculpture.

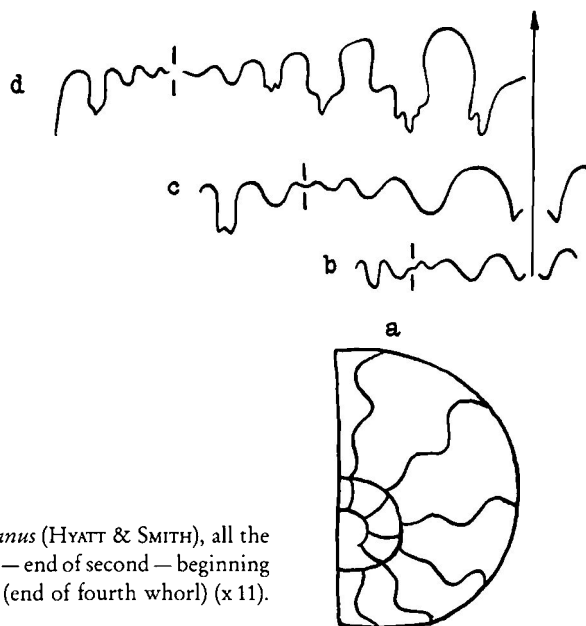


Text-fig. 5. Cross-section of a *Longobardites nevadanus* HYATT & SMITH shell, specimen N 15/321 with D = 8,5 (x6). Kharaulakh Range, Nyakutchan River, "oleshkoï" zone.

Lobe line: At the beginning of the first whorl the line is 4-lobed — VL:ID (Text-fig. 4, a). At the beginning of the second whorl there appears lobe U¹ on the suture. At the beginning of the third whorl lobe U¹ is shifted to the outer side of the whorl (Text-fig. 4, c), lobe U² is on the suture. The basis of ventral lobe flattens. By the end of the third whorl lobe U² is shifted to the outer side of the shell, ventral lobe is divided into two branches by a low saddle (Text-fig. 4, d). In the middle of the fourth whorl, at H = 3,8 mm, the line is 8-lobed (Text-fig. 4, e). Lateral lobe is indented at the basis, dorsal lobe is narrow and deep, bifid. The line formula is (V₁V₁)LU¹U²U⁴:U³I(D₁D₁). At the end of the fifth whorl, with H = 13 (?) mm the outer section of the suture has finely-indented lobes at the basis and lateral sides and phylloid main saddles (Text-fig. 4, f).

Geological and geographic range: *Rotelliforme*, *nevadanus* zones of the north-eastern part of the USSR, *varium* and *deleeni* zones of British Columbia.

Material: 11 specimens (NN 6—15/321, 19/321).



Text-fig. 6. Ontogenetic development of lobe line in *Longobardites* ex gr. *nevadanus* (HYATT & SMITH), all the stages were drawn from specimen N 17/321: a — middle of second whorl (x 33), b — end of second — beginning of third whorl (x 16), c — end of third whorl (x 16), d — with H = 5,1 (?) mm (end of fourth whorl) (x 11).
K.....l k R g , , k..... R v , evada us z , spect ri u zo .

Genus *Indigirites* POPOV 1961

Type species: *Indigirites krugi* POPOV 1946.

Indigirites constantis (ARCHIPOV 1974)

Plate 1, figs. 5—10

1974 *Longobardites constantis* ARCHIPOV, p. 240, pl. XI, fig. 3.

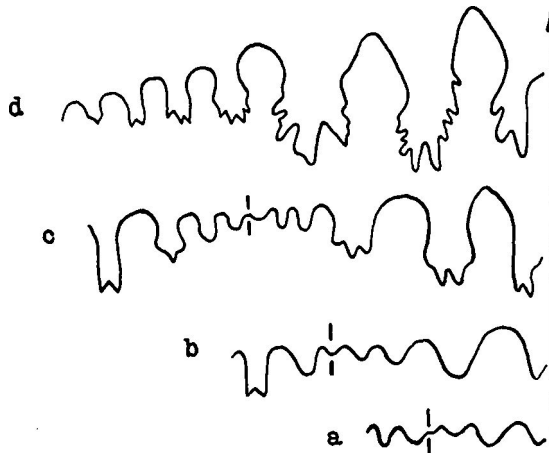
Holotype: ARCHIPOV 1974, pl. XI, fig. 3.

Type locality: North-East of the USSR, Kular region, Tuona Creek, the Oyuun-Yureghe basin.

Type level: Middle Triassic, ladinian, *kruzini* zone.

Form and sculpture (Text-fig. 19, g): The first two whorls represent a smooth, moderately evolute shell having a rounded cross-section, broad flatly rounded ventral side and convex lateral sides. On the third whorl the shell cross-section becomes pentagonal, broad ventral side tapers and becomes tectiform. On narrow and rounded lateral sides fine near-umbilical tubercles appear. On the fourth whorl the shell becomes moderately involute ($D_u/D = 0,30$). Ventral side is distinctly limited by ventrolateral shoulders, a convex keel with two side furrows appears on it. On the lateral sides tubercles are retained. Whorl width exceeds its height. At the beginning of the fifth whorl the form and sculpture of the shell undergo considerable changes: umbilicus narrow ($D_u/D = 0,20$), whorl height increases greatly, lateral sides flatten, near-umbilical tubercles disappear. A convex keel limited by two furrows is retained on the ventral side. At the beginning of the sixth whorl with $D = 20,5$ mm the shell is involute, disk-shaped with broad flattened lateral and tapering ventral sides. The latter has a convex keel bounded by furrows. At the end of the sixth whorl (specim. N 20/321, 22/321) the keel disappears and ventral side becomes narrow, slightly tapering. The surface of the shell is smooth, covered with very poorly developed growth lines. The maximum thickness of the shell is in the zone of umbilicus.

Shell dimensions of *Indigirites constantis* (ARCHIPOV) at different whorls are given in Table 1.



Text-fig. 7. Ontogenetic development of lobe line in *Indigirites constantis* (ARCHIPOV), all the stages were drawn from specimen N 21/321: a — beginning of third whorl (x 11), b — with $H = 1,8$ mm (beginning of fourth whorl) (x 11), c — with $H = 4,5$ mm (beginning of fifth whorl) (x 8), d — with $H = 14,5$ mm (beginning of sixth whorl) (x 6). Kharaulakh Range, Nyakutchan River, Ladinian Stage, *omolojensis* zone.

Lobe line: At the beginning of the third whorl the line is 6-lobed (Text-fig. 7, a). Ventral lobe is being divided into two slightly tapering branches by a median saddle. Lobe U^2 is lying on the suture. The line formula is $(V_1 V_1) LU^1:U^2:ID$. At the beginning of the fourth whorl with $H = 1,8$ mm lobe U^2 is shifted to the outer side of the shell, lobe U^3 is on the suture (Text-fig. 7, b). Dorsal lobe is narrow, deep and bifid. By the beginning of the fifth whorl ($H = 4,5$ mm) the line is 10-lobed (Text-fig. 7, c). The basis of the main lobes is indented. The line formula is $(V_1 V_1) LU^1 U^2 U^4 U^6:U^5 U^3 I(D_1 D_1)$. At the beginning of the sixth whorl with $H = 14,5$ mm the outer section of the suture

contains 8—10 lobes (Text-fig. 7, d). Ventral lobe is divided by a high median saddle into two slightly tapering branches. Lateral and first umbilical lobes are of about the same depth, coarsely indented at the basis (1—2 big dents) and crenulated on the lateral sides. The other lobes are indented only at the basis, their size and degree of their indentedness decrease regularly towards suture. The main saddles are phylloid, slightly tapering, the others are roundosquare. The suture of adult shells is studied in other specimens (Text-fig. 15, i, j). At the end of the sixth whorl with H = 28—29 mm the suture has bulbous saddles and the lobes are strongly indented at the basis and on lateral sides. Ventral, lateral and first umbilical lobes are the deepest, the others are fine, slightly indented.

Changeability: Changeability of the species manifests itself in different times of appearance of a convex keel on the ventral side (4th—5th whorls) and respectively its disappearance (5th—6th whorls), and also in different size of shell tumulus.

Comparison: It differs from *Indigirites krugi* Popow by a less tumulused shell and smaller size of near-umbilical tubercles which do not merge and do not form a near-umbilical ridge.

Notes: YU. V. ARCHIPOV (1974), when establishing *Longobardites constantis* species, observed that its earlier volutions morphology is very much like that of an adult shell of *Lenotropites*, i.e. their cross-section is pentagonal and ventral side flattened and tectiform. Such a form of earlier volutions is not typical for the genus *Longobardites* but rather characteristic of genus *Indigirites*, as investigation carried out by the authors showed it (ARKADIEV & VAVILOV 1984a).

Geological and geographic range: Ladinian stage, *omolojensis* zone, north-eastern part of the USSR.

Material: 13 specimens (NN 16—18/321, 20—29/321).

Table 1. Earlier volutions of shells belonging to *Longobardites* and *Indigirites* genera.

Species and number of specimen	Appearance of keel, whorl number	4 whorls						5 whorls					
		D	H	W	D _u	D _u /D	W/D	D	H	W	D _u	D _u /D	W/D
<i>Indigirites krugi</i> POPOV, N 31/321		7,5	3,2	6,8	2,1	0,28	0,90	20	12,3	9,2	2,8	0,14	0,46
<i>I. krugi</i> POPOV, N 30/321		7,0	3,2	5,1	1,7	0,24	0,72	17,5	9,8	7,6	2,4	0,13	0,43
<i>I. constantis</i> (ARCH.), N 25/321	5	?	2,3	4,7	1,9	?	?	?	8,3	6,5	2,3	?	?
<i>I. constantis</i> (ARCH.), N 24/321		6,8	2,7	5,7	2,1	0,30	0,83	14,6	7,6	7,3	3,2	0,21	0,50
<i>I. constantis</i> (ARCH.), N 23/321		7,5	3,0	4,6	2,2	0,29	0,61	18	10,1	7,4	2,7	0,15	0,41
<i>I. constantis</i> (ARCH.), N 22/321	4,5	5,9	2,3	4,7	1,8	0,30	0,79	15	7,5	7,3	3,0	0,20	0,48
<i>I. constantis</i> (ARCH.), N 21/321	4	6,8	3,0	5,4	2,1	0,30	0,79	15,5	12,0	7,8	3,2	0,20	0,50
<i>I. constantis</i> (ARCH.), N 20/321	4	6,8	2,8	5,2	1,9	0,27	0,76	14,5	7,5	7,8	3,0	0,20	0,53
<i>Longobardites</i> ex gr. <i>nevadanus</i> HYATT & SMITH, N 18/321	4												
<i>L. ex gr. nevadanus</i> HYATT & SMITH, N 17/321	4												
<i>L. ex gr. nevadanus</i> HYATT & SMITH, N 16/321	4	6,5	2,5	3,5	2,2	0,33	0,53	16,5?	9,7	5,6	2,9	0,17?	0,33?
<i>L. nevadanus</i> HYATT & SMITH, N 19/321	4,5	5,3	2,0	2,8	1,8	0,34	0,52	12,8	6,3	4,2	3,0	0,23	0,32
<i>L. nevadanus</i> HYATT & SMITH, N 15/321		8,5	4,1	3,3	2,0	0,23	0,38						
<i>L. nevadanus</i> HYATT & SMITH, N 14/321	4	9,1	4,2	4,1	2,0	0,22	0,45	26?	15,8	7,2	1,9	0,073?	0,27
<i>L. nevadanus</i> HYATT & SMITH, N 12/321		7,9	3,2	3,2	2,5	0,31	0,40	16,3	8,7	6,0	3,0	0,18	0,36
<i>L. nevadanus</i> HYATT & SMITH, N 11/321	3	9,9	4,2	4,1	2,5	0,28	0,46	26?	15,7	8,0	2,2	0,084?	0,30?
<i>L. nevadanus</i> HYATT & SMITH, N 10/321		6,8	3,0	3,3	2,2	0,32	0,48	14,9	7,6	5,1	3,5	0,23	0,34
<i>L. nevadanus</i> HYATT & SMITH, N 9/321		9,1	4,6	3,1	1,9	0,20	0,34	45	14,2	7,0	1,8	0,04	0,15
<i>L. nevadanus</i> HYATT & SMITH, N 8/321		9,0	4,0	3,4	2,7	0,30	0,37	26,8	16,5	6,4	1,2	0,044	0,23
<i>L. nevadanus</i> HYATT & SMITH, N 6/321		10	4,9	3,3	2,4	0,24	0,33	25	14,5	7,4	1,0	0,04	0,29
<i>Longobardites</i> sp., N 3/321	3,5?	7,0	2,8	2,7	2,3	0,32	0,38						

Family Ceratitidae MOJSISOVIC 1879

Genus *Eutomoceras* HYATT 1877

Type species: *Eutomoceras laubei* MEEK 1877.

Eutomoceras rarum sp. nov.

