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Stratigraphy and Fossil Assemblages of the Upper Cretaceous System in the Makarov Area, Southern Sakhalin, Russian Far East

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Abstract The stratigraphy and paleontology of the Cretaceous Yezo Group in the Makarov area has been thoroughly investigated. Exposures of the group in this area range in age from Santonian to Maastrichtian, and attain a total thickness of 2,500 m. The group is divided into the Bykov and Krasnoyarka formations in ascending order. The Bykov Formation consists mostly of offshore mudstones, and is lithologically subdivided into four lithostratigraphic units designated as B1–B4, while the Krasnoyarka Formation is composed mainly of nearshore sandstones and deltaic deposits, and is subdivided into five units: K1–K4b.

Except for the uppermost part of the Krasnoyarka Formation, the remaining Cretceous strata are very fossiliferous. Among the fossil fauna, pachydiscid, tetragonitid, and gaudryceratid ammonoids are especially abundant. *Sphenoceramus schmidti*, of Middle Campanian age, also occurs frequently, and forms the characteristic *S. schmidti* Zone, which is widely traceable throughout the area. It is noteworthy that a nearly complete faunal succession of Campanian and Maastrichtian age can be continuously observed even though internationally recognized, stage-diagnostic taxa are few.

The relatively uniform sedimentary features of the mudstone deposits as well as the faunal composition of the Yezo Group are similar throughout southern Sakhalin and Hokkaido. Although the datum planes of a few fossil zones extend across some lithostratigraphic boundaries, almost identical lithofacies and biofacies extend over 1,200 km in a north to south direction. Such depositional and faunal uniformity, which reflects the marine environment in the North Pacific during this portion of Upper Cretaceous time, is a remarkable characteristic of the Yezo Group.

Twenty-five species of ammonoids, distributed among fourteen genera, are described, two of which, *Hypophylloceras* (*Neophylloceras*) *victriense* and *Gaudryceras makarovense*, are new species.

Key words: ammonoids, Makarov, Sakhalin, stratigraphy, Upper Cretaceous

Introduction

A continuous succession of the Cretaceous Yezo Group is well exposed along the middle course of the Makarova River and four of its tributaries: the Victoria R., the Rechitsa R., the Acacia R., and the Grudzovka R. (Figs. 1, 2). As in the Naiba section, it is worthy of consideration as one of the reference sections for Cretaceous stratigraphy in Sakhalin. The re-

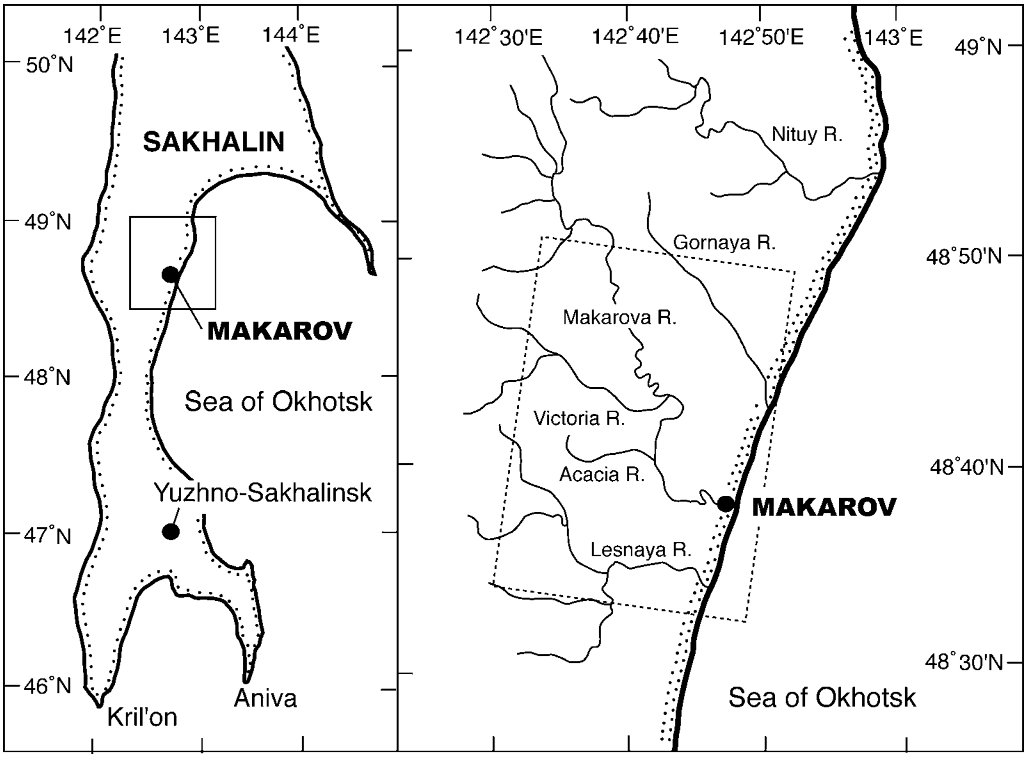

Fig. 1. Map showing the study area in the Makarov area, southern Sakhalin.

gional geology of the area has already been outlined, and Cretaceous megafossils have been partly described by previous authors (Sasa & Koiwai, 1960; Vereshchagin 1970, 1977; Salnikova, 1980; Poyarkova 1987; Zonova *et al.*, 1993; Yazikova, 1994 etc.).

In order to achieve precise stratigraphic correlation between Sakhalin and Hokkaido, a Japanese–Russian Joint Research Program was begun in 1990 (Kodama *et al.*, 2000, 2002). Scientific expeditions to the Makarov area were successfully carried out by geologists from both countries in 1993, 1994 and 1996. Utilizing satellite photography for detailed mapping, we investigated distinctive sedimentary features of the Cretaceous sequence, and carefully observed modes of fossil occurrence as well as the biostratigraphy of megafossils.

