Genus ***Pseudosageceras*** Diener, 1895

Type species: *Pseudosageceras* sp. indet. Diener, 1895.

Pseudosageceras multilobatum
Noetling, 1905
Figs. 129, 130

Pseudosageceras sp. indet. Diener, 1895, p. 28, pl. 1, fig. 8.
Pseudosageceras multilobatum Noetling, 1905a, p. 181, pls. 19–27; Noetling, 1905b, pl. 23, fig. 4, pl. 25, fig. 1, pl. 26, fig. 3; Krafft and Diener, 1909, p. 145, pl. 21, fig. 5; Smith, 1932, p. 87, pl. 4, figs. 1–3, pl. 5, figs. 1–6, pl. 25, figs. 7–16, pl. 60, fig. 32, pl. 63, figs. 1–6; Collignon, 1933, p. 56, pl. 11, fig. 2; Spath, 1934, p. 54, text-fig. 6a; Kiparosova, 1947, p. 127, pl. 25, figs. 3, 4; Chao, 1959, p. 183, pl. 1, figs. 9, 12; Kummel and Steele, 1962, p. 701, pl. 102, figs. 1, 2; Hada, 1966, pl. 4, fig. 6; Kummel and Erben, 1968, p. 112, pl. 19, fig. 9; Shevyrev, 1968, p. 79, pl. 1, figs. 1, 2; Weitschat and Lehmann, 1978, p. 95, pl. 10, fig. 2; Tozer, 1994, p. 83, pl. 18, fig. 1, text-fig. 17; Brayard and Bucher, 2008, p. 70, pl. 37, figs. 1–5.

Lectotype: Designated by Spath (1934, p. 54), is original of Noetling (1905a, p. 181, pl. 19, fig. 1, pl. 24, fig. 12) from the Ceratite Marls of Salt Range, Pakistan.

Material examined: One specimen, NSM PM23289, from AB1024, two specimens, NSM PM23290, 23291, from AB1022.

Description: Very involute, very compressed oxycone with very narrow, bicarinate venter and weakly convex flanks, convergent from occluded umbilicus to venter. Surface smooth without ornamentation. Suture line ceratitic with many adventitious elements. Lateral lobes trified, other lobes bified.

Measurements (*mm*):

Specimen no.	D	U	H	W	W/H
NSM PM23289	30.2	0.0	18.7	6.2	0.33
NSM PM23291	43.8	0.0	28.0	10.0	0.36

Occurrence: Described specimens from AB1022, AB1024 within the *Clypeoceras timorense* Zone (early Early Olenekian=early Smithian) in the main part of the Zhitkov Formation, Abrek Bay area, South Primorye.

Discussion: The specimen Diener (1895, p. 28) described as *Pseudosageceras* sp. indet from the Early Triassic of the Shamara Bay area, South Primorye is only a partial phargmocone, but it displays the same shell shape and suture as *Pseudosageceras multilobatum* Noetling, and it is probably conspecific. *P. multilobatum* is one of the most cosmopolitan species of the Early Triassic.

Scaphopods (by Y. Shigeta)

Systematic descriptions basically follow the classification by Palmer (1974), Skelton and Benton (1993), and Steiner and Kabat (2001).

Abbreviations for shell dimensions: L=shell length; D=diameter of anterior aperture.

Institution abbreviations: NSM=National Museum of Nature and Science, Tokyo.

Class Scaphopoda Bronn, 1862
Order Dentalioida Palmer, 1974
Family Laevidentaliidae Palmer, 1974
Genus ***Laevidentalium*** Cossmann, 1888

Type species: *Dentalium incertum* Deshayes, 1825.

Laevidentalium? sp. indet.
Fig. 131

Material examined: NSM PM23344 from AB1014, and NSM PM23345 from AB1016.

Description: Shell slender, tapering, moderately curved, with circular cross section. Shell wall thin to moderately thick. Ornamentation consists of oblique, circular annulations of various strength as well as fine growth lines. Internal mould smooth.

Measurements (*mm*):

Specimen no.	L	D
NSM PM23344	12.4	2.1
NSM PM23345	9.6	1.4

Occurrence: Described specimens from AB1014 within the *Clypeoceras spitiense* “bed” (early Late Induan=early Dienerian) and from AB1016 within the *Paranorites vari-*

Fig. 131. *Laevidentalium*? sp. indet. 1, NSM PM23344, from AB1014. 2, NSM PM23345, from AB1016. Scale bar=2 mm.

ans Zone (Late Induan=Dienerian) in the Zhitkov Formation, Abrek Bay area, South Primorye.

Discussion: The assignment of the specimens to *Laevidentalium* is uncertain and is based only on the similarity of their morphology with *Laevidentalium*. The described specimens are somewhat similar to *L. bangtoupoensis* Stiller (2001, p. 620) from the Upper Anisian of Qingyan, South-western China.

Gastropods (by A. Kaim)

Systematic descriptions basically follow the classification by Bouchet *et al.* (2005). Morphological terms are those used in the Treatise on Invertebrate Paleontology (Cox, 1960) and the glossary of malacological terms by Arnold (1965).

Abbreviations for shell dimensions: For bellerophontids (according to Yochelson, 1960): L=length, W=width, T=thickness; all others: H=shell height; D=shell diameter.

Institution abbreviation: NSM=National Museum of Nature and Science, Tokyo.

Class Gastropoda Cuvier, 1798
Order Amphigastropoda Simroth, 1906
Superfamily Bellerophontoidea McCoy, 1852
Family Euphemitidae Knight, 1956
Genus ***Warthia*** Waagen, 1880

Type species: *Warthia brevisinuata* Waagen, 1880.

Warthia zakharovi Kaim sp. nov.
Figs. 132–134

Type specimens: Holotype, NSM PM23322; four paratypes, NSM PM23323–23326, all from AB1016.

Diagnosis: *Warthia* with wide shell in comparison to its thickness and weakly depressed selenizone.

Etymology: In honor of Yuri D. Zakharov.

Description: Shell globular, almost as long as wide and lacking ornamentation. Slit short and broad at base of U-shaped sinus. Selenizone weakly depressed. Umbilicus absent.

Measurements (*mm*):

Specimen no.	L	W	T
NSM PM23322	10.3	10.1	8.9
NSM PM23323	10.8	10.0	7.7
NSM PM23324	14.3	12.7	11.2
NSM PM23325	14.5	10.8	9.8
NSM PM23326	9.2	9.4	7.5
NSM PM23329	13.0	12.1	11.1
NSM PM23330	17.6	17.5	15.0

Occurrence: Type specimens from AB1016 within the *Paranorites varians* Zone (Late Induan=Dienerian) in the lower main part of the Zhitokv Formation, Abrek Bay area, South Primorye, where this species locally forms a coquina composed mostly of *Warthia* shells.

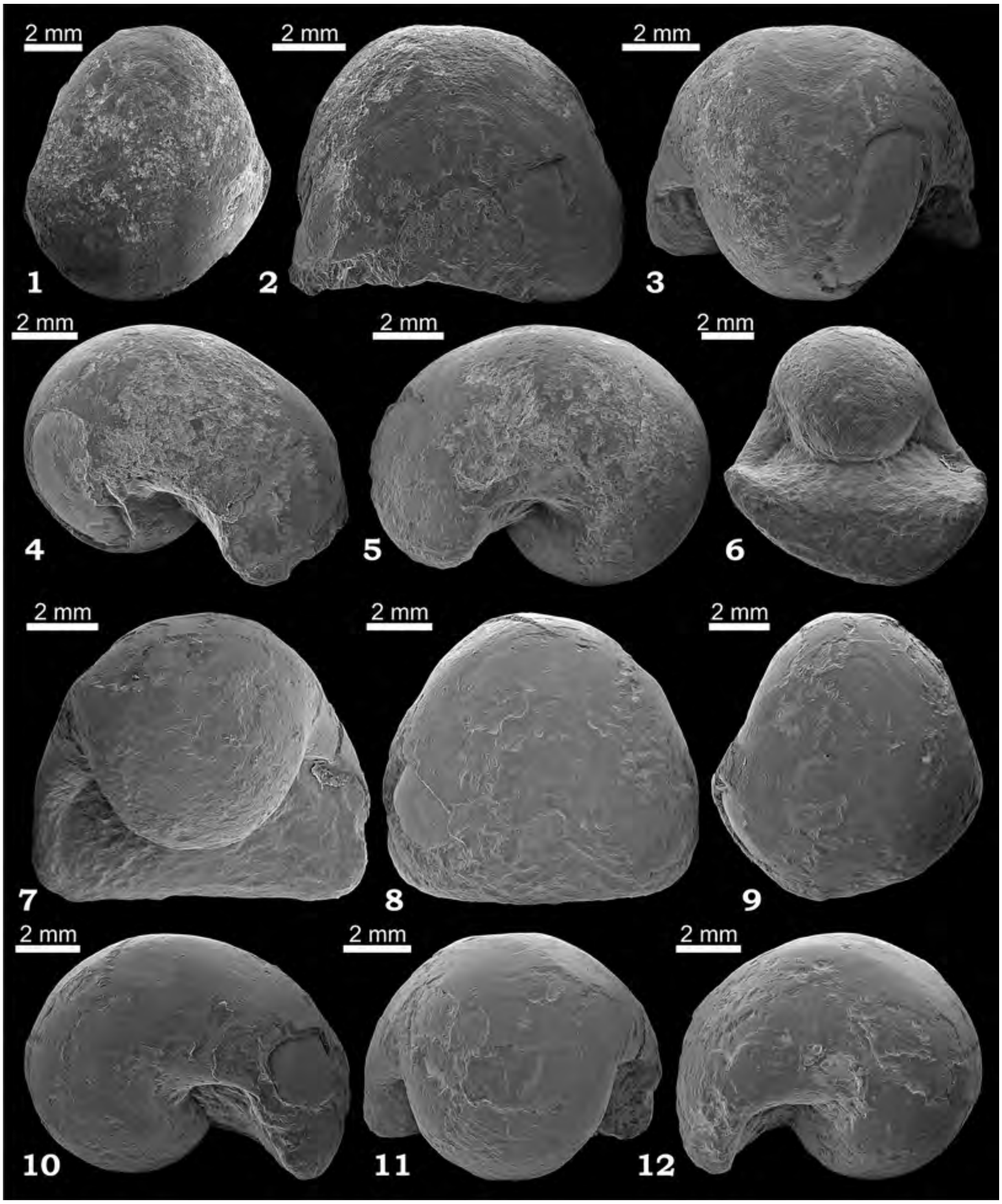


Fig. 132. *Warthia zakharovi* Kaim sp. nov. from AB1016. 1–5, NSM PM23323, paratype. 6–12, NSM PM23322, holotype. All SEM images.

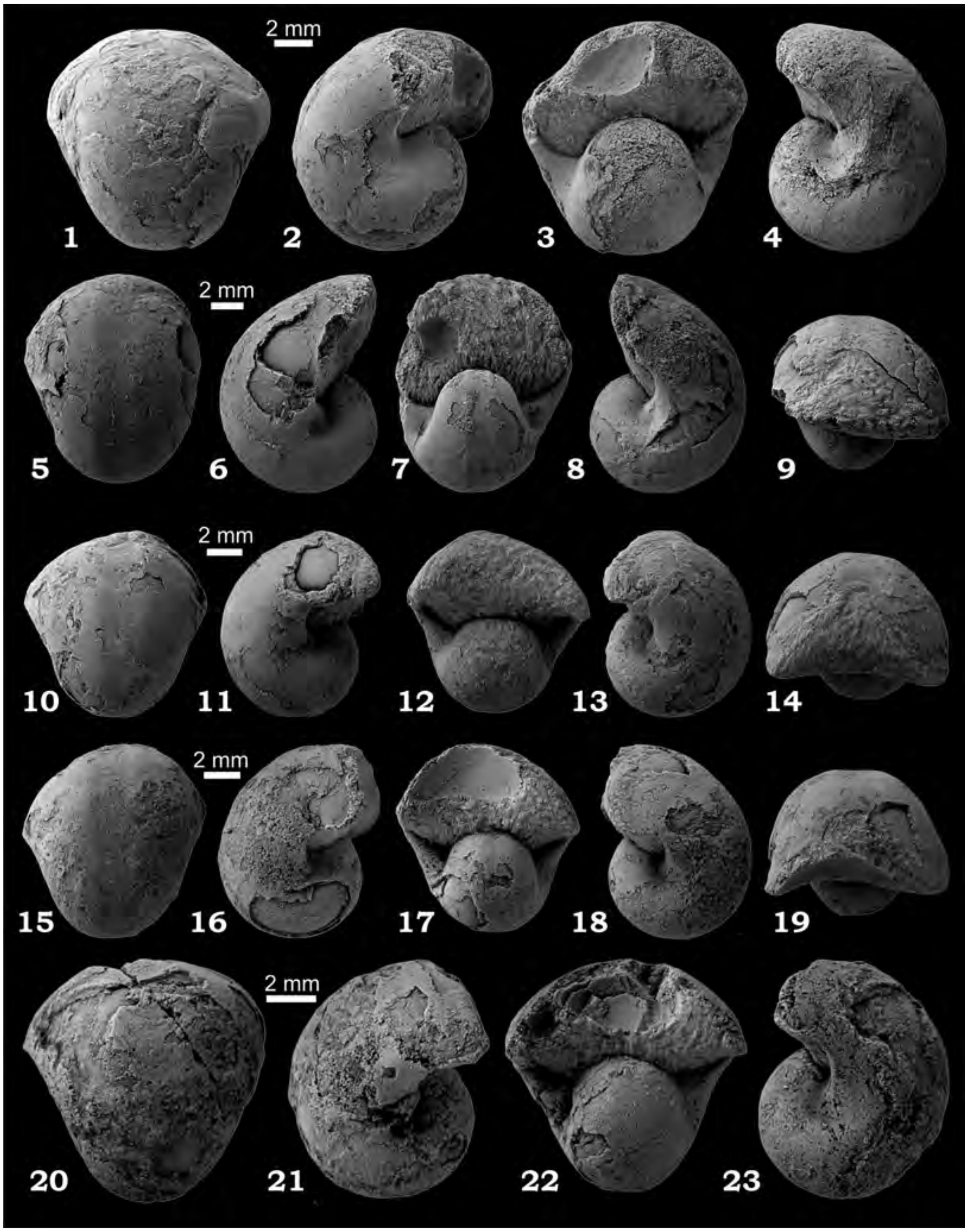


Fig. 133. *Warthia zakharovi* Kaim sp. nov. from AB1016. 1–4, NSM PM23324, paratype. 5–9, NSM PM23325, paratype. 10–14, NSM PM23322, holotype. 15–19, NSM PM23323, paratype. 20–23, NSM PM23326, paratype. All light images by Y. Shigeta.

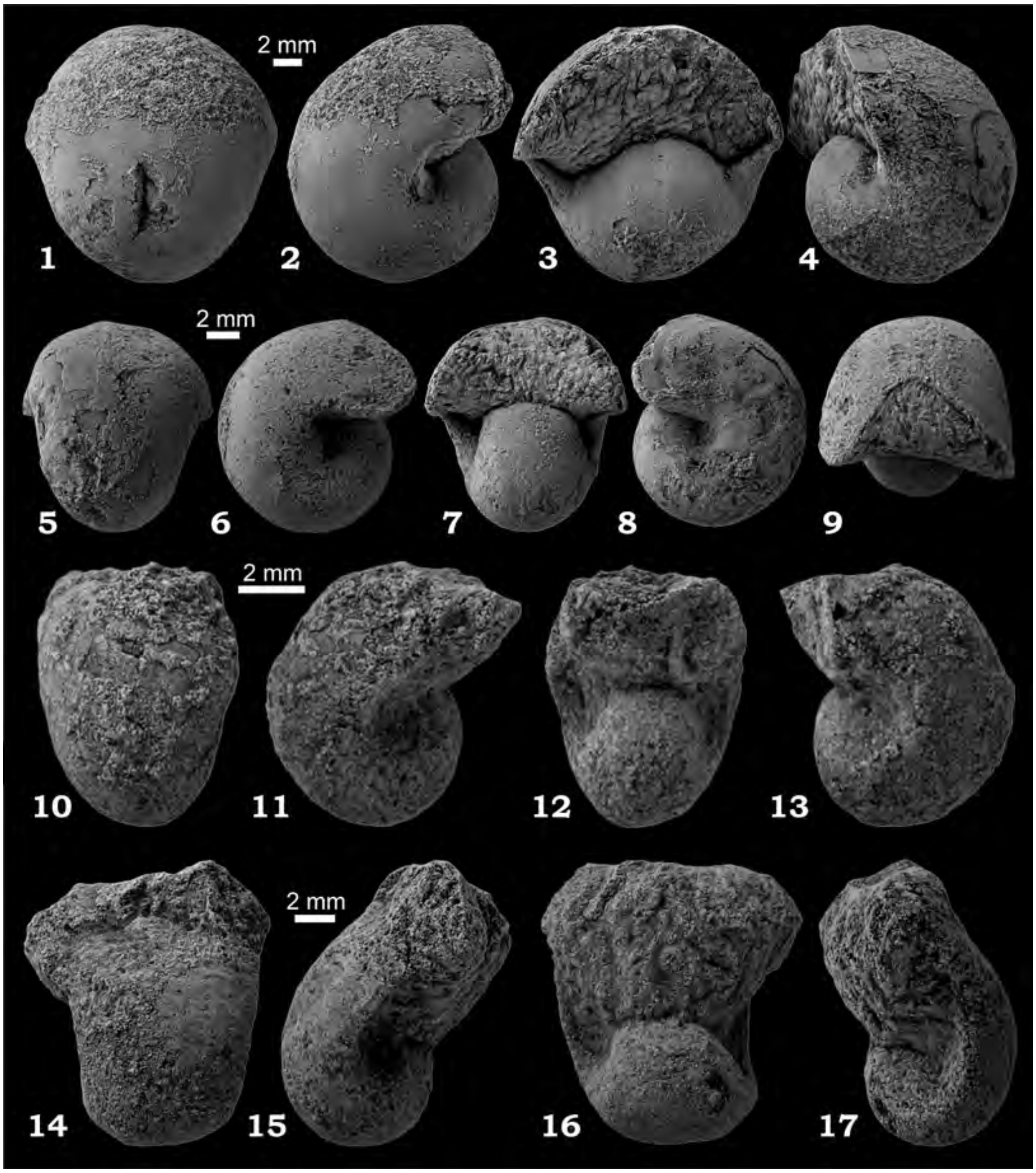


Fig. 134. *Warthia zakharovi* Kaim sp. nov. 1–4, NSM PM23330, from AB1021. 5–9, NSM PM23329, from AB1008. 10–13, NSM PM23327, from AB1004. 14–17, NSM PM23328, from AB1004. All light images by Y. Shigeta.

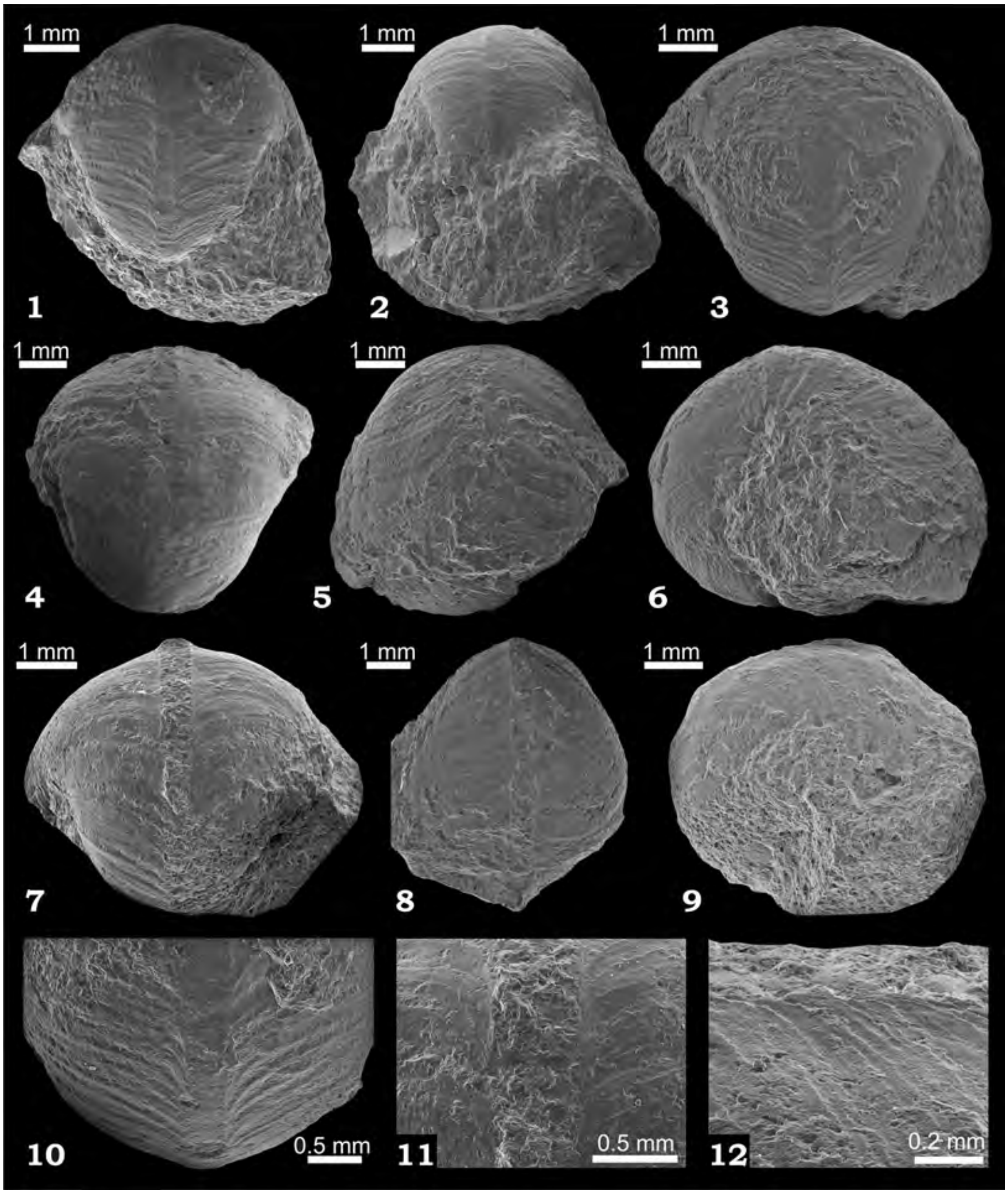


Fig. 135. *Bellerophon abrekensis* Kaim sp. nov. from AB1010. 1–6, 10, NSM PM23332, paratype. 7–9, 11–12, NSM PM23333, paratype. All SEM images.

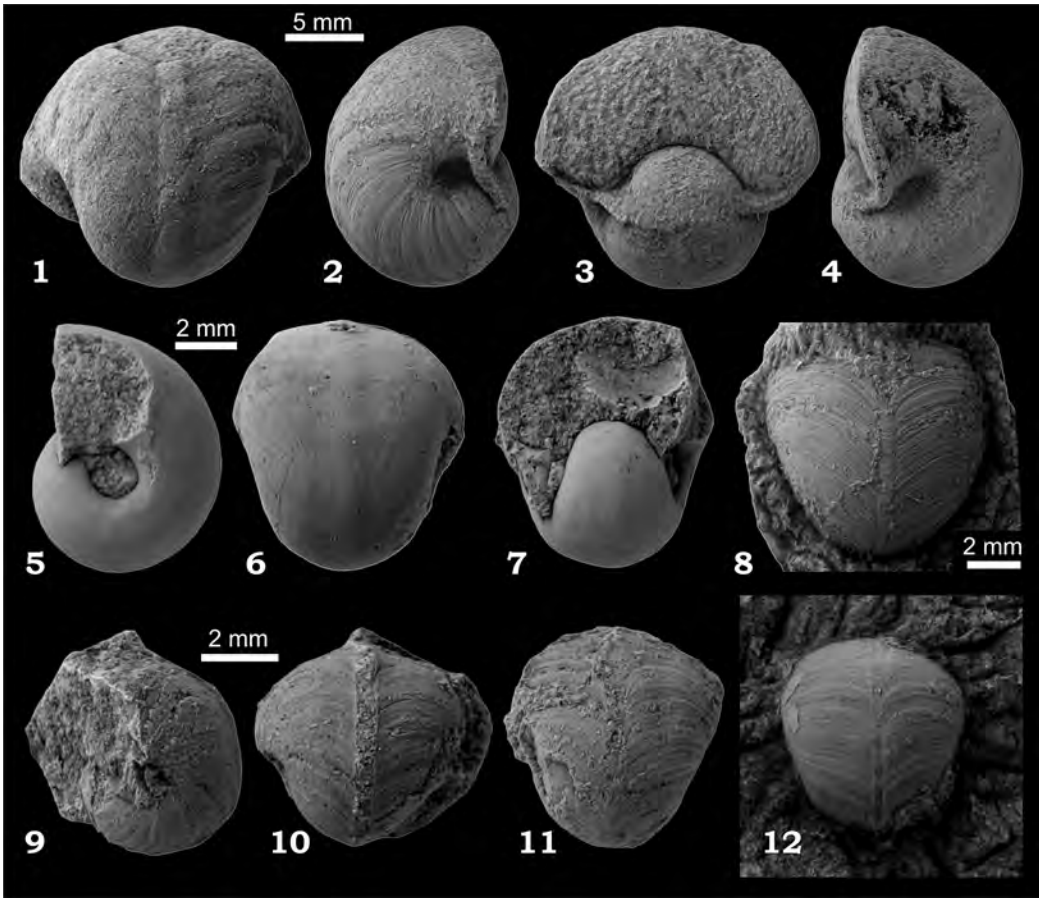


Fig. 136. *Bellerophon abrekensis* Kaim sp. nov. from AB1010. 1–4, NSM PM23331, holotype. 5–7, NSM PM23343, inner mould. 8, NSM PM23334, paratype. 9–10, NSM PM23333, paratype. 11, NSM PM23332, paratype. 12, NSM PM23335, paratype. All light images by Y. Shigeta.

Additional specimens from AB1004, AB1008, and AB1021. Two specimens, (NSM PM23327 and PM23328) from AB1004 (Early Induan=Griesbachian), are poorly preserved and tentatively assigned to *W. zakharovi*. Fossiliferous horizon at AB1008 (Early Induan=Griesbachian) yielded only a single specimen, NSM PM23329. The largest shell, NSM PM23330, came from AB1021 within the *Clypeoceras timorense* Zone (early Early Olenekian=early Smithian).

Discussion: *Warthia zakharovi* sp. nov. differs from other species of the genus in having a strongly globular shell and weakly depressed selenizone. Poorly preserved shells of the putative euphemitid bellerophontid *Euphemites guizhouensis* Pan, 1982 from the Lower Triassic of China are much more compressed as is also the case of the poorly constituted genus *Stachella* (for discussion see Yochelson & Hongfu, 1985).

Family Bellerophontidae McCoy, 1852

Genus ***Bellerophon*** Montfort, 1808

Type species: *Bellerophon vasulites* Montfort, 1808.

Bellerophon abrekensis Kaim sp. nov.

Figs. 135, 136

Bellerophon sp. indet. Bittner, 1899b, p. 28, pl. 4, figs. 26–28.
non *Bellerophon asiaticus* Wirth, 1936, p. 441, fig. 14: 7a, b.
Bellerophon asiaticus Wirth. Kiparisova 1947a, p. 121, pl. 24, figs. 6, 7.

Type specimens: Holotype, NSM PM23331; four paratypes, NSM PM23332–23335, all from AB1010.

Diagnosis: *Bellerophon* with well developed collabral ornamentation on adults composed of sets of thicker ribs with numerous, smaller intercalated ribs. Selenizone slightly elevated. Moderately thick inductura well developed on adult specimens. No spiral ornamentation.

Etymology: After type locality.

Description: Shell strongly globular, wider than long. Shell ornamented with collabral ribs bent posteriorly towards selenizone. In adults, ribs differentiated into sets of stronger and weaker ribs. Selenizone long and slightly elevated. Umbilicus well developed, but partially obscured in adults by well developed inductura extending over the parietal region of aperture.

Measurements (*mm*):

Specimen no.	L	W	T
NSM PM23331	16.3	17.7	11.8

Occurrence: Type specimens from AB1010 within the *Gyronites subdharmus* Zone (late Early Induan = late Griesbachian) in the upper part of the Lazurnaya Bay Formation, where this species is relatively common. Additional specimens with rather imperfect preservation from AB1012 (one specimen, NSM PM23336) and AB1013 (three specimens, NSM PM23337-23339). Fossiliferous horizons at AB1012 and AB1013 are within the *Ambitoides fuliginatus* Zone (early Late Induan = early Dienerian).

Discussion: *Bellerophon abrekensis* sp. nov. is seemingly conspecific with "*Bellerophon* sp. indet." sensu Bittner (1899b) from the Lower Triassic of South Primorye, Far East Russia, which was later indentified as "*Bellerophon asiaticus*" by Kiparisova (1947a). I agree with Yochelson and Hongfu (1985) that specimens discussed by Bittner (1899b) and Kiparisova (1947a) are not conspecific with *Retispira asiatica* (Wirth, 1936), a species based on poorly preserved material from Sichuan Province of China. Yochelson and Hongfu (1985) based their concept of this species on a new material from Guizhou Province of China, which clearly displays spiral ornamentation that is diagnostic of the genus *Retispira*. I could not confirm such ornamentation on any of the well preserved specimens from Abrek Bay, and therefore, I retained the genus *Bellerophon* for *B. abrekensis*. On the other hand I concur with the opinion of Yochelson and Hongfu (1985) that the specimens from Far East Russia could be synonimized with *B. panxianensis* Yu in Wang and Xi (1980). I examined a latex cast of the holotype of the latter species and it is clearly an anomphalous form, while *B. abrekensis* sp. nov. has a well developed umbilicus.

Order Vetigastropoda Salvini-Plawen, 1980
Superfamily Trochonematoidea Zittel, 1895
Family Lophospiridae Wenz, 1938
Genus ***Worthenia*** de Koninck, 1883

Type species: *Turbo tabulatus* Conrad, 1835.

Worthenia sp. indet.

Fig. 137

Material examined: Single specimen NSM PM23340 from AB1010.

Description: Shell turbiniform, small-sized and slightly higher than wide. Ornamentation consists of five spiral cords. Two cords located at the upper portion of the lateral flank and three others at the lower portion, including also a cord situated at the base demarcation. Interspace between both sets of cords is relatively wide and slightly concave. Protoconch, selenizone, aperture, and umbilical area not

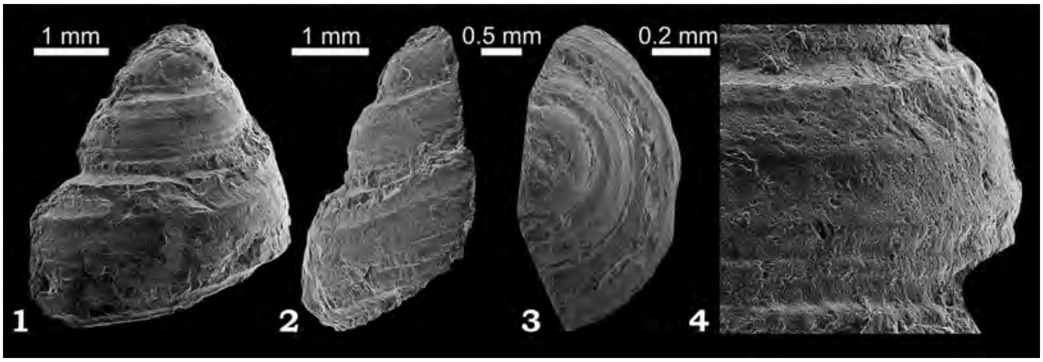


Fig. 137. *Worthenia* sp. indet. from AB1010. 1–4, NSM PM23340. All SEM images.

preserved on available specimen.