Plate 2, fig. 4

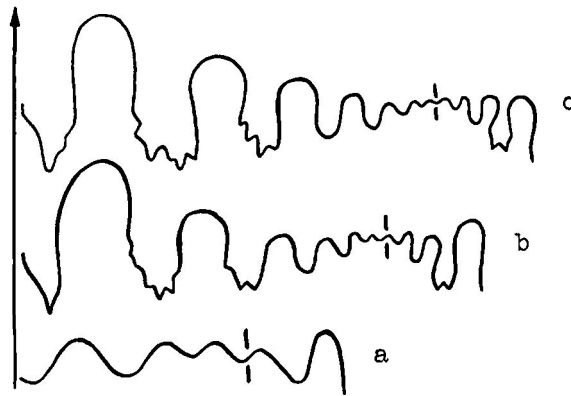
Derivatio nominis: *rarum* in latin means rare.

Holotype: N 34/321, museum of Leningrad Mining Institute.

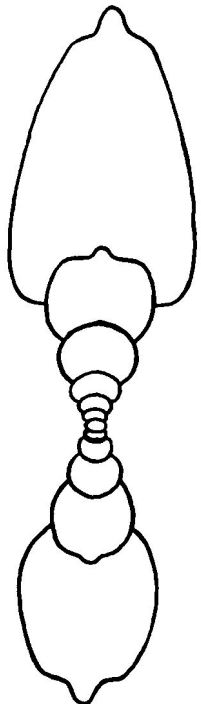
Type locality: Kharaulakh Range, the Artiste-Agatyn-Yurege Creek, the right tributary of the Kengdey river.

Type level: Middle Triassic, anisian, *rotelliforme* zone.

Form and sculpture: The shell is evolute at all stages of its development with strong lateral compression and roundosquare cross-section of the whorls (Text-fig. 9).



Text-fig. 8. Lobe lines of *Eutomoceras rarum* sp. nov., all the stages were drawn from specimen N 34/321: a — middle of the fourth whorl (x 33), b — end of fifth whorl with H = 3,3 mm and W = 3,2 mm (x 16), c — middle of sixth whorl with H = 6,0 mm and W = 3,9 mm (x 8). Kharaulakh Range, Kengdey Basin, Artiste-Agatyn-Yurege Creek, Upper Anisian Substage, *rotelliforme* zone.



Text-fig. 9. Cross-section of *Eutomoceras rarum* sp. nov. shell, specimen N 34/321 (x 8). Kharaulakh Range, Kengdey Basin, Artiste-Agatyn-Yurege Creek, Upper Anisian Substage, *rotelliforme* zone.

In the middle of the fourth whorl a convex keel bounded by two furrows appears on a smoothly rounded ventral side. On the fifth whorl with $H = 3-6$ mm lateral sides are covered with radial biconvex folds thickening in the near-umbilical and median parts of the whorl and looking like ribs. On the lateral sides towards near-ventral bend small conical tubercles that are widely spaced (2–3 mm apart) could be seen at this stage of development. By the end of the fifth whorl lateral sides flatten, whorl height increases. Towards the middle of the 6th whorl ($H = 6$ mm and more) the tubercles disappear and gradually the lateral sides of the shell become smooth. The ventral side of the shell having 5,5 whorls is adorned by a high convex keel bounded by two furrows. At all the stages of development the umbilical is broad and small, with a flat and low wall that becomes steep with the last whorl.

Dimensions in mm and ratios:

Specim. N	D	H	W	D_u	H/D	W/D	D_u/D
34/321	14	6	3,9	5	0,42	0,27	0,35

Lobe line (Text-fig. 8) is ceratitic. In the middle of the 4th whorl it contains only 6 ordinary non-indented lobes (Text-fig. 8, a). The lobe next to suture can be explained as being formed due to division of I — inner lateral lobe or as being formed on the top of the saddle lying on the suture. It was impossible to trace ontogeny of the suture at the earlier stages of development. The authors assumed rather by convention the variant according to which the lobe was formed on the top of the saddle: $(V_1 V_1)LU^1 U^2 : ID$. At the end of the 5th whorl (Text-fig. 8, b) with $H = 3,3$ mm and $W = 3,2$ mm the line is 11-lobed. The suture of an adult shell in the middle of the 6th whorl (Text-fig. 8, c) with $H = 6$ mm and $W = 3,9$ mm consists of 12 lobes: $(V_1 V_1)LU^1 U^2 U^4 U^6 U^8 : U^7 U^5 U^3 I(D_1 D_1)$. Ventral lobe is divided by a high median saddle into two slightly tapering branches. The lateral and first umbilical lobes are slightly indented at the basis. The saddles are high and rounded.

Comparison: The species described by us differs from all representatives of *Eutomoceras* known from the *rotelliforme* zone of Nevada (SMITH 1914, SILBERLING & NICHOLS 1982) by greater evoluteness and less developed sculpture represented, in comparison to the Nevada specimens, by scarce tubercles in the near-ventral part of the whorl.

Notes: The specimens described resemble in shape earlier evolutions of *Longobardites (Intornites) intornatus* MCLearn (ASSERETO 1966), were they juvenile *Longobardites (Intornites)*, however, they would not have had a shell of 5,5 whorls adorned by distinct widely-spaced tubercles. Such sculpture is not at all characteristic of *Longobardites (Intornites)*. The lobe line of the latter shells of 5,5 whorls is far more complicated than that of the forms described.

Geological and geographic range: upper anisian substage, *rotelliforme* zone, the Kharaulakh Range.

Material: 2 specimens (NN 34–35/321).

Family Beyrichitidae SPATH 1934

Genus *Frechites* SMITH 1932

Type species: *Ceratites humboldtensis* HYATT & SMITH 1905.

Frechites nevadanus (MOJSISOVICS)

Plate 2, fig. 5

1877 *Gymmotoceras blakei* — MEEK, pl. 11, figs. 6–6a.

1982 *Frechites nevadanus* — SILBERLING & NICHOLS, p. 29, pl. 9, figs. 19–25; pl. 10, figs. 1–24; pl. 11, figs. 1–6.

1984 *Frechites humboldtensis* — ARKADIEV & VAVILOV, p. 68, pl. 6, fig. 2.

Holotype: MEEK 1877, pl. 11, figs. 6–6a, USNM 12512.

Type locality: Nevada, Humboldt Range, Cottonwood Canyon.

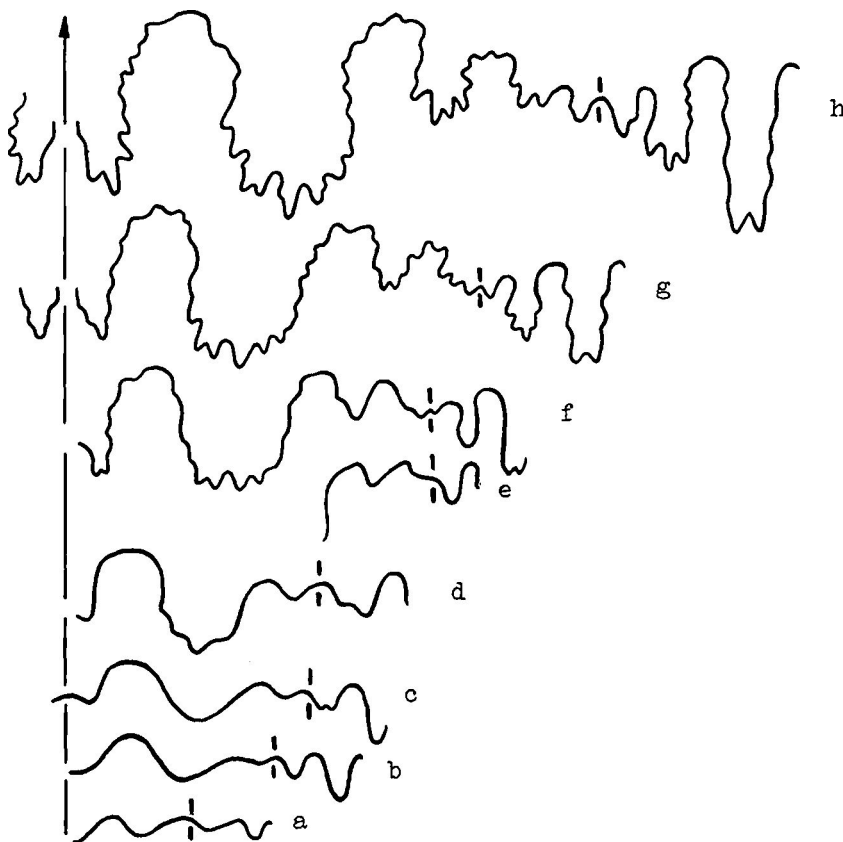
Type level: Middle Triassic, anisian, *meekei* zone.

Form and sculpture: With diameter equal to 0,85 mm (1 whorl) the shell is evolute, inflated, smooth. With $H = 1,1$ mm and $W = 1,5$ mm (2,2 whorls) the shell is evolute with broad rounded ventral side and slightly embracing,

almost spherical whorls. The umbilicous has a high steep wall. At the end of the third whorl with $H = 2$ mm and $W = 2,8$ mm a low submerged keel bounded by furrows appears on the broad flatly rounded ventral side. At the same time low ribs curved forward on ventro-lateral shoulders appear on lateral sides. With $H = 5,5$ mm and $W = 7,5$ mm (beginning of the fifth whorl) the cross-section of the shell is subrectangular, the ventral side is flatly rounded, lateral ones are slightly convex adorned with large elongated tubercles from which branching off are dichotomizing ribs curving forward on ventro-lateral shoulders and disappearing near a distinct ventral keel, forming a characteristic "herring-bone" pattern. With $H = 11$ mm and $W = 12$ mm (the end of the fifth whorl) tubercles appear on ventro-lateral shoulders, while near-umbilical tubercles become spiniform. An adult shell (5,5—6 whorls) of 52,5 mm in diameter is involute or moderately involute with flattened lateral and tectiform ventral sides. The latter carries a low obtuse keel on the phragmocone. Lateral sides are covered with rough dichotomizing ribs curving forward on ventro-lateral shoulders where they terminate in the form of spiniform ventral tubercles. Elongated tubercles are located in the near-umbilical part of the shell at the points where the ribs are forking. The most rough sculpture is observed on the body chamber. The umbilicous is moderately narrow with a high steep wall.

Dimensions in mm and ratios:

Specim. N	D	H	W	D_u	H/D	W/D	D_u/D
7/310	53	25	20	15	0,47	0,38	0,28
36/321 (4 whorls)	9,7	4	5,1	3,4	0,41	0,53	0,35
36/321 (5,5 whorls)	47	22	20	13	0,47	0,43	0,28



Text-fig. 10. Ontogenetic development of lobe line in *Frechites nevadanus* (Mojsisovics), all the stages were drawn from specimen N 36/321: a — with $H = 0,38$ mm, $W = 0,75$ mm (first whorl) (x 37), b — with $H = 0,6$ mm, $W = 1,0$ mm (1,5 whorl) (x 37), c — with $H = 0,8$ mm, $W = 1,25$ mm (1,8 whorl) (x 25), d — with $H = 1,3$ mm, $W = 2,0$ mm (2,6 whorls) (x 20), e — with $H = 2$ mm, $W = 2,5$ mm (3,2 whorls) (x 12), f — with $H = 2,5$ mm, $W = 3,0$ mm (3,4 whorls) (x 12), g — with $H = 3,5$ mm, $W = 5,0$ mm (3,7 whorls) (x 12), h — with $H = 9,0$ mm, $W = 8,0$ mm (4,6 whorls) (x 6). Kharaulakh Range, Kengdey Basin, Artiste-Agatyn-Yurege Creek, Upper Anisian Substage, *nevadanus* zone.

Lobe line: The suture line is four-lobed VL:ID (Text-fig. 10, a). Within a whorl and a half the lobe line consists only of four elements. Within 1—1,2 whorls ($H = 0,38$ mm, $W = 0,75$ mm) at the basis of ventral lobe a low saddle originates dividing the lobe into two branches. Saddle L/I becomes broad and low. With $H = 0,8$ mm and $W = 1,25$ mm (1,8 whorls) lobe U^1 appears in the vicinity of umbilical suture on the outer side of the whorl, the inner lateral lobe becomes bifid (Text-fig. 10, c). Lobe line formula at this stage is $(V_1 V_1)LU^1:(I_1 I_1)D$. With $H = 1,3$ mm and $W = 2$ mm (2,6 whorls) crenulation appears at the basis of lateral lobe (Text-fig. 10, d), bifid inner lateral lobe becomes asymmetric, its right component growing up to the size of normal lobe. With $H = 2$ mm and $W = 2,5$ mm (3,2 whorls) the left component of lobe I, which has turned into a low wall, extends to the outer side of the whorl (Text-fig. 10, e). The lobe line formula at this stage is $(V_1 V_1)LU^1 I_v:I_d(D_1 D_1)$. With $H = 2,5$ mm and $W = 3$ mm (3,4—3,5 whorls) the major elements of the line become corrugated (Text-fig. 10, f). Lobe I^1 appears on umbilical suture, which later shifts to the inner side of the whorl. Further on until the fifth whorl no new lobe appears on the lobe line. The lobe line of an adult shell consists of 7 lobes the major ones of which are coarsely indented at the basis, the saddles are corrugated, dorsal lobe is bifid with corrugated walls (Text-fig. 10, h). The lobe line formula is $(V_1 V_1)LU^1 I_v:I^1 I_d(D_1 D_1)$.