In an effort to investigate calcareous nannofossil biostratigraphy, we have examined a total of 31 samples (001 to 031) (Appendices 6, 7; locality maps). Smear slides were prepared from the samples and examined under a light microscope using both cross-polarized light and phase contrast methods at 1,000× magnification. In order to determine the relative abundance of species, more than 350 fields of view (FOV) were observed per sample. Relative abundance categories were adapted from Bown *et al.* (1998) and Burnett (1998). Additional FOVs were observed to check for the presence of rarely occurring, but biostratigraphically important species.

The results of the field survey and laboratory investigations as well as pertinent discussions are included in this paper.

Repository of specimen: The following abbreviations are used to indicate fossil repositories: NSM, National Science Museum, Tokyo; DGMKU, Department of Geology and Mineralogy, Kyoto University, Kyoto. Smear slides

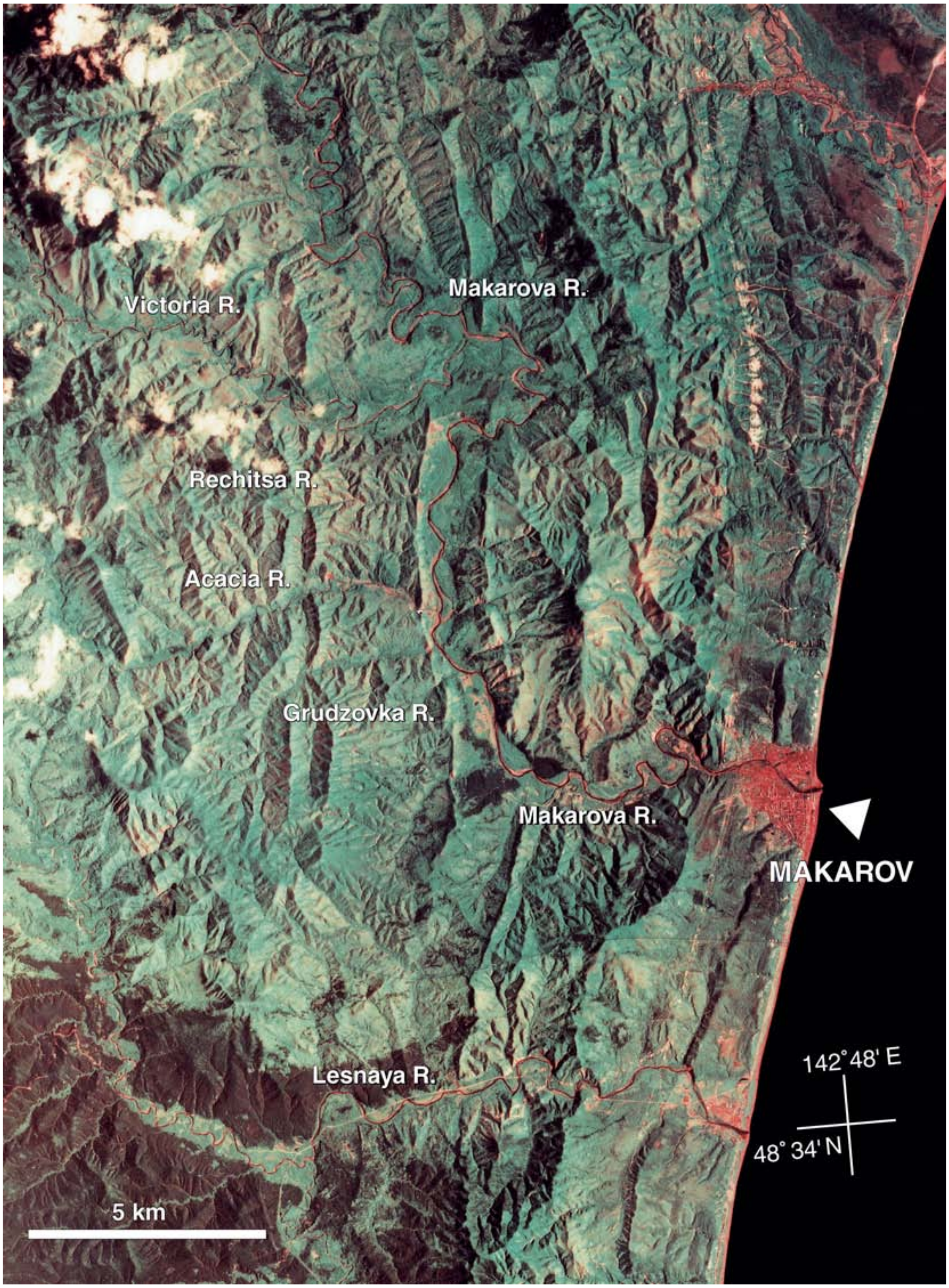

Fig. 2. Satellite photograph of the Makarov area, southern Sakhalin.

and original digital images of calcareous nannofossils are stored at Hokkaido University.

All fossils and samples utilized herein were collected during the field expeditions and were transported from Russia to Japan with permission from the Russian Government, the State Government of Sakhalin, and other concerned authorities.

Geologic setting

In general, the Cretaceous System dips 20–45° west, and its strike varies between a N–S direction and N30°E. It is in fault contact with Neogene volcaniclastic deposits in the eastern part of the area, and is unconformably overlain by Paleogene coal measures in the west (see satellite photography). A few diorite sills, extending in a N–S direction, intrude into the Cretaceous mudstone (Locs. MK2002, 3001, 5003; Fig. 3). At a few localities in the western part of the area, Cretaceous strata are repeatedly exposed by fault displacement and folding. However, such tectonic influences are generally slight, and continuous successions are easily observable (Appendices 1–8; route maps).

Stratigraphy

In the Makarov area, the Cretaceous System is stratigraphically equivalent to the Yezo Group (Supergroup) in Hokkaido, Japan. The group is generally represented by an extremely thick clastic marine sequence, which can be interpreted as having been deposited in a forearc basin (Okada, 1979, 1983).

Although only the upper part of the group is exposed in the Makarov area, it exceeds 2,500 m in thickness, and is lithologically similar to sediments of the stratotype section in the Naiba area. It is similarly divided into the Bykov and Krasnoyarka formations in ascending order. (Figs. 3–6).