Measurements (*mm*):

Specimen no.	H	D	H/D
NSM PM23340	4.00	3.43	1.17

Occurrence: Described specimen from AB1010 within the *Gyronites subdharmus* Zone (late Early Induan=late Griesbachian) in the upper part of the Lazurnaya Bay Formation, Abrek Bay area, South Primorye.

Discussion: The described specimen is similar to *Worthenia windowblindensis* Batten and Stokes, 1986 from the Lower Triassic Sinbad Limestone, Utah, USA. The latter species has a slightly different cord arrangement with the widest cord interspace in the upper portion of the lateral flank. Having at hand only a single specimen of imperfect preservation, I decided to leave the species from Abrek Bay in open nomenclature.

Superfamily Trochoidea Rafinesque, 1815
Family Paraturbinidae Cossmann, 1916
Genus **Chartronella** Cossmann, 1902

Type species: *Chartronella digoniata* Cossmann, 1902.

Chartronella maedai Kaim sp. nov.

Fig. 138

Type specimens: Holotype, NSM PM23341; paratype, NSM PM23342, both from AB1014.

Diagnosis: *Chartronella* with strong spiral keel and subsidiary sutural and basal cords. Shell is additionally ornamented by weaker spiral ribs on the interspaces between the cords and medial keel.

Etymology: In honor of Haruyoshi Maeda.

Description: Shell turbiniform, small-sized and clearly higher than wide. Ornamentation consists of strong medial keel and subsidiary spiral cords at the suture and base demarcation, respectively. Additional fine spiral ribs appear on lateral flank on interspaces between cords and medial keel. On fourth whorl of the holotype, there are three spiral ribs between sutural cord and medial keel and one spiral rib between keel and basal cord. Aperture and umbilical area not preserved on available specimens.

Measurements (*mm*):

Specimen no.	H	D	H/D
NSM PM23341	6.67	4.86	1.37
NSM PM23342	5.77	4.46	1.29

Occurrence: Type specimens from AB1014 within the *Clypeoceras spitiense* “bed” (early Late Induan=early Dienerian) in the lower part of the Zhitkov Formation, Abrek Bay area, South Primorye.

Discussion: *Chartronella maedai* sp. nov. differs from the type of the genus *C. digoniata* Cossmann, 1902 by having only one strong keel, while the latter species has two keels. (see e.g., Gründel 1997; Nützel 2005). *C. uni-*

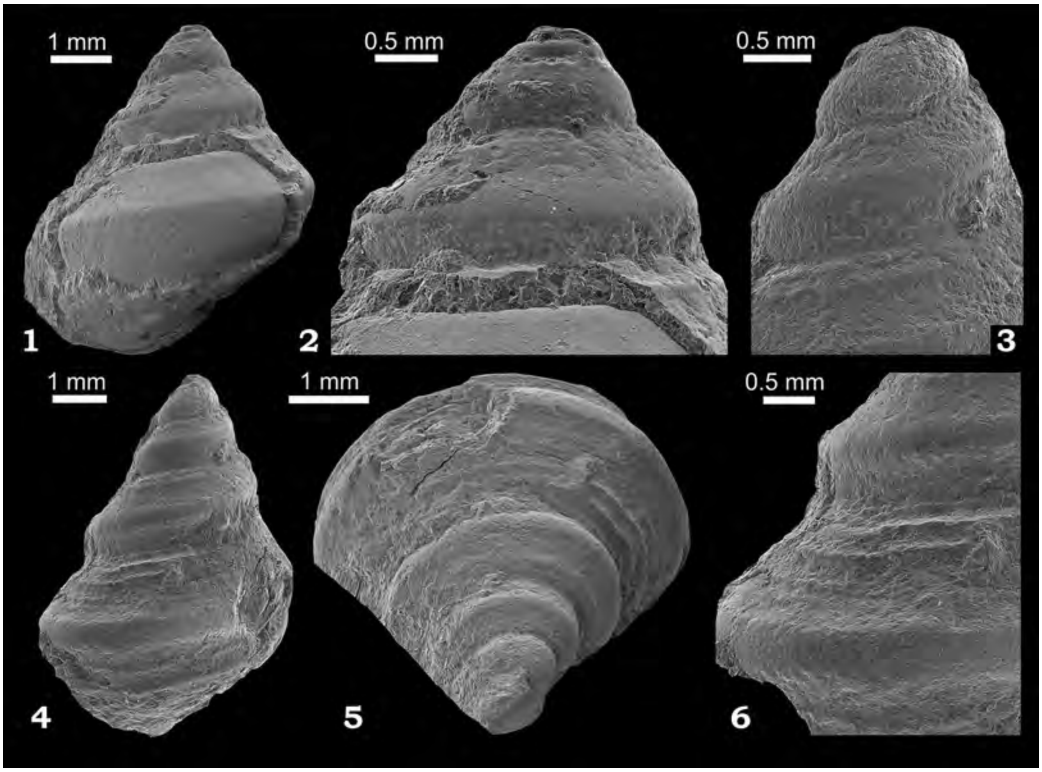


Fig. 138. *Chartronella maedai* Kaim sp. nov. from AB1014. 1–2, NSM PM23342, paratype. 3–6, NSM PM23341, holotype. All SEM images.

costata Batten and Stokes, 1986 has only a medial keel and no sutural and basal cords. *C. pagina* Batten and Stokes, 1986 has axial ornament, a feature lacking in *C. maedai*. Moreover, *C. maedai* has well developed fine spiral ribs, which are absent in the aforementioned species. Similar to, or even conspecific is *Chartronella* sp. indet. of Batten and Stokes (1986) from the Sinbad Limestone, Utah, USA, which also has a medial keel and two cords, but no fine spiral ribs are visible on the single specimens from Batten and Stokes (1986). However, this absence may be preservational bias.

Order Neritimorpha Koken, 1896
Superfamily Neritoidea Rafinesque, 1815
Family Trachyspiridae Nützel, Frýda, Yancey, and Anderson, 2007

Trachyspiridae gen. et sp. indet.
Fig. 139

Material examined: Three protoconchs, NSM PM23292–23294, from AB1014.

Description: Protoconch is turbiniform in shape and consists of about three whorls. Whorls are convex and rapidly expanding covering majority of spire. Initial whorl smooth while remaining whorls ornamented by sinusoidal axial ribs with sinus at periphery. Teleconch unknown.

Measurements (*mm*):

Specimen no.	H	D	H/D
NSM PM23292	0.71	0.67	1.06

Occurrence: Described specimens from *Clypeoceras spitiense* “bed” (AB1014, early Late Induan=early Dienerian) in the lower part of the Zhitkov Formation, Abrek Bay

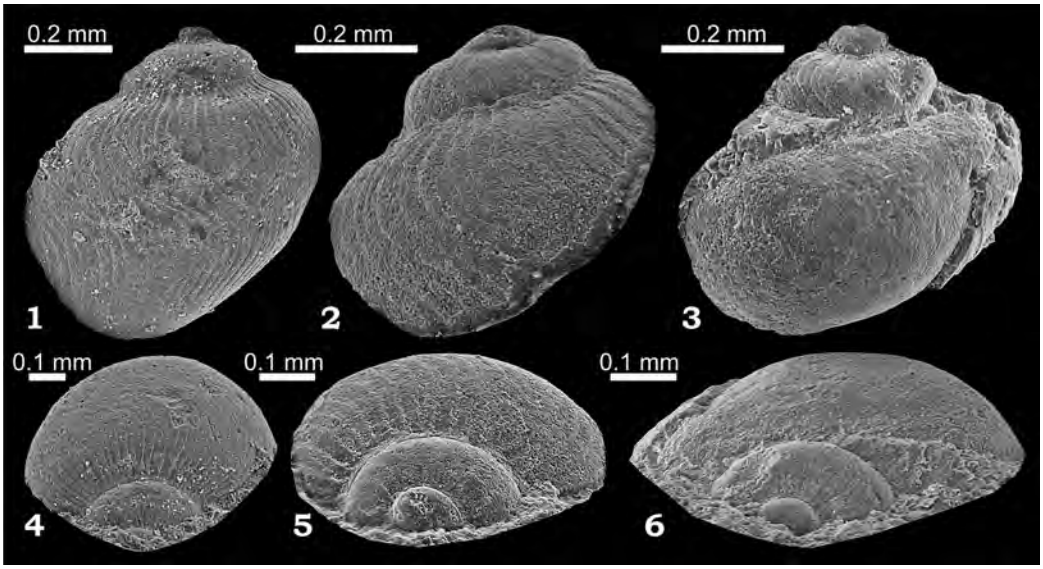


Fig. 139. Trachyspiridae gen. et sp. indet. from AB1014. 1, 4, NSM PM23292. 2, 5, NSM PM23293. 3, 6, NSM PM23294. All SEM images.

area, South Primorye.

Discussion: The trachysprid protoconchs from Abrek Bay are very similar to the Pennsylvanian trachyspirid protoconchs illustrated by Nützel *et al.* (2007). The only difference is the absence of a faint spiral pattern on the specimens from Abrek Bay, which is clearly visible on the Pennsylvanian specimens. This absence, however, might result from the poorer preservation of the Triassic shells.

Family Neritidae Rafinesque, 1815
Genus ***Abrekopsis*** Kaim gen. nov.

Type species: *Naticopsis* (*Naticopsis*) *depressispirus* (Batten and Stokes, 1986).

Composition of the genus: Type species only.

Diagnosis: Naticopsid- or neritid-like shell with short protoconch having a wide initial whorl. Teleoconch starts with collabral terrace-like ornamentation.

Etymology: After type locality and -opsis common ending in neritimorphs.

Occurrence: Upper part of the Lower Induan (Upper Griesbachian) to Upper Induan (Dienerian) in South Primorye, Russia, and the Smithian (Early Triassic) of Utah and Nevada, USA (Batten & Stokes, 1986).

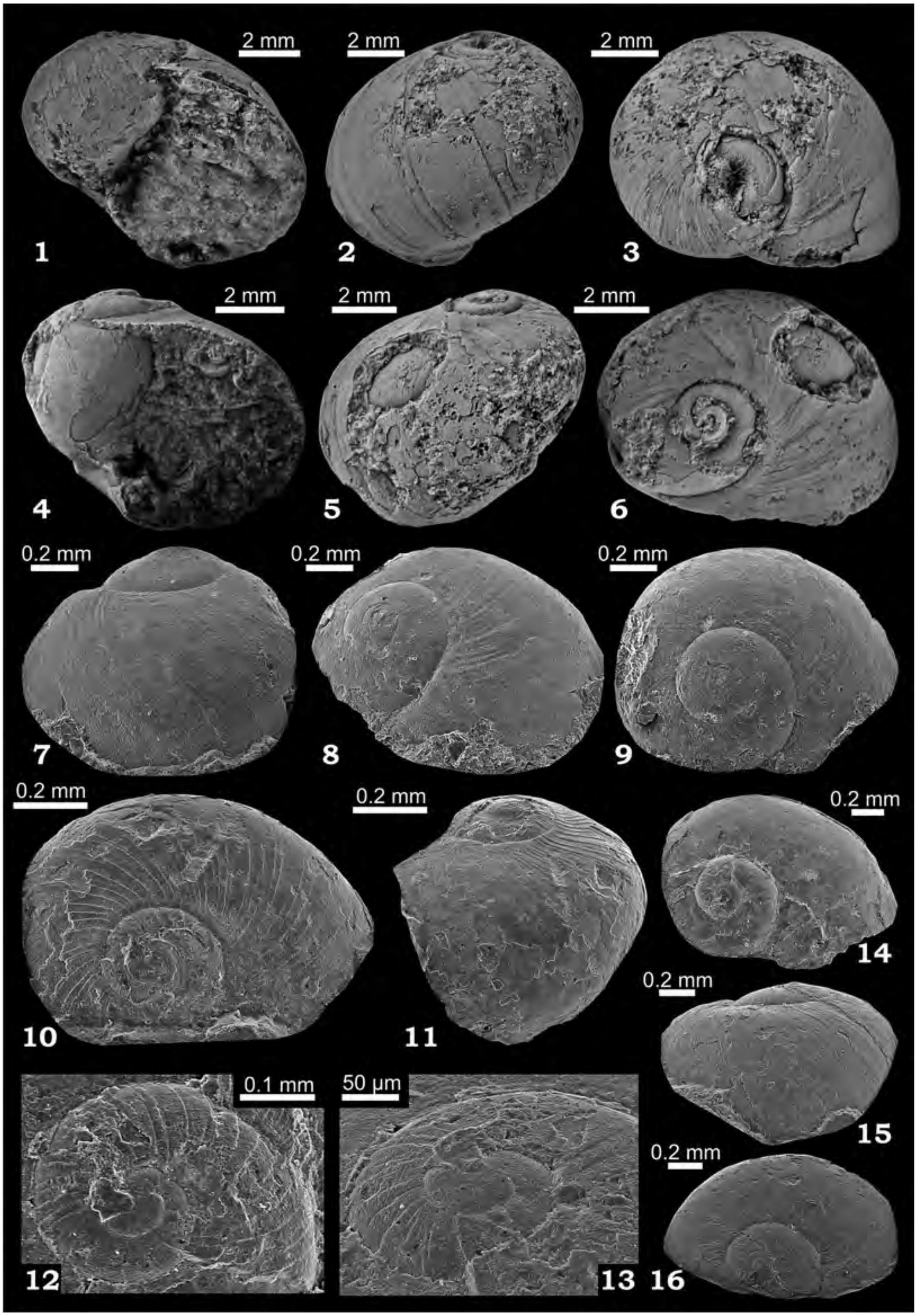
Discussion: The protoconch morphology of *Abrekopsis* seems to be intermediate between the naticopsid type (see e.g., Nützel *et al.*, 2007) and the characteristic neritoid type.

Abrekopsis depressispirus (Batten and Stokes, 1986)
Fig. 140

Naticopsis (*Naticopsis*) *depresispirus* Batten and Stokes, 1986, p. 12, figs. 11–13.

→

Fig. 140. *Abrekopsis depressispirus* (Batten and Stokes, 1986) gen. nov. 1–3, NSM PM23302, from AB1016. 4–6, NSM PM23303, from AB1016. 7–9, NSM PM23295, from AB1010. 10–11, NSM PM23297, from AB1014. 12–14, NSM PM23298, from AB1014. 15–16, NSM PM23296, from AB1013. 1–6, light images by Y. Shigeta; 7–16 SEM images.


2 mm
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0.2 mm
0.2 mm
10
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14
0.2 mm
15
0.1 mm
50 μm
0.2 mm
12
13
16

Holotype: AMNH 42975, figured by Batten and Stokes (1986, p. 12, fig. 11) from the Lower Triassic (Spathian) of the Virgin Limestone at Blue Diamond Mine, Nevada, USA.

Material examined: NSM PM23295, from AB1010, NSM PM23296, from AB1013, five specimens, NSM PM23297–23301, from AB1014, and six specimens, NSM PM23302–23307, from AB1016.

Description: Neritoid shell with flattened upper whorl surface. Every succeeding whorl embraces majority of spire. Protococh slightly more than one whorl with initial part wide and flattened. Protoconch not ornamented apart from a faint granular pattern. Teleoconch starts with collabral terrace-like ornamentation and faint spiral pattern. Later on, shells are smooth apart from prosocline growth lines. Early whorls have weakly incised suture, which later becomes indistinct. Umbilicus absent. Aperture D-shaped. No teeth or inductura visible on available material.

Measurements (*mm*):

Specimen no.	H	D	H/D
NSM PM23302	7.70	8.93	0.86
NSM PM23303	7.17	8.12	0.88

Occurrence: Described specimens from AB1010 within the *Gyronites subdharmus* Zone in the upper part of the Lazurnaya Bay Formation, and from AB1013 within the *Ambitoides fuliginatus* Zone, from AB1014 within the *Clypeoceras spitiense* “bed”, and from AB1016 within the *Paranorites varians* Zone, all from the Zhitokv Formation, Abrek Bay area, South Primorye. Thus, in this particular area, the species ranges from late Early Induan (late Griesbachian) to Late Induan (Dienerian). Also known from Smithian of Utah and Spathian of Nevada (both Early Triassic), USA (Batten & Stokes 1986).

Discussion: The adult specimens of *Abrekopsis depressispirus* (Batten and Stokes, 1986) from the Abrek Bay area are very similar to the paratypes from the Smithian of the Sinbad Limestone of Utah (Batten & Stokes 1986). Unfortunately, this identification cannot be fully supported because juveniles have not yet been reported from the Sinbad Limestone.

Order Caenogastropoda Cox, 1960
Superfamily Acteoninoidea Cossmann, 1895
Family Soleniscidae Knight, 1931
Genus ***Strobeus*** de Koninck, 1881

Type species: *Strobeus ventricosus* de Koninck, 1881.

Strobeus shigetai sp. nov.

Fig. 141

Type specimens: Holotype, NSM PM23308, from AB1013; paratypes, NSM PM2309, 2310, from AB1014.

Diagnosis: *Strobeus* with faint axial lirae, bulbous first whorl and strongly globular shell outline.

Etymology: In honor of Yasunari Shigeta, who collected the type specimens.

Description: Shell strongly globular with sutures covered by thin layer of following whorl. Protoconch paucispiral, beginning with bulbous embryonic whorl. Demarcation between protoconch not clearly visible, but probably expressed by enhanced prosocline growth line after 1.5–2.0 whorls. Teleoconch with rapidly expanding whorls and ornamented with faint prosocline, apparently collabral axial lirae. Aperture and umbilicus not visible on available specimens.

Measurements (*mm*):

Specimen no.	H	D	H/D
NSM PM23308	1.49	1.05	1.42
NSM PM23309	1.83	1.48	1.23
NSM PM23310	0.76	0.63	1.21

Occurrence: Described specimens from AB1013 within the *Ambitoides fuliginatus* Zone and from AB1014 within the *Clypeoceras spitiense* “bed”, both of early Late Induan (early Dienerian) age in the lower part of the Zhitkov Formation, Abrek Bay area, South Primorye.

Discussion: *Strobeus shigetai* sp. nov. dif-

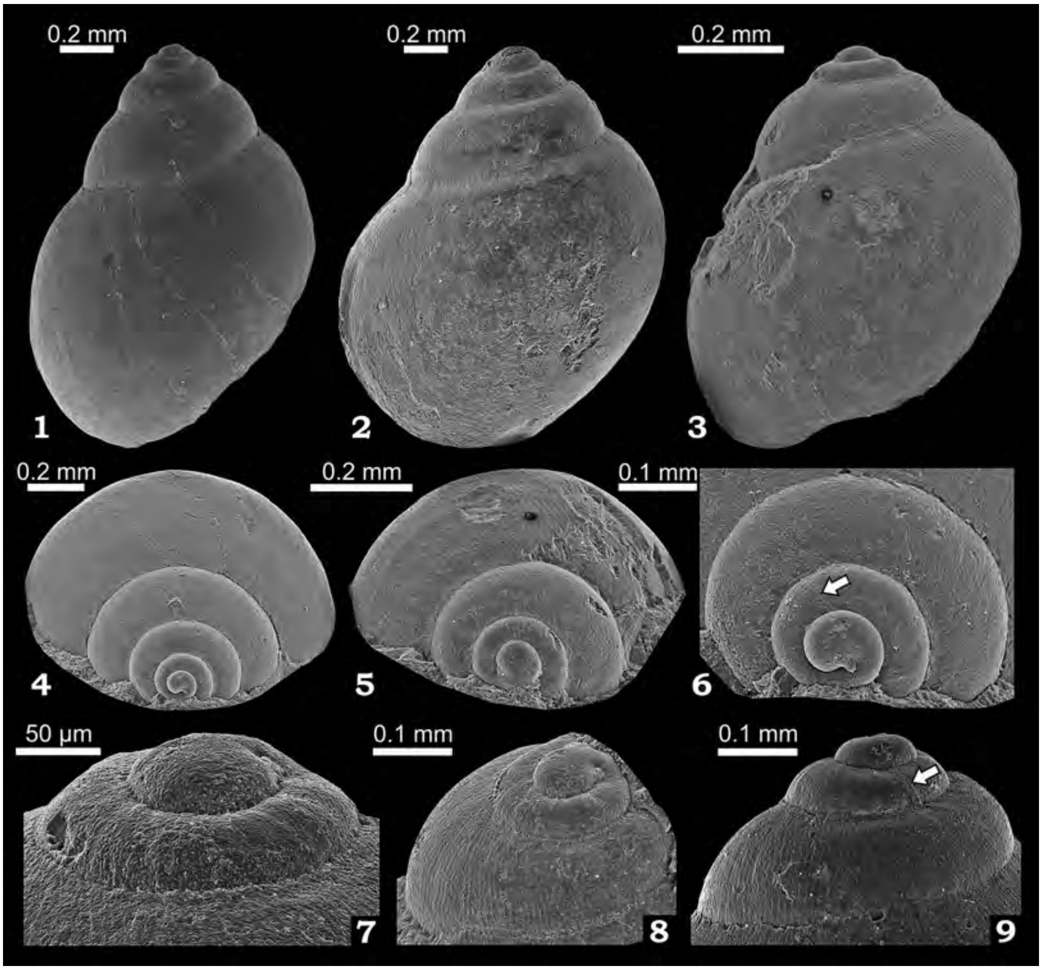


Fig. 141. *Strobeus shigetai* Kaim sp. nov. 1, 4, 6, 9, NSM PM23308, holotype, from AB1013. 2, NSM PM23309, paratype, from AB1014. 3, 5, 7, 8, NSM PM23310, paratype, from AB1014. Possible protoconch/teleoconch demarcation indicated by arrows. All SEM images.

fers from other species of the genus in having axial ornamentation. It remains uncertain if the species from the Smithian Sinbad Limestone of Utah identified by Batten and Stokes (1986, p. 29) as *S*. cf. *paludinaeformis* (Hall, 1858) is conspecific with *S. shigetai* sp. nov., since it is not that well preserved and no ornamentation is reported. While the Abrek Bay specimens are definitely juveniles, the more elongated nature of the American specimens may represent adolescence or maturity. A similar type of collabral ornamentation is observed by Yoo (1988) in a Carboniferous soleniscid from Australia.

Superfamily Zygopleuroidea Wenz, 1938
Family Zygopleuridae Wenz, 1938
Subfamily Coelostylininae Cossmann 1909
Genus ***Coelostylina*** Kittl, 1894

Type species: *Melania conica* Münster, 1841.

Coelostylina sp. indet.
Fig. 142

Material examined: Four specimens, NSM PM23311–23314, from AB1010.

Description: High spired and elongated

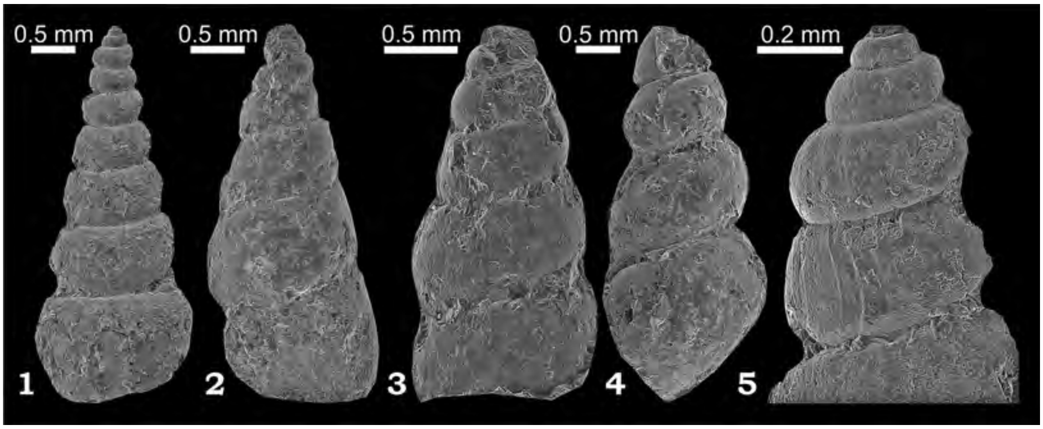


Fig. 142. *Coelostylina* sp. indet. from AB1010. 1, 5, NSM PM23311. 2, NSM PM23312. 3, NSM PM23313. 4, NSM PM23314. All SEM images.

shells with moderately expanding whorls. Initial three whorls more rounded and more inflated than remaining ones. Sutures weakly to moderately incised. There is a sector of the shell on the fourth whorl with enhanced opisthocyrtic growth lines, which may be a demarcation between protoconch and teleoconch. Otherwise, the teleoconch is smooth. Aperture and umbilicus could not be observed.

Measurements (*mm*):

Specimen no.	H	D	H/D
NSM PM23311	4.17	1.75	2.38
NSM PM23312	3.57	1.64	2.17
NSM PM23313	2.50	1.22	2.04
NSM PM23314	4.17	1.83	2.28

Occurrence: Described specimens from AB1010 within the *Gyronites subdharmus* Zone (late Early Induan=late Griesbachian) in the upper part of the Lazurnaya Formation, Abrek Bay area, South Primorye.

Discussion: This species is similar to "*Coelostylina* species b" sensu Batten and Stokes (1986, p. 25). The imperfect preservation of both forms persuades me to leave them in open nomenclature. The smooth early whorls of the shells from Abrek Bay suggest that this species may not belong to the zygopleurids, but rather to the pseudomelaniids. This, however, should be substantiated by better preserved juvenile shells.

Genus ***Omphaloptycha*** von Ammon, 1893

Type species: *Chemnitzia nota* von Ammon, 1878.

Omphaloptycha hormolira Batten and Stokes, 1986

Fig. 143

Omphaloptycha hormolira Batten and Stokes, 1986, p. 26, figs. 41–43.

Holotype: AMNH 43010, figured by Batten and Stokes (1986, p. 26, fig. 41) from the Lower Triassic (Smithian) of the Sinbad Limestone at locality AMNH 3026, Utah, USA.

Material examined: One specimen, NSM PM23315, from AB1011, six specimens, NSM PM23316–23321, from AB1014.

Description: Shell moderately high-spired with moderately incised sutures and moderately inflated whorls. Two earliest whorls almost smooth apart from some fine granular sculpture. Next two whorls ornamented with orthocline to weakly opisthocyrtic axial ribs. Approximately 60 ribs per whorl. At height of about 0.8 mm, ribs disappear, which may indicate end of protoconch. No other clear demar-

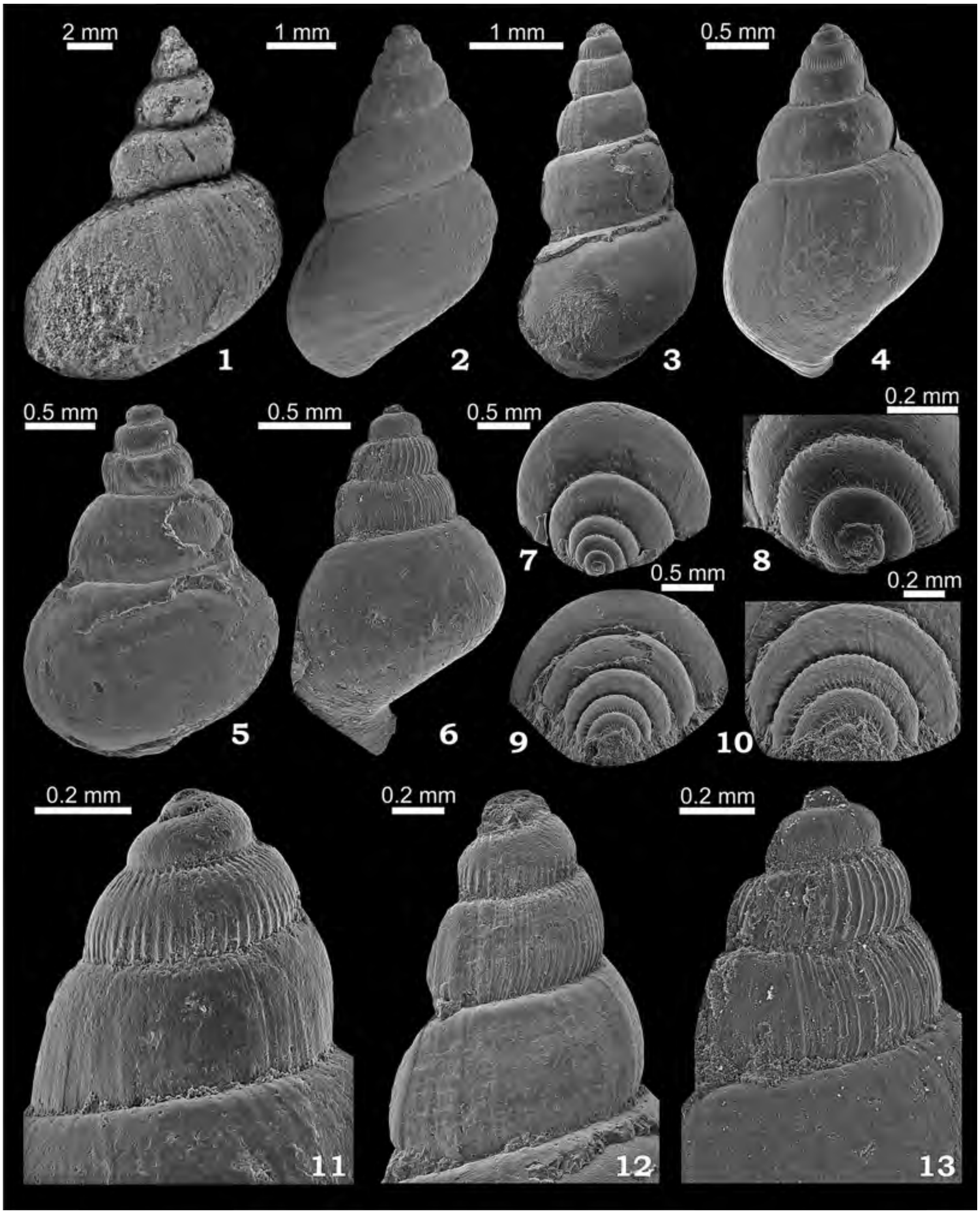


Fig. 143. *Omphaloptycha hormolira* Batten and Stokes, 1986. 1, NSM PM23315, from AB1011. 2, NSM PM23316, from AB1014. 3, 9, 10, 12, NSM PM23317, from AB1014. 4, 7, 8, 11, NSM PM23318, from AB1014. 5, NSM PM23319, from AB1014. 6, 13, NSM PM23320, from AB1014. 1, light image by Y. Shigeta; 2–13 SEM images.

cation visible on the specimens at hand. Teleoconch whorls smooth apart from growth lines, which are weakly opisthocyrtic on whorl periphery. Whorls expand at similar rate apart from last whorl of largest specimen, which is much more expanded. Aperture and umbilicus could not be observed.