Comparison: *Frechites nevadanus* differs from other representatives of this genus by a broad flatly-rounded ventral side, distinct adorned tubercles, ventro-lateral shoulders and subrectangular cross-section of the whorls.

Geological and geographic range: Upper Anisian substage, *nevadanus* zone, *nevadanus* subzone of north-eastern Asia; *meekei* zone (layers with *F. nevadanus*) of Nevada; layers with *Frechites* in Arctic Canada and *chischa* zone in British Columbia.

Material: 3 specimens (NN 36—37/321, 7/310).

Frechites darkiensis sp. nov.

Plate 2, figs. 6—8

Derivatio nominis: Species name was given after the Darky river.

Holotype: Pl. 2, fig. 6, N 39/321, Museum of Leningrad Mining Institute.

Type locality: Kharaulakh range, the Darky river.

Type level: Middle Triassic, anisian, *nevadanus* zone.

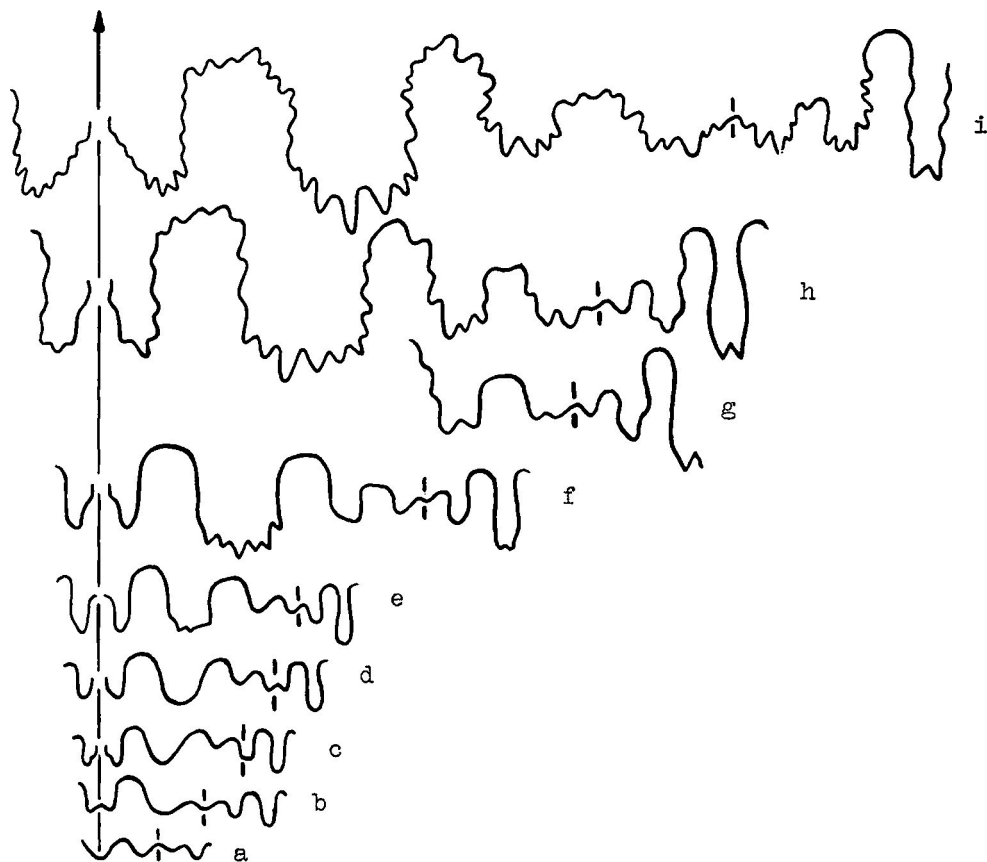
Form and sculpture: Until the third whorl the shell is evolute, smooth with broad flatly-rounded ventral side and convex lateral ones. The cross-section is almost spherical. Umbilicus is broad and fine with a low wall. Within the 3—3,4 whorl interval a low keel bounded by poorly defined furrows appears on the ventral side. Simultaneously slight ribs originate on lateral sides. At the end of the fourth whorl the whorl height starts gradually prevailing over the width. Ventral side becomes tectiform, lateral sides flatten, distinct ventro-lateral shoulders appear. Gradually the ribs increase in size approaching their maximum at the end of the sixth whorl. The shell of 5—6 whorls is from moderately evolute to moderately involute with vertically elongated oval whorls. Ventro-lateral shoulders are subdued, ventral side is tectiform due to a high keel without bounding furrows. Lateral sides are almost flat, covered with coarse dichotomizing ribs, in the branching points of which in the near-umbilical part of the shell inflations could be observed. On rounded ventro-lateral shoulders the ribs bend sharply forward and disappear sharply. No near-ventral tubercles are observed. The sculpture is noticeably subdued on the body chamber.

Dimensions in mm and ratios:

Specim. N	D	H	W	D_u	H/D	W/D	D_u/D
38/321	38	17	11,5	11	0,45	0,31	0,29
39/321 holotype	58	26	19	14,5	0,45	0,33	0,25
40/321	58	28	17	13,5	0,48	0,29	0,23
41/321	40	18,5	13?	11	0,46	0,33?	0,29
42/321	54	27	19	13	0,50	0,35	0,24

Lobe line: The suture line is 4-lobed: at least half the whorl suture line ($H = 0,30$ mm, $W = 0,45$ mm, Text-fig. 11, a) contains 4 lobes — VL:ID. With $H = 0,50$ mm and $W = 0,70$ mm (1,1 whorl) lobe U^1 appears on the suture (Text-fig. 11, b) which is shifted to the outer side of the shell by the end of 1,5 whorls (Text-fig. 11, c). Ventral lobe becomes bifid. Inner lateral lobe is on the umbilical suture, its basis being flattened. With $H = 1,5$ mm and $W = 2,1$

mm (2,2 whorls) inner lateral lobe is subdivided by a low saddle into two parts that later become asymmetric (Text-fig. 11, d, e). Crenulation originates at the basis of lateral lobe. With H = 3 mm and W = 3,6 mm (3,2 whorls) lobe I¹ originates between lobes I_v and I_d of forking inner lateral lobe (Text-fig. 11, f), which further (3,5 whorls) shifts to the inner side of the whorl (Text-fig. 11, g). Dorsal lobe becomes bifid. Major elements of the suture gradually become corrugated (Text-fig. 11, h). Lobe line formula on the fifth whorl is (V₁V₁)LU¹I_v:I¹I_d(D₁D₁).



Text-fig. 11. Ontogenetic development of lobe line in *Frechites darkeyensis* sp. nov., all the stages were drawn from specimen N 38/321: a — with H = 0,3 mm, W = 0,45 mm (0,5 whorl) (x 33), b — with H = 0,5 mm, W = 0,7 mm (1,1 whorl) (x 20), c — with H = 1,2 mm, W = 1,6 mm (1,5 whorl) (x 12), d — with H = 1,5 mm, W = 2,1 mm (2,2 whorls) (x 12), e — with H = 2,3 mm, W = 3,0 mm (2,5 whorls) (x 10,5), f — with H = 3,0 mm, W = 3,6 mm (3,2 whorls) (x 10), g — with H = 3,6 mm, W = 4,2 mm (3,5 whorls) (x 10), h — with H = 6,5 mm, W = 6,5 mm (fourth whorl) (x 10), i — with H = 16,0 mm, W = 12,0 mm (fifth whorl) (x 5). The shore of Olenek Bay, Laptevs Sea, Stannakh-Khocho settlement, Upper Anisian Substage, *nevadanus* zone.

Comparison: The species described differs from *Frechites nevadanus* first of all by its more evolute and less inflated shell with tectiform ventral side adorned with a high keel without bounding furrows. The morphology of the new species is close to that of *Parafrechites meeki* (MOJS.) described recently by SILBERLING (SILBERLING & NICHOLS 1982) from Upper Anisian deposits of Nevada. *F. darkeyensis* sp. nov. differs from it by a more compressed and more evolute shell, presence of a keel on the last whorl of phragmocone and on body chamber, tectiform ventral side, coarse sculpture of adult whorls and presence of ventro-lateral shoulders.

Geological and geographic range: Upper Anisian substage, *nevadanus* zone (*nevadanus* subzone) of the north of Middle Siberia.
Material: 5 specimens (NN 38—42/321).

Family Ussuritidae HYATT 1900

Genus *Monophyllites* MOJSISOVICS 1879

Type species: *Ammonites sphaerophyllus* HAUER 1850.

Monophyllites bytschkovi VAVILOV sp. nov.

Plate 2, figs. 9—10

1976 *Monophyllites* aff. *sphaerophyllus* — ВУСНКОВ, p. 148, pl. 31, fig. 7, Text-fig. 17, b.

Derivatio nominis: The species was given its name after Y. M. ВУСНКОВ, a geologist.

Holotype: ВУСНКОВ 1976, pl. 31, fig. 7.

Type locality: North-East of the USSR, upper reaches of the Zyryanka River.

Type level: Middle Triassic, ladinian, *lenticularis* zone (at present *krugi* and *mcconnelli* zones).

Form and sculpture: The shell is evolute, disk-shaped with rounded ventral side and slightly convex lateral ones. The first four whorls are transverse oval, smooth, slightly embracing. At the end of the fourth whorl the cross-section becomes rounded, then the whorls begin growing vertically. Embracing and evoluteness remain the same. Umbilicus is broad and fine with a rounded high wall. Sculpture appears only on the fifth whorl: it is represented by thin densely-located radial stria of growth going across the ventral side.



Text-fig. 12. Ontogenetic development of lobe line in *Monophyllites bytschkovi* sp. nov., all the stages were drawn from specimen N 43/321: a — with H = 0,6 mm, W = 0,9 mm (0,8 whorl) (x 16), b — with H = 1,1 mm, W = 1,5 mm (1,8—2 whorls) (x 16), c — with H = 2,2 mm, W = 3,2 mm (2,7 whorls) (x 12), d — with H = 3,0 mm, W = 4,0 mm (3,3 whorls) (x 8), e — with H = 4,5 mm, W = 5,0 mm (3,8 whorls) (x 8), f — with H = 11,0 mm, W = 9,0 mm (4,5 whorls) (x 5). Kharaulakh Range, Nyakutchan River, Ladinian Stage, *omolojensis* zone.

Dimensions in mm and ratios:

Specim. N	D	H	W	D _u	H/D	W/D	D _u /D
43/321	41	17	14	15	0,42	0,34	0,37
44/321	29	11	11	10	0,38	0,38	0,35

Lobe line: The suture line of the species studied is four-lobed, at least at the end of the first whorl with $H = 0,6$ mm and $W = 0,9$ mm it contains four lobes (Text-fig. 12, a). Ventral lobe is broad, with flattened basis, saddle L/I is low and extended. With $H = 1,1$ mm and $W = 1,5$ mm (1,8–2 whorls) the lobe line consists of five lobes (Text-fig. 12, b) — $(V_1 V_1)LU^1:I:D$. Ventral lobe is broad and bifid, on the basis of lateral lobe the beginning of division into three branches could be seen. The inner lateral lobe located on the umbilical suture has a flattened, a little concave basis. With $H = 2,2$ mm and $W = 3,2$ mm (2,7 whorls) lobe line acquires a distinctly “phyllitic” appearance (Text-fig. 12, c). Lateral lobe becomes trifid. The inner lateral lobe is divided into two branches — I_v and I_d — located on either side of umbilical suture. With $H = 3$ mm and $W = 4$ mm (3,3 whorls) the saddles become bulbous (Text-fig. 12, d), lobe I^1 appears on the suture, which further is shifted to the outer side of the whorl (Text-fig. 12, e). At the end of the fourth whorl the line is seven-lobed — $(V_1 V_1)LU^1 I_v I^1 : I_d (D_1 D_1)$. Most lobes are coarsely indented at the basis, lateral lobe is trifid and it can possibly be written as $(L_1 L_1 L_1)$, the saddles are round, intact, bulbous. Side walls of the lobes are converging. The line retains such an appearance to the end of the fifth whorl (Text-fig. 12, f).