Bykov Formation (Vereshchagin, 1961)

Only the uppermost part of the Bykov Formation is exposed in the Makarov area. It consists mainly of monotonous mudstone and is subdivided into lithostratigraphic units designated as B1–B4.

Stratotype: Naiba area, southern Sakhalin (see Matsumoto 1942d, 1954; Zakharov *et al.*, 1984; Poyarkova, 1987; Kodama *et al.*, 2002).

B1 Unit

Exposures: Middle course of the Makarova River.

Thickness: Greater than 100 m.

Stratigraphic relationship: The basal part is not exposed. The B1 Unit conformably underlies the B2 Unit.

Lithology: The B1 Unit consists of dark gray, massive, fine mudstone. Its detailed sedimentological features are uncertain because of poor exposures.

Megafossils: A few lenticular calcareous nodules were observed in the mudstone but no megafossils were found in the Makarov area. In the Lesnaya area, which is about 8 km south of the Makarov area, *Damesites* sp., *Tetragonites glabrus* (Jimbo), and *Gaudryceras denseplicatum* (Jimbo) occur in calcareous nodules which are derived from mudstone in the B1 Unit. This ammonoid assemblage is of Coniacian or Santonian age.

B2 Unit

Exposures: Loc. MK5002, along the lower course of the Rechitsa River (typical section); lower course of the Gruzdovka River.

Thickness: 20–60 m.

Stratigraphic relationship: The B2 Unit conformably overlies the B1 Unit, and conformably underlies the B3 Unit.

Lithology: The B2 Unit consists of light gray, massive, fine to medium-grained, thickly bedded sandstone. Unlike the sandstones of the Krasnoyarka Formation, the sandstones of the B2 Unit contain few volcanic fragments.

The unit extends laterally over adjacent

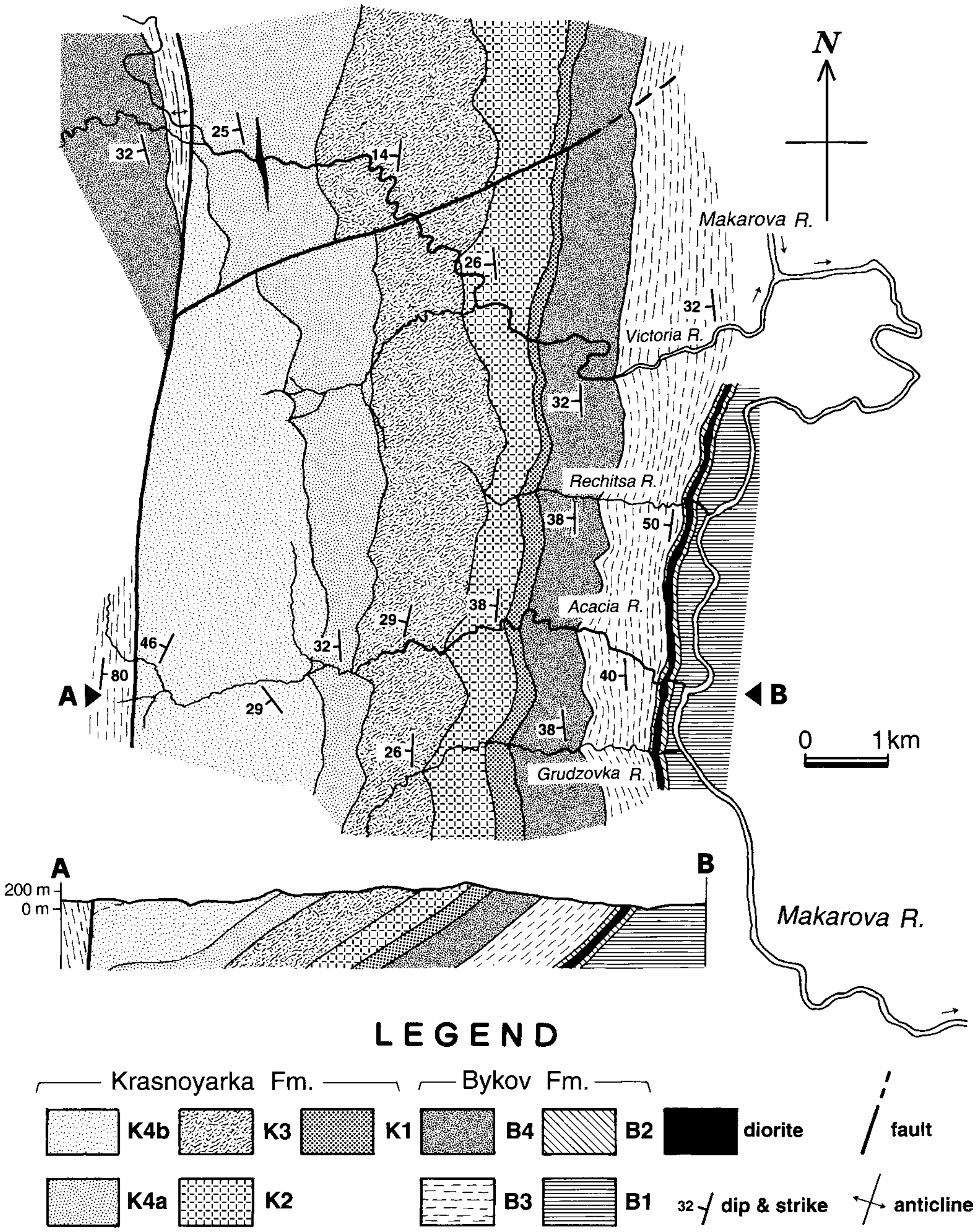

Fig. 3. Geological map of the Makarov area, southern Sakhalin.

areas. In the Lesnaya area, the sandstones of the B2 Unit coarsen and display slumping structures.

The B2 Unit is often intruded by diorite sills. The contact between the diorite and sandstone is distinct and a thin chilled margin about 1 cm thick, can be observed (Loc. MK2002).