Measurements (*mm*):

Specimen no.	H	D	H/D
NSM PM23315	15.30	11.38	1.34
NSM PM23316	5.00	3.00	1.67
NSM PM23317	3.85	1.92	0.50
NSM PM23318	2.78	1.72	1.61

Occurrence: Described specimens from AB1011 within the *Gyronites subdharmus* Zone (late Early Induan=late Griesbachian) in the upper part of the Lazurnaya Formation, and from AB1014 within the *Clypeoceras spitiense* "bed" (early Late Induan=early Dienerian) in the lower part of the Zhitkov Formation, Abrek Bay area, South Primorye.

Discussion: Species of *Omphaloptycha* are generally difficult to classify due to the simplicity of shell morphology. The material from Abrek Bay is similar to the Smithian *O. hormolira* described by Batten and Stokes (1986) from the Sinbad Limestone in Utah, USA, in having a generally similar gross morphology and lirate protoconch. The *Omphaloptycha* from the Abrek Bay area may represent a new species; however, a detailed comparison with the type material of *O. hormolira* is necessary to substantiate this assumption. The American species is rather poorly illustrated–especially concerning its early whorls–which impedes meaningful taxonomical comparisons.

Bivalves (by T. Kumagae and K. Nakazawa)

Systematic classification is primarily based on Moore (1969).

Abbreviations for shell dimensions: RV=right valve; LV=left valve; H=valve height; L=valve length; pU=pre-umbonal length; Lh=hinge length; $\alpha°$=angle between hinge line and growth axis.

Institution abbreviations: NSM=National Museum of Nature and Science, Tokyo.

Class Bivalvia Linné, 1758
(Buonanni, 1681)
Subclass Pteriomorphia Beurlen, 1944
Order Mytiloida Ferussac, 1822
Superfamily Mytilacea Rafinesque, 1815
Family Mytilidae Rafinesque, 1815
Subfamily Modiolinae Keen, 1958
Genus ***Modiolus*** Lamarck, 1799

Type species: *Mytilus modiolus* Linné, 1758.

"***Modiolus***" sp. indet.
Fig. 144.1

Material examined: One specimen, NSM PM23363, from AB1010.

Description: Shell small, elongate, modioliform and inflated. Umbo not prominent, obtuse, subterminal and prosogyrate. Anterior lobe small, but set off from rest of shell. Anterior margin straight, forming a near right angle with somewhat concave ventral margin. Posterodorsal margin nearly straight or feebly arched. Posterior margin broadly rounded, forming an abrupt curvature with ventral margin. Oblique, rounded ridge runs from umbo to posteroventral edge. Shell surface entirely ornamented with faint concentric lines. Weak radial costae parallel to oblique ridge, vanishing toward anterior side and weakened on anteroventral area. Inner structures unknown.

Measurements (*mm*):

Specimen no.	H	L	H/L	Remarks
NSM PM23363	7.1	11.6	0.61	RV

Occurrence: Described specimen from AB1010 in the lower *Gyronites subdharmus* Zone (late Early Induan=late Griesbachian) in the upper part of the Lazurnaya Bay Formation, Abrek Bay area, South Primorye.

Discussion: Although the present specimen is similar to *Modiolus* s.l. in external shell morphology (modioliform), it cannot be assigned to it with certainty because its shell surface is clearly ornamented with both radial and concentric sculptures. Modioline bivalves generally have only concentric costae with minor exceptions (e.g., Recent *Geukensia* or Devonian *Phthonia* in Moore, 1969). Even though its internal characters could not be confirmed, it is tentatively placed in *Modiolus*.

Order Pterioida Newell, 1965
Suborder Pteriina Newell, 1965
Superfamily Ambonychiacea S. A. Miller, 1877
Family Myalinidae Frech, 1891
Genus ***Promyalina*** Kittl, 1904

Type species: *Promyalina hindi* Kittl, 1904.

Promyalina schamarae (Bittner, 1899)
Fig. 144.2–144.3

Myalina schamarae Bittner, 1899b, p. 19, pl. 4, figs. 20–25; Vozin and Tikhomirova, 1964, p. 22, pl. 10, figs. 6–8.

Promyalina schamarae (Bittner). Dagys and Kurushin, 1985, p. 62, pl. 11, figs. 2–7; Kurushin and Truschelev in Dagys *et al.*, 1996, p. 29, pl. 4, figs. 16–19.

Type: Not designated in Bittner (1899b) or in other previous studies.

Material examined: One specimen, NSM PM23373, from AB1010, three specimens, NSM PM23374–23376, from AB1012.

Description: Shell small, equivalve, myaliniform, subround to subquadrate in outline (H/L ratio about 1.2) and moderately inflated. Umbo small, terminal and prosogyrate. Posterodorsal margin straight, forming an angle of 55° with growth axis. Posterior margin forms an angle of about 140° with posterodorsal margin, rounded and passing to broadly arched ventral margin. Surface nearly smooth, except for irregular faint concentric lamellae. Inner surface smooth.

Measurements (*mm*):

Specimen no.	H	L	H/L	α°	Remarks
NSM PM23373	24.3	21.9	1.11	–	LV*
NSM PM23374	23.5+	24.8	–	54	art.**
NSM PM23375	22.8	17.5	1.31	56	art.**

* incomplete shell, ** internal mold, art.: articulated shells.

Occurrence: Described specimens from AB1010 in the lower *Gyronites subdharmus* Zone (late Early Induan=late Griesbachian), and from AB1012 in the *Ambitoides fuliginatus* Zone (early Late Induan=early Dienerian) in the upper part of the Lazurnaya Bay Formation, Abrek Bay area, South Primorye. This species also occurs in the *Gyronites subdharmus* Zone on the western coast of Ussuri Gulf and in the Artyom area, South Primorye (Bittner, 1899b; Markevich & Zakharov, 2004), as well as in the Lower Triassic of Northeastern Siberia, Russia (Vozin & Tikhomirova, 1964; Dagys *et al.*, 1996).

Discussion: The specimens from the Lazurnaya Bay Formation of the Abrek Bay area are undoubtedly conspecific with Bittner's specimen (Bittner, 1899b, p. 19, pl. 4, figs. 20–25). This species characteristically possesses a convex anterior margin and as such, is distinguished from other Early Triassic *Promyalina*; namely, *P. putiatinensis* (Kiparisova), *P. kochi* (Spath), and *P. groenlandica* Newell. Even though the Siberian specimens have been synonymized with *P. schamarae* (Vozin & Tikhomirova, 1964; Dagys & Kurushin, 1985; Dagys *et al.*, 1996), some of them can be distinguished from *P. schamarae* by their shorter height and more rounded shell shape and they could be separated as a subspecies.

Promyalina putiatinensis (Kiparisova, 1938)
Fig. 144.4–144.5

Myalina vetusta Benecke. Bittner, 1899b, p. 17, pl. 4, figs. 17–19.

Myalina putiatinensis Kiparisova, 1938, p. 261, pl. 6, figs. 10–12; Newell and Kummel 1942, p. 957, pl. 3, figs. 9, 10.

Promyalina putiatensis (Kiparisova). Ciriacks, 1963, p. 75, pl. 16, figs. 1–5.

Promyalina putiatinensis (Kiparisova). Gan and Yin, 1978, p. 315, pl. 110, fig. 4; Yin and Yin in Yang *et al.*, 1983, p. 168, pl. 22, figs. 14, 15.

Syntype: Specimens figured by Kiparisova (1938, p. 261. Pl. 6, figs. 10, 12) as holotype, from the Lower Triassic of the Putiatin Island in South Primorye, Russia.

Material examined: Two specimens, NSM PM23377, 23378, from AB1004.

Description: Shell small, inequilateral, subquadrate or myaliniform, prosocline, higher than long (H/L=1.6) and weakly inflated. Umbo small, terminal, and prosogyrate. Posterodorsal margin straight, about three fourths as long as shell length, forming an angle of about 68° with growth axis. Posterior margin slightly convex, forming a rounded posteroventral margin. Anterior margin long, nearly straight or weakly arcuate and partly depressed near umbo.

Measurements (*mm*):

Specimen no.	H	L	H/L	α°	Remarks
NSM PM23377	21.7	13.2	1.64	65	RV**
NSM PM23378	24.9	16.1	1.55	70	RV**

** internal mold.

Occurrence: Described specimens from AB1004 in the *Lytophiceras* sp. Zone (early Induan=Griesbachian) in the lower part of the Lazurnaya Bay Formation, Abrek Bay area, South Primorye. This species also occurs in the Lower Triassic of Putiatin Island, South Primorye (Bittner, 1899b; Kiparisova, 1938), the *Lingula* Zone (Lower Triassic) of the Dinwoody Formation, Wyoming and Idaho, Western-Central USA (Newell & Kummel, 1942; Ciriacks, 1963) and the Lower Triassic of Guizhou and Qinghai Provinces, China (Gan & Yin, 1978; Yang *et al.*, 1983).

Discussion: The angle between the hinge line and growth axis (α) of the figured specimens is about 68°. Based on illustrations in previous studies, and as pointed out by Kiparisova (1938, p. 292), this angle is rather variable as demonstrated by the following specimens: South Primorye: 55–70°, China: 50–60°, and USA: 60–65°.

Superfamily Pteriacea Gray, 1847
Family Pteriidae Gray, 1847
Genus ***Pteria*** Scopoli, 1777

Type species: *Mytilus hirundo* Linné, 1758.

Pteria ussurica (Kiparisova, 1938)
Fig. 144.6–144.8

Gervilleia cf. *exporrecta* Lepsius. Bittner, 1899b, p. 15, pl. 3, figs. 1–6 not 7–16.

?*Gervilleia* aff. *exporrecta* Lepsius. Spath, 1930, p. 48, pl. 10, fig. 11a, b; pl. 12, fig. 4.

Gervillella aff. *exporrecta* (Lepsius). Spath, 1935, p. 69, pl. 22, fig. 9a–c.

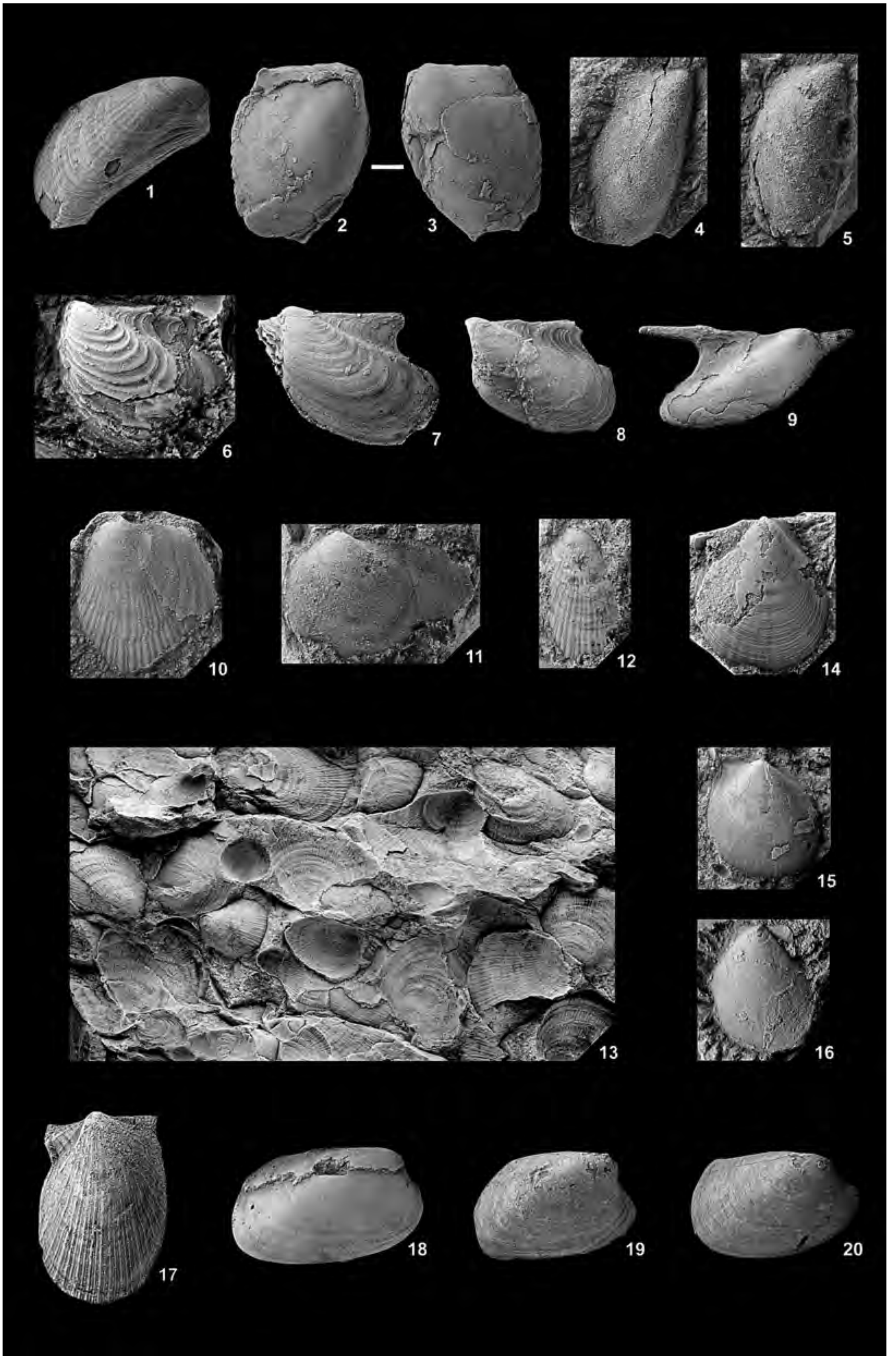
Gervillia usssurica Kiparisova, 1938, p. 241, pl. 6, figs. 5–8; Newell and Kummel, 1942, p. 959.

Avicula usssurica (Kiparisova). Kiparisova and Krishtofovich, 1954, p. 10, pl. 1, figs. 15, 16, 18.

Syntype: Specimens figured by Kiparisova (1938, p. 241. Pl. 6, figs. 5, 6, 8; figs. 5, 6 are

→

Fig. 144. 1, “*Modiolus*” sp. indet., NSM PM23363, from AB1010, right valve, ×2.5. 2–3, *Promyalina schamarae* (Bittner, 1899), NSM PM23375, from AB1012, internal mold of articulated valves (2: right valve, 3: left valve). 4–5, *Promyalina putiatinensis* (Kiparisova, 1938) from AB1004. 4, NSM PM23377, internal mold of right valve, ×1.25. 5, NSM PM23378, internal mold of right valve, ×1.0. 6–8, *Pteria ussurica* (Kiparisova, 1938). 6, NSM PM23380, from AB1010, incomplete left valve, ×2.5. 7, NSM PM23384, from AB1014, left valve, ×2.5. 8, NSM PM23383, from AB1014, incomplete left valve, ×1.5. 9, *Bakevellia*? sp. indet., NSM PM23346, from AB1021, internal mold of right valve, ×2.5. 10–13, *Claraia stachei* Bittner, 1901. 10, NSM PM23347, from AB1007, incomplete left valve, ×1.25. 11, NSM PM23349, from AB1007, incomplete left valve, ×2.5. 12, NSM PM23350, from AB1010, fragmental valve, ×2.5. 13, NSM PM23351, from AB1012, shell concentration, ×0.8. 14, *Entolioides* sp. indet., NSM PM23352, from AB1014, right valve, ×2.5. 15–16, *Leptochondria minima* (Kiparisova, 1938). 15, NSM PM23359, from AB1010, left valve, ×2.5. 16, NSM PM23353, from AB1014, right valve, ×3.5. 17, *Eumorphotis multiformis* (Bittner, 1899), NSM PM23357, from AB1014, left valve, ×0.8. 18–20, *Trigonodus orientalis* Bittner, 1899 from AB1021. 18, NSM PM23419, incomplete right valve, ×1.5. 19, NSM PM23417, right valve, ×1.8. 20, NSM PM23418, right valve, ×1.8.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photographs taken from Bittner's originals, corresponding to figs. 2, 3) as holotype, from the Lower Triassic of the Shamara River, western coast of Ussuri Gulf, South Primorye, Russia.

Material examined: Three specimens, NSM PM23379–23381, from AB1010, one specimen, NSM PM23382, from AB1013, three specimens, NSM PM23383–23385, from AB1014.

Description: Shell small, inequilateral, oblique, bialate, and moderately convex. Umbo narrowly rounded, elevated above hinge line, subterminal and slightly prosogyrate. Hinge line straight, forming an angle of about 40° with growth axis. Anterior auricle small and demarcated from body. Posterior auricle elongate, pointed, and separated by shallow depression from main body of valve. Ventral margin gently arched. Coarse, regular concentric ribs on flank and irregular faint lamellae on wings. Inner surface smooth.

Measurements (*mm*):

Specimen no.	H	L	H/L	α°	Remarks
NSM PM23379	6.5	11.6	0.56	38	RV**
NSM PM23380	9.7	10.9+	–	47	LV
NSM PM23381	6.9	8.1	0.85	40	LV
NSM PM23382	5.5	4.4	1.26	–	LV*
NSM PM23383	10.4	15.7+	–	37	LV
NSM PM23384	8.8	11.4	0.77	40	LV

* imcomplete shell, ** internal mold.

Occurrence: Described specimens range from AB1010 in the lower *Gyronites subdharmus* Zone (late Early Induan=late Griesbachian) in the upper part of the Lazurnaya Bay Formation to AB1014 in the *Clypeoceras spitiense* "bed" (early Late Induan=early Dienerian) in the lower part of the Zhitkov Formation, Abrek Bay area, South Primorye. This species is also reported from the Lower Triassic of the Shamara River and Russian Island, South Primorye (Bittner, 1899b; Kiparisova, 1938) as well as the Lower Triassic of Greenland, where it occurs with *Otoceras*? and *Ophiceras* (Spath, 1930). The species is also common in the *Claraia* zone (Lower Triassic) of the upper Dinwoody Formation in Wyoming and Idaho, Western-Central USA (Newell & Kummel, 1942; Ciriacks, 1963).

Discussion: The present species was first described as *Gervilleia* cf. *exporrecta* Lepsius, 1878 by Bittner (1899b), but Kiparisova (1938) later erected a separate species, *Gervillia ussurica*, for some of the specimens. Afterward, Kiparisova and Krishtofovich (1954) confirmed a single ligament groove in the ligament area and emended the species as *Avicula* (=*Pteria*) *ussurica*. Ozaki and Shikama (1954) reported the occurrence of *Gervilleia* cf. *exporrecta* from the *Eumorphotis multiformis* bearing limestone in Gunma Prefecture, Central Japan. Nakazawa (1959) clarified the characteristics of this taxon's hinge and confirmed that the Japanese specimens belong to *Pteria* as is the case for the specimens from South Primorye. The Japanese species, which was separated as subspecies *P. ussurica yabei*, is almost identical to *P. ussurica*, but can be distinguished from the latter by the wider angle between its umbonal ridge and hinge margin and the more robust shape of its main body. The species is now known from various parts of Southwest Japan (Nakazawa, 1971; Kambe, 1963). Another species related to *P. ussurica* was described from South China as a new subspecies, *P. ussurica variabilis* by Chen and Lan (in EGFLC, 1976). It differs from *P. ussurica* by the presence of weak radial striae in the umbonal area.

Family Bakeveliidae King, 1850

Genus ***Bakevellia*** King, 1848

Type species: *Avicula antiqua* von Münster in Goldfuss, 1836.

Bakevellia? sp. indet.

Fig. 144.9

Material examined: One specimen, NSM PM23346, from AB1021.

Description: Shell small in size, narrow, pteriiform, prosocline, inequilateral, bialate, and moderately inflated. Umbo medium-sized, slightly protruding above hinge margin, terminal and orthogyrate. Hinge margin straight, forming an angle of 34° with growth axis. Anterior auricle small and short. Posterior auricle narrow, prolonged posteriorly and sharply pointed and separated by depression from valve body. Internal structures unknown.

Measurements (*mm*):

Specimen no.	H	L	H/L	α°	Remarks
NSM PM23346	6.1	13.4	0.45	34	RV**

** internal mold.

Occurrence: Described specimen from AB1021 in the *Clypeoceras timorense* Zone (early Early Olenekian=early Smithian) of the Zhitkov Formation, Abrek Bay area, South Primorye.

Discussion: Judging from its external shape, the present specimen is considered as assignable to either of the pteriacean genera, *Pteria* or *Bakevellia*. Since its internal characters cannot be observed, it is difficult to choose the correct genus with any degree of certainty. Although the specimen externally appears to be related to *Pteria ussurica* (Kiparisova) or *P. ussurica yabei* Nakazawa, it differs by its weaker concentric ornament and less robust main body. In addition, the specimen is also characterized by its acutely protruded triangular anterior auricle, prolonged posterior auricle, and oblique, slender body. The consideration of these points brings to attention two other species, which are thought to be related; *Bakevellia acutaurita* Yin and Yin (in Yang *et al.*, 1983, p. 137, pl. 13, figs 17–23) described from the lower Anisian of Qinghai, Northwest China, and *Pteria sturi* (Bittner) described in Allasinaz (1966, p. 652, pl. 42, figs. 4–8) from the Carnian of Lombardia, Italy. After comparing the proximity of the present specimen with the locality and age of these two species, we questionably assign it the genus *Bakevellia*.

Family Aviculopectinidae Meek and Hayden, 1864

Subfamily Aviculopectininae Meek and Hayden, 1864

Genus ***Claraia*** Bittner, 1901a

Type species: *Posidonomya clarae* von Hauer, 1850.

Claraia stachei Bittner, 1901

Fig. 144.10–144.13

Pseudomonotis (*Claraia*) *stachei* Bittner, 1901a, p. 587 (no figure); Kiparisova, 1947, p. 96, pl. 13, figs. 6, 8, 10, 14.

Claraia stachei Bittner. Spath, 1930, p. 46, pl. 9, fig. 1, pl. 10, fig. 5a, b; Newell and Kummel, 1942, p. 955, pl. 3, figs. 5–8; Tozer, 1961, p. 97, pl. 28, figs. 1, 2; Ciriacks, 1963, p. 79, pl. 15, figs. 1–3; Vozin and Tikhomirova, 1964, p. 10, pl. 1, figs. 13, 14; Vu Khuc in Vu Khuc *et al.*, 1965, p. 23, pl. 1, figs. 1–3; Chen in EGFLC, 1976, p. 197, pl. 31, figs. 28, 29; pl. 33, fig. 30; Dang, Trinh Tho and Vu Khuc in Vu Khuc *et al.*, 1991, p. 54, pl. 4, figs. 7–11; Kurushin and Truschelev in Dagys *et al.*, 1996, p. 38, pl. 4, figs. 10, 11; Tong *et al.*, 2006, p. 44, pl. 3, fig. 5; Komatsu *et al.*, 2008, p. 121, text-fig. 2.9.

Type: Not designated in Bittner (1901a) or in other previous studies.

Material examined: Three specimens, NSM PM23347–23349, from AB1007, one specimen, NSM PM23350, from AB1010, one specimen, NSM PM23351, from AB1012.

Description: Shell medium-sized, suborbicular. Left valve feebly inflated, prosocline and concentrically folded. Umbo small, slightly protruded above hinge margin and orthogyrate. Auricles not developed. Surface of shell ornamented with numerous, fine radial costae and irregular, weak concentric plicae. Right valve almost flat, concentrically folded and ornamented with irregular radial costae. Dorsal margin straight. Anterior auricle small, and subquadrate. Byssal notch narrow, debouching inward.

Occurrence: Described specimens range from AB1007 in the *Lytophiceras* sp. Zone (early Induan=Griesbachian) to AB1012 in the *Ambitoides fuliginatus* Zone (early Late

Induan=early Dienerian) in the middle to upper parts of the Lazurnaya Bay Formation, Abrek Bay area, South Primorye. This species also ranges from the upper *Glyptophiceras* bed to the *Proptychites* bed of the Cape Stosch section (Lower Triassic), Greenland (Spath, 1930). It also has been reported from the following localities: *Lingula* and *Claraia* zones of the Dinwoody Formation (Lower Triassic), Wyoming Idaho and Montana, Western-Central USA (Newell & Kummel, 1942; Ciriacks, 1963), Induan of Western Verkhoyansk, Sakha, Northeastern Russsia (Vozin & Tikhomirova, 1964), Lower Triassic of the Pamirs, Central Asia and Armenia, Western Asia (Kiparisova, 1947), Lower Triassic (T_1) distributed in Yunnan and Hunan Province (EGFLC, 1976) and the Yinkeng Formation (Induan), Chaohu, Anhui Province, South China (Tong *et al.*, 2006), and Induan of Vietnam (Vu Khuc *et al.*, 1965, 1991; Komatsu *et al.*, 2008).

Genus ***Eumorphotis*** Bittner, 1901a

Type species: *Pseudmonotis telleri* Bittner, 1898.

Eumorphotis multiformis (Bittner, 1899)

Fig. 144.17

Pseudomonotis multiformis Bittner, 1899b, p. 10, pl. 2, figs. 11–22.

Pseudomonotis (*Eumorphotis*) *multiformis* Bittner. Ogilvie Gordon, 1927, p. 22, pl. 2, fig. 11; Spath, 1935, p. 74, pl. 22, fig. 8; Kiparisova, 1938, p. 224, pl. 2, figs. 4, 5, 9–12; pl. 3, figs. 1–4 (including vars. *regularaecosta*, *rara* and *rudaecosta*)

Eumorphotis multiformis Bittner. Newell and Kummel, 1942, p. 957, pl. 2, figs. 10, 11; Ciriacks, 1963, p. 77, pl. 15, figs. 13–15; Kambe, 1963, p. 38, pl. 1, figs. 1–11; pl. 2, figs. 1–7; Nakazawa, 1971, p. 117, pl. 23, figs. 7–12; Chen in EGFLC, 1976, p. 185, pl. 30, figs. 34, 35; Dang, Trinh Tho and Vu Khuc in Vu Khuc *et al.*, 1991, p. 56, pl. 5, figs. 12–14; Nakazawa *et al.*, 1981, p. 142, pl. 1, figs. 12, 13, pl. 2, fig. 2.

Eumorphotis multiformis shionosawensis Ichikawa and Yabe, 1955, p. 5, pl. 2, figs. 1–15; Kambe, 1963, p. 40, pl. 2, fig. 8.

Type: Not designated in Bittner (1899b) or in other previous studies.

Material examined: Three specimens, NSM PM23355–23357, from AB1014.

Description: Shell (left valve) medium-sized, subcircular, orthocline, higher than long, subinequilateral, and well inflated. Umbo large, prominent, obtuse, located at subanterior to middle of shell and slightly prosogyrate. Posterior end nearly straight. Ventral margin well rounded. Hinge margin almost straight. Anterior auricle narrow, subtrigonal and distinctly delimited from body of valve by sulcation. Posterior wing larger and not clearly defined from body. Shell surface ornamented with numerous radial sculptures increasing in number with growth by insertion. Single secondary rib intercalated between primary ribs and higher order riblets between primary and secondary ribs (1-3-3-2-3-3-1). Growth lines fine and weak.

Measurements (*mm*):

Specimen no.	H	L	H/L	Remarks
NSM PM23355	26.6	21.9	1.21	LV*
NSM PM23356	26.6	21.1+	–	LV*
NSM PM23357	37.5	25.5	1.47	LV

* incomplete shell.

Occurrence: Described specimens from AB1014 in the *Clypeoceras spitiense* “bed” (early Late Induan=early Dienerian) in the lower part of the Zhitokv Formation, Abrek Bay area, South Primorye. The species also occurs in the Lower Triassic of Russian and Putiatin Islands, South Primorye (Bittner, 1899b; Kiparisova, 1938), as well as in the Lower Triassic of the following additional localities: upper Werfen Formation, Dolomites, Italy (Ogilvie Gordon, 1927), upper *Ophiceras* bed, Greenland (Spath, 1930, 1935), Central Alborz Range, Iran (Nakazawa *et al.*, 1981), Spitzbergen, Norway (Frebold, 1939), *Claraia* zone of the Dinwoody Formation in Idaho, Montana and Utah, Western-Central USA (Newell & Kummel, 1942; Ciriacks, 1963), Guizhou and Fujian Province, South China (EGFLC, 1976), Kurotaki, Shionosawa and

Kamura limestones, Japan (Ichikawa & Yabe, 1955; Kambe, 1963; Nakazawa, 1971), and Vietnam (Vu Khuc *et al.*, 1991).

Discussion: The ornamentation of *Eumorphotis multiformis* is quite variable and is described and ordered according to the number, sequence and strength of its radial ribs as well as the mode of its concentric sculpture. Kiparisova (1938) distinguished three varieties based on different types of ornamentation; namely, *E. multiformis* vars. *regularaecosta*, *rudaecosta* and *rara*. The first variety is characterised by regularly arranged radial ribs of the 1st to 3rd or 4th systems. Variety *rudaecosta* is distinguished by coarser, less numerous radiating ribs of the 1st and 2nd system. Also, its 3rd radials are much thinner. Variety *rara* is characterized by 1st radials, which conspicuously intervene in the 2nd to 4th orders, and its radials exhibit the following formula at the lower margin: 1-2-2-2-2-2-2-2-1 or 1-3-3-3-2-3-3-3-1. As noted by Bittner (1899b) and Kiparisova (1938) this taxon exhibits many intermediate forms, which lead us to suggest that the three varieties, with their different forms of sculpture, simply represent a very wide range of intraspecific variation. Furthermore, *E. multiformis* s.s. cannot be clearly distinguished from *E. multiformis* var. *regularaecosta*, and these specimens should be grouped together as *regularaecosta*. The described specimens should also be placed within *regularaecosta*.

In South China three additional varieties or subspecies are proposed; namely, *E. multiformis fasciculiformis* Gan and Yin (1978), *E. multiformis dissimilicostata* Gan and Yin (1978), and *E. multiformis reticulata* Chen (1976). *E. multiformis fasciculiformis* exhibits a *rara* form of ornamentation and *E. multiformis reticulata* cannot be distinguished from the *regularaecosta* form. *E. multiformis dissimilicostata* exhibits a *reguraraecosta* style of ornamentation, but it is somewhat obscured on both lateral sides of the shell by its sculpture, which consists of very distinctive concentric folds in combination with undulating radials This species should be regarded as a legitimate subspecies. *E. multiformis hongshuichuanensis* Zhang (1979), described from Qinghai Province, North China, is distinguished from *E. multiformis* s.s. by its large, circular shape, irregular radial ribs and weak concentric sculpture, but more material must be scrutinized to validate these differences.

Genus ***Leptochondria*** Bittner, 1891

Type species: *Pecten* (*Leptochondria*) *aeolicus* Bittner, 1891.

Leptochondria minima (Kiparisova, 1938)

Fig. 144.15–144.16

Pecten (*Leptochondria*?) ex aff. *alberti* Goldfuss. Bittner, 1899b, p. 6, pl. 2, figs. 1, 2, 4–10, 13?, 14?