Comparison: By the pattern of lobe line and outer form our specimens resemble very much those of *Monophyllites* aff. *sphaerophyllus* (HAUER), described by Y.M. BYCHKOV, from Upper Ladinian deposits in the basin of the river Kolyma and northern coast of the Okhotsk sea. As regards true *Monophyllites*, *M. sphaerophyllus* in particular, their lobe line is much more complicated, their heights being the same. However, in *Ussurites* shell that are of a similar morphology, for example *U. spitsbergensis* (OEBERG) (WEITSCHAT & LEHMANN 1983), the lobe line is very simple, the whorl height being equal or even greater.

Notes: Four-lobed suture with representatives of the family Ussuritidae was first established by Y.D. ZAKHAROV (1978) who studied the ontogeny of the *Monophyllites* sp. lobe line from the Anisian of Southern Maritime Territory. The data obtained by us confirm the presence of four-lobed suture with representatives of Ussuritidae and enable us, after Y.D. ZAKHAROV (1978), to refer them to the ceratites not to the ammonites, as it was considered before (SHEVYREV 1968, BYCHKOV et al. 1976, KULLMANN & WIEDMANN 1970, WIEDMANN & KULLMANN 1980, TOZER 1971, 1980).

Geological and geographic range: Ladinian stage, *omoljensis* and *krugi* zones of North Siberia, the Kolyma basin and northern coast of the Okhotsk sea.

Material: 3 specimens (NN 43–45/321).

Family Ptychitidae MOJSISOVICS 1882

Genus *Arctoptychites* ARCHIPOV, KORCHINSKAJA & TOZER, 1974

Type species: *Ptychites kruzini* BYTSCHKOV 1973.

Arctoptychites kruzini BYTSCHKOV 1976

Plate 2, fig. 13

1976 *Arctoptychites kruzini* BYCHKOV, p. 143, pl. 26, fig. 4, text-fig. 14, u.

Holotype: BYCHKOV 1976, pl. 26, fig. 4.

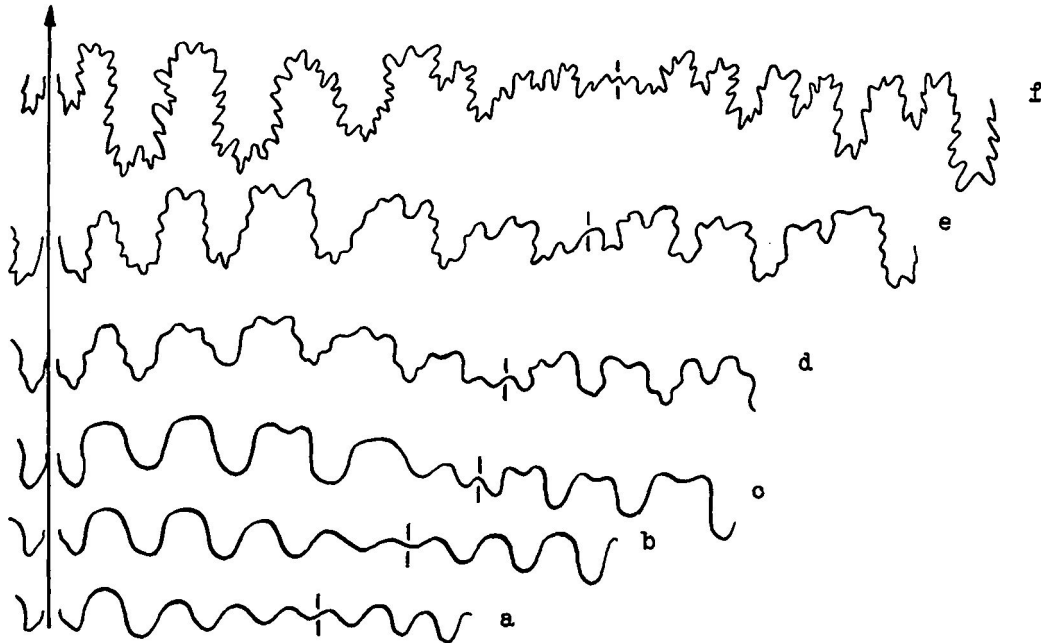
Type locality: North-East of the USSR, upper reaches of the river Yana-Okhotskaya.

Type level: Middle Triassic, ladinian, *kruzini* zone (= *omoljensis* zone).

Form and sculpture: The shell is greatly inflated, close to spheroidal, involute. Until the eighth whorl the whorl width exceeds its height more than twice. Ventral side is broad and rounded. At the last whorl (9–10) ventral side becomes roundo-tectiform. Umbilicous is narrow, deep, funnellform with a high steep wall. The sculpture in the form of coarsely-rounded radial ribs appears only with the seventh whorl. The ribs originate in the near-umbilical part of the shell, cross the lateral side, slightly curving backwards, and bend sharply forward in the near-ventral part of the whorl and then become subdued.

Dimensions in mm and ratios:

Specim. N	D	H	W	D _u	H/D	W/D	D _u /D
47/321	49	34	29	9	0,70	0,59	0,18



Text-fig. 13. Ontogenetic development of lobe line in *Arctoptychites kruzini* BYTSCHEKOV, all the stages were drawn from specimen N 46/321: a — with H = 0,7 mm, W = 1,8 mm (2,5 whorls) (x 16), b — with H = 0,8 mm, W = 2,2 mm (2,8 whorls) (x 16), c — with H = 1,0, W = 2,8 mm (3,4 whorls) (x 12), d — with H = 2,0 mm, W = 5,0 mm (4,6 whorls) (x 12), e — with H = 8,0 mm, W = 19 mm (7,4 whorls) (x 4), f — with H = 14,0 mm, W = 28,0 mm (8,5 whorls) (x 4). Kharaulakh Range, Adgirhai River, Ladinian Stage, *omoljensis* zone.

Lobe line: Development of *Arctoptychites kruzini* BYTSCHEKOV lobe line obeys the same laws as that of *Aristoptychites* (VAVILOV & ALEKSEYEV 1979), i. e. in the process of ontogeny even-numbered lobes extend to the outer side of the shell while odd-numbered lobes to the inner side. With H = 0,7 mm and W = 1,8 mm (2,5 whorls) the line consists of 8 lobes — (V₁V₁)LU¹U²U⁴:U³ID, lobe U⁴ being located immediately near the suture on the outer side of the whorl (Text-fig. 13, a). Ventral lobe is bifid, all lobe elements are rounded. With H = 0,8 mm and W = 2,2 mm (2,8 whorls) (Text-fig. 13, b) lobe U⁵ appears on umbilical suture. Saddles on the inner side of the line gradually acquire characteristic “ptychitic” box form. With H = 1 mm and W = 2,8 mm (3,4 whorls) this form of saddles extends to the outer side of the whorl, while, on the inner side of the whorl hollows appear in the tops of the saddles (Text-fig. 13, c). Lobe U⁵ is shifted to the inner side of the whorl while lobe U⁶ originates on the outer side near suture. With H = 2 mm and W = 5 mm (4,6 whorls) the major elements of the line become corrugated, the tops of all saddles become box-like and hollows develop in them, lobe U⁶ starts forking (Text-fig. 13, d). With H = 8 mm and W = 19 mm (7,4 whorls) dorsal lobe is bifid, most elements of the line are corrugated (Text-fig. 13, e). Lobe line of the shell of 8 whorls consists of 10 lobes. Coarse corrugation of the elements makes the line look like that of an ammonite (Text-fig. 13, f). The line formula is (V₁V₁)LU¹U²U⁴U⁶:U⁵U³I(D₁D₁). On the inner side of the line at the top of saddles poorly developed adventive lobes can be observed, which are practically absent on the outside part of the line.

Comparison: The species described differs from other known ptychites by coarse ribs sharply bending forward when approaching ventral side to form the peculiar sinus. Typical for *Arctoptychites kruzini* BYTSCHEKOV is almost complete absence of adventive lobes at the tops of saddles on the outer stretch of the line.

Geological and geographic range: Ladinian stage, *omoljensis* zone in the north-east of the USSR.

Material: 2 specimens (NN 46—47/321).

Arctoptychites euglyphus (MOJSISOVICS 1886)

Plate 2, figs. 11–12

- 1877 *Ammonites trochleaeformis* — OEBERG, p. 4, pl. 1, figs. 2–3, non fig. 1.
 1886 *Ptychites euglyphus* MOJSISOVICS, p. 94, pl. XIV, figs. 1–3.
 1886 *Ptychites lundgreni* MOJSISOVICS, p. 90–94, pl. XIII, fig. 4, pl. XIV, fig. 4.
 1886 *Ptychites nordenskjöldi* MOJSISOVICS, p. 92–93, pl. XIII, fig. 3.
 1886 *Ptychites latifrons* MOJSISOVICS, p. 95, pl. XIII, figs. 5–6.
 1961 *Ptychites* ex gr. *euglyphus* — POPOV, p. 104, pl. X, fig. 6.
 1983 *Aristoptychites euglyphus* — WEITSCHAT, LEHMANN, p. 41, pl. I, figs. 2–3, pl. II, figs. 1–3.

Lectotype: OEBERG 1877, pl. 1, figs. 2–3, Coll. Naturhist. Riksmus. Paleozool. Avd. Stockholm, no. Mo. 314, a, b.

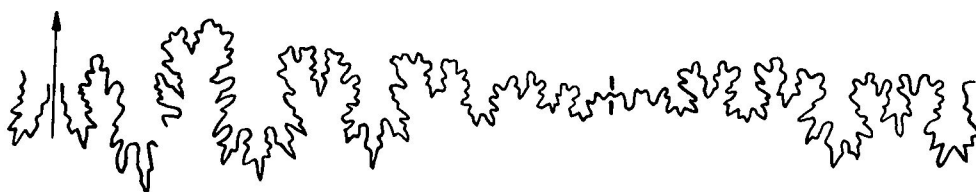
Type locality: Spitsbergen.

Type level: Middle Triassic, Lower Ladinian, *Daonella* Shales (Botneheia Formation).

Form and sculpture: The shell is involute or moderately involute and greatly inflated. Ventral side is broad, rounded, roundo-tectiform on the last whorls. Lateral sides are convex merging smoothly with ventral side. Umbilicus is narrow, with the last whorls it becomes moderately narrow, funnellform with a high, very steep wall. The sculpture in the form of radial ribs appears with the eighth whorl. When approaching the ventral bend, the ribs are slightly curved forward, forming a shallow sinus, and disappear.

Dimensions in mm and ratios:

Specim. N	D	H	W	D _u	H/D	W/D	D _u /D
48/321	24	12,5	25	6	0,52	1,004	0,25
49/321	46	22	36	10	0,48	0,79	0,22



Text-fig. 14. Lobe line of *Arctoptychites euglyphus* (MOJSISOVICS), specimen N 49/321 with H = 22,0 mm, W = 36,0 mm (9,7 whorls) (x2). Kharaulakh Range, Nyakutchan River, Ladinian Stage, *omolovensis* zone.

Lobe line: The line is subammonitic (Text-fig. 14) of the peculiar “ptychitic” type with broad box-like saddles provided with rather deep cuts. Saddles on the inner side of the line are more dissected than the ones on the outer side. Ventral lobe is small, bifid, lateral lobe is less than the first umbilical one. All lobes of the line are coarsely indented, the saddles are corrugated. Adventive lobes are apparently absent. The suture of *A. euglyphus* (MOJSISOVICS) in its development seems to obey the laws inherent in ptychites: even-numbered lobes pass to the outer side of the whorl, odd-numbered ones to the inner side. The suture line formula (ninth whorl) may be presented as follows: $(V_1 V_1) LU^1 U^2 U^4 (U_1^1 U_1^1) : U^5 U^3 I (D_1 D_1)$.

Comparison: Siberian specimens resemble greatly those of *A. euglyphus* (spec. of SGPIHM 2803, 2805) described from Ladinian deposits of Spitsbergen (WEITSCHAT & LEHMANN 1983). The presence of characteristic sculpture makes it possible to refer this species to *Arctoptychites*, not to *Aristoptychites*, as it was suggested by the German authors. The species described differs from *A. kruzini* BYTSCHKOV by a more inflated shell on the younger whorls and less sharply bending ribs on the ventral side of the shell without forming a deep sinus.

Geological and geographic range: Ladinian stage, *omolovensis* zone of the northern part of Middle Siberia and *varius* zone of Spitsbergen.

Material: 2 specimens (NN 47–48/321).

Analysis of *Longobardites* and *Indigirites* occurrence in Anisian and Ladinian deposits of the Boreal Region

In Anisian and Ladinian deposits of the North-eastern part of the USSR the following species of the genus *Longobardites* have so far been established: *L. ex gr. nevadanus* HYATT & SMITH from the *kharaulakhensis* zone of Middle Anisian substage (DAGYS & KAZAKHOV 1984); *L. nevadanus* HYATT & SMITH from the *rotelliforme* and *humboldtensis* zone of the Upper Anisian substage (DAGYS & KAZAKHOV 1984); *L. taimyrensis* KIPARISOVA characterizes, according to L. D. KIPARISOVA (BYCHKOV & KIPARISOVA 1968), the Middle Anisian or, according to Y. M. BYCHKOV (BYCHKOV et al. 1976) the Upper Anisian substage; *L. arkagalensis* BYTCHKOV from Upper Anisian or Lower Ladinian deposits (BYCHKOV et al. 1976); *L. oleshkoi* ARCHIPOV from the Lower Ladinian substage zone of the same name (ARCHIPOV 1974); *L. constantis* ARCHIPOV from the *omolajensis* zone of the Upper Ladinian substage (ARCHIPOV 1974, DAGYS et al. 1979); *Longobardites* sp. from the *krugi* zone of the Upper Ladinian substage (DAGYS et al. 1979). In a later study (DAGYS & KAZAKHOV 1984) this species is not mentioned in the list of fauna characterizing the *krugi* zone.