Megafossils: No fossils were found in the B2 Unit.

B3 Unit

Exposures: Locs. MK2005–2008 along the lower course of the Acacia River (typical section); lower course of the Victoria R. and Rechitsa R.

Thickness: 600 m.

Stratigraphic relationship: At Loc. MK-2003 along the Acacia River, the basal part of the unit is in direct contact with an intruded diorite sill. At other localities, the B3 Unit conformably overlies the B2 Unit and conformably underlies the B4 Unit.

Lithology: The B3 Unit consists mainly of dark gray, intensely bioturbated, fine mudstone. Laminations or bedding planes are barely observable in the mudstone. Poorly sorted sandstone beds varying in thickness from 10 to 30 cm are occasionally intercalated, and the thinner beds are usually mottled and penetrated by burrows. Ellipsoidal calcareous nodules, 30–60 cm diameter, are commonly embedded in the mudstone.

At Loc. MK2003, mudstone beds adjacent to the contact plane with a diorite sill are hornfelsed.

Microfossils: *Repagulum parvidentatum* (Deflandre and Fert), *Prediscophaera arkhangelskyi* (Reinhardt) and *Biscutum magnum* Wind and Wise occur rarely in the upper part of the B3 Unit (Figs. 7, 8; Table 1).

Megafossils: Many ammonoids and inoceramids are found in ellipsoidal calcareous nodules as well as in the host mudstone (Table 2), but the faunal components change stratigraphicaly within the unit. *Menuites naumanni* (Yokoyama) (Fig. 11) is common in the upper part, while *Eupachydiscus haradai* (Jimbo) and *Sphenoceramus orientalis* (Sokolov) (Fig. 16) are abundant in the uppermost part. Usually, these pachydiscids are adult macroconchs that attain a diameter of 30 cm.

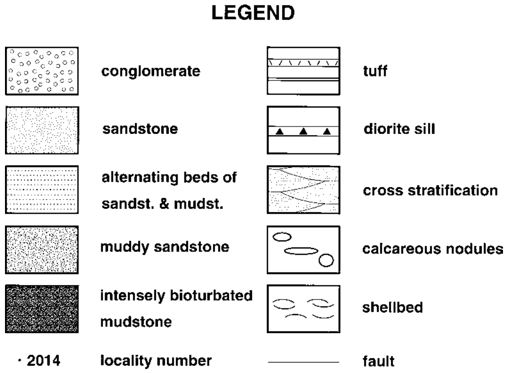

Fig. 4. Lithological symbols in columnar sections (Figs. 5, 6, 19).

In addition, *Tetragonites glabrus* (Fig. 42) and *Gaudryceras striatum* (Jimbo) (Fig. 25) as well as plant remains are common in the calcareous nodules in the uppermost part.

B4 Unit

Exposures: Locs. MK2009–2014 along the lower course of the Acacia River (typical section); lower course of the Victoria R., Rechitsa R., and Gruzdovka R.

Thickness: 300–400 m.

Stratigraphic relationship: The B4 Unit conformably overlies the B3 Unit, and conformably underlies the Krasnoyarka Formation.

Lithology: The unit consists mainly of dark gray, intensely bioturbated, massive or mottled sandy mudstone interbedded with white vitric tuff layers that vary in thickness from 5–20 cm. Usually, the basal beds are not exposed, but the more resistant main part of the unit is well exposed. Several shellbeds comprised of *Sphenoceramus schmidti* (Michael) are intercalated in the lower part of the unit (Loc. MK2009). The *S. schmidti* Zone, consisting of such composite type shell-