?*Pecten albertii* Goldfuss. Philippi, 1903, p. 50, pl. 4, fig. 8.

?*Pseudomonotis* cf. *iwanowi* Bittner. Yehara, 1928, p. 170, pl. 16, figs. 13, 14.

Pecten (*Velopecten*) *minimus* Kiparisova, 1938, p. 246, pl. 4, figs. 10, 12a, b, pl. 5, figs. 1–6; Kiparisova and Krishtofovich, 1954, p. 12, pl. 3, figs. 3–7.

Leptochondria? *minima* (Kiparisova). Nakazawa, 1961, p. 260, pl. 12, figs. 16, 17.

Eopecten minimus (Kiparisova). Kambe, 1963, p. 47, pl. 5, figs. 17–21.

Leptochondria minima (Kiparisova). Kurushin and Truschelev in Dagys *et al.*, 1996, p. 40, pl. 7, figs. 7, 8.

Holotype: Specimen figured by Kiparisova (1938, p. 246, pl. 5, fig. 5), from the Lower Triassic on Russian Island (Karpinsky Bay) in South Primorye, Russia.

Material examined: Two specimens, NSM PM23358, 23359, from AB1010, three specimens, NSM PM23353, 23360, 23361, from AB1014, one specimen, NSM PM23362, from AB1021.

Description: Shell small in size, subcircular, acline, equilateral and height nearly equal to length. Left valve weakly inflated. Umbo small, slightly protruded, obtuse, lying near middle of hinge margin and orthogyrate. Hinge margin straight, and about three-fourths of shell in length. Anterior and posterior auricles obtusely trigonal, small and indistinctly delimited from body. Dorsal edge straight. Ventral margin circular. Surface ornamented with fine radial ribs and faint concentric lines, except for both auricles. Right valve feebly convex or almost flat. Umbo small, obtuse and situated near middle of straight hinge margin. Small posterior auricle delimited from body of shell by sulcation. Anterior auricle obtuse with a narrow subauricular notch. Posterior auricle trigonal, smaller than anterior auricle. Shell surface smooth.

Measurements (*mm*):

Specimen no.	H	L	Lh	H/L	Lh/L	Remarks
NSM PM23353	6.1	4.7	3.2	1.31	0.68	RV
NSM PM23358	5.0	4.7	4.0	1.06	0.85	LV
NSM PM23359	6.9	7.2	4.4	0.96	0.61	LV
NSM PM23360	6.8	6.2	4.6	1.09	0.74	LV*
NSM PM23361	4.8	4.1	–	1.18	–	LV
NSM PM23362	5.7	5.8	2.7+	0.98	–	LV

* incomplete shell.

Occurrence: Described specimens range from AB1010 in the lower *Gyronites subdharmus* Zone (late Early Induan=late Griesbachian) in the upper part of the Lazurnaya Bay Formation to AB1021 in the *Clypeoceras timorense* Zone (early Early Olenekian=early Smithian) of the Zhitkov Formation, Abrek Bay area, South Primorye. Although this species is primarily a Lower Triassic taxon, it does occur in the Middle Triassic upper Muschelkalk of Austria (Philippi, 1903). It also occurs in the following additional Lower Triassic localities: Shamara River and Russian Island, South Primorye (Bittner, 1899b; Kiparisova, 1938), as well as from the Lower Triassic of the following additional localities: upper Muschelkalk, Austria (Philippi, 1903), Werfen Formation (Central Dolomites), Southern Alps, Italy (Frech, 1907), Taho limestone, Ehime Prefecture (Yehara, 1928), Kurotaki limestone, Kochi Prefecture, Narawara Formation, Kyoto Prefecture (Nakazawa, 1961, 1971), Kamura limestone, Miyazaki Prefecture, southwest Japan (Kambe, 1963), Qinghai Province, Western China (EGFLC, 1976), Chernokhrebetnaya River, Krasnoyarsk (east Taymyr) and the Kengdey River, Sakha, Northeastern Russsia (Dagys *et al.*, 1996)

Discussion: Kiparisova (1938) recognized two varieties of the species, namely, *Leptochondria minima* vars. *laevis* and *reticulatus*. The former is characterized by a nearly smooth shell surface and the latter by a cancellate sculpture created by relatively distinct radial costae and regularly arranged concentric sculpture. They are linked with *L. minima* s.s. by gradational forms, which represent infraspecific variation. Wittenburg (1909) reported *Pecten* (=*Leptochondria*) *albertii* var. *virgalensis* from the Lower Triassic of the Salt Range, Pakistan. This taxon is characterised by numerous radial ribs and is very similar to *Leptochondria* ex aff. *alberti* of Bittner (1899b) (=*L. minima* Kipariosva, 1938). Wittenburg (1909) identified the South Primorye species as var. *sibirica* without making a clear distinction between vars. *virgalensis* and *sibirica*. *L. albertii* var. *sibirica* is herein treated as an invalid name. Nakazawa (1981) described *L. minima* from Kashmir of India, and a Pakistani-Japanese Research Group (1985) reported it from the Salt Range. However, these taxa were later reassigned to *L. virgalensis* by Nakasawa (1996). *L. virgalensis* differs from *L. minima* by its slightly larger size, more numerous radial ribs and a slightly higher shell. Furthermore, the somewhat stronger radial ribs of *L. virgalensis* are arranged in wider intervals.

Kiparisova (1938) reassigned a specimen, originally described as *Pecten* (*Velopecten*) cf. *albertii* in Frech (1907, p. 35, pl. 4, fig. 8) from the Werfen Beds of Hungary, to *Leptochondria minima*, but the specimen can be distinguished from *L. minima* by its strong but less numerous radial ribs. The other European species also need further examination. The specimens figured by Chen (in EGFLC, 1976, p. 159, pl. 29, figs. 1–3) differ from *L. minima* by their differentiated and stronger radial ornaments.

Family Entoliidae Korobkov, 1960
Genus ***Entolioides*** Allasinaz, 1972

Type species: *Pecten zitteli* Wöehrmann and Koken, 1892.

Entolioides sp. indet.
Fig. 144.14

Material examined: Two specimens, NSM PM23352, 23354, from AB1014.

Description: Shell small in size, suborbicular, equilateral, higher than long and slightly inflated. Umbo small, sharply pointed, situated at middle of hinge margin and orthogyrate. Antero- and posterodorsal margins nearly straight. Ventral end rounded. Shell surface nearly smooth, but ornamented with numerous fine, sharp concentric lines and broad low concentric folds in addition to 10–15 wide, feeble, radial ribs. Both auricles small, subequal sized, rectangular, trigonal and ornamented with fine riblets, well defined from disc.

Measurements (*mm*):

Specimen no.	H	L	H/L	Remarks
NSM PM23352	9.5	8.4	1.14	RV*

* incomplete shell.

Occurrence: Described specimens from AB1014 in the *Clypeoceras spitiense* “bed” (early Late Induan=early Dienerian) in the lower part of the Zhitkov Formation, Abrek Bay area, South Primorye.

Discussion: As noted by Allasinaz (1972), *Entolioides* is distinguished from *Entolium* Meek, 1865, by its distinct radial ribs. Since the shell surface of the present specimens is ornamented with feeble, but distinct radial ribs, they can be placed within *Entolioides*. Chen (in EGFLC, 1976) described several entoliid species with weak radial costae or threads; that is, Lower Triassic *Entolium discites* (p. 208, p1. 34, figs. 7, 8), *E. discites microtis* (figs. 12, l3), and Upper Triassic *E. tenuistriatum rotundum* (p. 209, pl. 34, figs. 35–39). The last taxon exhibits distinct numerous radial ribs. *E. discites latum* Yin and Yin (in Yang *et al.*, 1983: p. 146, pl. 15. figs. 15–18), reported from the Middle Triassic of Qinghai, NW China, also is ornamented with differentiated numerous radial ribs similar to *E. discites microtis* figured in Chen (1976). Except for *E. discites*, the other three subspecies should undoubtedly be assigned to *Entolioides*. Nakazawa (1961) noted the presence of obsolete radial ribs in *E.* cf. *discites* sp. b (p. 254, pl. 12, figs. 3–4) from the Maizuru Zone of Japan. This species is similar to *E. discites* described by Chen (in EGFLC, 1976). These two species possibly should be assigned to *Entolioides*. An examination of the individual variation of *E. discites* is needed, since these two species exhibit forms that are intermediate between *Entolium* and *Entolioides*.

Subclass Palaeoheterodonta Newell, 1965
Order Unionoida Stoliczka, 1871
Superfamily Unionacea Fleming, 1828
?Family Pachycardiidae Cox, 1961
Genus ***Trigonodus*** Sandberger in Alberti, 1864

Type species: *Trigonodus sandbergeri* Alberti, 1864.

Trigonodus orientalis Bittner, 1899
Fig. 144.18–144.20

Trigonodus orientalis Bittner, 1899b, p. 21, pl. 3, fig. 27.
Trigonodus orientalis Bittner. Kiparisova, 1938, p. 217, pl. 2, figs. 1, 2.

Type: Not designated in Bittner (1899b) or in other previous studies.

Material examined: Five specimens, NSM PM23415–23419, from AB1021.

Description: Shell small, moderately inflated, subquadrate to elongately ovate (H/L ratio about 0.6), equivalve and inequilateral. Umbo small, subterminal and prosogyrate. Umbonal ridge feeble, rounded, and running to posteroventral end. Anterodorsal margin recurvate. Anterior end short and rounded. Posterodorsal margin straight, almost parallel to broadly arcuate ventral margin. Posterior end gently arched and slightly truncated. Surface smooth, ornamented with fine concentric lines.

Measurements (*mm*):

Specimen no.	H	L	H/L	Remarks
NSM PM23415	6.5	9.5	0.68	LV
NSM PM23416	7.1	11.8	0.60	RV
NSM PM23417	9.5	14.1	0.67	RV
NSM PM23418	9.4	14.5	0.65	RV
NSM PM23419	11.9	19.9	0.60	RV

Occurrence: Described specimens from AB1021 in the *Clypeoceras timorense* Zone (early Early Olenekian=early Smithian) of the Zhitkov Formation, Abrek Bay area, South Primorye. *Trigonodus orientalis* was originally described by Bittner (1899b) based on a specimen from the Lower Triassic of Paris Bay, Russian Island, South Primorye. Kiparisova (1938) also reported the species from the Lower Triassic of Russian Island.

Discussion: Judging from the illustrations, the specimen originally described by Bittner (1899b) exhibits dimensional ratios of H/L=0.71 and pU/L=0.26, whereas the ratios for Kiparisova's (1938) two specimens are H/L=0.65, 0.73 and pU/L=0.26, 0.25. Accordingly, the described specimens are slightly longer (H/L=around 0.64) and their umbo is more anteriorly located (pU/L=around 0.17). These differences may simply reflect intraspecific variation.

Genus ***Unionites*** Wissmann, 1841

Type species: *Unionites muensteri* Wissman, 1841.

Unionites canalensis (Catullo, 1848)

Fig. 145.1–145.4

Tellina canalensis Catullo, 1848, p. 56, pl. 4, fig. 4 (not seen).

Anodontophora (*Myacites*) *canalensis* (Catullo). Bittner, 1899b, p. 23, pl. 3, figs. 34–38; Ogilvie Gordon, 1927, p. 28, pl. 2, fig. 28.

Myacites canalensis (Catullo). Bittner, 1901b, p. 85, pl. 9, figs. 11, 12.

Anodontphora canalensis (Catullo). Frech, 1904, p. 10, text-fig. 15; Matsushita, 1926, pl. 8, fig. 12; Ozaki and Shikama, 1954, p. 44, text-fig. 4; Kambe, 1963, p. 48, pl. 5, figs. 24, 25.

Pleuromya canalensis (Catullo). Frech, 1907, p. 40, pl. 7, fig. 2.

Homomya canalensis (Catullo). Leonardi, 1935, p. 35, pl. 1, figs. 13–15.

Unionites canalensis (Catullo). Yabe, 1956, p. 287, pl. 16, figs. 12a, b; Ciriacks, 1963, p. 81, pl. 16, figs. 11, 12; Nakazawa, 1971, p. 126, pl. 24, figs. 14a, b, 15; Nakazawa *et al.*, 1981, p. 143, pl. 2, figs. 6–8; Yin and Yin in Yang *et al.*, 1983, p. 136, pl. 13, fig. 3; Neri and Posenato, 1985, p. 94, pl. 2, fig. 8.

Type: Details unknown.

Material examined: Four specimens, NSM PM23420–23423, from AB1010, one specimen, NSM PM23424, from AB1021.

Description: Shell small in size, gently inflated, elongately ovate (H/L ratio about 0.5), equivalve and inequilateral. Umbo large, elevated from dorsal margin, orthogyrate and located at about two-fifths of valve length from anterior end. Umbonal ridge somewhat elevated, but rounded. Anterodorsal margin recurvate. Posterodorsal margin long, almost straight. Anterior margin well rounded. Lunule narrow, deep. Escutcheon narrow. Posterior margin nearly straight, sub-truncated, and forming an angle of 70° with broadly arched ventral margin. Surface ornamented with numerous faint concentric striae.

Measurements (*mm*):

Specimen no.	H	L	H/L	pU	pU/L	Remarks
NSM PM23420	17.3	32.7+	–	10.4	–	RV*
NSM PM23421	12.7	24.2	0.52	9.0	0.37	LV
NSM PM23422	15.2	30.4	0.50	12.0	0.39	LV
NSM PM23423	14.3	30.8	0.46	12.7	0.41	RV
NSM PM23424	15.6	28.8	0.54	9.3	0.32	RV

* incomplete shell.

Occurrence: Described specimens from AB1010 in the lower *Gyronites subdharmus* Zone (late Early Induan=late Griesbachian) in upper part of the Lazurnaya Bay Formation, and from AB1021 in the *Clypeoceras timo-*

rense Zone (early Early Olenekian=early Smithian) of the Zhitkov Formation, Abrek Bay area, South Primorye. *Unionites canalensis* is also reported from various other Lower Triassic localities as follows: Shamara River, South Primorye, Russia (Bittner, 1899b), Bakony region, Hungary (Bittner, 1901b; Frech, 1904), Werfen Formation, Dolomites, Italy (Frech, 1907; Ogilvie Gordon, 1927; Leonardi, 1935; Neri & Posenato, 1985), *Claraia* zone of the Dinwoody Formation, Wyoming and Montana, Western-Central USA (Ciriacks, 1963), Central Alborz Range, Iran (Nakazawa *et al.*, 1981), Qilian Mountain, Qinghai Province, Northwest China (Yang *et al.*, 1983), and Miyazaki, Kochi and Gunma Prefectures, Japan (Matsushita, 1926; Ozaki & Shikama, 1954; Yabe, 1956; Kambe, 1963; Nakazawa, 1971).

Discussion: *Unionites* is a very common Lower Triassic bivalve in South Primorye, and Bittner (1899b) described two species of *Anodontphora* (=*Unionites*), namely, *U. canalensis* and *U. fassaensis*. *U. canalensis* is distinguished from *U. fassaensis* by its more elongated and subquadrangular shape, and its more developed umbonal ridge, which runs from the umbo to the posteroventral extremity. Also, *U. canalensis* is generally larger than *U. fassaensis*. Ichikawa and Yabe (in Yabe, 1956, p. 284, pl. 16, figs. 1–7) proposed a new variety, *U. canalensis* var. *bittneri*, from a limestone block in the Kwanto Massif of East Japan. It differs from *U. canalensis* of South Primorye by its less elongate outline and more anterior position of the umbo. This species also exhibits intermediate forms between *U. canalensis* and *U. fassaensis*. Among the specimens described by Bittner (1899b), Ichikawa and Yabe (Yabe, 1956) assigned some specimens (pl. 3, figs. 34–36) to *U. canalensis* var. *bittneri*. Nakazawa (1971), however, treated this variety as intraspecific variation, after examining illustrations of the species reported from various parts of the world.

Unionites fassaensis (Wissmann, 1841)

Fig. 145.5–145.9

Myacites fassaensis Wissmann, 1841, p. 9, pl. 16, fig. 2a–c; Curioni, 1856, p. 320, pl. 6, fig. 1.

Anoplophora fassaensis (Wissmann). Frech, 1907, p. 40, pl. 7, fig. 3a–f.

Anodontophora (*Myacites*) *fassaensis* (Wissmann). Bittner, 1899b, p. 22, pl. 3, figs. 28–33; Ogilvie Gordon, 1927, p. 27, pl. 1, fig. 25.

Myacites (*Anodontophora*) *fassaensis* Wissmann. Arthaber, 1906, p. 257, pl. 34. fig. 10.

Pleuromya fassaensis (Wissmann). Assmann, 1915, p. 631, pl. 36, fig. 8a, b.

Homomya fassaensis (Wissmann). Bender, 1921, p. 55, pl. 1, fig. 6a–c, pl.2, figs. 6–9; Leonardi, 1935, p. 32, pl. 1, figs. 5, 6.

Anodontophora fassaensis (Wissmann). Matsushita, 1926, pl. 8, fig. 11; Hsu, 1936–37, p. 317, pl. 1, figs. 15, 16; Newell and Kummel, 1942, p. 958, pl. 2, fig. 13; Yabe, 1956, p. 286, pl. 16, figs. 8–11; Kambe, 1963, p. 50, pl. 5, figs. 28–32, pl. 6, figs. 1, 2; Vu Khuc in Vu Khuc *et al.*, 1965, p. 26, pl. 2, figs. 14, 15.

Myophoria aff. *laevigata* (Ziethen). Matsushita, 1926, pl. 8, fig. 14.

Unionites fassaensis (Wissmann). Ciriacks, 1963, p. 82, pl. 16, fig. 13; Nakazawa, 1971, p. 127, pl. 25, figs. 1–4; Chen, Ma and Zhang, 1974, p. 326, pl. 174, figs. 2, 3, 7; Gan and Yin, 1978, p. 371, pl. 122, fig. 5; Nakazawa *et al.*, 1981, p. 144, pl. 2, figs. 11,12; Yin and Yin in Yang *et al.*, 1983, p. 135, pl. 13, figs. 1,2; Dang, Trinh Tho and Vu Khuc in Vu Khuc *et al.*, 1991, p. 81, pl. 5, figs. 19, 20; Kurushin and Truschelev in Dagys *et al.*, 1996, p. 68, pl. 4, figs. 20, 21.

Type: Not designated in Wissmann (1841) or in other previous studies.

Material examined: Nine specimens, NSM PM23425–23433, from AB1010, five specimens, NSM PM23434–23438, from AB1012, and two specimens, NSM PM23439–23440, from AB1014.

Description: Shell small in size, moderately inflated, trigonally ovate (H/L ratio about 0.7), equivalve and inequilateral. Umbo small, slightly prosogyrate, located at about two-fifths of valve length from front. Anterodorsal margin somewhat recurvate. Posterodorsal margin straight or slightly convex. Anterior margin well rounded. Lunule narrow. Posterior margin nearly straight, sub-truncated, forming an angle of 80° with arched ventral margin. Posterior ridge weakly elevated. Escutcheon narrow. Surface of main body ornamented with fine concentric growth lines. Entire inner margin smooth.

Measurements (*mm*):

Specimen no.	H	L	H/L	pU	Pu/L	Remarks
NSM PM23425	6.1	8.7	0.71	3.9	0.45	RV
NSM PM23426	14.6	18.4	0.79	6.6	0.36	RV
NSM PM23427	9.6	13.7	0.70	4.9	0.35	RV
NSM PM23428	10.5	15.4	0.68	7.9	0.51	LV*
NSM PM23429	12.1	20.3	0.60	7.4	0.36	RV**
NSM PM23430	13.0	18.7	0.69	7.8	0.42	LV
NSM PM23431	6.4	9.2	0.69	2.9	0.32	LV
NSM PM23432	5.7	9.0	0.63	4.3	0.48	RV
NSM PM23433	11.2	16.7+	–	–	–	LV*
NSM PM23434	12.1	16.1	0.76	7.1	0.44	LV*
NSM PM23435	11.7	16.5	0.71	8.0	0.48	RV*
NSM PM23436	12.8	19.7	0.65	7.1	0.36	LV*
NSM PM23437	11.7	16.9	0.69	7.8	0.46	LV*
NSM PM23439	5.7	9.6	0.60	5.0	0.53	RV*
NSM PM23440	14.2	22.0+	–	8.5	–	LV**

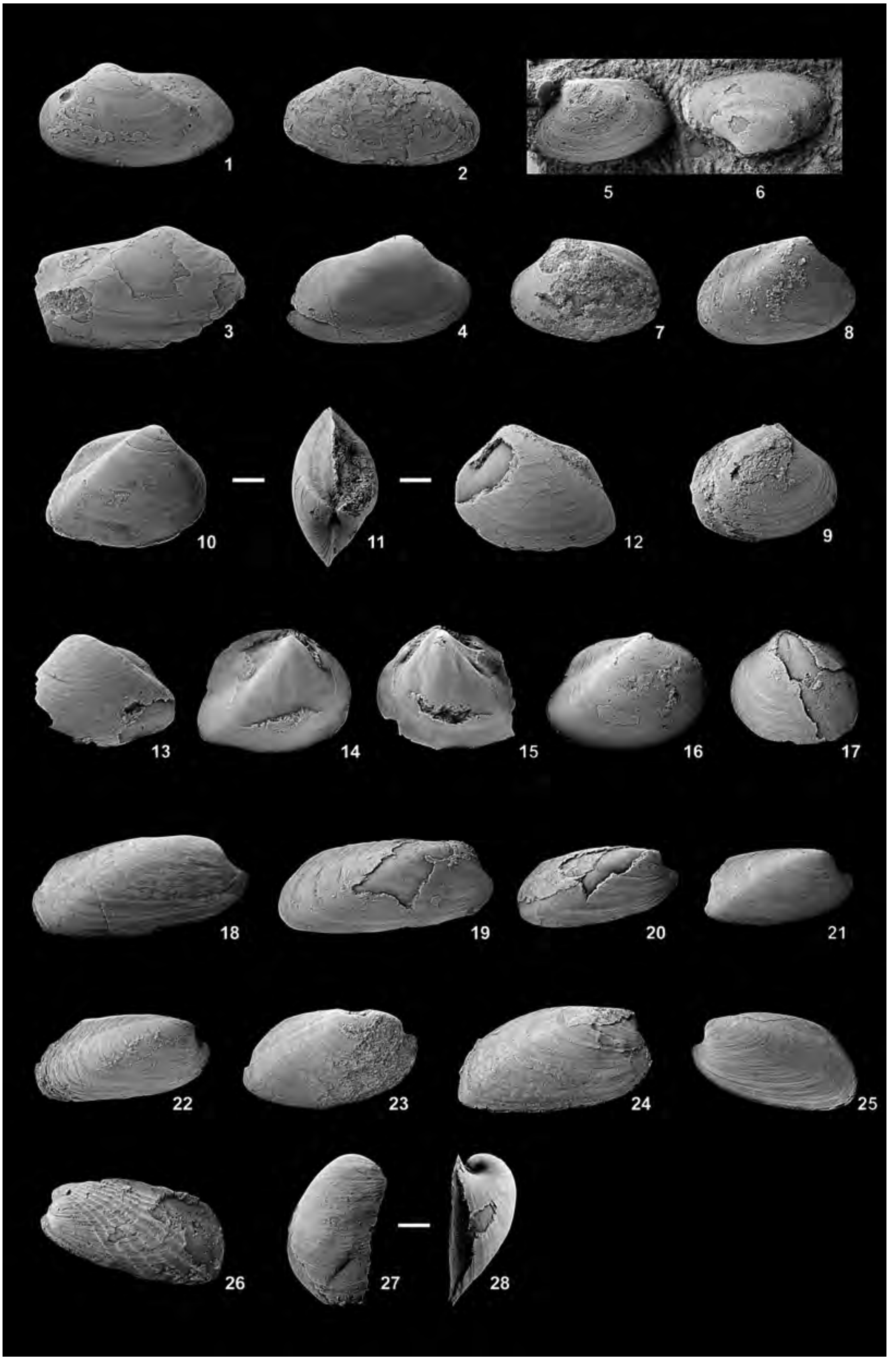
* incomplete shell, ** internal mold.

Occurrence: Described specimens from AB1010 in the lower *Gyronites subdharmus* Zone, and from AB1012 in the *Ambitoides fuliginatus* Zone in the upper part of the Lazurnaya Bay Formation, and from AB1014 in the *Clypeoceras spitiense* "bed" in the lower part of the Zhitkov Formation, Abrek Bay area, South Primorye. Thus, in this particular area, the species ranges from late Early Induan (late Griesbachian) to early Late Induan (early Dienerian). The species also occurs in the Lower Triassic on the western coast of Ussuri Gulf, Shamara River and Askold Island, South Primorye (Bittner, 1899b; Kiparisova, 1938). It also has been reported from various other Lower Triassic localities as follows: Olenek and Indigirka Rivers, Siberia, Russia (Dagys *et al.*, 1996), Werfen Formation, Dolomites, Italy (Curioni, 1856; Arthaber, 1906; Frech, 1907; Ogilvie Gordon, 1927; Leonardi, 1935), *Claraia* zone of the Dinwoody Formation, Wyoming, Western-Central USA (Newell & Kummel, 1942; Ciriacks, 1963), Central Alborz Range, Iran (Nakazawa *et al.*, 1981), Olenekian of Vietnam (Vu Khuc *et al.*, 1965, 1991), Qinghai, Zhejiang and Guizou Provinces, China (Hsu, 1936–37; Chen, Ma & Zhang, 1974; Gan & Yin, 1978; Yang *et al.*, 1983), and Miyazaki, Kochi and Gunma Prefectures, Japan (Matsushita, 1926; Yabe, 1956; Kambe, 1963; Nakazawa, 1971).

Discussion: The species differs from *Unionites canalensis* (Catullo) by its shorter length, less prominent beak and more centrally located umbo. The H/L ratio is less than 0.7, but that of the subspecies, *U. fassaensis* var. *brevis* (Bittner, 1901b), is about 0.75. The described specimens are quite similar to *U. fassaensis* (s.s.) in shell form and for all practical purposes, are identical with it.

→

Fig. 145. 1–4, *Unionites canalensis* (Catullo, 1848). 1, NSM PM23421, from AB1010, left valve, ×1.25. 2, NSM PM23422, from AB1010, left valve, ×1.0. 3, NSM PM23420, from AB1010, incomplete right valve, ×1.0. 4, NSM PM23424, from AB1021, right valve, ×1.0. 5–9, *Unionites fassaensis* (Wissmann, 1841) from AB1010. 5, NSM PM23431, left valve, ×2.5. 6, NSM PM23432, right valve, ×2.5. 7, NSM PM23430, incomplete left valve, ×1.25. 8, NSM PM23427, right valve, ×1.8. 9, NSM PM23426, right valve, ×1.25. 10–15, *Neoschizodus* cf. *laevigatus* (Ziethen, 1830). 10–12, NSM PM23367, from AB1021, right valve, dorsal view, incomplete left valve, ×1.8. 13, NSM PM23366, from AB1021, incomplete left valve, ×1.0. 14, NSM PM23365, from AB1021, internal mold of right valve, ×1.8. 15, NSM PM23364, from AB1010, internal mold of left valve, ×1.25. 16–17, *Neoschizodus* cf. *ovatus* (Goldfuss, 1838) from AB1013. 16, NSM PM23371, right valve, ×1.8. 17, NSM PM23372, incomplete left valve of immature individual, ×2.5. 18–25, *Triaphorus* aff. *multiformis* Kiparisova, 1966 from AB1021. 18, NSM PM23413, right valve, ×1.25. 19, NSM PM23391, right valve, ×1.25. 20, NSM PM23409, right valve, ×1.8. 21, NSM PM23414, right valve, ×1.8. 22, NSM PM23390, right valve, ×1.25. 23, NSM PM23392, right valve, ×1.8. 24, NSM PM23412, right valve, ×1.8. 25, NSM PM23411, left valve, ×1.8. 26, *Myoconcha* sp. indet., NSM PM23386, from AB1010, incomplete left valve, ×2.5. 27–28, *Ochotomya*? sp. indet., NSM PM23441, from AB1010, flank view and anterior view of imcomplete left valve, ×2.5.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Order Trigonioida Dall, 1889
Superfamily Trigoniacea Lamarck, 1819
Family Myophoriidae Bronn, 1849
Genus ***Neoschizodus*** Giebel, 1855

Type species: *Lyrodon laevigatum* Goldfuss, 1837.

Neoschizodus cf. ***laevigatus*** (Ziethen, 1830)

Fig. 145.10–145.15

Myophoria cf. *laevigata* Alberti. Bittner, 1899b, p. 19, pl. 3, figs. 17–23, 25 (not 24, 26).

cf. *Trigonia laevigata* Ziethen, 1830, p. 94, pl. 71, figs. 2, 6 (not seen).

cf. *Lyrodon laevigatum* (Ziethen). Goldfuss, 1837, p. 107, pl. 135, fig. 12 (not seen).

cf. *Myophoria laevigata* (Ziethen). Philippi , 1903, p. 53, pl. 5, fig. 9a, b; Ciriacks, 1963, p. 82, pl. 16, figs. 18, 19.

cf. *Neoschizodus laevigatus* (Ziethen). Kiparisova, 1972, p. 91, pl. 12, fig. 11; Newell and Boyd, 1975, p. 142, text-fig. 82; Dang and Vu Chau in Vu Khuc *et al.*, 1991, p. 89, pl. 11, fig. 17; Kurushin and Truschelev in Dagys *et al.*, 1996, p. 71, pl. 9, figs. 14, 15.

cf. *Myophoria* (*Neoschizodus*) *laevigata* (Ziethen). Chen in EGFLC, 1976, p. 40, pl. 20, figs. 1–6.

cf. *Neoschizodus* cf. *laevigatus* (Ziethen). Nakazawa, 1960, p. 10, pl. 6, figs. 21–32; Neri and Posenato, 1985, p. 95, pl. 2, fig. 1.

Material examined: One specimen, NSM PM23364, from AB1010, and six specimens, NSM PM23365–23370, from AB1021.

Description: Shell small, equivalve, moderately inflated, trigonally subobate, longer than high (H/L ratio about 0.8) and inequilateral. Umbo small, prominent, sharply rounded, orthogyrate or somewhat opisthogyrate. Umbonal ridge elevated and subangular to rounded. Anterodorsal margin recurvate. Anterior margin rounded, passing to widely arched ventral margin. Lunule narrow. Posterodorsal margin straight. Posterior margin truncated. Posteroventral edge subangulated. Posterior area slightly concave. Flank evenly convex. Escutcheon wide, surface smooth and concentrically striated. Entire inner margin smooth. Anterior adductor muscle scar oval, situated in front of myophoric buttress. Posterior adductor scar circular, lying at posterodosal margin. Pallial line entire. Dentition myophorian type.

Measurements (*mm*):

Specimen no.	H	L	H/L	Remarks
NSM PM23364	14.6	17.7	0.82	LV**
NSM PM23365	13.9	13.4	1.04	RV**
NSM PM23366	17.3	21.9+	–	LV*
NSM PM23367	10.8	13.9	0.78	art.
NSM PM23368	15.5+	16.8	–	LV**
NSM PM23369	18.0	16.5+	–	LV*
NSM PM23370	10.6	13.1	0.81	RV**

* incomplete shell, ** internal mold, art.: articulated shells.