Mainly external morphological features without consideration of peculiarities in shell development during the process of ontogeny were used as the basis for distinguishing species of the genus *Longobardites*. By means of such an approach it is rather difficult to diagnose certain species of this genus that are characterized by a strong morphological similarity of adult shells having no distinct features. Furthermore, incomplete characteristics of certain distinguished species makes their validity doubtful.

To establish the actual validity of certain species of *Longobardites* and their stratigraphic value the authors made an attempt of a comprehensive study of the material, including obtained data on the ontogenetic development of the lobe line and morphologic features of Anisian and Ladinian *Longobardites* shells. They stress the importance of certain features to distinguish species and to determine the nature of changes of these features in time. Characteristic developmental features of the lobe line of Late Anisian *Longobardites* were established earlier (ALEKSEYEV et al. 1984). In the present study the main attention was paid to the establishment of characteristic features in the ontogenetic development of form and sculpture of *Longobardites* from the *kharaulakhensis*, *nevadanus*, "*oleshkoii*" and *omolajensis* zones on different whorls. For this purpose a great number of shells have been studied in transverse polished sections (Text-fig. 16—19). Principal parameters of the shells (D, H, W, D_u and ratios) at different stages of development are given in Table 1. Internal structures of *Longobardites* representatives have been discussed earlier and are not discussed here (ALEKSEYEV et al. 1984).

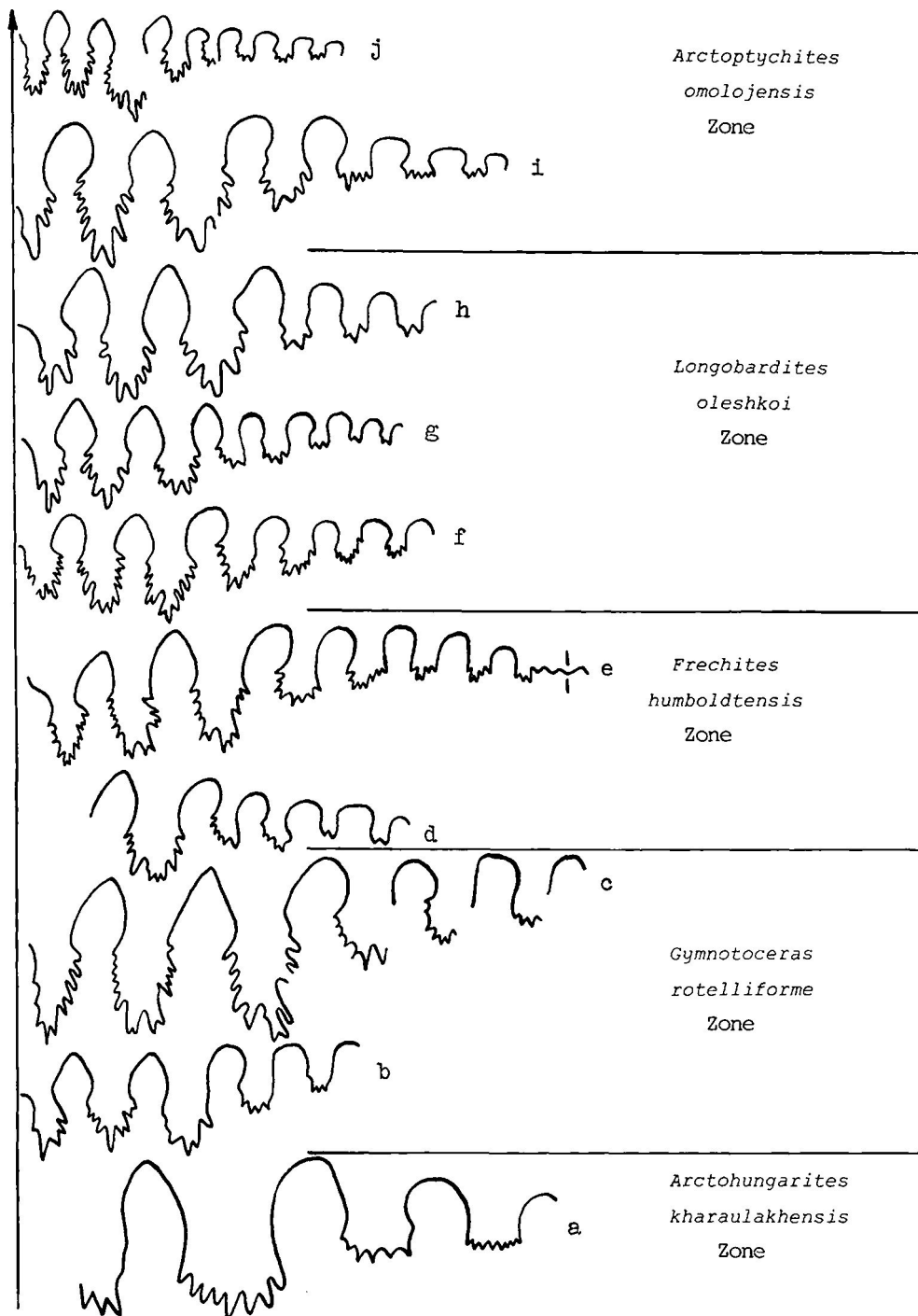
The earliest representatives of genus *Longobardites* from the *kharaulakhensis* zone were collected by the authors from the geological section of Anisian deposits near the settlement Stannakh-Khocho on the shore of Olenyek bay, the Laptev sea (Text-fig. 1). Well preserved *Longobardites* from the overlying *rotelliforme* zone were found on the island of Taas-Ary in the lower course of the river Lena and in the basin of the river Kengdey in the Artiste-Agatyn-Yurege Creek. The youngest Anisian *Longobardites* from *nevadanus* zone were found in the geological section near the settlement Stannakh-Khocho and in the basin of the river Kengdey. A detailed description of the above mentioned sections and their paleontological characteristics were given in the papers of A. S. DAGYS (DAGYS et al. 1979) and V. V. ARKADIEV (1981). The Ladinian *Longobardites* described come from the section on the river Nyakutchan.

The analysis of stratigraphic range of *Longobardites* in Anisian and Ladinian deposits of the North-eastern part of the USSR and the study of the shell morphology and ontogeny of the suture make it possible to infer:

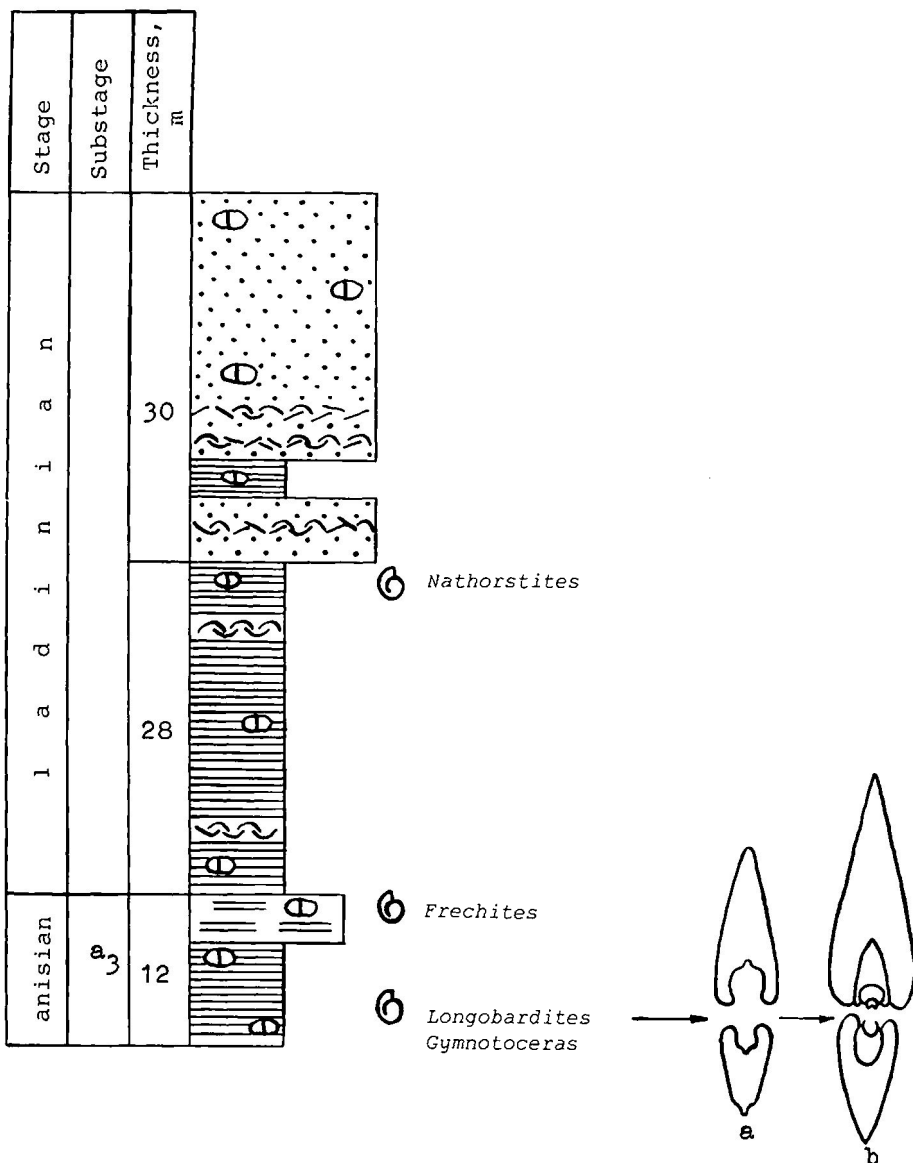
1. In the sections studied in detail the genus *Longobardites* is connected through a very gradual transition with *Indigirites*, forming a complete phylogenetic sequence. The supposition expressed earlier after that *Indigirites* belongs to the subfamily Longobarditinae is confirmed (ARKADIEV & VAVILOV 1984a).

2. Lobe lines of *Longobardites*, studied on representatives of this genus from the *kharaulakhensis*, *nevadanus*, "*oleshkoii*" zones and *Indigirites* from the *omolajensis* and *krugi* zones (Text-fig. 15) develop after to the same pattern. In the process of ontogeny even numbered lobes formed on the suture, or near it, are shifted to the outer side of the shell while odd-numbered lobes are shifted to the inner side. Similar results were obtained earlier by ASSERETO (ASSERETO 1966). The time of appearance of new elements on the lobe line of Anisian *Longobardites* coincides, as a whole, with that of Ladinian forms, or a little earlier.

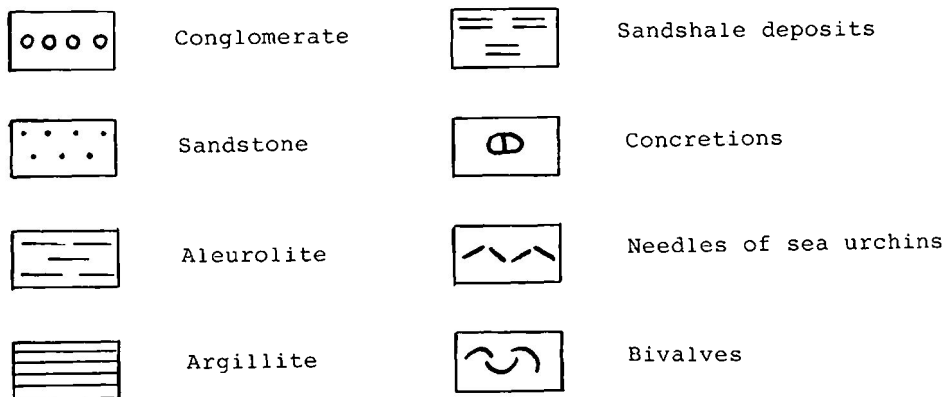
It should be noted that there are no pseudoadventive elements in the *Longobardites* lobe line. According to NOETLING (1905), pseudoadventive lobes originate as a result that the ventral lobe becomes more complicated. It should



Text-fig. 15. Lobe lines of *Longobardites* and *Indigirites* genera. Their stratigraphic allocation is given according to "Geostratigraphical scale" (1984). a — *Longobardites* sp., 2/321 with H = 24 (?) mm (sixth ? whorl) (x 4), the shore of Olenek Bay, Laptevs Sea, Stannakh-Khocho settlement; b — *L. nevadanus* HYATT & SMITH, 8/321 with H = 28,5 mm (sixth whorl) (x 3), the Lena delta, Taas-Ary island; c — *L. nevadanus* HYATT & SMITH, 6/321 with H = 34,0 mm (x 3), same location; d — *L. nevadanus* HYATT & SMITH, 9/321 with H = 27,0 mm (sixth whorl) (x 3), Kharaulakh Range, Kengdey Basin, Artiste-Agatyn-Yurege Creek; e — *L. nevadanus* HYATT & SMITH, 3/831 with H = 33,0 mm (sixth whorl) (x 2), the Kolyma basin, Olguya River; f — *L. nevadanus* HYATT & SMITH, 14/321 with H = 38,0 mm (end of sixth whorl) (x 1,9), Kharaulakh Range, Nyakutchan River; g — *L. ex gr. nevadanus* HYATT & SMITH, 18/321 with H = 21,0 mm (x 3), same location; h — *L. ex gr. nevadanus* HYATT & SMITH, 16/321 with H = 18,5 mm (beginning of sixth whorl) (x 6), same location; i — *Indigirites constantis* (ARCHIPOV), 20/321 with H = 28,5 mm (end of sixth whorl) (x 3), same location; j — *I. constantis* (ARCHIPOV), 25/321 with H = 29,5 mm (end of sixth whorl) (x 1,9), same location.