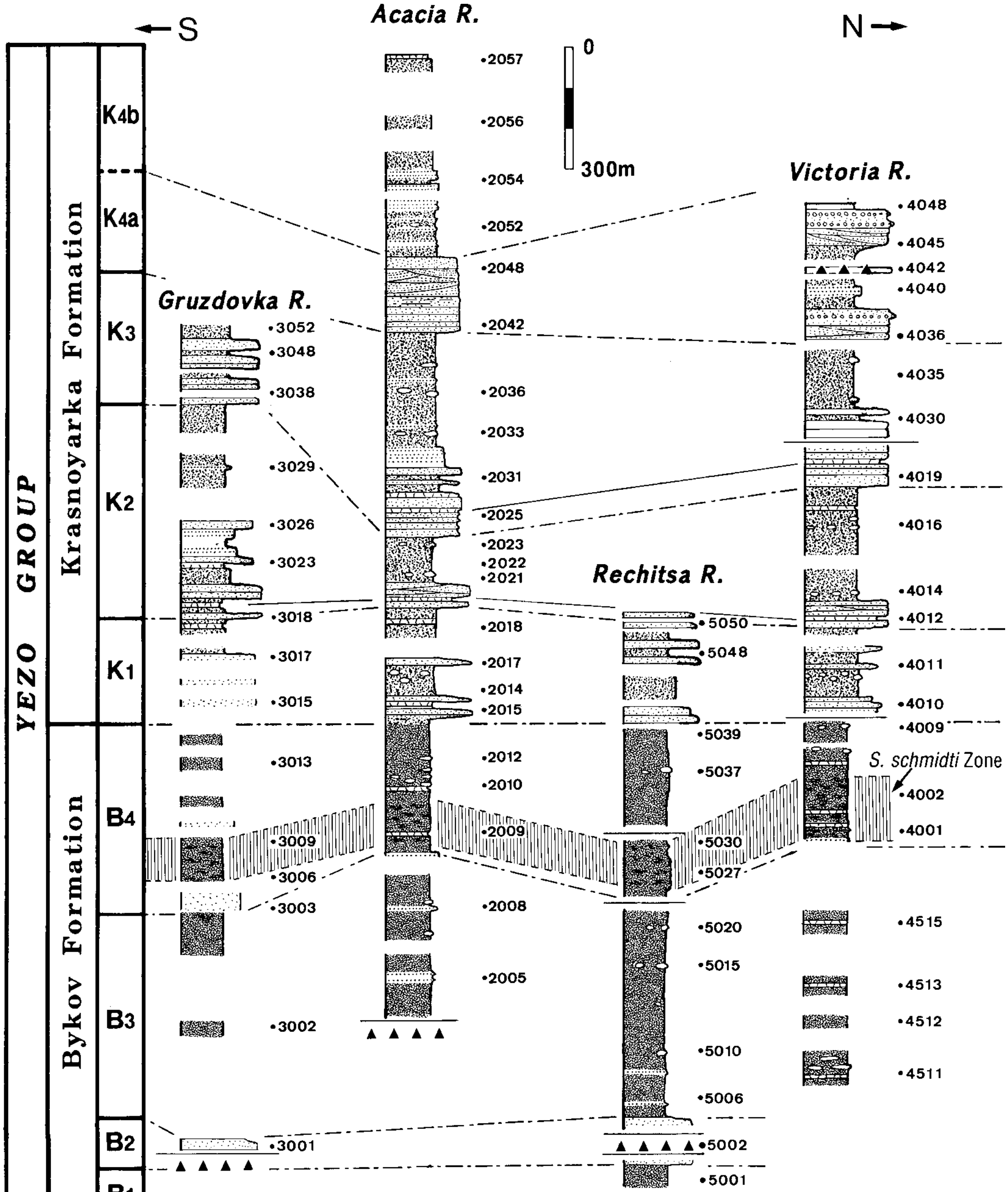

Fig. 5. Columnar sections of the Cretaceous Yezo Group at four major localities in the Makarov area. Shaded part in the B4 Unit represents the traceable *Sphenoceramus schmidti* Zone.

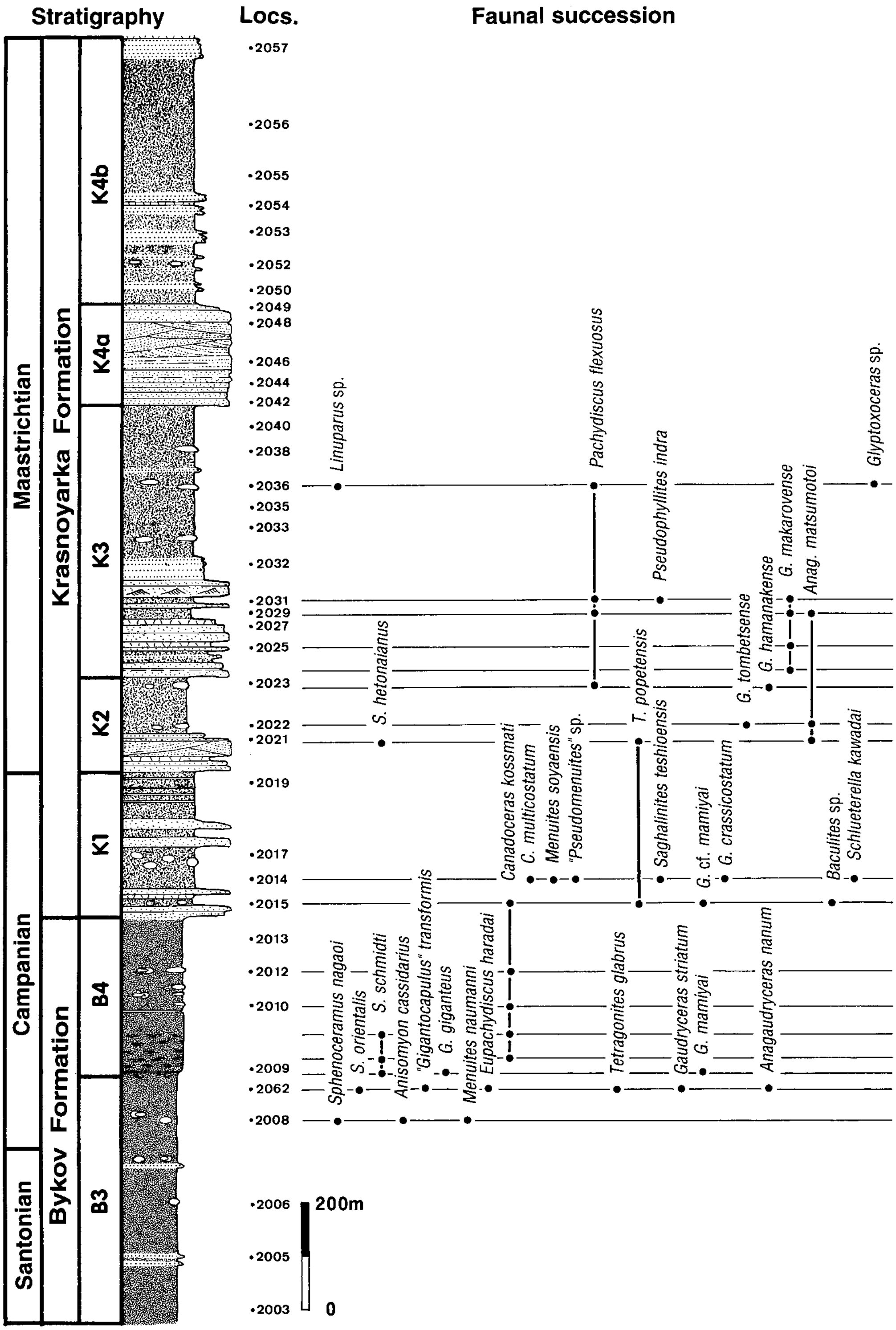

Fig. 6. Lithology and faunal succession of the Cretaceous deposits along the Acacia River.

Table 1. List of calcareous nannofossils from the Bykov Formation along the Acacia River. Relative abundance categories were adopted from Bown *et al.* (1998) and Burnett (1998). F (=few): 1 specimen/2–50 FOV. R (=rare): 1 specimen/>50 FOV.