Occurrence: Described specimens from AB1010 in the lower *Gyronites subdharmus* Zone (late Early Induan=late Griesbachian) in the upper part of the Lazurnaya Bay Formation and from AB1021 in the *Clypeoceras timorense* Zone (early Early Olenekian=early Smithian) of the Zhitkov Formation, Abrek Bay area, South Primorye. The specimens described by Bittner (1899b) are from the Lower Triassic of Paris Bay, Russian Island.

Discussion: *Neoschizodus laevigatus*, originally described from the Muschelkalk of Germany, is a cosmopolitan species and as such, occurs in various forms, which exhibit slightly different features in the shape of its shell as well as its posterior ridge. Bittner (1899b) noted these slight variations in the specimens from South Primorye. Among the specimens figured as *Myophoria* cf. *laevigatus*, the large specimens (pl. 3, figs. 17, 18) are clearly distinguished from those in figs. 24 and 26, which exhibit a low indistinct posterior ridge, a relatively low-inclined posterior area and a well rounded ventral margin. The former is related to typical *N. laevigatus*, and the latter is similar to *N. ovatus* (Goldfuss), whereas the smaller specimens (figs. 19–21, 23, 25), which have a distinct posterior ridge and well rounded ventral margin, are considered to be intermediate. The described specimens in the present article also exhibit characteristics of the two forms mentioned above. The specimens shown in Fig. 145.10–145.15 are of the *N. lae-*

vigatus (s.s.) type, while those in Fig. 145.16–145.17 are of the *N. ovatus* type. Compared with specimens of *N. laevigatus* from Germany (e.g., Newell & Boyd, 1975, p. 142, fig, 82A–D), the South Primorye specimens differ by their more rounded posterior ridge and more rounded posteroventral corner. The intermediate smaller samples of Bittner (1899b) are tentatively assigned to *N.* cf. *laevigatus*, but additional material is needed to permit a more certain assignment.

Neoschizodus cf. ***ovatus*** (Goldfuss, 1838)

Fig. 145.16–145.17

Myophoria cf. *laevigata* Alberti. Bittner, 1899b, p. 19, pl. 3, figs. 24, 26.

Myophoria laevigata var. *ovalis* Philippi? Kiparisova, 1938, p. 219, pl. 1, fig. 20 (no description).

cf. *Lyrodon ovatum* Goldfuss, 1838, p. 197, pl. 135, fig. 11 (not seen).

cf. *Neoschizodus ovatus* (Goldfuss). Neri and Posenato, 1985, p. 96, pl. 2, figs. 11, 12; Dang, Trinh Tho and Vu Khuc in Vu Khuc *et al.*, 1991, p. 89, pl. 6, fig. 1.

cf. *Neoschizodus* (*Leviconcha*) *ovatus* (Goldfuss). Farsan, 1972, p. 180, pl. 46, figs. 2, 3.

cf. *Myophoria ovata* (Goldfuss). Leonardi, 1935, p. 41, pl. 1, fig. 29.

Material examined: Two specimens, NSM PM23371, 23372, from AB1013.

Description: Shell small in size, weakly inflated, subquadrate to trigonally oval and inequilateral. Umbo small and orthogyrate. Umbonal ridge broadly rounded. Anterodorsal margin recurvate. Anterior margin rounded, passing to broad curvature of ventral margin. Posterior margin truncated. Posteroventral margin well rounded. Posterior area slightly concave. Surface smooth, ornamented with fine concentric lines.

Measurements (*mm*):

Specimen no.	H	L	H/L	Remarks
NSM PM23371	9.3	14.0	0.67	RV
NSM PM23372	7.6	8.0	0.95	LV*

* incomplete shell.

Occurrence: Described specimens from AB1013 in the *Ambitoides fuliginatus* Zone (early Late Induan=early Dienerian) in the lowest part of the Zhitkov Formation, Abrek Bay area, South Primorye. The species also occurs in the Lower Triassic of Russian and Putiatin Islands (Bittner, 1899b; Kiparisova, 1938)

Discussion: As mentioned above, the present species is distinguished from *Neoschizodus laevigatus* (s.s.) by its more rounded posterior ridge and more circular shell outline. It is similar to *N. ovatus* (e.g., Leonardi, 1935, p. 41, pl. 1, fig. 29; Farsan, 1972, p. 180, pl. 46, figs. 2, 3). *Myophoria laevigatus* var. *ovalis*, illustrated by Kiparisova (1938), is probably conspecific with the present species.

Subclass Heterodonta Neumayr, 1884
Order Veneroida H. Adams and A. Adams, 1856
Superfamily Carditacea Fleming, 1820
Family Permophoridae van de Poel, 1959
Subfamily Permophorinae van de Poel, 1959
Genus ***Triaphorus*** Marwick, 1953

Type species: *Pleurophorus zelandicus* Trechmann, 1918.

Triaphorus aff. ***multiformis*** Kiparisova, 1966

Fig. 145.18–145.25

aff. *Triaphorus multiformis* Kiparisova, in Kiparisova *et al.*, 1966, p. 73, pl. 31, figs. 5–9.

aff. *Triaphorus multiformis*, Kurushin and Truschelev in Dagys *et al.*, 1996, p. 73, pl. 29, fig. 9.

Material examined: Three specimens, NSM PM23387–23389, from AB1010, twenty-four specimens, NSM PM23390–23413, from AB1021, and one specimen, NSM PM23414, from AB1022.

Description: Shell small in size, moderately inflated, transversely suboval, somewhat extended posteriorly (H/L ratio about 0.5), equivalve and inequilateral. Umbo small, nearly terminal and prosogyrate. Subangular to rounded ridge running from umbo to posteroventral edge. Anterodorsal margin short and depressed. Anterior margin short and narrowly rounded. Posterodorsal margin slightly convex. Lunule narrow and deep. Posterior margin nearly straight or gently arched and truncated obliquely. Ventral margin slightly curved. Surface ornamented with irregular fine concentric lines. Weak radial ribs on posterior area. Inner structures unknown.

Measurements (*mm*):

Specimen no.	H	L	H/L	pU	pU/L	Remarks
NSM PM23387	8.0	15.6	0.51	3.4	0.22	RV
NSM PM23388	5.2	10.0	0.52	1.7	0.17	LV*
NSM PM23389	5.2	10.9	0.48	3.0	0.28	RV
NSM PM23390	10.3	21.7	0.47	2.6	0.12	LV
NSM PM23391	11.8	27.0	0.44	2.6	0.09	RV*
NSM PM23392	8.7	15.1	0.57	1.8	0.12	RV
NSM PM23393	8.3	17.2	0.49	2.8	0.17	LV*
NSM PM23394	7.9	14.0	0.57	2.2	0.15	RV
NSM PM23395	9.2	16.2+	–	3.5	–	LV
NSM PM23396	8.7	14.8+	–	1.9	–	LV*
NSM PM23397	10.0	19.1	0.52	3.4	0.18	RV
NSM PM23398	4.9	9.3	0.53	1.6	0.17	LV
NSM PM23399	10.3	13.1+	–	3.9	–	LV*
NSM PM23400	4.9	8.8	0.55	2.4	0.28	LV*
NSM PM23401	7.7	15.2+	–	2.0	–	LV*
NSM PM23402	6.6	12.8+	–	0.9	–	RV
NSM PM23403	4.9	9.3	0.53	0.6	0.06	RV
NSM PM23404	10.1	14.7	0.69	2.6	0.17	LV*
NSM PM23405	6.3	11.9	0.53	2.1	0.18	RV
NSM PM23406	4.6	7.2	0.64	1.1	0.15	RV
NSM PM23407	8.2	16.9	0.48	2.7	0.16	LV*
NSM PM23408	3.4	7.2	0.47	1.4	0.19	LV
NSM PM23409	6.0	14.0	0.43	2.1	0.15	RV*
NSM PM23410	7.3	14.1	0.52	1.4	0.10	RV*
NSM PM23411	7.8	14.3	0.55	1.5	0.11	LV
NSM PM23412	9.6	16.7	0.58	1.9	0.11	RV
NSM PM23413	8.3	18.1	0.46	3.0	0.17	RV
NSM PM23414	6.5	13.1	0.50	2.3	0.17	RV

* incomplete shell.

Occurrence: Described specimens from AB1010 in the lower *Gyronites subdharmus* Zone (late Early Induan=late Griesbachian) in upper part of the Lazurnaya Bay Formation, and from AB1021 and AB1022 in the *Clypeoceras timorense* Zone (early Early Olenekian=early Smithian) of the Zhitkov Formation, Abrek Bay area, South Primorye.

Discussion: Since the internal structures of the specimens cannot be observed, it is difficult to ascertain their generic position with full confidence. However, the external features of the present specimens are quite similar to *Triaphorus multiformis* from the Upper Triassic strata of Siberia. For these reasons, they are herein assigned to *Triaphorus*. The described specimens differ from *T. multiformis* by their smaller size and slightly less elongate form.

Subfamily Myoconchinae Newell, 1957

Genus ***Myoconcha*** J. de C. Sowerby, 1824

Type species: *Myoconcha crassa* J. de C. Sowerby, 1824.

Myoconcha sp. indet.

Fig. 145.26

Material examined: NSM PM23386, from AB1010.

Description: Shell small, moderately inflated and transversely subquadrate (H/L ratio about 0.6). Umbo small, subterminal and prosogyrate. Anterior end short, narrowly rounded and concentrically striated. Posterodorsal margin nearly straight. Posterior end gently arched and subtruncated. Ventral margin nearly straight. Ornamented posteriorly by coarse, radial ribs, which together with concentric lines, form a reticulate pattern. Internal structures unknown.

Measurements (*mm*):

Specimen no.	H	L	H/L	Remarks
NSM PM23386	7.3	11.5	0.64	LV

Occurrence: Described specimen from AB1010 in the lower *Gyronites subdharmus* Zone (late Early Induan=late Griesbachian) in upper part of the Lazurnaya Bay Formation, Abrek Bay area, South Primorye.

Discussion: Since the internal characters cannot be observed, it is difficult to identify the present specimen with certainty. The elongate, posteriorly expanded shape and subterminal umbo remind one of several different taxa; namely, the Permian *Netschajewia* Yakovlev, the Triassic *Curionia* Rossi

Ronchetti, the Lower Jurassic *Kalentera* Marwick and the Permian?-Jurassic *Myoconcha* J. de C. Sowerby. Among these *Myoconcha* is more closely related to the present specimen by its developed radial ornament. Regarding this point the Permian taxon *Stutchburia* Etheridge is also similar to the described specimen, but differs by its subquadrangle shape. "*Modiolus*" sp. indet. (this paper) is also ornamented with radial ribs, but differs by its sinuated ventral margin and its more delicate radials.

Subclass Anomalodesmata Dall, 1889
Order Phoradomyoida Newell, 1965
Superfamily Phoradomyacea Gary, 1847
Family Ceratomyidae Arkell, 1934
Genus ***Ochotomya*** Polubotko, 1966

Type species: *Ochotomya anyuensis* Polubotko in Kiparisova *et al.*, 1966.

Ochotomya? sp. indet.
Fig. 145.27–145.28

Material examined: NSM PM23441, from AB1010.

Description: Shell small, thin, gibbous, strongly inflated and orbicular. Umbo large, obtuse, elevated above dorsal margin, prosogyrate and slightly incoiled. Anterior, posterior and ventral margins well rounded. Surface smooth, ornamented with fine concentric lines. Internal structures unknown.

Measurements (*mm*):

Specimen no.	H	L	H/L	Remarks
NSM PM23441	9.5	7.0+	–	LV*

* incomplete shell.

Occurrence: Described specimen from AB1010 in the lower *Gyronites subdharmus* Zone (late Early Induan=late Griesbachian) in upper part of the Lazurnaya Bay Formation, Abrek Bay area, South Primorye.

Discussion: Approximately one-third of the present specimen's posterior portion has been broken off, but based on growth lines, its shape is reasonably presumed to be orbicular. If we disregard its Lower Triassic stratigraphical origin and instead consider just its gibbous, strongly incurved umbo and the general shape of its left valve, the specimen could then be assignable to either the Jurassic-Cretaceous *Buchia* Rouillieror or the Middle-Upper Triassic *Ochotomya* Polubotko or the Devonian-Triassic *Megalodon* J. de C. Sowerby. *Buchia* has inequivalve shells consisting of a strongly convex left valve and a nearly flat right valve. In contrast, *Ochotomya* and *Megalodon* have equivalve shells. Unfortunately, only one valve (left) is at hand, and its generic position cannot be ascertained with certainty. It is tentatively referred to *Ochotomya* based on its distribution in Upper (and probably Lower and Middle) Triassic strata in Northeast Asia, South Primorye, Japan, North America and other areas (Polubotko in Kiparisova *et al.*, 1996, p. 196).

Brachiopods (by A. M. Popov)

Early Triassic brachiopods are generally rare and sparse worldwide (Dagys, 1993; Chen *et al.*, 2005). They have been sporadically reported from the Himalayas (Bittner, 1899a, Sun *et al.*, 1981; Chen, 1983; Ager & Sun, 1988), North America (Girty, 1927; Newell & Kummel, 1942; Hoover, 1979), Greenland (Frebold, 1939), Russian Far East (Bittner, 1899b, Dagys, 1965), North Caucasus, Mangyshlak and Balkans (Dagys, 1974), and South China (Chen & Shi, 1999; Chen *et al.*, 2002, 2005).

One of the most abundant and best-preserved Early Triassic brachiopod faunas in the world has been reported from the Lower Triassic successions in South Primorye. Some of these brachiopods have been described by previous authors (Bittner, 1899b; Dagys, 1965, 1974). More recently, I also found considerably rich brachiopods from the Lower Triassic sequences of the Abrek Bay area, South Primorye. These newly found brachiopods are generally very small and include inarticulated and articulated forma. They are described as below.

A number brachiopod taxa, found out recently together with *Abrekia sulcata* Dagys (?*Piarorhynchella* sp.nov., Wellerellidae gen. et sp. nov. A, Wellerellidae gen. et sp. nov. B, Pontisiinae gen. et sp. nov., ?Rhynchonellidae gen. et sp. nov.), are resulted and figured for fuller characteristic of the given assemblage.

Systematic classifications follow the revised versions of the Treatise on Invertebrate Paleontology. Part H. Brachiopoda (Kaesler ed., 2000, 2002).

Abbreviations for shell dimensions: L=shell length; Lv=ventral valve length; Ld=dorsal valve length; W=shell width; T=shell thickness.

Institution abbreviations: CGM=Central Research Geological Prospecting Museum (CNIGR Museum), St. Petersburg; DVGI=Far Eastern Geological Institute, Vladivostok; IGIG=Institute of Geology and Geophysics, Novosibirsk.

Subphylum Linguliformea Williams *et al.*, 1996

Class Lingulata Goryansky and Popov, 1985

Order Lingulida Waagen, 1885

Superfamily Linguloidea Menke, 1828

Family Lingulidae Menke, 1828

Genus ***Lingula*** Bruguiere, 1797

Type species: *Lingula anatina* Lamarck, 1801.

Lingula borealis Bittner, 1899

Fig. 146.5–146.6

Lingula borealis Bittner, 1899b, p. 25, pl. 4, figs. 1–7; Moisseiev, 1947, p. 64, pl. 6, figs. 5–7; Kiparisova, 1954, p. 9, pl. 1, figs. 3–5; Dagys, 1965, p. 10, pl. 1, figs. 1–4.

Lectotype: CGM 221/103, figured by Bittner (1899b, p. 25, Pl. 4, fig. 1) and designated by Dagys (1965, p. 10, pl. 1, fig. 2), from the Lower Triassic in the Paris Bay area of Russian Island, South Primorye, Russia.

Material examined: Six specimens, DVGI 2052/28–30, 41–43, from AB1005, two specimens, DVGI 2052/26, 40, from AB1006, seven specimens, DVGI2052/27, 34–39, from AB1008, which are ventral and dorsal valves, partly represented by molds or cores with shell fragments.

Description: Large shells for genus (see measurements below); elongately oval in outline; anterior and posterior margins rounded; side borders subparallel; posterior parts of both valves moderately elevated along median longitudinal line, with two slopes gradually down to lateral margins. Shell surface generally smooth except for concentric delicate growth lines. Dorsal interior paired muscular scars weakly impressed. Ventral interior with a pair of foremost adductor scars positioned near anterior end of median elevation, extending anterior-laterally; both external and internal oblique muscle scars conspicuous.

Occurrence: The *Lytophiceras* sp. Zone (Early Induan=Griesbachian) of the middle part of the Lazurnaya Bay Formation of AB1005, AB1006 and AB1008, Abrek Bay area, South Primorye. This species also occurs in the Induan of Idaho, western USA and Olenekian? of Mangyshlak, Kazakhstan.

Measurements (*mm*):

Specimen no.	L	W	L/W
DVGI 2052/27	7.0	4.6	1.52
DVGI 2052/34	4.9	3.8	1.29
DVGI 2052/35	4.9	2.8	1.75
DVGI 2052/36	>8.5	7.4	>1.15
DVGI 2052/37	6.6	3.5	1.89
DVGI 2052/38	3.6	1.3	2.77
DVGI 2052/39	4.1	2.5	1.64
DVGI 2052/26	10.0	5.3	1.87
DVGI 2052/40	5.0	2.2	2.27
DVGI 2052/29	6.5	3.5	1.86
DVGI 2052/28	9.0	4.1	2.20
DVGI 2052/30	4.3	2.8	1.54
DVGI 2052/41	5.5	2.2	2.50
DVGI 2052/42	>6.0	2.7	>2.22
DVGI 2052/43	7.8	5.6	1.39

Discussion: Lingula has long been regarded as a living fossil as the genus has undergone little morphological changes since its origina-

Fig. 146. 1–4, 7–8, *Orbiculoidea* sp. indet., 1, DVGI 2052/31, from AB1006, dorsal valve exterior, ×3.0. 2, DVGI 2052/32, from AB1008, dorsal valve interior, ×3.0. 3, DVGI 2052/63, from AB1008, dorsal valve exterior, ×3.0. 4, DVGI 2052/55, from AB1006, dorsal valve interior, ×3.0. 7, DVGI 2052/56, from AB1006, dorsal valve interior, ×3.0. 8, DVGI 2052/29, from AB1006, ventral valve exterior, ×3.0. 5–6, *Lingula borealis* Bittner, 1899. 5, DVGI 2052/54, from AB1008, dorsal valve exterior, ×3.0. 6, DVGI 2052/26, from AB1007, ventral valve exterior, ×3.0.

tion in Early Palaeozoic (Rudwick, 1970). However, several recent studies reveal that the pre-Cretaceous specimens previously ascribed to *Lingula* may represent various genera, for example, the Carboniferous-Cretaceous *Lingularia* Biernat and Emig, 1993, the Early Permian *Semilingula* Popov (in Egorov & Popov, 1990) and the Late Permian *Lunoglossa* Xu and Xie, 1985. The convincing fossil records of *Lingula* are confined in the post-Jurassic strata (Holmer & Popov, 2000; Emig, 2003). As such, the pre-Cretaceous *Lingula* requires further studies and revisions.

Although their generic assignment remains problematic due to poorly preserved material, lingulids, as disaster taxa, were extremely abundant in the aftermath of the end-Permian mass extinction worldwide (i.e., Broglio Loriga, 1968; Rowell, 1970; Broglio Loriga *et al.*, 1980; Liao, 1980; Rodland & Bottjer, 2001). In particular, the well-illustrated study by Broglio Loriga (1968) exhibits *Lingula tenuissima* Bronn, 1837 (Bronn, 1850–1851) from the lowest Triassic of Dolomites, northern Italy bears comparable internal features with those of *Lingula anatina* Lamarck, 1801, Type species of the genus, from the Recent Oceans. This fact indicates that true *Lingula* may have occurred earlier in Early Triassic. Consequently, I assign tentatively these Primoryan specimens to *Lingula* with question mark.

The described specimens agree with Bittner's (1899b) description for the species. The South Primorye species also approaches externally *Lingula keuperea* Zenker (1834, p. 394, pl. 5, b), from which the Bittner's species is distinguished by its more convex valves and less curved growth lines at anterior margins.

Superfamily Discinoidea Gray, 1840
Family Discinidae Gray, 1840
Genus ***Orbiculoidea*** d'Orbigny, 1847

Type species: *Orbicula forbessi* Davidson, 1848.

Orbiculoidea sp. indet.
Fig. 146.1–146.4, 146.7–146.8

Material examined: Three specimens, DVGI 2052/31, 33, 44, from AB1004, four specimens, DVGI 2052/54–57, from AB1005, one specimen , DVGI 2052/58, from AB1006, ten specimens, DVGI 2052/32, 45–53, from AB1007, five specimens, DVGI 2052/59–63, from 1008, which are ventral and dorsal valves, partly represented by molds or cores with fragments of shell.

Description: Shell large, up to 14 mm in length and 11 mm in width; oval to subcircular in outline. Both valves sculptured with fine, concentrically arranged growth lines. Ventral median groove narrow, but distinct. Dorsal valve flattened posteriorly with small, but distinctive beak extending posteriorly.

Measurements (*mm*):

Specimen no.	L	W	H	L/W
DVGI 2052/33	10.7	7.5	2.5	1.43
DVGI 2052/31	13.8	10.7	5.0	1.29
DVGI 2052/44	5.7	4.0	2.5	1.42
DVGI 2052/45	4.0	4.0	1.0	1.00
DVGI 2052/32	8.6	5.7	2.0	1.51
DVGI 2052/46	6.8	6.0	1.3	1.13
DVGI 2052/47	3.7	3.6	1.0	1.03
DVGI 2052/48	7.5	6.7	2.2	1.12
DVGI 2052/49	4.5	4.5	1.3	1.00
DVGI 2052/50	2.3	2.1	0.5	1.10
DVGI 2052/51	>3.5	6.5	1.5	>0.54
DVGI 2052/52	5.4	4.2	2.0	1.29
DVGI 2052/53	4.2	4.3	0.8	0.98
DVGI 2052/54	5.4	5.1	1.6	1.06
DVGI 2052/55	8.0	5.0	1.7	1.60
DVGI 2052/56	6.5	5.5	1.8	1.18
DVGI 2052/57	4.0	4.0	1.4	1.00
DVGI 2052/58	3.6	3.7	1.3	0.97
DVGI 2052/59	11.0	>8.6	2.0	<1.28
DVGI 2052/60	6.6	5.6	1.9	1.18
DVGI 2052/61	5.6	3.5	0.9	1.60
DVGI 2052/62	>7.6	9.0	2.5	>0.84

Occurrence: The *Lytophiceras* sp. Zone (Griesbachian, Early Induan) of the middle Lazurnaya Bay Formation at AB1004, AB1005, AB1006, AB1007, and AB1008 of the Abrek Bay area, South Primorye. This species also occurs in the Induan in Idaho and Olenekian? in Mangyshlak.

Discussion: The distinctive features of the specimens enable to assign them with reasonable confidence to the genus *Orbiculoidea*. However, a definitive species assignment cannot be made. The described specimens more closely resemble specimen identified as *O. sibirica* Moisseiev (1947, p. 65) by Dagys (1965, p. 16) from Carnian of Pronchishhev Range, North-Eastern Siberia, but differs from it by significantly lesser inflation of ventral valve.

Subphylum Rhynchonelliformea
Class Chileata Williams *et al.*, 1996
Order Rhynchonellida Kuhn, 1949
Superfamily Rhynchonelloidea d'Orbigny, 1847
Family Rhynchonellidae d'Orbigny, 1847
Subfamily Piarorhynchiinae Shi and Grant, 1993
Genus ***Abrekia*** Dagys, 1974

Type species: *Abrekia sulcata* Dagys, 1974.

Abrekia sulcata Dagys, 1974
Figs. 147.1–147.24, 148, 149

Abrekia sulcata Dagys, 1974, p. 99, pl. 31, figs. 3, 4; text-fig. 64.

Holotype: IGIG 394/40, figured by Dagys (1974, p. 99, pl. 31, fig. 3), from the Lower

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Fig. 147. 1–24, *Abrekia sulcata* Dagys, 1974. 1–4, DVGI 2052/18, from AB1008, ×3.0. 5–8, DVGI 2052/16, from AB1008, ×3.0. 9–12, DVGI 2052/15, from AB1008, ×3.0. 13–16, DVGI 2052/5, from AB1008, ×3.0. 17–20, DVGI 2052/2, from AB1022, ×3.0. 21–24, DVGI 2052/1, from AB1008, ×3.0. 25–28, ?Rhynchonellidae gen. et sp. nov., DVGI 2052/7, from AB1008, ×3.0. 29–32, ?*Piarorhynchella* sp. nov., DVGI 2052/10, from AB1008, ×3.0. 33–36, Wellerellidae gen. et sp. nov. A, DVGI 2052/12, from AB1008, ×3.0. 37–40, Wellerellidae gen. et sp. nov. B, DVGI 2052/4, from AB1008, ×3.0. 41–48, Pontisiinae gen. et sp. nov., from AB1008, ×3.0. 41–44, DVGI 2052/3. 45–48, DVGI 2052/6. Ventral valve view, dorsal valve view, anterior commissure view and lateral view are shown in order in each specimen.

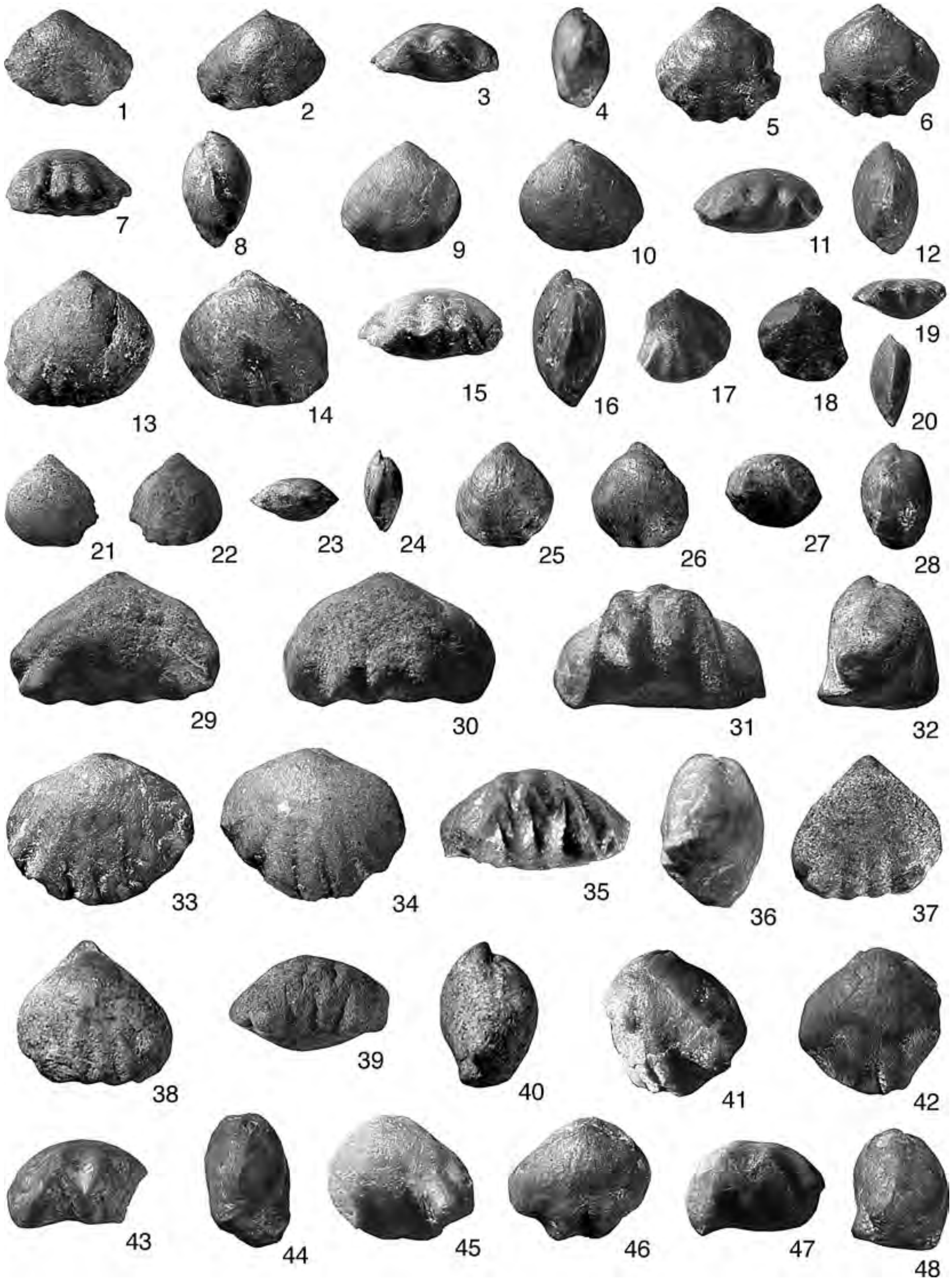
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Fig. 148. Holotype of *Abrekia sulcata* Dagys, 1974, IGIG 390/40, from the Induan in the Abrek Bay area, ×2 (after Dagys, 1974, pl. 31, fig. 3). 1, ventral valve view. 2, dorsal valve view. 3, anterior commissure view. 4, lateral view.

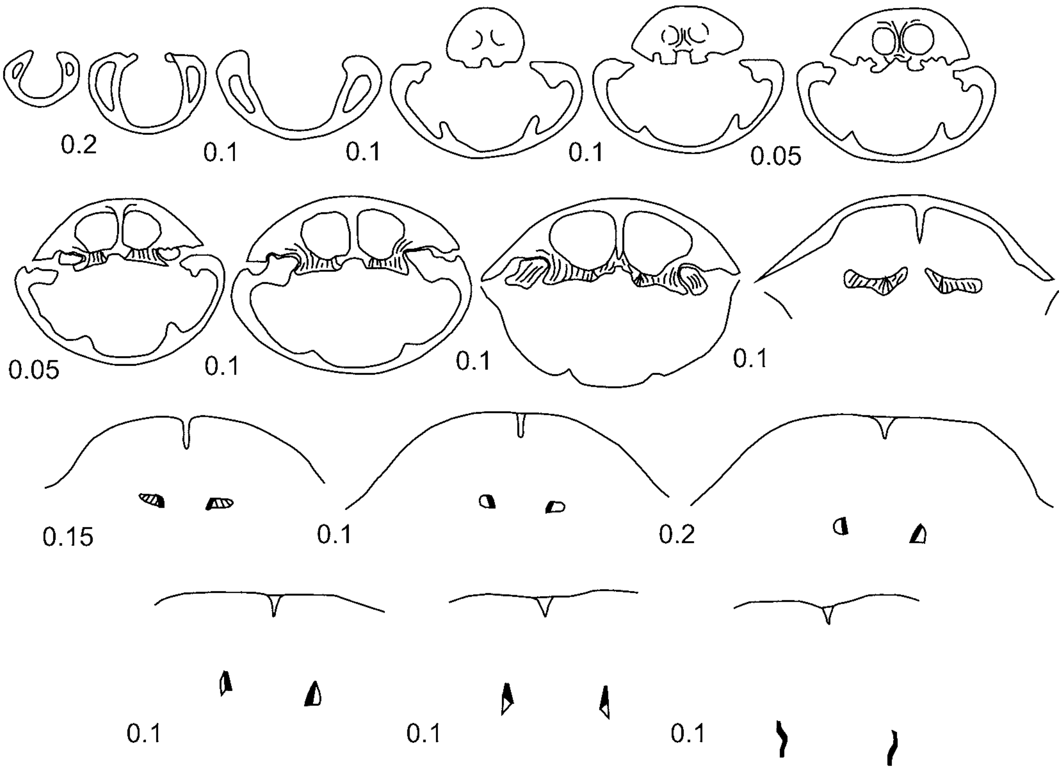

Fig. 149. Serial sections of *Abrekia sulcata* Dagys, 1974, IGIG 390/45, from the Induan in the Abrek Bay area (after Dagys, 1974, text–Fig. 64). By arabic number are shown intervals between adjacent sections.