Text-fig. 16. Geological section of Anisian and Ladinian deposits on Taas-Ary island. a, b — cross-section of *Longobardites nevadanus* HYATT & SMITH shells, a — 8/321 (x1,3), b — 6/321 (x1,1), *rotelliforme* zone.

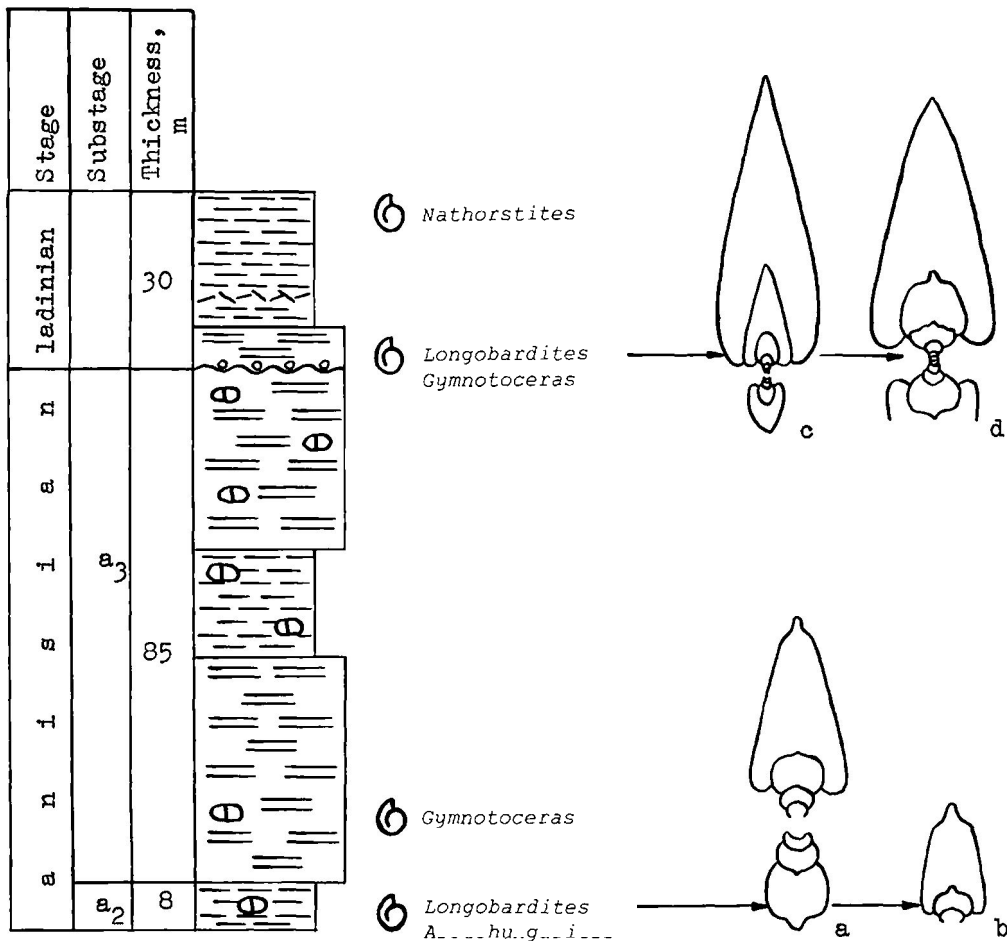


be considered incorrect to call certain lobes and saddles on the outer part of *Longobardites* suture “pseudoadventive” only because they grow faster in the process of ontogeny, as it introduces confusion into the terminology of lobe line elements.

3. Lobe lines of adult shells of *Longobardites* and *Indigirites* are very similar except for the lobe lines of *Longobardites* from the *kharaulakhensis* zone, which are the simplest ones (slightly phylloid saddles and broad lobes crenulated at the basis) (Text-fig. 15). According to this feature *Longobardites* from the *kharaulakhensis* zone seems to represent a new species.

Lobe lines of Upper Anisian and Ladinian *Longobardites* are difficult to distinguish though Ladinian forms have a still more complicated suture and are closer to *Indigirites*. As a result the nature of lobe line, without consideration of other features, cannot be used to distinguish between Upper Anisian and Ladinian *Longobardites*.

4. The form of adult shells of *Longobardites* characterized by a much similar morphology cannot be used as a distinguishing feature either (these are strongly involute, laterally compressed oxycones without distinct sculpture). Only the study of shells in transverse polished sections enabled us to establish a number of important diagnostic features which include, first of all, change of the pattern of cross-section of the shell in the process of ontogeny and the extent of involuteness and inflation of the shell on the first whorls. To distinguish between certain groups of the phylogenetic sequence of *Longobardites-Indigirites* morphologic features of the shell at the third to fifth stage of development should be used, as at this period, generally, sharp morphologic changes take place (the appearance of

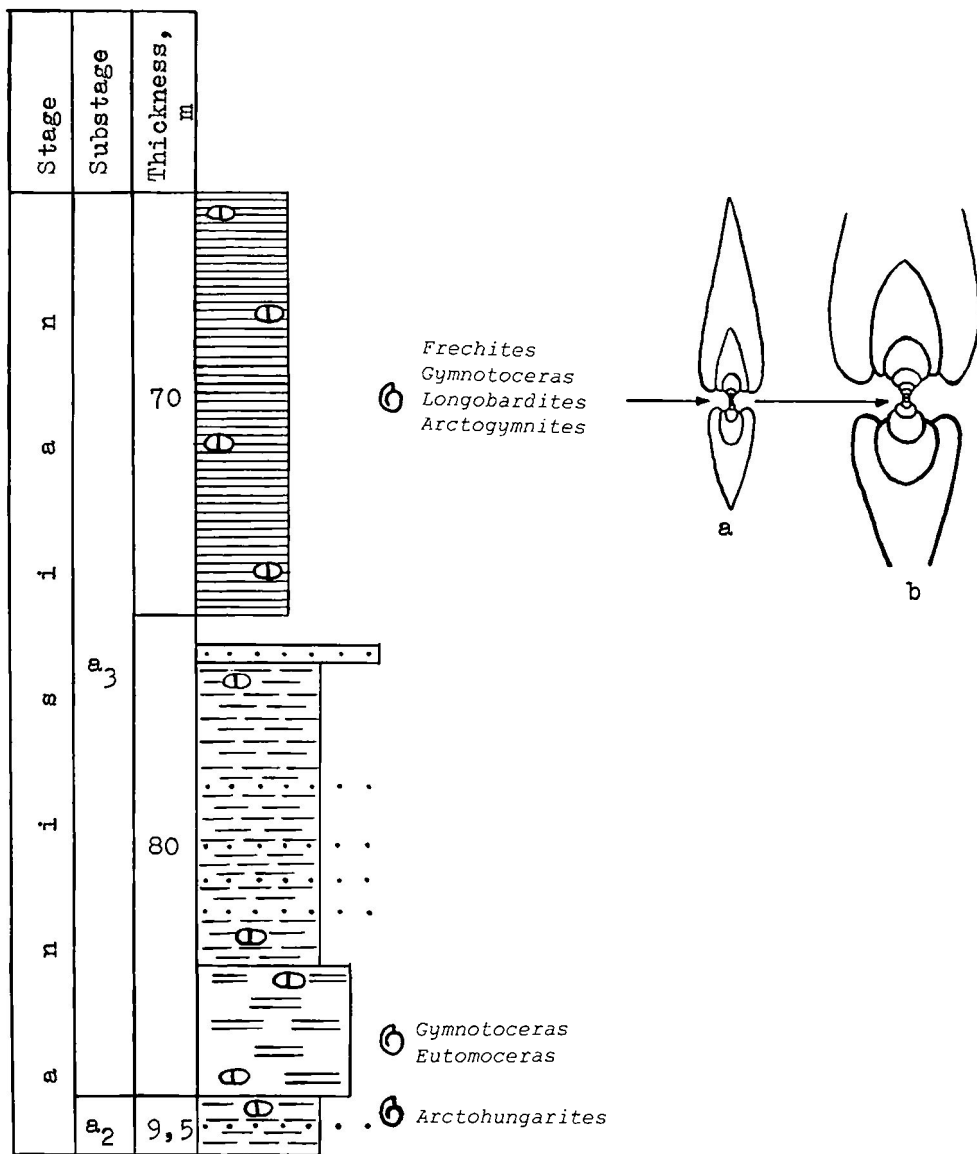


Text-fig. 17. Geological section of Anisian and Ladinian deposits on the shore of Olenek Bay, Laptev Sea (Stannakh-Khocho settlement). a—d — cross-sections of *Longobardites* shells, a — 3/321 (x 3,6), b — 2/321 (x 2,0), *kharaulakhensis* zone; c — 12/321 (x 0,7), d — 11/321 (x 2,0), *nevadanus* zone.

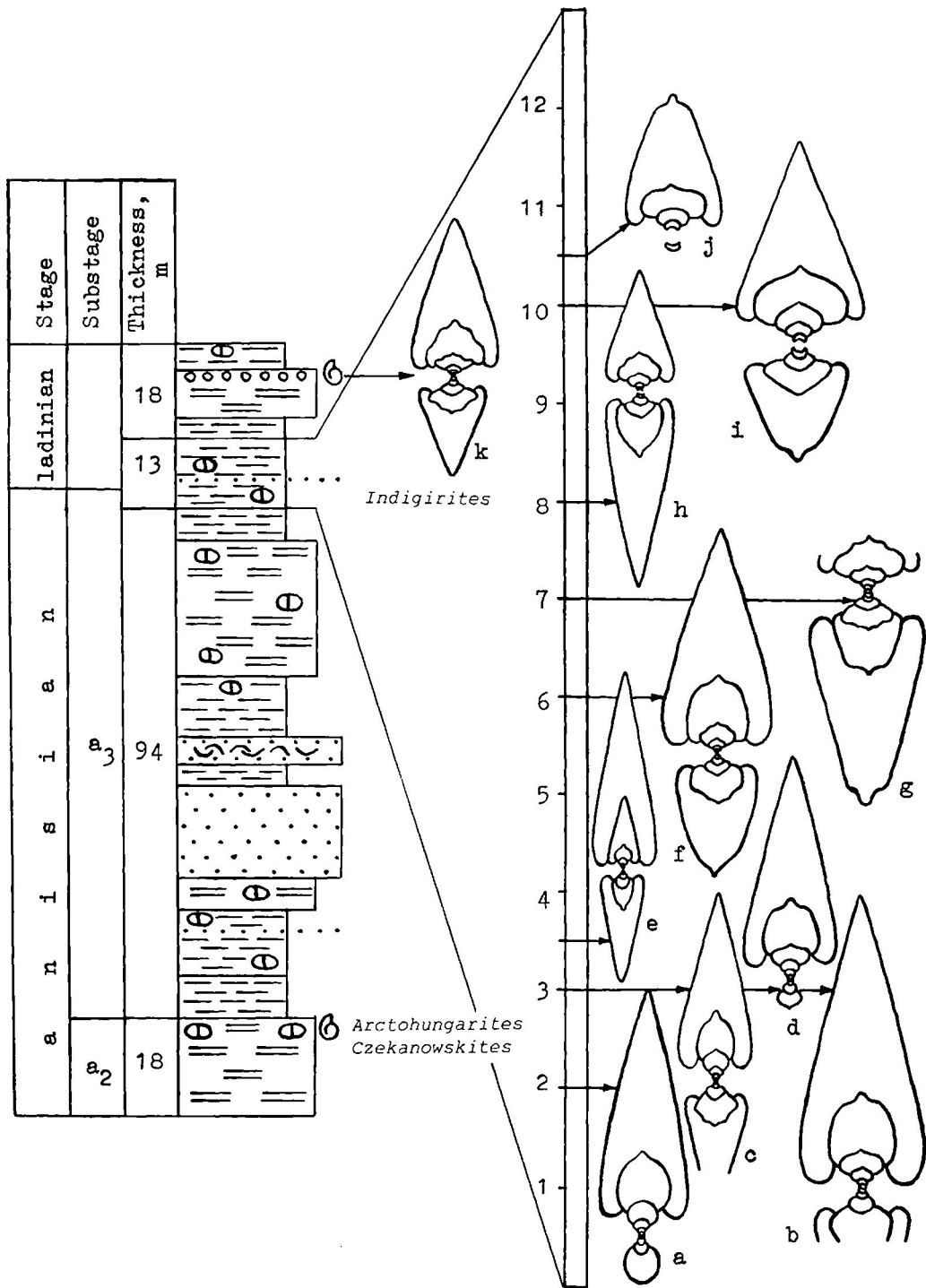
a keel on the ventral side, changes in the form of cross-section, changes in the extent of involuteness and shell inflation, abrupt complications of lobe line, change in the type of septal necks).