Species	B3 Unit						B4 Unit								
	001	002	003	004	005	006	007	008	009	010	011	012	013	014	015
Reinhardtites anthophorus (Deflandre)								R					R		
Reinhardtites levis Prins & Sissingh													R		
Staurolithites zoensis Burnett								R					R		
Tranolithus orionatus (Reinhardt)													R		
Zeugrhabdotus praesigmoides Burnett								R							
Zeugrhabdotus spiralis (Bramlette & Martini)													R		
Zeugrhabdotus trivectis Bergen								R					R		
Chiastozygus litterarius (Górka)													R		
Chiastozygus synquadriperforatus Bukry													R		
Chiastozygus sp. A													R		
Eiffellithus eximius (Stover)					R										
Eiffellithus turriseiffelii (Deflandre)									R						
Helicolithus trabeculatus (Górka)													R		
Cribrosphaerella ehrenbergii (Arkhangelsky)													R		
Biscutum coronum Wind & Wise								R							
Biscutum ellipticum (Górka)					R			R					R		
Biscutum magnum Wind & Wise					R										
Discorhabdus ignotus (Górka)						R		R		R					
Prediscophaera arkhangelskyi (Reinhardt)					R	R									
Prediscospaera cretacea (Arkhangelsky)								R					R		
Prediscospaera grandis Perch-Nielsen													R		
Prediscophaera incohatus (Stover)													R		
Cyclagelosphaera rotaclypeata Bukry					R										
Watznaueria barnesae (Black)						R		R					R		
Watznaueria spp.					R	R		R					R		
Arkhangelskiella cymbiformis Vekshina								R					R		
Repagulum parvidentatum (Deflandre & Fert)					R	R	R	F	F	R	R	R	F		
Braarudosphaera bigelowii (Gran & Braarud)								R							
Micula staurophora (Gardet)								R	R						

beds (Ando & Kondo, 1999), attains a thickness of 100 m, and is traceable throughout the Makarov area.

Richly fossiliferous spherical and lenticular calcareous nodules, 30–60 cm in diameter, are common particularly in the upper part of the unit.

Microfossils: *Reinhardtites anthophorus* (Deflandre), *R. levis* Prins and Sissingh and *Arkhangelskiella cymbiformis* Vekshina occur rarely in the B4 Unit (Figs. 7, 8; Table 1). Calcareous nannofossil assemblages are few and their respective abundance values are generally very low. Their preservation is poor to moderate. With the exception of three samples (008, 009 and 013) that contain a few *Repagulum parvidentatum*, nannofossil abundance values are less than 10 specimens per 100 FOV.

Megafossils: The entire unit is fossiliferous (Table 2). In the lower part, *Sphenoceramus schmidti* (Figs. 17, 18) is abundant in calcareous nodules as well as in the surrounding sandy mudstone. Specimens of *S. schmidti*, 20–50 cm in length, are typically preserved with their valves in the closed position, and are embedded horizontally in the intensely bioturbated, sandy mudstone. Some specialists argue for taxonomic division of the *S. schmidti* group (e.g., Michael, 1899; Nagao & Matsu-