Triassic (Induan) in the Abrek Bay area in South Primorye, Russia.

Material examined: Five specimens, DVGI 2052/1, 5, 15, 16, 18, from AB1008, and one specimen, DVGI 2052/2, from AB1022.

Description: Shells small in sizes (see measurements below); outline subpentagonal, transversely ovate to rounded, wider than long in adults, but shell width equating or smaller than length in juveniles; equibiconvex in profile; hingeline straight, shorter than greatest shell width positioning at midlength of shell; anterior commissure sulcate. External surface generally smooth, except for tiny, but distinct concentric growth lines.

Ventral valve evenly convex with greatest convexity anterior to umbo; umbo rounded, convex, gradually to lateral margins; beak small, weakly incurved, beyond hingeline; foramen submesothyrid, circular in outline, 0.2–0.5 mm in diameter; ventral valve medially convex to form poorly defined median fold, confined to middle and posterior parts of the shell; a broad median sulcus occurring near anterior margins. Dorsal valve moderately convex; beak small, indistinct; median fold consisting of two distinct costae, originating anterior to beak, extending to anterior margins; intercostal space forming a narrow, but distinct median groove, originating anterior to beak, slightly broadening near anterior margin; one median costa intercalating between two fold costae, but confined to anterior part of shell. External costae rounded in cross section, one costa in ventral median sulcus, three costae on dorsal median fold, and 1–3 costae on each flank.

Ventral interior dental plates short, convergent toward ventral floor. Dorsal septa low, but distinct, extending to a half of valve length; hinge plates rather broad, subhorizontal; crura long, raduliferlike, flattening distally (Fig. 149).

Measurements (*mm*):

Specimen no.	Lv	Ld	W	T
DVGI 2052/1	4.65	4.3	4.65	2.3
DVGI 2052/2	4.3	3.9	4.6	1.9
DVGI 2052/5	6.7	6.2	7.5	3.6
DVGI 2052/15	5.7	5.2	6.3	3.6
DVGI 2052/16	5.1	4.75	6.8	2.7
DVGI 2052/18	4.9	4.7	6.4	2.9

Occurrence: The *Lytophiceras* sp. Zone (Griesbachian, Early Induan) of the middle Lazurnaya Bay Formation at AB1008 and the *Clypeoceras timorense* Zone (early Smithian, early Early Olenekian) of the main part of the Zhitkov Formation at AB1022, Abrek Bay area, South Primorye.

Discussion: Dagys (1974) illustrated several relatively flat, mature specimens to represent his new genus, *Abrekia*, which is therefore considered to be confined to these flat, wider than long shells. In fact, our new collections from the topotype locality show that *Abrekia sulcata* may include morphologically more diverse specimens in terms of shell length, width and thickness. Our measurements show that juveniles often have relatively flat valves and longer than wide outlines, while adults possess relatively inflated valves and wider than long outlines. The present species differs clearly from *Abrekia*? *procreatrix* (Bittner, 1899a, p. 9), another common species in the Lower Triassic of Himalayas, in having distinct median groove/sulcus on the dorsal valve.

In addition, Chen and Shi (2002, p. 154) established *Meishanorhynchia* from the Griesbachian (Early Induan) of the Meishan section, South China. These authors inferred that their new genus could be ancestor of *Abrekia* in light of morphological evolutionary lineages and fossil horizons of both genera. It is true that both genera share similar internal features, a distinct dorsal median sulcus and variously developed costae. These incipient costae of *Meishanorhynchia* appear to be primitive characters of *Abrekia*, which possesses distinct, rounded costae on both valves. Accordingly, I agree with Chen *et al.* (2002) that the South Chinese genus may have given rise to *Abrekia* in late Griesbachian, not Dienerian as suggested by these authors.

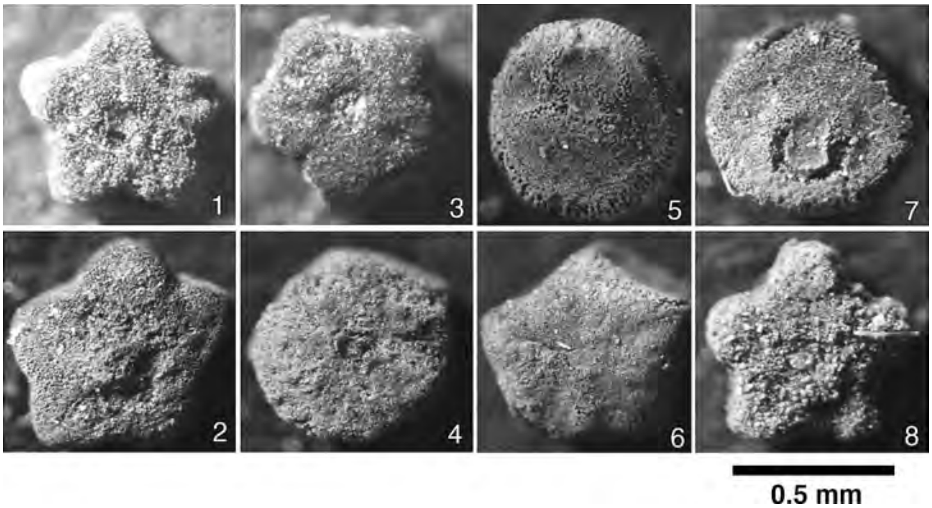

Fig. 150. *Holocrinus* sp. indet. from AB1022. 1, UMUT ME30044, columnal. 2, UMUT ME30046, columnal. 3, UMUT ME30045, columnal. 4, UMUT ME30047, columnal. 5, UMUT ME30050, cirri. 6. UMUT ME30048, columnal. 7, UMUT ME30051, cirri. 8, UMUT ME30049, columnal.

Crinoids (by T. Oji)

The systematic description below basically follows the classification by Rasmussen (1978).

Institution abbreviations: UMUT=University Museum, University of Tokyo.

Class Crinoidea Miller, 1821
Order Isocrinida Siverts-Doreck, 1952
Family Holocrinidae Jaekel, 1918
Genus ***Holocrinus*** Wachsmuth and Springer, 1886

Type species: *Encrinus beyrichi* Picard, 1883.

Remarks: *Holocrinus* possesses pentagonal coloumnals with five petals surrounded by crenulations on the articulation facet, the pattern common to the genus *Isocrinus*. However, *Holocrinus* is distinguished from *Isocrinus* by having elongated high basals, which are very low and usually separated on the surface in the case of Isocrinus.

Holocrinus sp. indet.
Fig. 150

Material examined: Six columnals, UMUT ME30044–30049, two cirrals, UMUT ME30050, 30051, all from AB1022. They were contained in a fine-grained, calcareous turbiditic sandstone. Specimens were removed from the rocks by dissolving the calcareous cement and disintegrate the rock by acetic acid, then were hand-picked using a binocular microscope after sieving and washing.

Description: Columnals small, ranging from 0.6–0.8 mm. Cross section of columnals pentagonal to stellate in outline. Probably due to abrasion, ornamentation disappeared during transportation, only central canal recognized on the articular facet, and no other conspicuous features observable. Some columnals show faint radial furrows, and weak embayment in the petaloid area (ligamentary field). Cirrals approximately 0.7 mm in diameter, as large as columnals. Cirrals rounded in outline. On the articular facet, there is fulcral ridge with two prominent tubercle-like protrusions near the both ends.

Occurrence: Described specimens from AB1022 within the *Clypeoceras timorense* Zone (early Early Olenekian=early Smithian) in the main part of the Zhitkov Formation, Abrek Bay area, South Primorye.

Discussion: These columnals and cirrals show common characteristics found in most of the taxa of Isocrinida. However, reliably assigned *Isocrinus* has never been reported from the early Triassic. Thus it would be safe to assign these columnals and cirrals to the genus *Holocrinus*. However, poor state of preservation (surface abrasion on the articular facet) prohibit from assigning these to any particular species.

Remark: The size of the columnals and cirrals from the Abrek Bay area are similar, both in the range of 0.6–0.8 mm. Usually columnals of the order Isocrinida are much larger than the cirri, which are components of appendages to the column (stalk). Thus, the size of the cirri is much larger than the usual columnals in this case, if compared with the present small sized columnals. This is probably due to size sorting of crinoid skeletal components, during transportation in a turbidity current. If this interpretation is right, there were originally different sized individuals of *Holocrinus*, and other larger columnals may be found in other localities near the present horizon.

Conodonts (by H. Igo)

The orientation of elements is now largely modified by intensive analyses of multielement reconstruction of conodont animals (e.g., Purnell *et al.*, 2000). All of the specimens described herein are discrete P elements; hence the author applies traditional usage of orientation terms proposed by Sweet (in Clark *et al.*, 1981). The author basically adopted the supra-generic classification proposed by Sweet (1988) herein.

Institution abbreviation: MPC=Micropaleontology Collection, National Museum of Nature and Science, Tokyo.

Order Prioniodinida Sweet, 1988
Family Ellisoniidae Clark, 1972
Genus ***Foliella*** Budurov and Pantic, 1973

Type species: *Polygnathus gardenae* Staesche, 1964.

Foliella gardenae (Staesche, 1964)
Fig. 155.12

Polygnathus gardenae Staesche, 1964, p. 286, pl. 30, figs. 3–6.
Foliella gardenae (Staesche). Budurov and Pantic, 1973, p. 52, pl. 1, figs. 19–20.
Foliella gardenae (Staesche), morphotypes A, B, Kolar-Jurkovsek and Jurkovsek, 1996, p. 8, pl. 1, figs. 1–4, pl. 2, figs. 1–3, pl. 3, fig. 3.
Platyvillosus aff. *gardenae* (Staesche). Buryi, 1979, p. 67, pl. 17, fig. 1.
Furnishius wangcangensis Dai and Tian, in Tian *et al.*, 1983, p. 355, pl. 95, figs. 13–14.

Material examined: MPC6646, from AB1025-1.

Occurrence: Studied specimen from AB1025 within the *Neospathodus* ex gr. *waageni-N. novaehollandiae* Zone with the *Radioprionites abrekensis* “bed” (early Early Olenekian= early Smithian) in the main part of the Zhitkov Formation, Abrek Bay area, South Primorye.

Foliella gardenae was first described from the Upper Campiller Formation (Smithian), South Tirol, Austria. The species was also reported from the Smithian in South Primorye (Buryi, 1979) and the Iska Valley of Slovenia (Kolar-Jurkovsek & Jurkovsek, 1996). *Furnishius wangcangensis* Dai and Tian assignable to this species occurs in the Smithian strata of Sichuan, China (Tian *et al.*, 1983).

Remarks: This species is a pastiniplanate element characterized by an arrow-headed plate with a sharply pointed posterior end. The original Alpine specimens have a rounded subellipsoidal plate, but the plate of the present one exhibits a different outline. The shape of denticles and their arrangement are similar each other but denticles of the present one are fewer in number. The described Slovenian specimens by Kolar-Jurkovsek and Jurkovsek (1996) are similar to the present specimen.

Genus ***Ellisonia*** Müller, 1956

Type species: *Ellisonia triassica* Müller, 1956.

Ellisonia*? cf. *peculiaris (Sweet, 1970)

Fig. 152.22

cf. *Neospathodus peculiaris* Sweet, 1970a, p. 255, pl. 5, fig. 19; Birkenmajor and Trammer, 1975, pl. 1, fig. 8; Wang, 1978, p. 224, pl. 1, figs. 1–3, 15; Tian *et al.*, 1983, p. 379, pl. 96, fig. 5; Beyers and Orchard, 1991, pl. 5, fig. 9.

Material examined: MPC6612, from AB1021-P2.

Occurrence: Specimen from AB1021 within the lower part of the *Neospathodus* ex gr. *waageni-N. novaehollandiae* Zone with the *Clypeoceras timorense* Zone (early Early Olenekian = early Smithian) in the main part of the Zhitkov Formation, Abrek Bay area, South Primorye.

Sweet (1970a) described this species from his Zone 5 (upper Dienerian *Neospathodus cristagalli* Zone) in the Mittiwali Member of the Mianwali Formation. Birkenmajor and Trammer (1975) reported this species together with *N. dieneri* Sweet and *N. svalbardensis* Trammer (= *N. pakistanensis* Sweet) from Hornsund, South Spitsbergen. Wang (1978) and Tian *et al.* (1983) recorded the joint occurrence of this species and *N. pakistanensis* in the Lower Triassic formations in Shaanxi and Tibet. Beyers and Orchard (1991) figured a poorly preserved specimen from Fauna 4 (Dienerian) of the Cache Creek Complex, British Columbia, Canada. The occurrence of this species is restricted to the *N. waageni waageni* Subzone of the Chaohu Section, Anhui Province, China (Zhao *et al.*, 2007).

Remarks: The fragmentary specimen illustrated herein resembles Sweet's specimen in characteristic denticulation and the shape of blade. The original one has a long cusp that is twice the length of other denticles. The present specimen retaines only the basal portion of cusp that does not permit further comparison. Identification is tentative.

Family Gondolellidae Lindström, 1970
Subfamily Neogondolellinae Hirsh, 1994
Genus ***Borinella*** Budurov and Sudar, 1994

Type species: *Neogondolella buurensis* Dagis, 1984.

Borinella* cf. *nepalensis (Kozur and Mostler, 1976)

Fig. 152.25–152.26

cf. *Gondolella nepalensis* Kozur and Mostler, 1976, p. 9, pl. 1, figs. 1–6.
cf. *Neospathodus labiatus* Goel, 1977, p. 1093, pl. 1, figs. 3–11.
cf. *Neospathodus nepalensis* (Kozur and Mostler). Matsuda, 1982, p. 93, pl. 4, figs. 1–7.
cf. *Neogondolella nepalensis* (Kozur and Mostler). Dagis, 1982, p. 56, pl. 1, figs. 1–3; Dagis, 1984, p. 6, pl. 1, figs. 1–7.
cf. *Borinella nepalensis* (Kozur and Mostler). Orchard, 2007a, pl. 1, figs. 1, 2.

Material examined: Two specimens, MPC6615, 6616, from AB1016-P1.

Occurrence: Specimens from AB1016 within the *Neospathodus dieneri-N. pakistanensis* Zone with the *Paranorites varians* Zone (Late Induan = Dienerian) in the lower main part of the Zhitkov Formation, Abrek Bay area, South Primorye.

Borinella nepalensis yields from the *Flemingites* Beds (MO3–12C) of the Mikin Formation Muth, Spiti. The beds should be the uppermost Dienerian (Krystyn *et al.*, 2007). Orchard (2007a) further noted that this species appeared in late Dienerian and its range extended into early Smithian in pelagic environments.

Remarks: Denticles are mostly broken and the surface of narrow platform is more or less attrited. The present specimens are similar to Orchard's (2007a) figured one in development of platform and denticulation.

Genus ***Eurygnathodus*** Staesche, 1964

Type species: *Eurygnathodus costatus* Staesche, 1964.

Eurygnathodus costatus Staesche, 1964

Fig. 152.23–152.24

Eurygnathodus costatus Staesche, 1964, p. 269, pl. 28, figs. 1–6; Budurov and Pantic, 1973, p. 51, pl. 1, figs. 1–15.

Platyvillosus costatus (Staesche). Goel, 1977, p. 1098, pl. 2, figs. 15–21; Wang and Cao, 1981, p. 371, pl. 2, figs. 1–4, 28, 29; Koike, 1982, p. 44, pl. 5, figs. 1–9; Matsuda, 1984, p. 128, pl. 6, figs. 6–10; Duan, 1987, pl. 3, fig. 4; Koike, 1988, pl. 1, fig. 1–57, pl. 2, figs. 1–37; Wang and Zhong, 1994, p. 404, pl. 1, figs. 15, 23.

Platyvillosus paracostatus Wang and Cao, 1981, p. 371, pl. 2, figs. 9–10.

Material examined: MPC6613, from AB1016-P1, MPC6614, from AB1021-P2.

Description: Two dextral and sinistral segminiplanate elements; outline of platform slender blade-like with narrowly rounded posterior and sharply pointed anterior ends; length 0.50 and 0.52 mm; width 0.16 to 0.21 mm; giving length to width ratio 2.5 to 3.1; and upper surface of platform transversed by 11 rows of ridged denticles.

Occurrence: Described specimens from AB1016 within the *Neospathodus dieneri-N. pakistanensis* Zone with the *Paranorites varians* Zone (early Late Induan = early Dienerian) and from AB1021 within the *N.* ex gr. *waageni-N. novaehollandiae* Zone with the *Clypeoceras timorense* Zone (early Early Olenekian = early Smithian) in the main part of the Zhitkov Formation, Abrek Bay area, South Primorye.

Staesche's original ones were recorded from the middle part of the "Campiller Schichten" on South Tirol (Staesche, 1964; Budurov & Pantic, 1973). Goel (1977) described this species from the Dienerian limestone exposed at Khar in the Spiti Valley, India. Orchard (2007a), however, pointed out that the stratigraphic levels of Goel's specimens could be Smithian rather than Dienerian. Matsuda (1984) collected this species from beds immediately below the first appearance of *N. waageni* Sweet in Kashmir. Koike's (1988) *Platyvillosus costatus* occurred abundantly in the Smithian part of the Taho Limestone in Shikoku, Japan. Wang and Cao (1981) and Wang and Zhong (1994) announced the occurrence of this species and similar ones, *Eurygnathodus paracostatus*, in the upper Dienerian in Lichuan, Hubei and other regions of South China. The above-mentioned records suggest that *E. costatus* persisted in Dienerian to Smithian and did not range into Spathian.

Remarks: The element collected from AB1016-P1 is sinistral with slightly concave line in right edge of the anterior part of platform. Ridged denticles in a posterior half of the platform are discontinuous. The other element from AB1021-P2 is dextral one with a convex profile in right side of a posterior half of the platform. This type is similar to *Eurygnathodus paracostatus* (Wang and Cao, 1981) in platform shape and complete ridges of denticles. According to Orchard (2007a), *E. paracostatus* is a precursor of *E. costatus* that occurs in higher levels than *E. paracostatus* in Hubei. On the contrary, the stratigraphic position of *E. paracostatus*-like element occupies the higher level than that of typical *E. costatus* in the present Abrek Bay section. Koike (1982) pointed out that these features are intraspecific variation in his numerous specimens of *Platyvillosus costatus* from the Taho Limestone in Shikoku, Japan. *E. paracostatus* is probably conspecific with *E. costatus*.

Genus ***Neogondolella*** Bender and Stoppel, 1965

Type species: *Gondolella mombergensis* Tatge, 1956.

Neogondolella carinata (Clark, 1959)

Fig. 151.1–151.3

Gondolella carinata Clark, 1959, p. 308, pl. 44, figs. 15–19; Matsuda, 1984, p. 119, pl. 1, figs. 1–11, pl. 2, figs. 1, 3–5.

Neogondolella carinata (Clark). Sweet, 1970b, p. 240, pl. 3, figs. 1–17, 24, 26, 27; McTavish, 1973, p. 288, pl. 2, fig. 13; Wang and Wang, 1976, p. 409, pl. 5, figs. 6–9; Buryi, 1979, p. 66, pl. 9, fig. 5, pl. 17, fig. 2; Tian *et al.*, 1983, p. 368, pl. 80, figs. 8–9; Dagis, 1984, p. 5, pl. 1, fig.13; Cao and Wang, 1993, p. 256, pl. 54, figs. 7, 11, pl. 55, fig. 10; Orchard and Krystyn, 1998, p. 358, pl. 4, figs. 9, 11, 16, 17, 20.

Material examined: MPC6572, from AB1008-1b, MPC6573, from AB1010-P2, MPC6574, from AB1012-2.

Occurrence: Illustrated specimens range from AB1008 to AB1012 within the *Neogondolella carinata* Zone with the *Lytophiceras* sp. Zone (Early Induan＝Griesbachian), the *Gyronites subdharmus* Zone (late Early Induan＝late Griesbachian), and the *Ambitoides fuliginatus* Zone (early Late Induan＝early Dienerian) in the middle to upper part of the Lazurnaya Bay Formation, Abrek Bay area, South Primorye.

The range of this worldwide species is the Griesbachian to the lower part of Smithian (Orchard & Krystyn, 1998).

Remarks: Unfortunately, specimens identified are rare and poorly preserved. General outline and denticulation, however, are identical to those of many previously described specimens.

Genus ***Neospathodus*** Mosher, 1968

Type species: *Spathognathodus cristagalli* Huckriede, 1958.

Neospathodus concavus Zhao and Orchard, 2007

Fig. 154.13

Neospathodus concavus Zhao and Orchard, in Zhao *et al.*, 2007, p. 35, pl. 1, figs. 1A, B, C; Orchard and Krystyn, 2007, fig. 4.

Material examined: MPC6637, from AB1022-2.

Occurrence: The specimen is recovered from AB1022 within the lower part of the *Neospathodus* ex gr. *waageni*-*N. novaehollandiae* Zone with the *Clypeoceras timorense* Zone (early Early Olenekian＝early Smithian) in the main part of the Zhitkov Formation, Abrek Bay area, South Primorye.

The range of this species in the Pingdingshan Section is restricted to the *N. waaageni eowaageni* Subzone and the lowermost part of the *N. waageni waageni* Subzone (MO4-10＝lower part of the *Flemingites*-*Euflemingites* Zone). This implies the lowest Olenekian.

Remarks: The description and illustration of this species were originally given by Zhao and Orchard (in Zhao *et al.*, 2007). Orchard and

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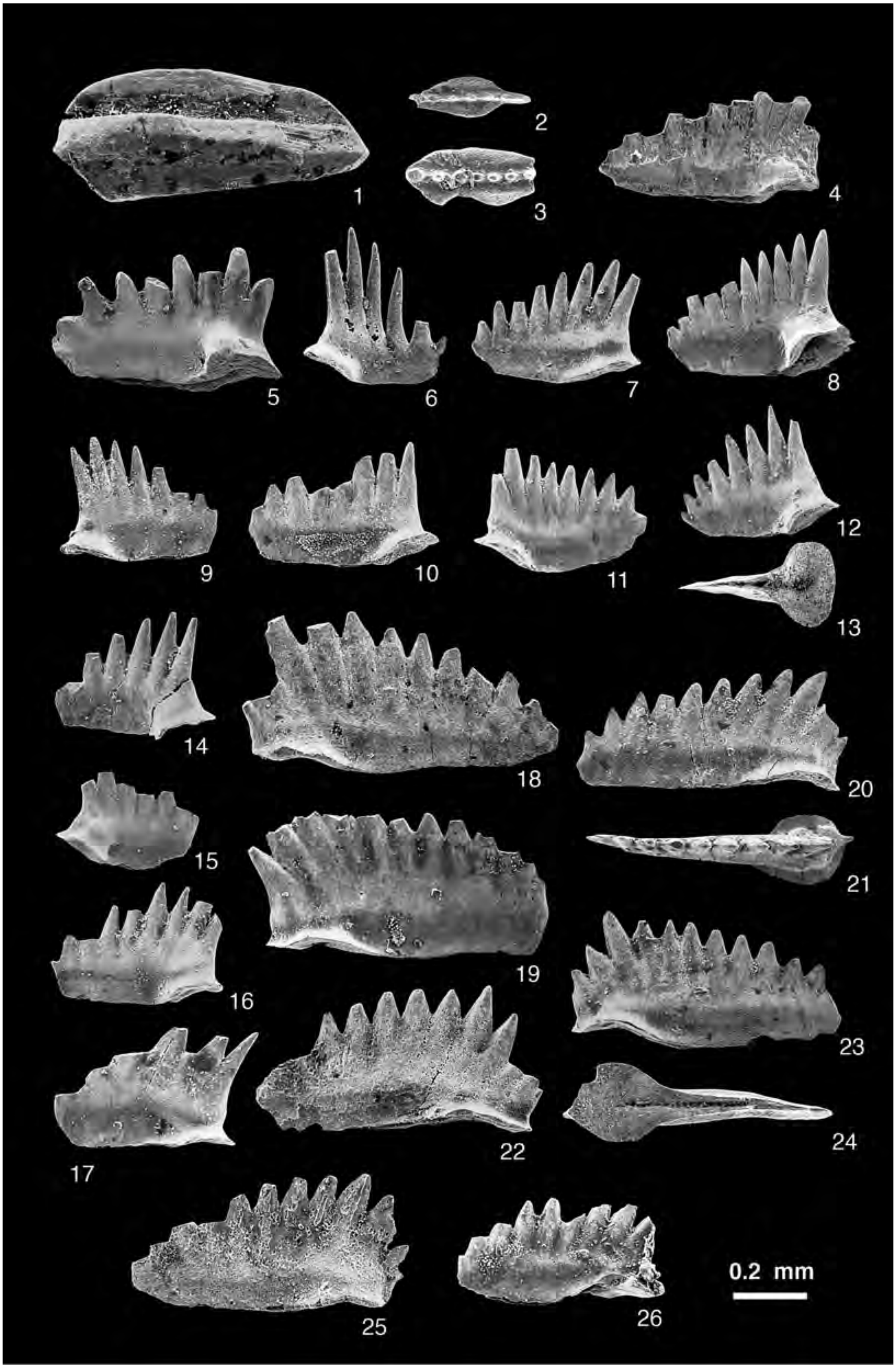
Fig. 151. 1–3. *Neogondolella carinata* (Clark, 1959). 1, MPC6672, from AB1008-1b. 2, MPC6573, from AB1010-P2. 3, MPC6574, from AB1012-2. 4–5, *Neospathodus* cf. *cristagalli* (Huckriede, 1958) from AB1014-1. 4, MPC6575. 5, MPC6576. 6–16, *Nospathodus dieneri* Sweet, 1970 from AB1014-1 (6–9), AB1014-P1 (10–16). 6, MPC6577. 7, MPC6578. 8, MPC6579. 9, MPC6580. 10, MPC6581. 11, MPC6582. 12–13, MPC6583. 14, MPC6584. 15, MPC6585. 16, MPC6586. 17, *Neospathodus* sp. A, MPC6587, from AB1014-P1. 18–26, *Neospathodus pakistanensis* Sweet, 1970 from AB1014-P1. 18, MPC6588. 19, MPC6589. 20–21, MPC6590. 22, MPC6591. 23–24, MPC6592. 25, MPC6593. 26, MPC6594.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0.2 mm

Krystyn (2007), however, illustrated the other type of this species that bears 13 denticles on strongly arched blade. The present specimen resembles the Spiti specicmen in number of denticles.

Neospathodus cf. ***cristagalli*** (Huckriede, 1958)

Fig. 151.4–151.5

cf. *Spathognathodus cristagalli* Huckriede, 1958, p. 161, pl. 10, figs. 14, 15.
cf. *Neospathodus cristagalli* (Huckriede). Sweet, 1970a, p. 246, pl. 1, figs. 14, 15; Matsuda, 1982, p. 92, pl. 3, figs. 1–12.
cf. multielement apparatuses, *Neospathodus* cf. *cristagalli* (Sweet). Orchard, 2005, p. 88, text-fig. 14.
Many other synonyms of this species are eliminated herein.

Material examined: Two specimens, MPC6575, 6576, from AB1014-1.

Occurrence: Specimens from AB1014 within the lower part of the *Neospathodus dieneri-N. pakistanensis* Zone with the *Clypeoceras spitiense* bed (early Late Induan=early Dienerian) in the lower part of the Zhitkov Formation, Abrek Bay area, South Primorye.

This species and its morphotypes are known from the Dienerian and Smithian associated with *N. dieneri* Sweet elsewhere.

Remarks: Denticles are suberect and stought in the present specimens. Their tips are mostly lacking but probably discreted. Identification is reserved in the future research.

Neospathodus dieneri Sweet, 1970

Figs. 151.6–151.16, 152.8–152.9

Neospathodus dieneri Sweet, 1970a, p. 9, pl. 1, fig. 17; Sweet, 1970b, p. 249, pl. 1, figs. 1, 4; McTavish, 1973, p. 293, pl. 2, figs.3, 6; Buryi, 1979, p. 52, pl. 7, fig. 7; Wang and Cao, 1981, pl. 2, figs. 24, 25; Matsuda, 1982, p. 90, pl. 2, figs. 1–11; Koike, 1982, p. 37, pl. 6, figs. 15–21, 28, 29; Tian *et al.*, 1983, p. 376, fig. 3; Dagis, 1984, p. 27, pl. 6, figs. 4–7; Buryi, 1989, p. 26, pl. 1, fig.1; Beyers and Orchard, 1991, pl. 5, fig. 4; Wang and Zhong, 1994, p. 400, pl. 1, fig. 18; Buryi, 1997, pl. 1, fig. 9; Zhao and Orchard (in Zhao *et al.*, 2007), p. 35, pl. 1, figs. 12A, B, 9A, B, C, 11A, B, C; Orchard and Krystyn, 2007, figs. 3, 6, 7.

Material examined: Four specimens, MPC6577–6580, from AB1014-1, six specimens, MPC6581–6586, from AB1014-P1, two specimens, MPC6602, 6603, from AB1016-P1.

Description: Thin segminate elements, 0.35 to 0.50 mm long and 0.33 to 0.38 mm high, length to height ratio 0.9 to 1.5. Denticles 6 to 10 in number, average 8, discrete in upper half, pointed, reclined to erect, height gradually decreases toward anterior. Terminal cusp slightly higher or shorter than other denticles. Basal margin straight or slightly arched in anterior portion, upturned in posterior one-third of unit. Basal cavity large, subrounded or oval around deep pit.

Occurrence: Described specimens from AB1014 and AB1016 within the lower part of the *Neospathodus dieneri-N. pakistanensis* Zone with the *Clypeoceras spitiense* “bed” (early late Induan=early Dienerian) and the lower part of the *Paranorites varians* Zone (late Induan=Dienerian) in the lower part of the Zhitkov Formation, Abrek Bay area, South Primorye.