5. Comparison of Upper Anisian *Longobardites* from the *nevadanus*-group and *Longobardites* occurring in layers above those containing *Frechites* allows to state that there are no distinct differences pertaining to the species. For *Longobardites* of both groups the presence (or absence) of a keel on the ventral side of earlier volutions, similar parameters of shells (extent of involuteness and inflation) and also the pattern of an adult shell suture are characteristic. The authors believe *Longobardites oleshkoi* ARCHIPOV to be the synonym of Upper Anisian *Longobardites nevadanus* HYATT & SMITH.

6. At the basis of the *omolajensis* zone comparatively sharp differences in the sequence of *Longobardites* species have been established.



Text-fig. 18. Geological section of Anisian deposits on Artiste-Agatyn-Yurege Creek (the Kengdey Basin): a, b — cross-sections of *Longobardites nevadanus* HYATT & SMITH shells, a — 9/321 (x 1,0), b — 10/321 (x 2,0), *nevadanus* zone.



Text-fig. 19. Geological section of Anisian and Ladinian deposits on the river Nyakutchan (the Tchubukulakh Basin), a—k — cross-sections of *Longobardites* and *Indigirites* shells, a — *Longobardites nevadanus* HYATT & SMITH, 14/321 (x 2,1), b — *L. ex gr. nevadanus* HYATT & SMITH, 17/321 (x 3,3), c — *L. ex gr. nevadanus* HYATT & SMITH, 16/321 (x 1,5), d — *L. ex gr. nevadanus* HYATT & SMITH, 18/321 (x 2,1), e — *L. nevadanus* HYATT & SMITH, 19/321 (x 0,8), f — *Indigirites constantis* (ARCHIPOV), 20/321 (x 1,2), g — *I. constantis* (ARCHIPOV), 21/321 (x 2,0), h — *I. constantis* (ARCHIPOV), 22/321 (x 1,0), i — *I. constantis* (ARCHIPOV), 24/321 (x 2,0), j — *I. constantis* (ARCHIPOV), 25/321 (x 2,1), k — *I. krugi* POPOV, 31/321 (x 1,1). (a—e) — *nevadanus* zone (*spectori* subzone = “*oleshkoi*” zone), (f—j) — *omoljensis* zone, k — *krugi* zone.

In the section on the Nyakutchan (Text-fig. 19) this boundary can be drawn some 6 m upwards from the foot of the member containing *Longobardites*. “*Longobardites*” from the *omolojensis* zone are distinguished by a greater inflation of the shell ($W/D = 0,61-0,83$ with four whorls), they are, as a rule, of pentagonal form in the cross-section (with four whorls), have isolated ventro-lateral shoulders and are more evolute. In *Longobardites* species that occur below that level $W/D = 0,38-0,53$ (with four whorls, Table 1) the ventro-lateral shoulders are absent in the majority of cases, the cross-section of the whorl is elongated in height. These *Longobardites* species are more involute for the closure of the umbilicus in some of them is already completed with the fifth whorl ($D_u/D = 0,04-0,084$) and by 4,5 whorls their diameter amounts to 15 mm (*Longobardites* from “*oleshkoii*” zone grows faster). From all points of view *Longobardites* species from the *omolojensis* zone are closer to true *Indigirites* species and that is why the species *Longobardites constantis* described by ARCHIPOV (1974) is referred to the genus *Indigirites* by the authors.

It should be noted, however, that in “*oleshkoii*” zone there appear forms with pentagonal cross-section of earlier volutions (Text-fig. 19), which are intermediate between *Longobardites* and *Indigirites*. We identify them as *Longobardites ex gr. nevadanus* HYATT & SMITH.

7. The presence or absence of a keel on the ventral side of *Longobardites* shells cannot be used as a basis to their distinguish them as both keeled and non-keeled forms are encountered together at the same stratigraphic levels in the *rotelliforme*, *nevadanus* zones and in the overlying layers. As for the *kharaulakhensis* zone, no definite conclusions can be made due to the lack of information. The authors believe that a keel is a convex formation on the ventral side, bounded by two furrows, but not the tapering of the ventral side formed by flat converging lateral sides.

The material studied by us suggests a later appearance of a keel in Ladinian *Longobardites*: in Anisian forms the keel appears on the 3–3,5 whorl growth stage (the data obtained on the 2 specimens), in Ladinian *Longobardites* it appears on the 4–5 whorl growth stage.

8. As a result of the investigations carried out by the authors the following species of *Longobardites* and *Indigirites* and their stratigraphic sequence have been established in Anisian deposits of the north-eastern part of the USSR (Table 2): *Longobardites* sp. — *kharaulakhensis* zone of Middle Anisian substage; *L. nevadanus* HYATT & SMITH — *rotelliforme*, *nevadanus* zones; *Indigirites constantis* (ARCHIPOV) — *omolojensis* zone; *I. krugi* POPOV — *krugi* zone.

9. A little unusual situation is observed in the development of the *Longobardites-Indigirites* phylogenetic branch: a faster development of Anisian *Longobardites* compared to Ladinian ones (faster shell growth and its closure, an earlier appearance of the keel on the ventral side and complication of the suture). Many Triassic groups of ammonoidea show the reverse tendency in their development.

10. It is rather difficult to make comparison with forms from Nevada because in North America species of *Longobardites* are very well represented in the Middle and Upper Anisian, while in the north-east of the USSR they are mainly represented in Upper Anisian and Ladinian. Besides, SILBERLING & NICHOLS (1982) based their differentiation of *Longobardites* species on the differences in shell morphology with $D = 15$ mm without considering the number of whorls. The material collected by us showed that *Longobardites* of different number of whorls can have such a diameter, i. e. it is impossible to use this feature for the purpose of comparison without considering the number of whorls. The *Longobardites* sequence in Nevada is characterized by decrease in evoluteness of the shell, with $D = 15$ mm, from 0,15–0,40 in the *hyatti* zone to 0,05 in the *occidentalis* zone. For *Longobardites* of the north-eastern part of the USSR the reverse is true — increase in evoluteness from 0,04–0,23 in Upper Anisian (with 5 whorls) to 0,15–0,27 in the *omolojensis* zone of the Ladinian stage; no forms having $D_u/D = 0,40$ have been found in the north-eastern part of the USSR.

Longobardites from the Middle Anisian of Nevada are characterized by the presence of a keel on the ventral side of earlier volutions, while in the Upper Anisian forms from Nevada there is no keel at all. It has not been possible to establish the same regularity for *Longobardites* from the north-eastern part of the USSR.

11. When erecting the species *Longobardites nevadanus* its authors HYATT & SMITH (1905) chose as the holotype the form without a keel on the ventral side of earlier volutions.

ASSERETO (1966) who revised the genus *Longobardites* subdivided it into three subgenera: *Longobardites* s. s., *Intornites* ASSERETO and *Longobarditoides* SHEVYREV. According to ASSERETO the subgenus *Intornites* differs from the true *Longobardites* by evolute earlier volutions and the presence of a hollow convex keel on the ventral side of earlier volutions. The following species were referred by him to the subgenus *Intornites*: *Longobardites (Intornites) intornatus* MCLEARN, *L. (I.) nevadanus* HYATT & SMITH, *L. (?I.) taimyrensis* KIPARISOVA.

McLEARN (1969) pointed to the variable nature of representatives of the genus *Longobardites* and on this basis he united the species *L. nevadanus* HYATT & SMITH, *L. canadensis* McLEARN and *L. intornatus* McLEARN into one species *L. nevadanus*.

Table 2. Stratigraphic distribution of species *Longobardites*, *Indigirites*, *Eutomoceras*, *Frechites*, *Monophyllites* and *Arctoptychites* in North-east Asia.

STAGE		SUBSTAGE		Zone	Species described	Canada
LADINIAN	Upper			<i>Nathorstites mcconnelli</i>	<i>Longobardites</i> sp. <i>L. nevadanus</i> HYATT & SMITH <i>Indigirites constantis</i> (ARCHIPOV) <i>I. krugi</i> POPOV <i>Eutomoceras tarium</i> ARKADIEV & VAVILOV <i>Frechites nevadanus</i> (MOJISOVICS) <i>F. darkyensis</i> VAVILOV & ARKADIEV <i>Monophyllites bytschkovi</i> VAVILOV <i>Arctoptychites kruzini</i> BYTTSCHKOV <i>A. englyphus</i> (MOJISOVICS)	<i>sutherlandi maclearni</i>
				<i>Indigirites krugi</i>		<i>meginae</i>
				<i>Arctoptychites omolojensis</i>		<i>poseidon</i>
	Lower			?		<i>subasperum</i>
ANISIAN	Upper	Frechites nevadanus	<i>Arctogymnites spektori</i> (= "oleshkoi")		(same as above)	<i>chischa</i>
			<i>Frechites nevadanus</i>			
			<i>Gymnotoceras rotelliforme</i>	<i>deleeni</i>		
Middle			<i>Arctohungarites kharaulakhensis</i>		<i>varium</i>	
			<i>Czekanowskites decipiens</i>			

SILBERLING & NICHOLS (1982) promoted the subgenus *Intornites* to the rank of a genus. These authors who made a revision of HYATT & SMITH's descriptions (HYATT & SMITH 1905) noted poor preservation of the holotype and the paratypoid of this species. One of the paratypoids (MCZ 3903a) studied by them, which HYATT & SMITH failed to show, has a keel on the ventral side. Based on this evidence SILBERLING & NICHOLS, following McLEARN (1969) refer the forms with keeled (or non-keeled) earlier volutions to the species *Intornites nevadanus*. According to SILBERLING & NICHOLS (1982) *Longobardites* with keeled and more or less evolute earlier volutions (*Intornites mctaggarti*,

I. nevadanus) are characteristic for the Middle Anisian of Nevada, while *Longobardites* (true ones) with compressed earlier volutions without a keel on the ventral side (*Longobardites parvus*, *L. zsigmondyi*) are characteristic for upper Anisian.

At present all Anisian and Ladinian species of *Longobardites* known in the north of Middle Siberia are referred to *Intornites* (DAGYS & KAZAKOV 1984).

The authors believe that differences in morphology of earlier volutions of *Longobardites* and *Intornites* shells, even though their adult forms are similar and, what is more, their structure and development of lobe line and internal features are monotypic, cannot serve as the basis for promoting *Intornites* to the rank of a genus. According to the initial diagnosis only the forms with evolute, comparatively flattened keeled earlier volutions, such as *Longobardites* (*Intornites*) *mctaggarti* (McLEARN), should be referred to the subgenus *Intornites*. Species *Longobardites nevadanus* HYATT & SMITH which, according to the new data (SILBERLING & NICHOLS 1982), includes both keeled and non-keeled forms and cannot be considered as *Intornites*. Referring all Anisian and Ladinian *Longobardites* from the north of Middle Siberia to *Intornites* seems doubtful. To establish their identity in each individual case ontogenic investigations are required.