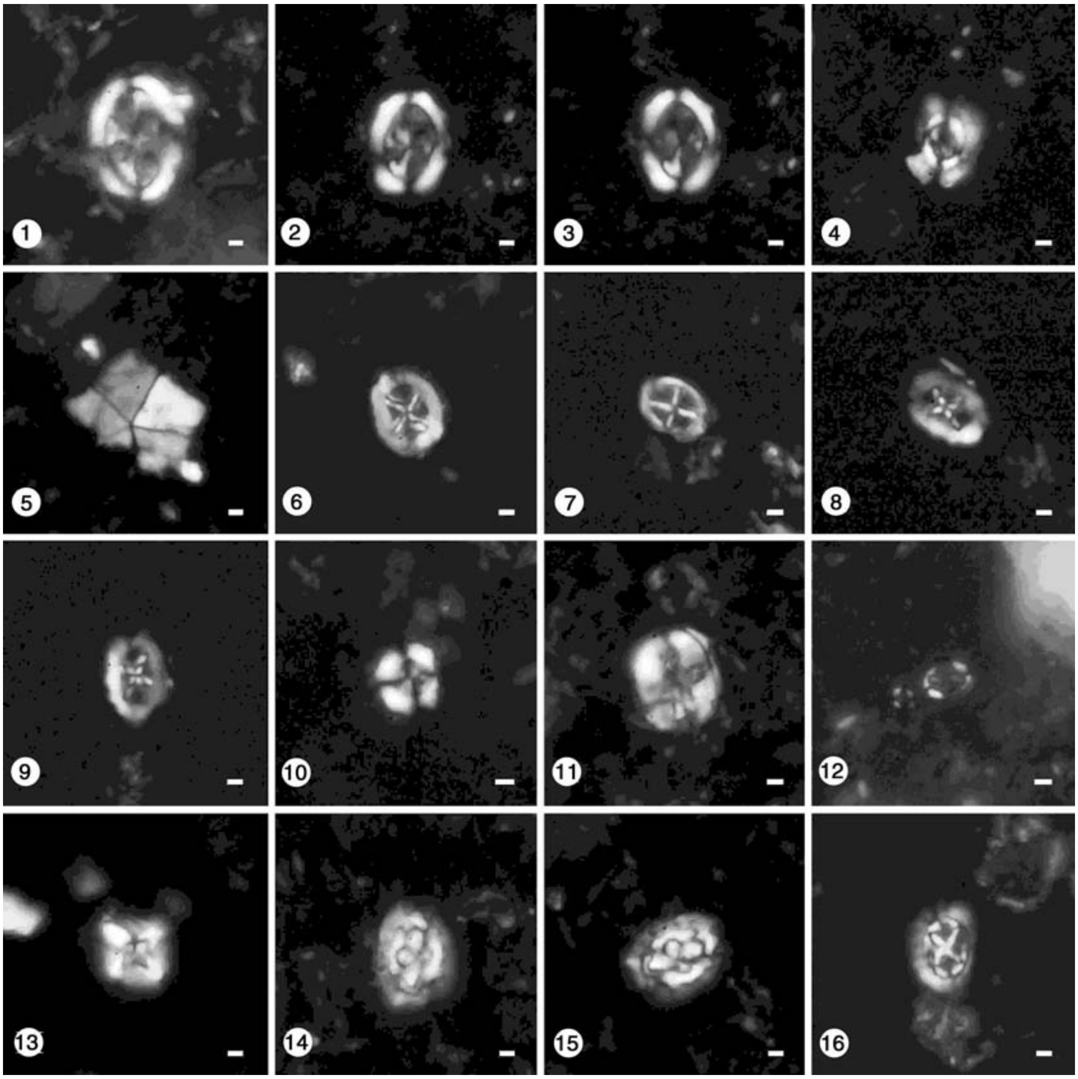

Fig. 7. Optical micrographs of calcareous nannofossils under cross-polarized light from the B3 and B4 units, Bykov Formation, along the Acacia River. Scale bar=1 μm. 1–3, *Arkhangelskiella cymbiformis* Vekshina, sample 013. 4, *Biscutum coronum* Wind and Wise, sample 008. 5, *Braarudosphaera bigelowii* (Gran and Braarud), sample 008. 6, *Chiastozygus litterarius* (Górka), sample 013. 7, *Chiastozygus synquadriperforatus* Bukry, sample 013. 8–9, *Chiastozygus* sp. A, sample 013, a species of *Chiastozygus* with a small cross superimposed over the symmetrical, central cross. The arms of the smaller cross are approximately half as long and appear to be parallel to the arms of the larger cross. 10, *Cyclagelosphaera rotaclypeata* Bukry, sample 005. 11, *Eiffellithus eximius* (Stover), sample 005. 12, *Helicolithus trabeculatus* (Górka), sample 013. 13, *Micula staurophora* (Gardet), sample 008. 14–15, *Prediscosphaera arkhangelskyi* (Reinhardt), sample 005. 16, *Prediscosphaera cretacea* (Arkhangelsky), sample 013.

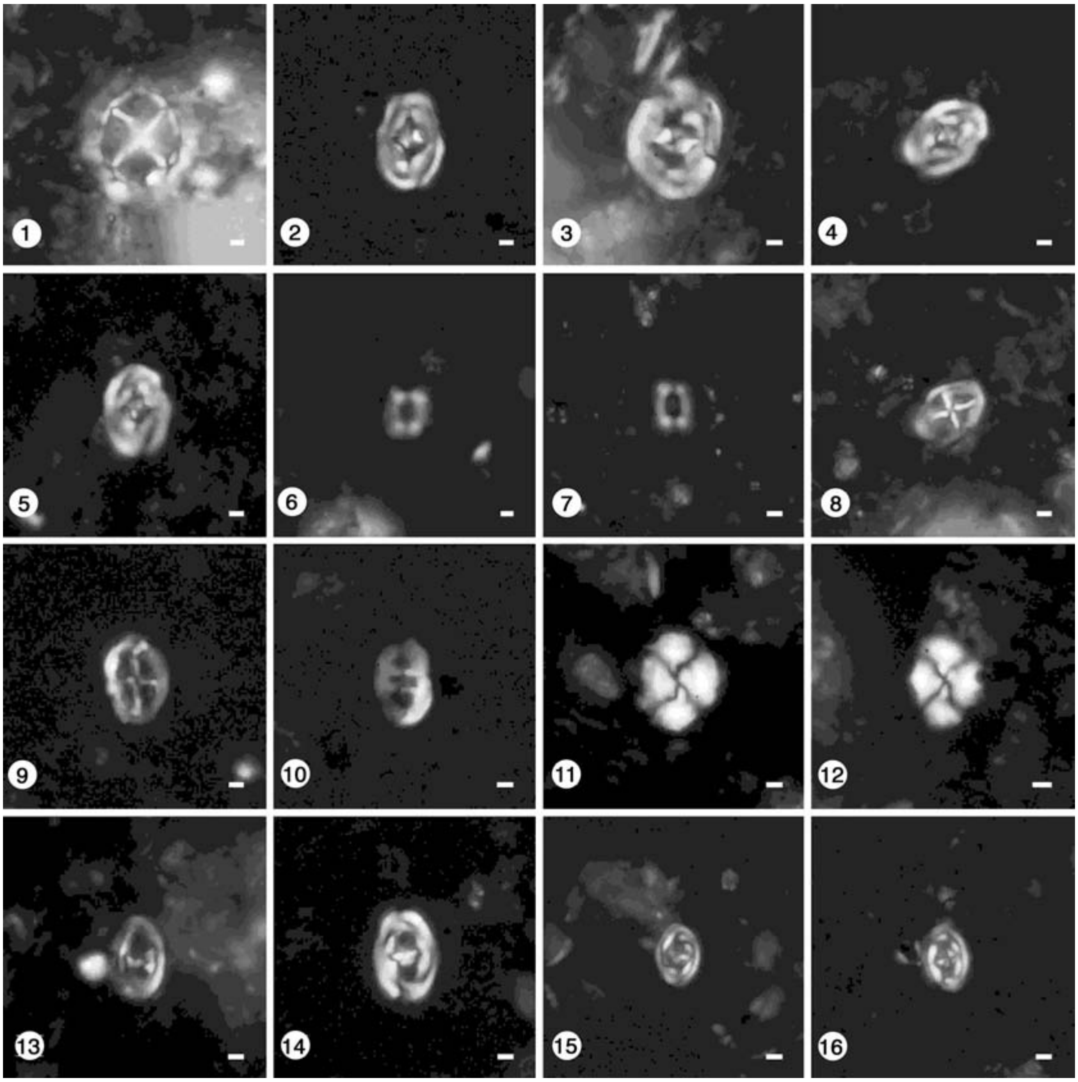

Fig. 8. Optical micrographs of calcareous nannofossils under cross-polarized light from the B4 Unit, Bykov Formation, along the Acacia River. Scale bar = 1 μm. 1, *Prediscosphaera grandis* Perch-Nielsen, sample 013. 2–3, *Reinhardtites anthophorus* (Deflandre), sample 013. 4–5, *Reinhardtites levis* Prins and Sissingh, sample 013. 6–7, *Repagulum parvidentatum* (Deflandre and Fert), sample 013. 8–9, *Staurolithites zoensis* Burnett. 8, sample 013. 9, sample 008. 10, *Tranolithus orionatus* (Reinhardt), sample 013. 11–12, *Watznaueria barnesae* (Black). 11, sample 008. 12, sample 013. 13, *Zeugrhabdotus praesigmoides* Burnett, sample 008. 14, *Zeugrhabdotus spiralis* (Bramlette and Martini), sample 013. 15–16, *Zeugrhabdotus trivectis* Bergen, sample 013.