N. dieneri is a well-known species in the upper Dienerian to Smithian strata elsewhere.

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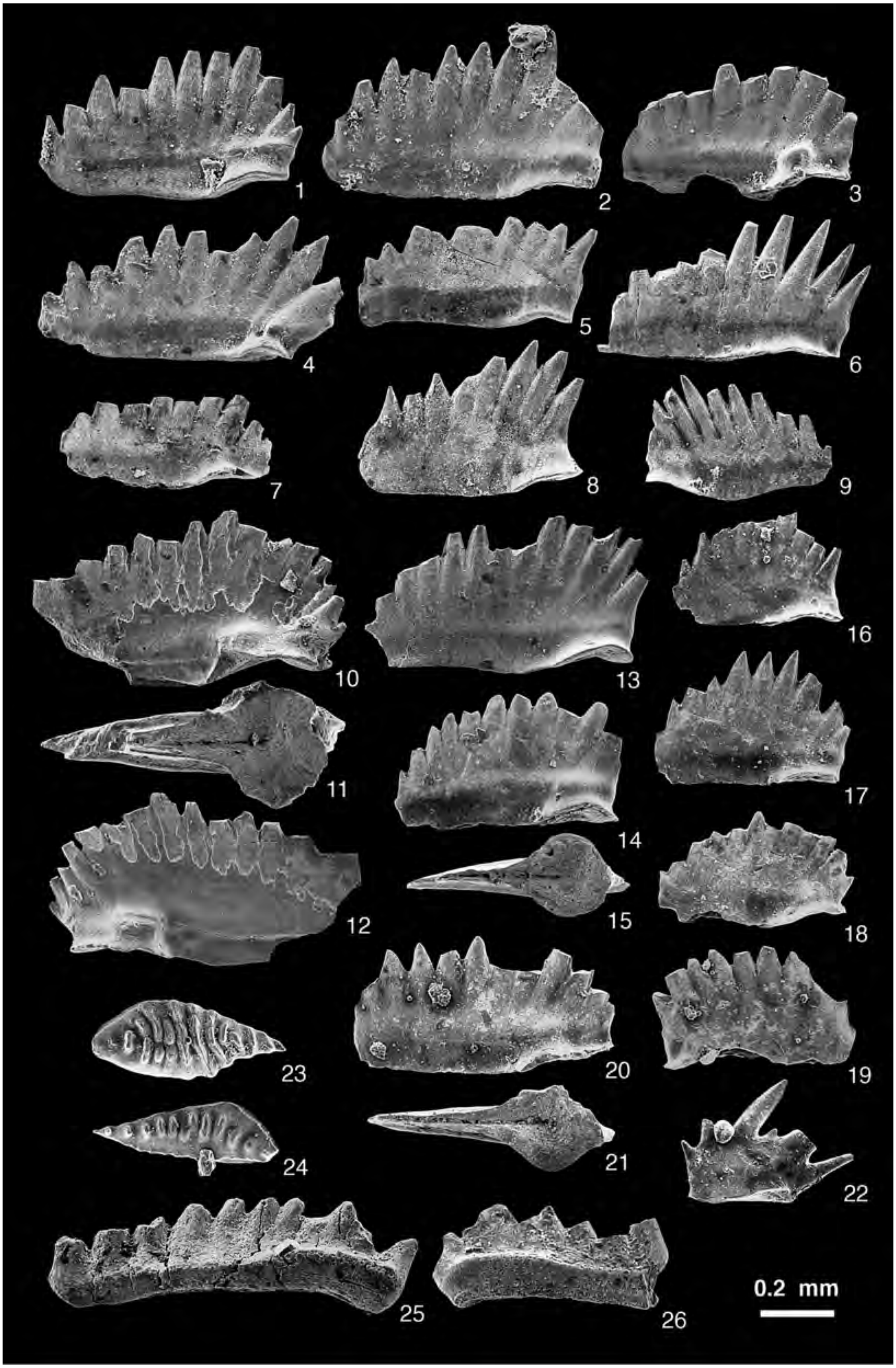
Fig. 152. 1–7, 10–13, 20–21. *Neospathaodus pakistanensis* Sweet, 1970. 1–2, MPC6595, 6596, from AB1016-1. 3–6, MPC6597, 6598, 6599, 6600, from AB1016-P1. 7, MPC6601, from AB1021-P2. 10–12, MPC6604, fused elements, from AB1019-1. 13, MPC6605, from AB1019-1. 20–21, MPC 6611, from AB1021-P2. 8–9, *Neospathodus dieneri* Sweet, 1970 from AB1016-P1. 8, MPC6602. 9, MPC6603. 14–19, *Neospathodus* ex gr. *waageni* Sweet, 1970 from AB1021-P2. 14–15, MPC6606. 16, MPC6607. 17, MPC6608. 18, MPC6609. 19, MPC6610. 22, *Ellisonia*? cf. *peculiaris* (Sweet, 1970), MPC6612, from AB1021-P2. 23–24, *Eurygnathodus costatus* Staesche, 1964. 23, MPC6613, from AB1016-P1. 24, MPC6614, from AB1021-P2. 25–26, *Borinella* cf. *nepalensis* (Kozur and Mostle, 1976) from AB1016-P1. 25, MPC6615. 26, MPC6616.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The *N. dieneri* Zone corresponds to the stratigraphic interval including Bed 20 to Bed 24 of the Yinkeng Formation (uppermost Induan) at the West Pingdingshan Section in Chaohu, China (Zhao *et al.*, 2007). The occurrence of three morphotypes of *N. dieneri* is recorded also in Pakistan, Guryul Ravine Section in Kashmir, Lalung Section in Spiti, the Locker and Kockatea shale of Western Australia, South Primorye, and various localities in South China, Malaysia, and many others (e.g., Sweet, 1970; McTavish, 1973; Buryi, 1979; Matsuda, 1982; Koike, 1982; Tian *et al.*, 1983; Wang & Zhong, 1994; Orchard & Krystyn, 2007).

Remarks: Zhao and Orchard (in Zhao *et al.*, 2007) introduced three morphotypes in this *Neospathodus dieneri*. Specimens illustrated in Fig. 151.6–151.10, 151.12 in this paper are similar to their Morphotype 1 characterized by a higher and broader terminal cusp than other denticles. Specimens from AB1014 (MPC6580, 6584, 6585 in Fig. 151.9, 151.14, 151.15) are identical with their Morphotype 2 having posteriorly inclined and almost the same sized denticles. Two specimens from AB1016 (MPC6602, 6603 in Fig. 152.8, 152.9) exhibit a characteristic feature in a shorter and broader cusp compared with other denticles. These specimens resemble Morphotype 3 defined by Zhao and Orchard (op. cit.).

Neospathodus novaehollandiae McTavish, 1973

Figs. 153.8–153.14, 154.7–154.11, 155.1–155.11

Neospathodus novaehollandiae McTavish, 1973, p. 294, figs. 4, 5, 14, 16–23; Goel, 1977, p. 1091, pl. 1, figs. 1, 2; Tian *et al.*, 1983, p. 379, pl. 93, fig. 9; Duan, 1987, pl. 3, fig. 1; Beyers and Orchard, 1991, pl. 5, fig. 7; Orchard, 2007b, figs. 16–18.

Material examined: Twelve specimens, MPC6623–6626, 6633–6635, 6638–6642, from AB1022-2, one specimen, MPC6645, from AB1024-1, two specimens, MPC6643, 6644, from AB1025-1.

Description: Blade-like large elements 0.73 to 1.30 mm, average 0.93 mm in length; 0.43 to 0.62 mm, average 0.53 in height; length to height ratio 1.6 to 2.3, average 1.7 in 15 specimens. Upper edge of elements arched to straight or more or less tapers anteriorly; base essentially straight. Denticles robust, high, erect to reclined posteriorly, sharply pointed, fused in a lower half, discrete in upper part, end at sharply pointed tip; numbers 10 to 17, average 14; 2 to 3 posterior and anterior denticles shorter than others. Cusp slightly longer than other denticles, situated above basal cavity. Lateral face of base bears straight rib becomes strong posteriorly in large specimens. Platform flange on flanks of element at posterior end conspicuously developed in some large specimens. Lateral process with fused denticles appears on lateral face near posterior end and surface of basal cup. In some aberrant or pathologic specimens, lateral process branched posterior-lateral and forms Y-shaped basal cavity in lower view. Basal cavity in most of specimens large, rounded to elliptical in lower view with deep pit. Deep furrow extended to anterior end of base.

Occurrence: Described specimens range from AB1022 to AB1025 within the *Neospathodus* ex gr. *waageni-N. novaehollandiae* Zone with the *Clypeoceras timorense*

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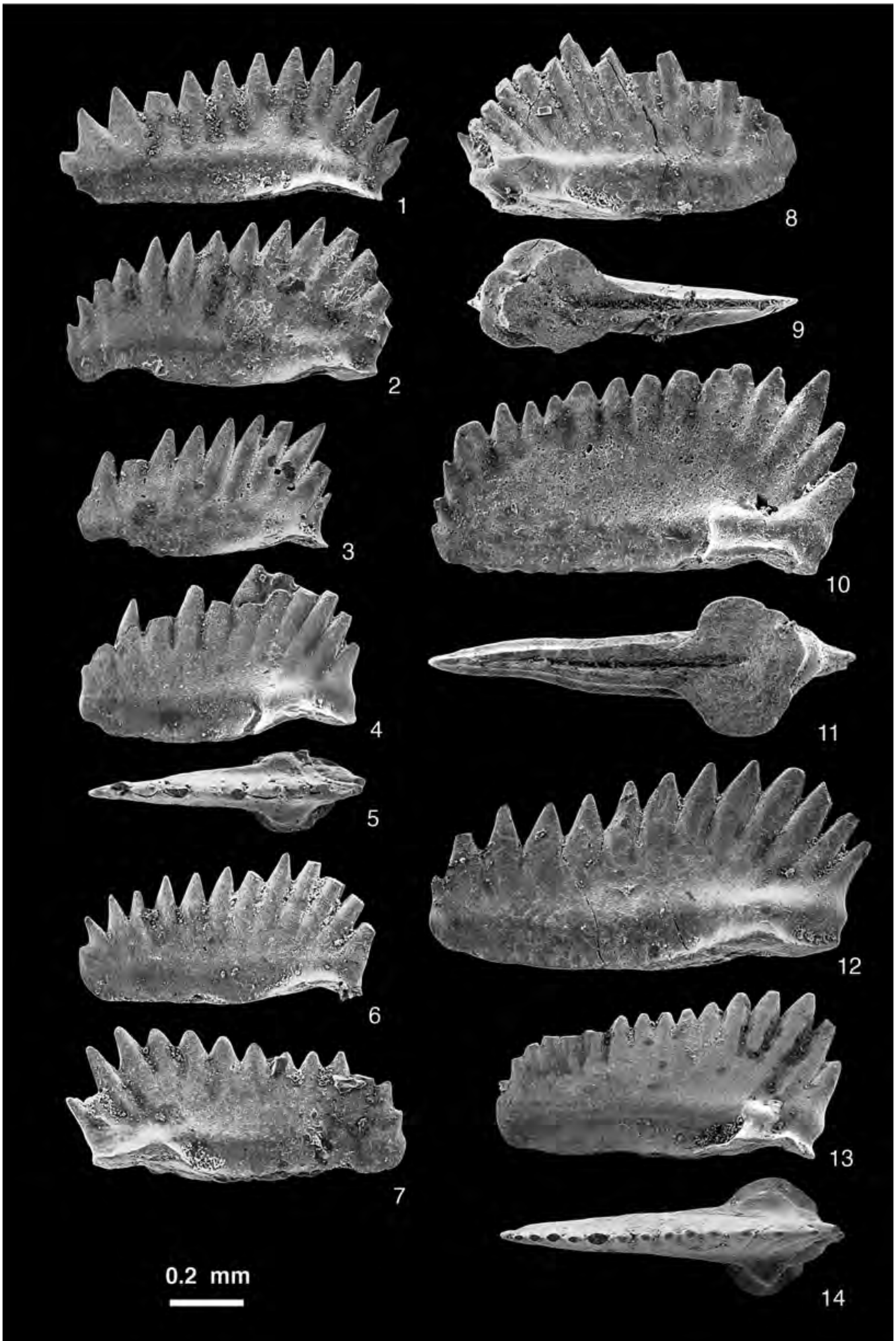
Fig. 153. 1–7, *Neospathodus pakistanensis* Sweet, 1970 from AB1022-2. 1, MPC6617. 2, MPC6618. 3, MPC6619. 4–5, MPC6620. 6, MPC6621. 7, MPC6622. 8–14, *Neospathodus novaehollandiae* McTavish, 1973 from AB1022-2. 8–9, MPC6623. 10–11, MPC6624. 12, MPC6625. 13–14, MPC6626.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Zone and *Radioprionites abrekensis* "bed" (early Early Olenekian=early Smithian) in the main part of the Zhitkov Formation, Abrek Bay area, South Primorye.

This species is originally described from the Locker shale (Smithian) of Western Austlaria (McTavish, 1973). Goel (1977) reported the abundant occurrence of this species associated with *N. dieneri* Sweet in the Khar Section of Spiti. Matsuda (1983) regarded this species with a synonym of *N. pakistanensis* Sweet from the Guryul Ravine in Kashmir. Beyers and Orchard (1991) reported this species from Fauna 6 (Smithian) contained in the Cache Creek Complex, south-central British Columbia. Orchard (2007b) and Orchard and Krystyn (2007) pointed out that *N. novaehollandiae* occurs in association with *N. pakistanensis* in Bed 13A-1 and Bed 13A-2 of IOB strata in Mud, Spiti.

Remarks: Many specimens identified to this species exhibit considerable variations as already pointed out by McTavish (1973) and other previous authors. General configuration of denticles, large and stout elements, and almost straight basal margin enable the author to distinguish from the similar species, such as *N. pakistanensis*. The author follows McTavish's oppinion that *N. pakistanensis* is the progenitor of *N. novaehollandiae*.

Several large specimens at hand show extreme development of lateral process and the surface of flare of basal cavity. There are possibilities that the specimens may belong to a new species, but the author tentatively assigned them with pathologic and/or aberrant ones of *N. novaehollandiae* in this study. Further consideration, however, is required to conclude.

Neospathodus pakistanensis Sweet, 1970

Figs. 151.18–151.26, 152.1–152.7, 152.10–152.13, 152.20–152.21, 153.1–153.7, 154.1–154.6

Neospathodus pakistanensis Sweet, 1970a, p. 254, pl. 1, figs. 16. 17; McTavish, 1973, p. 295, pl. 1, figs. 1, 2; Buryi, 1979, p. 57, pl. 9, fig. 2, pl. 18, fig. 5; Wang and Cao, 1981, p. 367, pl. 2, fig. 27; Dagis, 1982, p. 57, pl. 1, fig. 4; Matsuda, 1983, p. 87, pl. 1, figs. 1–5; Dagis, 1984, p. 26, pl. 5, figs. 9–11, pl. 12, fig. 6; Beyers and Orchard, 1991, pl. 5, fig. 2; Cao and Wang, 1993, p. 260, pl. 58, fig. 14; Wang and Zhong, 1994, p. 401, pl. 1, fig. 16, 24; Buryi, 1997, pl. 2, fig. 9; Orchard, 2007b, figs. 19, 20, 23–26. Orchard and Krystyn, 2007, figs. 19, 20.

Neospathodus svalbardensis Trammer, in Birkenmajer, and Trammer, 1975, p. 306, pl. 1, figs. 5–7, pl. 2, figs. 1–7.

Material examined: Seven specimens, MPC6588–6594, from AB1014-P1, two specimens, MPC6595, 9596, from AB1016-1, four specimens, MPC6597–6600, from AB1016-P1, two specimens, MPC6604, 6605, from AB1019-1, two specimens, MPC6601, 6611 from AB1021-P2, eleven specimens, MPC6617–6622, 6627–6631, from AB1022-2, one specimen, MPC6632, from AB1022-3.

Description: Laterally compressed blade-shaped elements 0.55 mm to 0.83 mm long, average 0.71 mm; 0.31 mm to 0.49 mm high, average 0.41 mm in 20 samples. Ratio of length to height 1.5 to 2.3, average 1.73 in 20 individuals. Upper edge of element gently arched, highest point located posterior one-forth; lower edge generally straight or weakly curved upward in anterior most part; posterior part of lower margin downcurved or slightly deflected upward. Lateral rib prominent, par-

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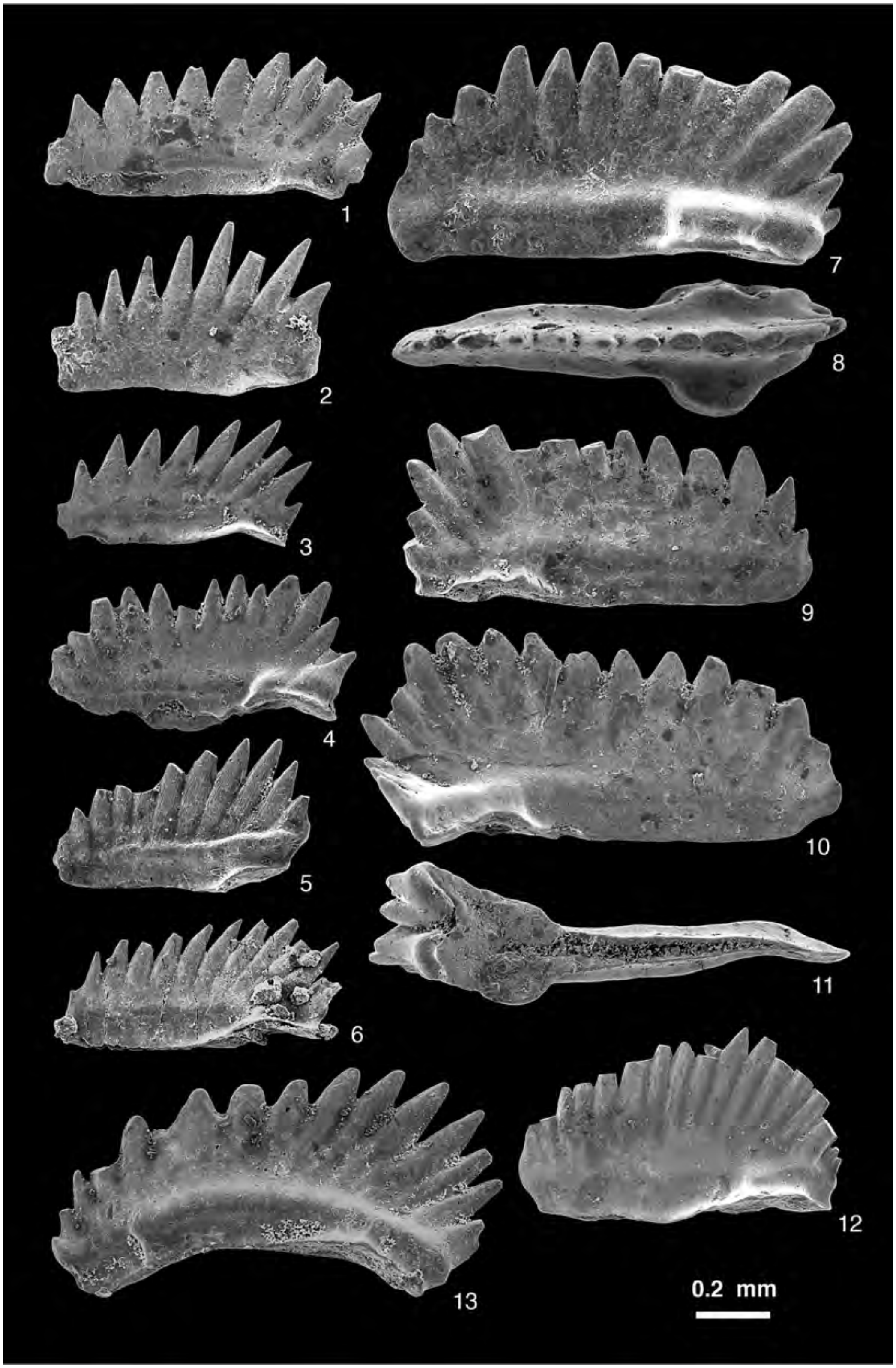
Fig. 154. 1–6, *Neospathodus pakistanensis* Sweet, 1970 from AB1022-2 (1–5), AB1022-3 (6). 1, MPC6627. 2, MPC6628. 3, MPC6629. 4, MPC6630. 5, MPC6631. 6, MPC6632. 7–11, *Neospathodus novaehollandiae* McTavish, 1973 from AB1022-2. 7–8, MPC6633. 9, MPC6634. 10–11, MPC6635, aberrant or pathologic element. 12, *Neospathodus* aff. *posterolongatus* Zhao and Orchard 2007, MPC6636, from AB1022-2. 13, *Neospathodus concavus* Zhao and Orchard, 2007 MPC6637, from AB1022-2.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ticularly in posterior part. Denticles laterally flattend, triangular with sharp tip, slightly reclined posteriorly or erect, fused in lower base, discrete in upper half; number of denticles 12 to 14. Cusp slightly longer than other denticles, with 2 to 3 shorter denticles above posterior basal cup. Basal cavity subrounded, spatulate, with deep pit, and distinct furrow extended anteriorly.

Occurrence: Described specimens range from AB1014 to AB1022 within the *Neospathodus dieneri-N. pakistanensis* and the *Neospathodus* ex gr. *waageni-N. novaehollandiae* zones with the *Clypeoceras spitiense* "bed" (early late Induan＝early Dienerian), the *Paranorites varians* Zone (late Induan＝Dienerian), and the *Clypeoceras timorense* Zone (early Early Olenekian＝early Smithian) in the Zhitokov Formation, Abrek Bay area, South Primorye.

This species is originally described from West Pakistan and defines the *N. pakistanensis* Zone (Zone 6) in the Mittiwali Member of the Mianwali Formation (Sweet, 1970b). The zone overlies immediately above the *N. cristagalli* Zone and ends the base of the *N. waageni* Zone. The species is also known to occur in South Primorye (Buryi, 1979), Siberia (Dagis, 1982, 1984), Idaho (Paull, 1988), Cache Creek in British Columbia (Beyers & Orchard,1991), and other loclities in the North American Continent. Recent investigations by Orchard (2007a) and Orchard and Krystyn (2007), and Krystyn *et al.* (2007) clarified the range of this species starts from Bed 12 and ends at Bed 13A-2 in the *Flemingites* beds in Spiti. Thus the range of *N. pakistanensis* straddles the Dienerian-Smithian boundary (IOB); however, the species is one of the excellent indicators of latest Dienerian age.

Remarks: *N. pakistanensis* exhabits considerable morphological variations in size, general lateral profile, the shape of basal cavity, and numbers of denticles (e.g., Matsuda, 1983). The present specimens examined also exhabit similar broad variations mentioned above. The elements from AB1014 and AB1016 are slightly shorter in length, and denticles are fewer in number compared with those from AB1022.

Neospathodus aff. ***posterolongatus*** Zhao and Orchard, 2007

Fig. 154.12

aff. *Neospathodus posterolongatus* Zhao and Orchard, in Zhao *et al.*, 2007, p. 36, pl. 1, figs. 2A, B, C; Orchard, 2007b, figs. 1–6.

Material examined: MPC6636, from AB1022-2.

Occurrence: The specimen from AB1022 within the lower part of the *Neospathodus* ex gr. *waageni-N. novaehollandiae* Zone with the *Clypeoceras timorense* Zone (early Early Olenekian＝early Smithian) in the main part of the Zhitkov Formation, Abrek Bay area, South Primorye.

N. posterolongatus occurs in the *N. waageni waageni* Subzone of the Yinkeng Formation in Chaohu sections, and the species is one of the index species of the basal Olenekian (Zhao *et al.*, 2007).

Remarks: General profile of the present specimen is somewhat similar to this species that has recently been proposed as a new to science from the Yinkeng Formation in Chao-

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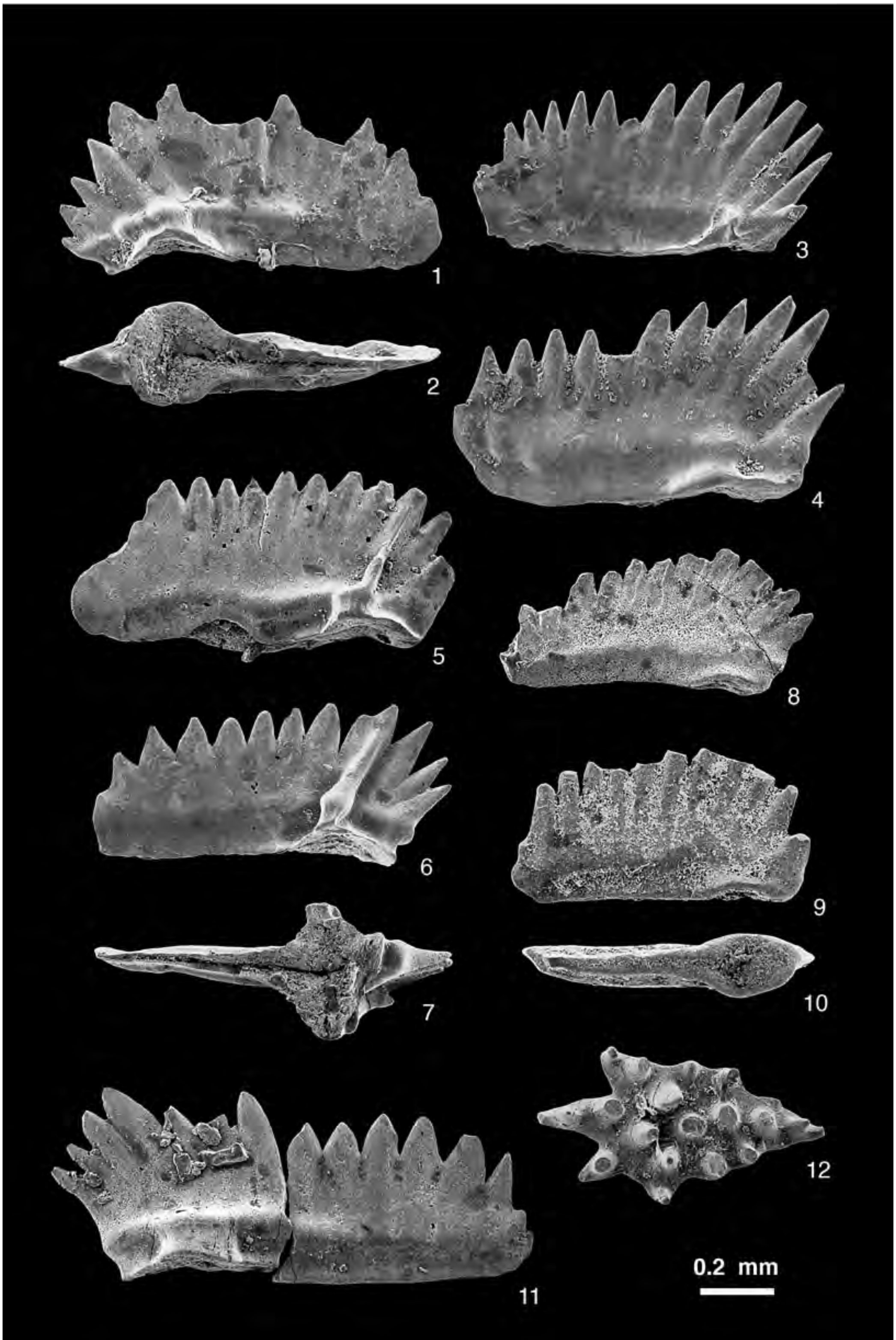
Fig. 155. 1–11, *Neospathodus novaehollandiae* McTavish, 1971 from AB1022-2 (1–7), AB1025-1 (8–11). 1–2, MPC6638. 3, MPC6639. 4, MPC6640. 5, MPC6641. 6–7, MPC6642, aberrant or pathologic elements. 8, MPC6643. 9–10, MPC6644. 11, MPC6645. 12, *Foliella gardenae* (Staesche, 1964), MPC6646, from AB1025-1.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hu. The present specimen, however, has more numbers of fused denticles than those of the latter. The author's present identification is tentative.

Neospathodus spitiensis Goel, 1977

Fig. 156.1–156.6, 156.21–156.22

Neospathodus spitiensis Goel, 1977, p. 1094, pl. 1, figs. 14–18; Tian *et al.*, 1983, p. 379, pl. 98, fig. 13.

Material examined: Seven specimens, MPC6647–6652, 6664, from AB1025-1.

Occurrence: Described specimens from AB1025 within the *Neospathodus* ex gr. *waageni-N. novaehollandiae* with the *Radioprionites abrekensis* "bed" (early Early Olenekian= early Smithian) in the main part of the Zhitkov Formation, Abrek Bay area, South Primorye.

The holotype and illustrated paratypes of *N. spitiensis* came from the Smithian strata at Khar in Spiti (Goel, 1977). This species also occurs in Bed 15 at Muth in Spiti and Bed 26 of West Pingdingshan both of which include typical succession of the Induan-Olenekian Boundary strata (e.g., Orchard & Krystyn, 2007).

Remarks: The specimens examined are similar to the original specimens from Spiti. The present ones differ in number of denticles, more or less higher elements, and shorter posterior process than those of Spiti specimens.

Neospathodus ex gr. ***waageni*** Sweet, 1970

Figs. 152.14–152.19, 156.7–156.19

Neospathodus waageni Sweet, 1970b, p. 260, pl. 1, figs. 11, 12; McTavish, 1973, p. 300, pl. 2, figs. 11, 22, 25–28; Mosher, 1973, p. 172, pl. 20, fig.5; Wang and Wang, 1976, p. 411, pl. 3, figs. 4–7, 17; Goel, 1977, p. 1094, pl. 2, figs. 1–4; Solien, 1979, p. 304, pl. 3, fig. 9; Buryi, 1979, p. 56, pl. 7, figs. 8, 9; Wang and Cao, 1981, pl. 2, fig. 26; Koike, 1982, p. 39, pl. 6, figs. 26, 27; Matsuda, 1983, p. 88, pl. 1, figs. 6–10, pl. 2, figs. 1–7; Dagis, 1984, p. 24, pl. 7, figs. 1–10, pl. 8, figs. 1–7; Duan, 1987, pl. 2, fig. 7; Cao and Wang, 1993, p. 261, pl. 56, figs. 5, 11; Wang and Zhong, 1994, p. 402, pl. 1, figs. 12, 13; Buryi, 1997, pl. 1, fig. 7.

Neospathodus waageni waageni Sweet. Zhao and Orchard, in Zhao *et al.*, 2007, p. 36, pl. 1, figs. 10A, B.

Neospathodus waageni eowaageni Zhao and Orchard, in Zhao *et al.*, 2007, p. 36, pl. 1, figs. 5A, B.

? *Neospathodus pingdingshanensis* Zhao and Orchard, in Zhao *et al.*, 2007, p. 36, pl. 1, figs. 4A, B, C.

Material examined: Five specimens, MPC6656, 6659–6662, from AB1024-1, five specimens, MPC6653–6655, 6657, 6658, from AB1025-1.