Boundary between Anisian and Ladinian Stages in Boreal region

Investigations carried out by us show that *Longobardites* from the “*oleshkoi*” zone neither by shell morphology nor by peculiarities of lobe line development differ from *Longobardites* of the *nevadanus* group which occur in Upper Anisian. *Gymnotoceras* and *Frechites* widespread in Upper Anisian are absent from the “*oleshkoi*” zone but there are no ammonoidea pointing definitely to a Ladinian age. All ammonoidea making up the zone complex — *Longobardites* “*oleshkoi*” ARCHIPOV, *Arctogymnites spectori* ARCHIPOV, *Monophyllites* ex gr. *wengensis* KLIPST. — do not allow to speak definitely of the Ladinian age of deposits. By its stratigraphic position the “*oleshkoi*” zone was earlier compared to the *Eoprotrachyceras subasperum* zone of British Columbia (Geostratigraphical Scale, 1984). According to TOZER (1971, 1980) the *subasperum* zone in this region is characterized by the oldest *protrachyceras* with a ceratite lobe line — *Eoprotrachyceras matitinum* TOZER — and besides that it contains *Gymnotoceras* spp., *Ptychites* sp. and *Daonella* cf. *moussoni* MERIAN. In Nevada where the type section of the zone *Eoprotrachyceras subasperum* is located (SILBERLING & TOZER 1968, SILBERLING & NICHOLS 1982), the ammonoidea *Eoprotrachyceras subasperum* (MEEK), *E. meeki* (MOJS.), *Frechites* (*Gymnotoceras*) *johnstoni* SILBERLING & NICHOLS, *Epigymnites alexandrae* (SMITH) were found above the Upper Anisian *Frechites occidentalis* zone. The appearance of *Eoprotrachyceras* distinctly defines the lower boundary of the Ladinian stage in this region. It is significant that Beyrichitidae (*Gymnotoceras*) do not disappear at the boundary between Anisian and Ladinian but pass into the overlying *subasperum* zone.

In Arctic Canada, like everywhere in the Boreal Region, *Eoprotrachyceras* species are not known. *Protrachyceras* distinguished earlier by TOZER (1967) in association with *Longobardites* and *Ptychites* (possibly *Aristoptychites*) from the layers with *Daonella frami* in a geological section on Ellesmere Island in the Canadian Arctic actually turned out to be a younger form with ammonitic lobe line, which proves the fact that it belongs to the overlying zone of *Progonoceratites poseidon* (TOZER 1980).

In the section on the Nyakutchan studied by us, and incidentally, in other sections of North-East Asia (BYCHKOV 1977, DAGYS et al. 1979), a distinct biostratigraphic boundary is established above the ambiguous “*oleshkoi*” zone. It is in this zone that “*Longobardites*” with a pentagonal form of the earlier volutions, more characteristic of *Indigirites* than *Longobardites*, appears. In connection with this we refer the *Longobardites constantis* ARCHIPOV found here to the genus *Indigirites*. Furtheron, *Tsvetkovites* and, which is most important, characteristic ribbed ptychites (*Arctoptychites*) appear at this level. The latter are typical representatives of the *Progonoceratites poseidon* zone of British Columbia (TOZER 1980). This fact allows to reliably correlate the *Arctoptychites omolojensis* zone of North-East Asia and the *Progonoceratites poseidon* zone of British Columbia. *Protrachyceras* in this *poseidon* zone are, according to TOZER (1980), true representatives of this genus, similar to *P. longobardicum* from *Protrachyceras archelaus* zone of the Tethys. In this connection the *poseidon* zone and its correlate, the *omolojensis* zone, are referred to the Upper Ladinian (Geostratigraphical Scale, 1984).

In the *Daonella* shales of the Svalbard Archipelago (WEITSCHAT & LEHMANN 1983) the lowest level of Ladinian fauna contains *Arctoptychites euglyphus* (MOJS.), *Tsvetkovites varius* WEITSCHAT & LEHMANN and *Ussurites spetsbergensis*

(OEBERG). This ammonioidea complex correlates with the *omolojensis* zone of North-East Asia and the *poseidon* zone of British Columbia and the Canadian Arctic.

Thus, there are no reliable correlation zones for the Lower Ladinian *Eoprotrachyceras subasperum* zone. The *Longobardites "oleshkoi"* zone would be more justifiably considered as Upper Anisian for the type-index of the zone seems to be synonymous to the Upper Anisian species of *L. nevadanus* while the entire complex of the zone consists mainly of the forms passing from Anisian into Ladinian deposits. Of course, it does not follow from this that there are no analogues to Lower Ladinian deposits in the Boreal Region. A conformable contact between Anisian and Ladinian deposits is observed in geological sections of North-East Asia. The absence of depositional interruptions between Anisian and Ladinian is also indicated by the fact that both *Longobardites* spread widely in Upper Anisian and Ladinian *Indigirites* make up together a phylogenetic branch.

Perhaps in this boundary level the ammonioidea will be found in future and present a possibility to allow a more accurate dating. As a tentative version, the authors suggest to refer the layers containing *Longobardites* and *Arctogymnites*, earlier considered to be Lower Ladinian, to the Anisian stage. The authors believe these layers to be the uppermost subzone of the *Frechites nevadanus* zone, for which the type-index *Arctogymnites spectori* is suggested. The lower boundary of the subzone is determined by the disappearance of *Frechites* from the *nevadanus* group. The subzone is characterized by *Longobardites nevadanus* HYATT & SMITH, *Arctogymnites spectori* (ARCHIPOV), *Monophyllites* ex gr. *wengensis* KLIPST.

The authors believe that the lower boundary of the Ladinian stage of the Boreal region is clearly established by the appearance of *Indigirites* and *Arctoptychites* which are not encountered downwards in the section but along with *Nathorstites* are typical for the Ladinian stage.

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Explications of plates

Plate 1

- Fig. 1. *Longobardites* ex gr. *nevadanus* HYATT & SMITH, 16/321: a — side view, b — oral view, life-size; Kharaulakh Range, Nyakutchan River, "oleshkoi" zone.
- Fig. 2. *Longobardites nevadanus* HYATT & SMITH, 9/321: a — side view, b — ventral view, life-size; Kharaulakh Range, Artiste-Agatyn-Yurege-Creek, *nevadanus* zone.
- Fig. 3. *Longobardites nevadanus* HYATT & SMITH, 7/321: a — side view, b — oral view, life-size; Kharaulakh Range, Kengdey Basin, Artiste-Agatyn-Yurege-Creek, *rotelliforme* zone.
- Fig. 4. *Longobardites nevadanus* HYATT & SMITH, 19/321: a — oral view, b — side view, life-size; Kharaulakh Range, Nyakutchan River, "oleshkoi" zone.
- Fig. 5. *Indigirites constantis* (ARCHIPOV), 24/321: a — side view, b — oral view, life-size; Kharaulakh range, Nyakutchan River, *omolojensis* zone.
- Fig. 6. *Indigirites constantis* (ARCHIPOV), 28/321, earlier volutions (x 2): a — oral view, b — ventral view, c — side view; Kharaulakh Range, Nyakutchan River, *omolojensis* zone.
- Fig. 7. *Indigirites constantis* (ARCHIPOV), 29/321, earlier volutions (x 2): a — side view, b — oral view, c — ventral view; Kharaulakh Range, Nyakutchan River, *omolojensis* zone.
- Fig. 8. *Indigirites constantis* (ARCHIPOV), 25/321: a — side view, b — oral view, life-size; Kharaulakh Range, Nyakutchan River, *omolojensis* zone.
- Fig. 9. *Indigirites constantis* (ARCHIPOV), 20/321: a — ventral view, b — side view, life-size; Kharaulakh Range, Nyakutchan River, *omolojensis* zone.
- Fig. 10. *Indigirites constantis* (ARCHIPOV), 27/321: a — oral view, b — side view, life-size; Kharaulakh Range, Nyakutchan River, *omolojensis* zone.

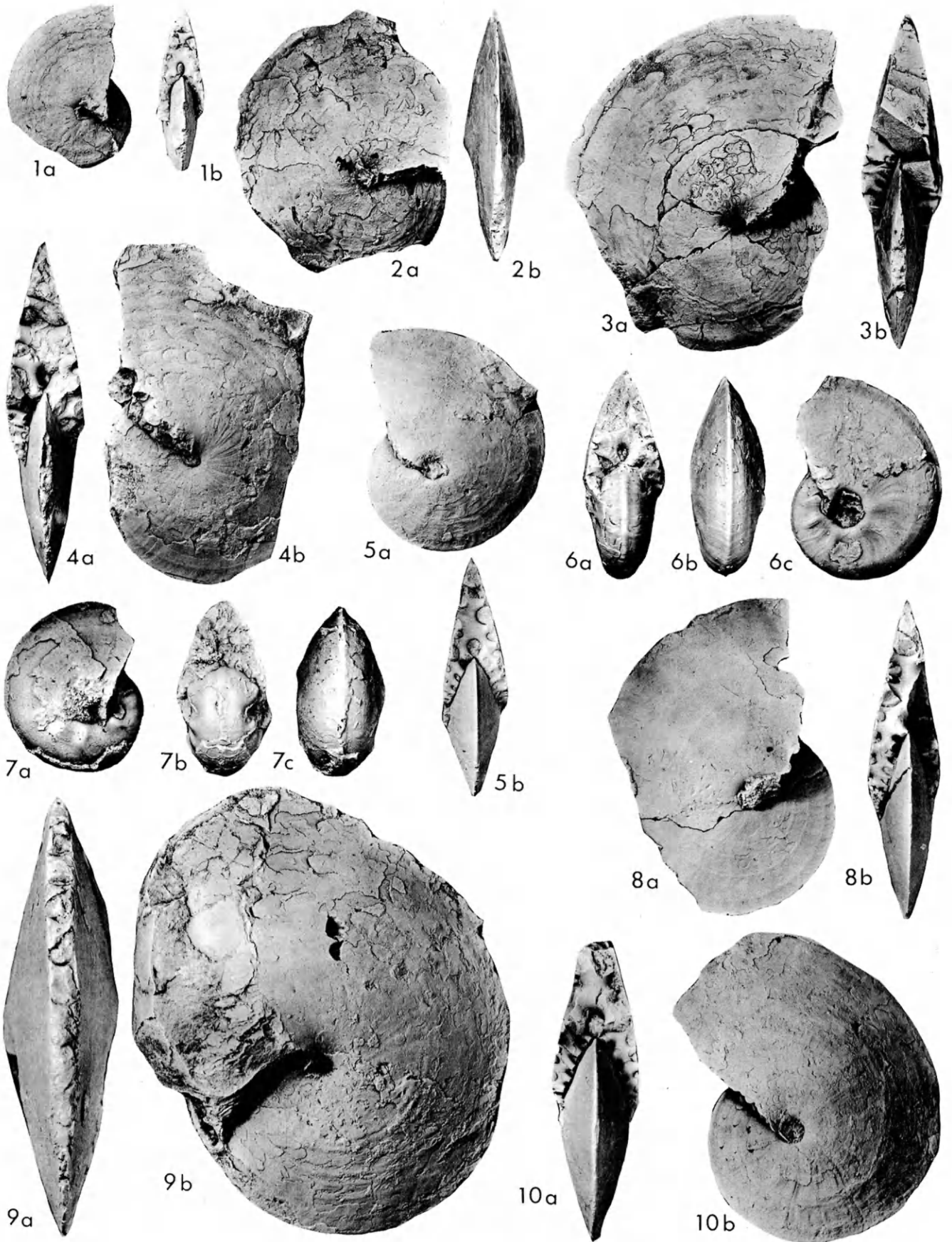


Plate 2

- Fig. 1. *Indigirites krugi* POPOV, 32/321, earlier volutions (x 2): a — ventral view, b — side view; Kharaulakh Range, Nyakutchan River, *krugi* zone.
- Fig. 2. *Indigirites krugi* POPOV, 31/321: a — side view, b — oral view, life-size; Kharaulakh Range, Nyakutchan River, *krugi* zone.
- Fig. 3. *Indigirites krugi* POPOV, 33/321, earlier volutions (life-size): a — ventral view, b — side view; Kharaulakh Range, Nyakutchan River, *krugi* zone.
- Fig. 4. *Eutomoceras rarum* sp. nov., 34/321, holotype: a — side view, b — ventral view (x 2); Kharaulakh Range, Kengdey Basin, Artiste-Agatyn-Yurege Creek, *rotelliforme* zone.
- Fig. 5. *Frechites nevadanus* (MOJSISOVICS), 37/321: a — oral view, b — ventral view, c — side view, life-size; Kharaulakh Range, Kengdey Basin, Artiste-Agatyn-Yurege Creek, *nevadanus* zone.
- Fig. 6—8. *Frechites darkyensis* sp. nov. 6 — 39/321, holotype: a — side view, b — oral view. 7 — 40/321, side view. 8 — 41/321, side view. Life-size. The shore of Olenek Bay, Laptevs Sea, Stannakh-Khocho settlement, *nevadanus* zone.
- Figs. 9—10. *Monophyllites bytschkovi* sp. nov. 9 — 44/321: a — side view, b — oral view, life-size. 10 — 45/321: side view, life-size. Kharaulakh Range, Nyakutchan River, *omolojensis* zone.
- Figs. 11—12. *Arctoptychites euglyphus* (MOJSISOVICS). 11 — 48/321: a — ventral view, b — side view, life-size. 12 — 49/321, side view, life-size. Kharaulakh Range, Nyakutchan River, *omolojensis* zone.
- Fig. 13. *Arctoptychites kruzini* BYTSCHKOV, 47/321: a — side view, b — oral view, life-size; Kharaulakh Range, Adgirhai River, *omolojensis* zone.