Description: Elements 0.43 mm to 0.85 mm, average 0.62 mm in length; 0.31 mm to 0.45 mm, average 0.37 mm in height; ratio of length to height 1.4–2.2, average 1.5 in 11 specimens. General profile of element arcuate, highest point situates at posterior half to near posterior margin. Lower margin of element almost straight to slightly undulated, posterior part upturned in some specimens. Denticles number 10 to 12, upturned, suberect to reclined posterioly, with pointed tip, discrete in upper part and fused in lower half. Cusp bears 2 small denticles at posterior end, slightly longer or shorter than other denticles. Lateral rib parallel to margin and more or less swollen. Platform flange developed on flanks

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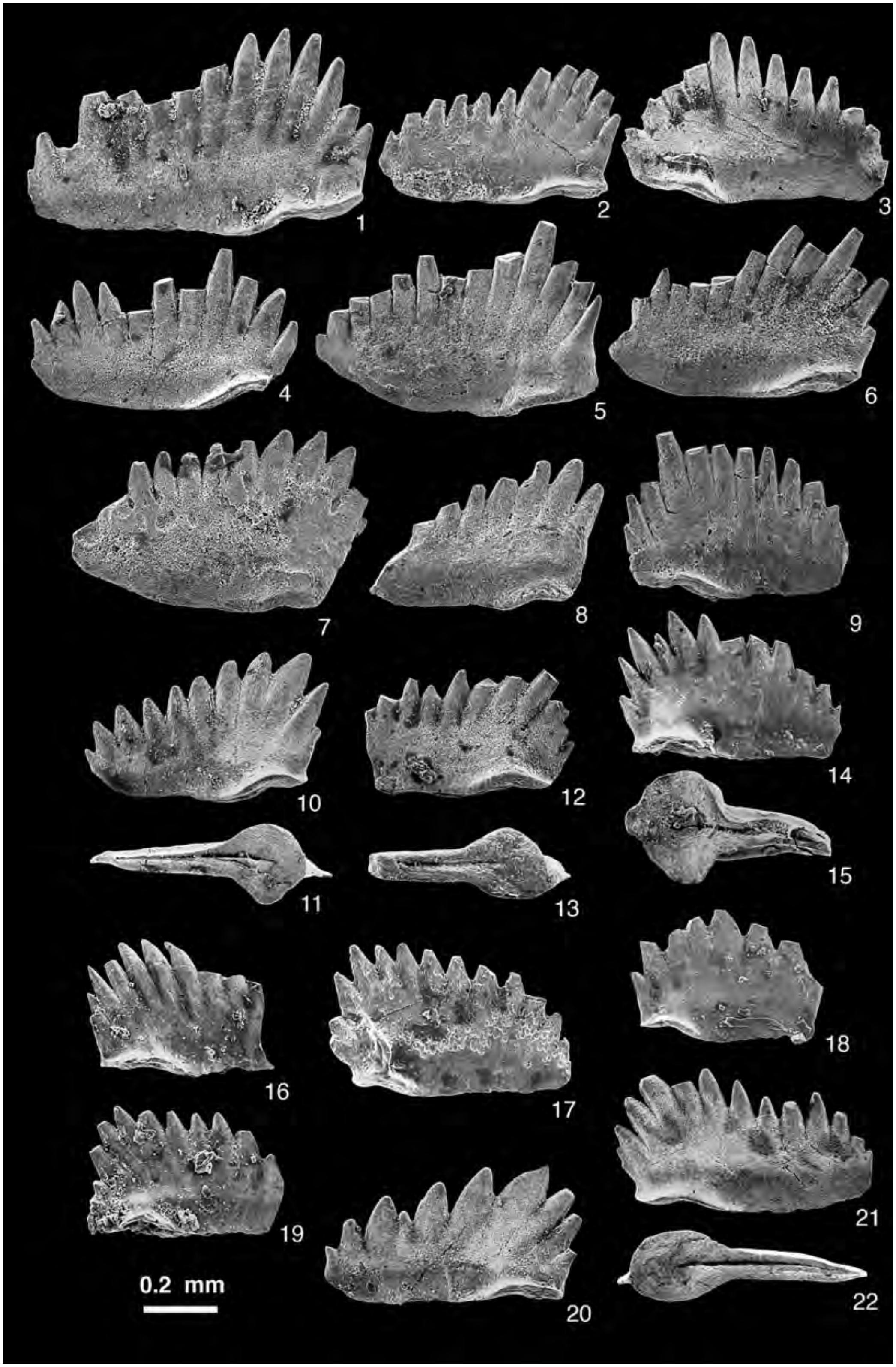
Fig. 156. 1–6, 21–22, *Neospathodus spitiensis* Goel, 1977 from AB1025-1. 1, MPC6647. 2, MPC6648. 3, MPC6649. 4, MPC6650. 5, MPC6651. 6, MPC6652. 21–22, MPC6664. 7–19, *Neospathodus* ex gr. *waageni* Sweet, 1970 from AB1025-1 (7–13), AB1024-1 (14–19). 7, MPC6653. 8, MPC6654. 9, MPC6655. 10–11, MPC6656. 12–13, MPC6657. 14–15, MPC6658. 16, MPC6659. 17, MPC6660. 18, MPC6661. 19, MPC6662. 20, *Neospathodus* sp. B, MPC6663, from AB1025-1.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of posterior end; cusp bears short lateral process in some specimens. Basal cavity large, rounded, and with deep pit.

Occurrence: Described specimens range from AB1021 to AB1025 within the *Neospathodus* ex gr. *waageni*-*N. novaehollandiae* Zone with the *Clypeoceras timorense* and *Radioprionites abrekensi*s "bed" (early Early Olenekian=early Smithian) in the main part of the Zhitkov Formation, Abrek Bay area, South Primorye.

N. waageni is a well-known species throughout the world. This species is subdivided into *waageni eowaageni*, *waageni waageni*, and *posterolongatus* (Zhao & Orchard, in Zhao *et al.*, 2007) based on the rich materials from the Pingdingshan Section. Furthermore, Orchard and Krystyn (2007) distinguished six morphotypes of *N.* ex gr. *waageni* from material collected from the Muth Section in Spiti. These studies clarify that *N.* ex gr. *waageni* is a variable species, however, their morophotypes and several allied new species range the entire part of the Smithian (=lower division of Olenekian) elsewhere.

Remarks: The specimens exhibit broad variation as pointed out by previous authors. Matsuda (1983) separated this species into three types. Orchard and Krystyn (2007) proposed six morphotypes in Spiti specimens. In the present specimens, four morphotypes of *N. waageni* are present that correspond with their Morphotypes 1, 2, 3, and 4. Specimens numbered MPC6606 (Fig. 152.14) and MPC6660 (Fig. 156.17) have a similar flange observed in Morphotype 1. Specimens MPC6607-6610 (Fig. 152.16–152.19) have slightly reclined, subequal denticles forming an arcuate crest. This type of *N. waageni* corresponds with the holotype of this species, *N. waageni waageni*. The specimen MPS6655 (Fig. 156.9) has upright denticles, straight basal margin, and upturned at both ends. These features recognized in *N. waageni eowaageni* Zhao and Orchard. Specimens MPC6658 (Fig. 156.14, 156.15) and MPC6662 (Fig. 156.19) have two small lower posteriormost denticles that are abruptly smaller/lower than those to the anterior. This feature is diagnostic in Morphotype 4.

Neospathodus **sp. A**

Fig. 151.17

Material examined: MPC6587, from AB1014-P1.

Occurrence: Figured specimen from AB1014 within the lower part of the *Neospathodus dieneri*-*N. pakistanensis* Zone with the *Clypeoceras spitiense* "bed" (early Late Induan=early Dienerian) in the lower part of the Zhitkov Formation, Abrek Bay area, South Primorye.

Remarks: A fragmentary small segminate element with straight basal margin bears posteriorly curved 6 denticles. This unidentified species is similar to *Neospathodus waageni* Sweet (s.l.), but identification is postponded.

Neospathodus **sp. B**

Fig. 156.20

Material examined: MPC6663, from AB1025-1.

Occurrence: This specimen from AB1025 within the *Neospathodus* ex gr. *waageni*-*N. novaehollandiae* Zone with the *Radioprionites abrekensi*s "bed" (early Early Olenekian=early Smithian) in the main part of the Zhitkov Formation, Abrek Bay area, South Primorye.

Remarks: A segminate element has 10 denticles, which are stout, posteriorly inclined, and uneven in size. This unidentified species may belong to the group of *Neospathodus waageni*.

Chondrichthyans (by H. Yamagishi)

Systematic descriptions basically follow Cappetta (1987) and Duffin and Ward (1995). Morphological terms follow Cappetta (1987) and Johns *et al.* (1997), and micromorphological terms follow Cuny and Benton (1999). All specimens described in this paper are reposited in the University Museum of the University of Tokyo (UMUT).

Class Chondrichthyes Huxley, 1880
Subclass Elasmobranchii Bonaparte, 1838
Cohort Euselachii Hay, 1902

Euselachii order, fam., gen., et sp. indet.
Fig. 157.5

Material obtained: Sixteen placoid scales, UMUT MV29694–29709, from AB1025–1, twenty-four placoid scales, UMUT MV29727–29750, from AB1024-1, thirteen placoid scales, UMUT MV29753–29765, from AB1022-3, five placoid scales, UMUT MV29771–29775, from AB1022-2, fourty-four placoid scales, UMUT MV29783–29826, from AB1021-P2, thirty-five placoid scales, UMUT MV29830–29864, from AB1019-1, sixty placoid scales, UMUT MV29880–29939, from AB1016-1, fourty placoid scales UMUT MV29943–29982, from AB1016-P1, nine placoid scales, UMUT MV29983–29991, from AB1014-P5, eight placoid scales, UMUT MV29996–30003, from AB1014-P1, and one placoid scale, UMUT MV30004, from AB1012-2.

Occurrence: Described specimens range from AB1012 within the *Ambitoides fuliginatus* Zone (early Late Induan＝early Dienerian) in the uppermost part of the Lazurnaya Bay Formation to AB1025 within the *Radioprionites abrekensis* “bed” (early Early Olenekian＝early Smithian) in the main part of the Zhitkov Formation, Abrek Bay area, South Primorye.

Discussion: A total of 255 placoid scales were recovered from the Abrek section. In the present study, these scales are not subjected to morphological description and taxonomical identification, but instead are treated as supplemental data to simply verify the presence of sharks.

Superfamily Hybodontoidea Owen, 1849
Family Acrodontidae Casier, 1959
Genus ***Acrodus*** Agassiz, 1837

Type species: *Acrodus gaillardoti* Agassiz, 1837.

Acrodus cf. ***cuneocostatus*** Cuny, Rieppel and Sander, 2001
Fig. 157.1–157.4

Material examined: Two teeth, UMUT MV29710–29711, from AB1024-1, a fragmented tooth, UMUT MV29751, from AB1022-3, one tooth, UMUT MV29766, from AB1022-2, one tooth, UMUT MV29776, from AB1021-P2, two fragmented teeth, UMUT MV29865–29866, from AB1016-1, two fragmented teeth, UMUT MV29940–29941, from AB1016-P1, and one tooth, UMUT MV29992, from AB1014-P1.

Description: Crown mesiodistally planar without obvious cusps. Crown has obvious occlusal crest and transverse ridges, with occlusal crest and longitudinal shoulder ridges at nearly same height. Root high and thin.

Occurrence: Described specimens range from AB1014 within the *Clypeoceras spitiense* “bed” (early Late Induan＝early Dienerian) to AB1024 within the *Clypeoceras timorense* Zone (early Early Olenekian＝early Smithian) of the Zhitkov Formation, Abrek Bay area, South Primorye.

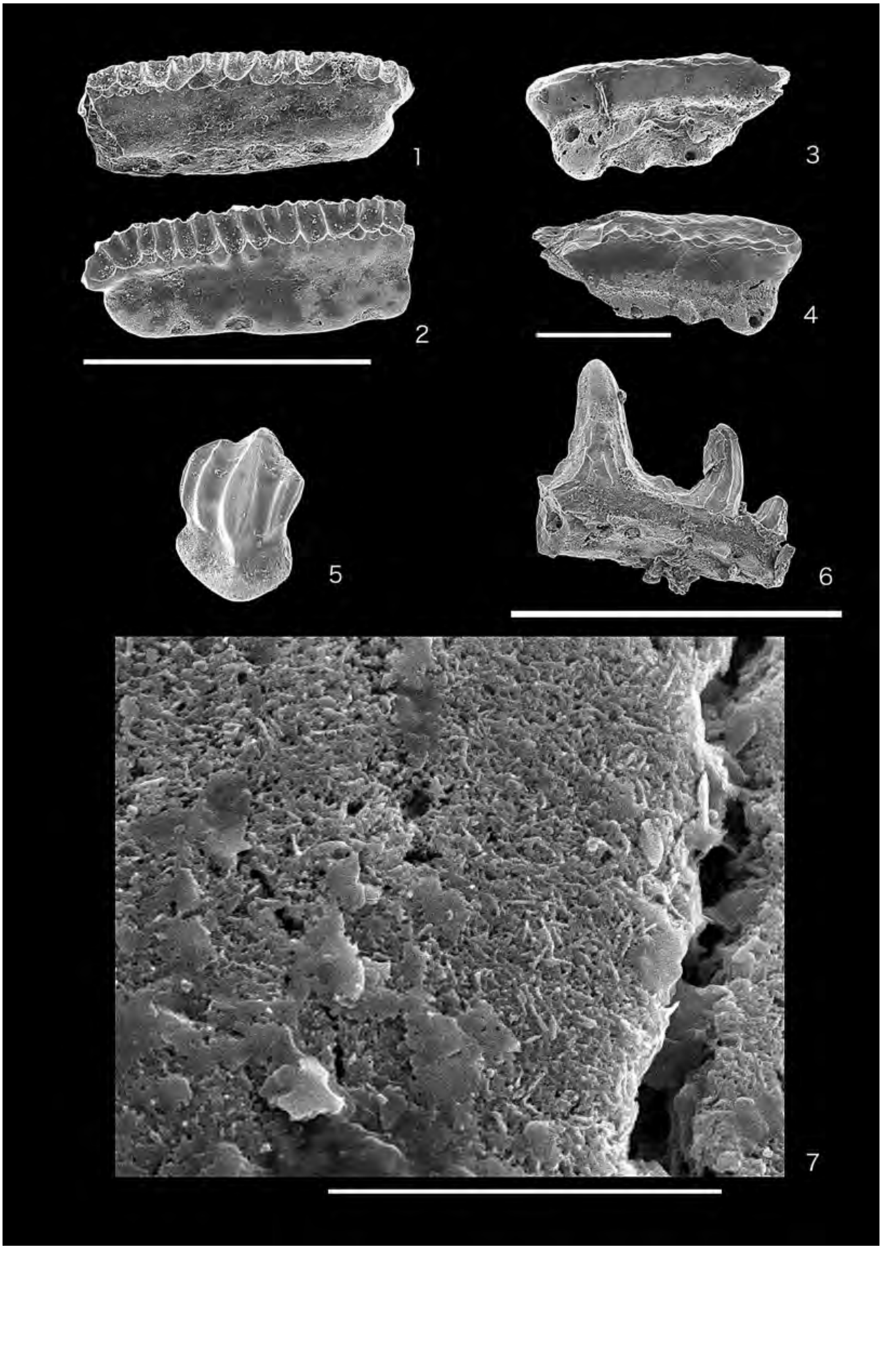
Discussion: Several specimens lack their roots and/or they have been abraded, but they do retain an obvious occlusal ridge on their crowns and part of the transverse lines on their shoulders. These teeth are similar to *Acrodus* cf. *cuneocostatus* Cuny, Rieppel and Sander (2001, Anisian, Fossil Hill Member, Favret Formation, Nevada) in terms of morphology, but their size range is quite different (holotype is 4.3 mm long mesio-distally and maximum labio-lingually width is 1.8 mm, whereas the Abrek specimens range only up to about

Table 2. List of shark teeth and scales obtained from the Lower Triassic Abrek Bay section.

Registered number	N	Sample	Species	Remarks
UMUT MV29692	1	AB1025-1	*Lissodus* cf. *cristatus* Delsate & Duffin	tooth
UMUT MV29693	1	AB1025-1	*Polyacrodus* sp. indet.	tooth
UMUT MV29694–29709	16	AB1025-1	Euselachii order, fam., gen., et sp. indet.	placoid scales
UMUT MV29710–29711	2	AB1024-1	*Acrodus* cf. *cuneocostatus* Cuny, Rieppel & Sander	teeth
UMUT MV29712–29714	3	AB1024-1	*Hybodus* sp. indet.	teeth
UMUT MV29715–29717	3	AB1024-1	*Lissodus* cf. *cristatus* Delsate & Duffin	teeth
UMUT MV29718–29726	9	AB1024-1	*Polyacrodus* sp. indet.	teeth
UMUT MV29727–29750	24	AB1024-1	Euselachii order, fam., gen., et sp. indet.	placoid scales
UMUT MV29751	1	AB1022-3	*Acrodus* cf. *cuneocostatus* Cuny, Rieppel & Sander	fragmented tooth
UMUT MV29752	1	AB1022-3	*Polyacrodus* sp. indet.	fragmented tooth
UMUT MV29753–29765	13	AB1022-3	Euselachii order, fam., gen., et sp. indet.	placoid scales
UMUT MV29766	1	AB1022-2	*Acrodus* cf. *cuneocostatus* Cuny, Rieppel & Sander	tooth
UMUT MV29767–29769	3	AB1022-2	*Lissodus* cf. *cristatus* Delsate & Duffin	teeth
UMUT MV29770	1	AB1022-2	Euselachii order, fam., gen., et sp. indet.	tooth
UMUT MV29771–29775	5	AB1022-2	Euselachii order, fam., gen., et sp. indet.	placoid scales
UMUT MV29776	1	AB1021-P2	*Acrodus* cf. *cuneocostatus* Cuny, Rieppel & Sander	tooth
UMUT MV29777	1	AB1021-P2	*Hybodus* sp. indet.	tooth
UMUT MV29778–29780	3	AB1021-P2	*Lissodus* cf. *cristatus* Delsate & Duffin	teeth
UMUT MV29781–29782	2	AB1021-P2	*Polyacrodus* sp. indet.	teeth
UMUT MV29783–29826	44	AB1021-P2	Euselachii order, fam., gen., et sp. indet.	placoid scales
UMUT MV29827–29828	2	AB1019-1	*Lissodus* cf. *cristatus* Delsate & Duffin	fragmented teeth
UMUT MV29829	1	AB1019-1	*Polyacrodus* sp. indet.	fragmented tooth
UMUT MV29830–29864	35	AB1019-1	Euselachii order, fam., gen., et sp. indet.	placoid scales
UMUT MV29865–29866	2	AB1016-1	*Acrodus* cf. *cuneocostatus* Cuny, Rieppel & Sander	fragmented teeth
UMUT MV29867	1	AB1016-1	*Hybodus* sp. indet.	fragmented tooth
UMUT MV29868–29879	12	AB1016-1	Euselachii order, fam., gen., et sp. indet.	fragmented teeth
UMUT MV29880–29939	60	AB1016-1	Euselachii order, fam., gen., et sp. indet.	placoid scales
UMUT MV29940–29941	2	AB1016-P1	*Acrodus* cf. *cuneocostatus* Cuny, Rieppel & Sander	fragmented teeth
UMUT MV29942	1	AB1016-P1	*Lissodus* cf. *cristatus* Delsate & Duffin	fragmented tooth
UMUT MV29943–29982	40	AB1016-P1	Euselachii order, fam., gen., et sp. indet.	placoid scales
UMUT MV29983–29991	9	AB1014-P5	Euselachii order, fam., gen., et sp. indet.	placoid scales
UMUT MV29992	1	AB1014-P1	*Acrodus* cf. *cuneocostatus* Cuny, Rieppel & Sander	tooth
UMUT MV29993–29995	3	AB1014-P1	*Hybodus* sp. indet.	fragmented teeth
UMUT MV29996–30003	8	AB1014-P1	Euselachii order, fam., gen., et sp. indet.	placoid scales
UMUT MV30004	1	AB1012-2	Euselachii order, fam., gen., et sp. indet.	placoid scale

→

Fig. 157. Elasmobranch remains from the Abrek Bay section. 1–4, Teeth of *Acrodus* cf. *cuneocostatus* Cuny, Rieppel and Sander, 2001. 1, 2, UMUT MV29766 from AB1022-2. 1, labial view. 2, lingual view. 3, 4, UMUT MV29940 from AB1016-P1. 3, labial view. 4, lingual view. 5, Placoid scale of Euselachii order, fam., gen., et sp. indet, UMUT MV29771 from AB1022-2. 6, 7, Tooth of *Hybodus* sp. indet. 6, UMUT MV29993 from AB1014-P1. Specimen etched with hydrochloric acid (1%) for 10 sec to observe microstructure of enameloid. 6, labial view. Scanning electolon micrograph of enameloid microstructure of the principal cusp. Scale bar=1 mm (1, 2, 5, 6), 0.5 mm (3, 4), 0.01 mm (7).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1 mm). They are also similar to *A.* cf. *spitzbergensis* Hulke (1873) from the Vardebukta Formation, Lower Triassic (Dienerian), Hornsund area, Hyrnefjellet Mt., South Spitzbergen as illustrated in Błażejowski (2004).

Family Hybodontidae Owen, 1846
Genus ***Hybodus*** Agassiz, 1837

Type species: *Hybodus reticulatus* (Agassiz), 1837.

Hybodus sp. indet.
Fig. 157.6–157.7

Material examined: Three teeth, UMUT MV29712–29714, from AB1024-1, one tooth, UMUT MV29777, from AB1021-P2, one fragmented tooth, UMUT MV29867, from AB1016-1, and three fragmented teeth, UMUT MV29993–29995, from AB1014-P1.

Description: Crown with cusps not well separated, notches between cusps fail to reach the level of root, cusps vertical or slightly lingually inclined and between one and five pairs of lateral cusps with cutting edges well developed. Crown bears relatively faint striae, which may bifurcate near base of labial crown shoulder. Anterolateral teeth with high, pointed cusps, presumed lateral teeth with distally inclined cusps and posterolateral teeth mesiodistally elongate with principal cusp and low lateral cusps. Root arcuate, root labial face shallow and flat perforated by regular row of foramina, and basal face flat to concave. Lingual face convex and lingually displaced, presenting some foramina. Root vascularisation anaulacorhize.

Occurrence: Described specimens range from AB1014 within the *Clypeoceras spitiense* "bed" (early Late Induan = early Dienerian) to AB1024 within the *Clypeoceras timorense* Zone (early Early Olenekian = early Smithian) of the Zhitkov Formation, Abrek Bay area, South Primorye.

Discussion: Frequently, the teeth of the genus *Hybodus* and those of primitive neoselachians can not be easily divided based on their gross morphology (Reif, 1973, 1977; Maisey, 1982; Cuny & Benton, 1999). One of our specimens (UMUT MV29993) was examined for histology. Its enameloid consists only of SCE (single crystallized enameloid), a component of hybodont tooth enameloid, and no PFE (parallel fibred enameloid), which is considered to be one of the synapomorphic characters of neoselachians (Maisey, 1982). Therefore, these particular teeth are regarded as belonging to the genus *Hybodus*.

Family Polyacrodontidae Glikman, 1964
Genus ***Lissodus*** Brough, 1935

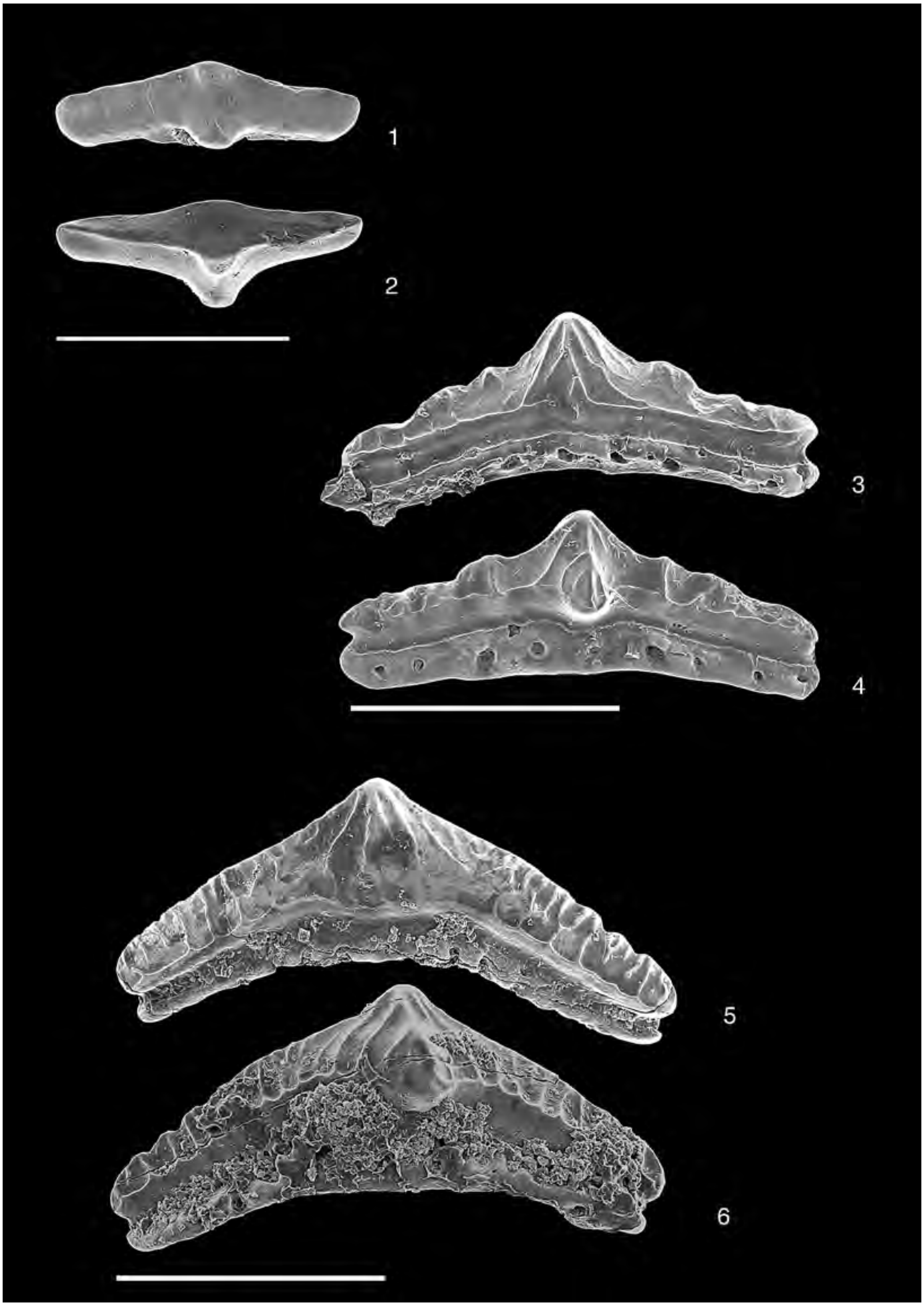
Type species: *Hybodus Africanus* (Broom), 1909.

Lissodus cf. ***cristatus*** Delsate and Duffin, 1999
Fig. 158.1–158.2

Material examined: One tooth, UMUT MV29692, from AB1025-1, two teeth, UMUT MV29715–29716, and fragmented tooth, UMUT MV29717, from AB1024-1, three teeth, UMUT MV29767–29769, from AB1022-2, three teeth, UMUT MV29778–29780, from AB1021-P2, two fragmented teeth, UMUT MV29827–29828, from AB1019-

→

Fig. 158. Elasmobranch remains from the Abrek Bay section. 1, 2, Tooth of *Lissodus* cf. *cristatus* Delsate and Duffin, 1999, UMUT MV29778 from AB1021-P2. 1, labial view. 2, occlusal view. 3–6, Teeth of *Polyacrodus* sp. indet. from AB1024-1. 3, 4, UMUT MV29718. 3, labial view. 4, lingual view. 5, 6, UMUT MV29719. 5, labial view. 6, lingual view. Scale bar = 1 mm.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1, and one fragmented tooth, UMUT MV29942, from AB1016-P1.

Description: Crown with obvious labial peg and low principal cusp, and smooth surface with almost no striae, due probably to the effects of abrasion. Most specimens lack their root because they were not preserved.

Occurrence: Described specimens range from AB1016 within the *Paranorites varians* Zone (Late Induan=Dienerian) to AB1025 within the *Radioprionites abrekensis* "bed" (early Early Olenekian=early Smithian) in the Zhitkov Formation, Abrek Bay area, South Primorye.

Discussion: Most specimens lack their root and/or have been abraded, but they retain an obvious labial peg on their crowns. These teeth are similar to *Lissodus cristatus* Delsate and Duffin (1999, Middle Triassic, Upper Muschelkalk, Moersdorf, Grand Duchy of Luxembourg and the Upper Muschelkalk of Dalhenheim, Bas-Rhin, France), and to *L. angulatus* (Stensiö, 1921) from the Vardebukta Formation, Lower Triassic (Dienerian), Hornsund area, Hyrnefjellet Mt., South Spitzbergen as illustrated in Błażejowski (2004). The Abrek teeth are very similar to these specimens by way of their outline and by having a smooth, unornamented crown, but differ in lacking an accessory cusplet.

Genus ***Polyacrodus*** Jaekel, 1889

Type species: *Hybodus polycyphus* (Agassiz), 1837.

Polyacrodus sp. indet.

Fig. 158.3–158.6

Material examined: One tooth, UMUT MV29693, from AB1025-1, nine teeth, UMUT MV29718–29726, from AB1024-1, one fragmented tooth, UMUT MV29752, from AB1022-3, two teeth, UMUT MV29781–29782, from AB1021-P2, and one fragmented tooth, UMUT MV29829, from AB1019-1.

Description: Teeth strongly to slightly arcuate mesio-distally with rather high, pyramidal principal cusp, more than 4 pair of blunt lateral cusps or transverse ridges, and well-developed lingual peg. Ornamentation nearly the same in labial and lingual faces of crown, aside from having a lingual peg. Root shallow with pores in labial and lingual root face.

Occurrence: Described specimens range from AB1019 within the *Paranorites varians* Zone (Late Induan=Dienerian) to AB1025 within the *Radioprionites abrekensis* "bed" (early Early Olenekian=early Smithian) in the Zhitkov Formation, Abrek Bay area, South Primorye.

Discussion: *Polyacrodus* specimens from the Abrek section resemble *Polyacrodus contraries* Johns *et al.* (1997) from the Ladinian and Carnian of Canada and *P. bucheri* Cuny *et al.* (2001) from the Anisian of North-Western Nevada in their overall morphology. They share a developed lingual peg and an ornamented circumferential rim. Abrek specimens differ from *P. bucheri* in having a more pointed, higher main cusp, lateral cusplets and a clear occlusal ridge. *P. contraries* teeth have a more elongate shape and stronger ornamentation than the Abrek specimens.

Concluding remarks

(by. Y. Shigeta, Y. D. Zakharov, H. Maeda and A. M. Popov)

The Japanese-Russian Joint investigation of a Lower Triassic section in the Abrek Bay area has resulted in a detailed analysis of its stratigraphy as well as an extensive description of its various faunal successions. Even though the section was withdrawn from consideration as a GSSP candidate for the I/O boundary due to magnetostratigraphy problems (remagnetization), our studies not only have resulted in the establishment of a biostratigraphic framework, but they also have contributed to a better understanding of global environmental change and the dynamics of the biotic recovery following the Permian-Triassic mass extinction. Several modern disciplines, such as stable-isotope stratigraphy, radioisotopic analysis and sedimentary facies analysis, have been utilized to broaden the knowledge of the Triassic of South Primorye, but much work still remains to be done. Therefore, it is anticipated that future efforts by the joint research team will result in even further significant contributions.

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