Table 2. List of ammonids, inoceramids and other invertebrates from the Bykov Formation in the Makarov area.

Species	B3 Unit	B4 Unit
Ammonoids		
Phyllopachyceras ezoense (Yokoyama)	2062	2015
Gaudryceras striatum (Jimbo)	2062	
Gaudryceras mamiyai Matsumoto & Miyauchi		2009
Gaudryceras cf. *mamiyai* Matsumoto & Miyauchi		2015
Anagaudryceras nanum Matsumoto	2062	
Tetragonites glabrus (Jimbo)	2062	
Tetragonites popetensis Yabe		4004, 2015
Baculites sp.		2015
Damesites cf. *sugara* (Forbes)		2062
Eupachydiscus haradai (Jimbo)	2062, 4049, 4102	
Menuites naumanni (Yokoyama)	2008, 4508, 4515, 5014, 5015, 5020	
Canadoceras kossmati Matsumoto		2009, 2010, 2011, 2012, 2014, 2015, 3012, 3013, 4001, 4002, 4003, 4004, 4007, 4008, 4009, 4112, 5035, 5036
Inoceramids		
Sphenoceramus nagaoi (Matsumoto & Ueda)	2008	
Sphenoceramus orientalis (Sokolov)	2062, 4049, 4101, 4102, 4103	
Sphenoceramus schmidti (Michael)		2009, 3003, 3006, 3007, 3008, 3009, 3010, 4000, 4001, 4002, 4003, 4004, 4005, 4006, 4007, 4103, 4104, 4105, 4106, 4107, 4108, 4109, 4110, 4112, 4115, 5026, 5029, 5030, 5033, 5035
Gastropods		
Anisomyon cassidarius (Yokoyama)	2008	
“*Gigantocaplus*” *transformis* (Dundo)	2062, 4102	
Gigantocaplus giganteus (Schmidt)		2009, 3003, 4000, 4001, 4005, 4006, 4104, 5026, 5029

moto, 1940; Tanabe, 1973; Zonova *et al.*, 1993 etc.), but we regard *S. schmidti* as one, highly variable species.

In the lower part of the *S. schmidti* Zone, morphotypes occur with diagnostic divergent ribs that are typical for the adult stage. In contrast, smooth morphotypes, in which divergent ribs appear only in the early growth stage, become dominant in the upper part of the zone (discussed later). *Canadoceras kossmati* Matsumoto (Fig. 12) is also abundant in this horizon. The lowermost shell bed is intercalated in predominately sandy matrix and yields *Gigantocapulus giganteus* (Schmidt) (Locs. MK-3003, 4005; Fig. 17). This species is restricted to the basal part of the zone with the divergent ribbed morphotypes of *S. schmidti*.

Krasnoyarka Formation (Vereshchagin, 1961)

Stratotype: Naiba area, southern Sakhalin (see Matsumoto 1942d, 1954; Zakharov *et al.*, 1984; Poyarkova, 1987; Kodama *et al.*, 2002).

The Krasnoyarka Formation consists mainly of various types of sandstone as well as sandy mudstones, and is divided into four lithostratigraphic units (K1–K4), which become progressively finer in an ascending sequence except for the K4. The formation conformably overlies the Bykov Formation, but the top portion is cut by a fault, and is not exposed in the area.

Table 3. List of ammonoids, inoceramids and other invertebrates from the Krasnoyarka Formation in the Makarov area.

Species	K1 Unit	K2 Unit	K3 Unit
Ammonoids			
Hypophylloceras victriense sp. nov.		4016, 4018	
Hypophylloceras cf. *nera* (Forbes)		4016	
Gaudryceras crassicostatum (Jimbo)	2014		
Gaudryceras tombetsense Matsumoto		2022, 4014, 4015	
Gaudryceras cf. *tombetsense* Matsumoto		4016	
Gaudryceras hamanakense Matsumoto & Yoshida		2023, 4019	
Gaudryceras makarovense sp. nov.			2023, 2025, 2029, 2031, 4030
Anagaudryceras seymouriense Macellari		4016	
Anagaudryceras matsumotoi Morozumi		2021, 2022, 4014, 4015, 4016, 4018	2029p
Zelandites varuna (Forbes)		3031p	
Tetragonites popetensis Yabe	2014	2021, 4014	
Saghalinites teshioensis Matsumoto	2014		
Pseudophyllites indra (Forbes)		4014, 4015, 4016, 4018	2031
Schlueterella kawadai Matsumoto & Miyauchi	2014		
Diplomoceras cf. *notabile* Whiteaves			4030
Glyptoxoceras sp.			2036
Desmophyllites diphylloides (Forbes)	2014		
Canadoceras kossmati Matsumoto	2014, 2015		
Canadoceras multicostatum Matsumoto	2014, 4010		
Menuites soyaensis (Matsumoto & Miyauchi)	2014, 2017		
Pseudomenuites sp.	2014		
Pachydiscus gracilis Matsumoto		4017, 4018	
Pachydiscus flexuosus Matsumoto		2023	2029, 2031, 2036, 4025, 4028, 4029, 4030, 4032, 4033, 4035
Inoceramids			
Sphenoceramus hetonaianus (Matsumoto)		2021, 3029, 4014, 4015, 4016, 4018	
Shahmaticeramus shahmati (Salnikova & Zonova)		2021, 4016, 4018 4016, 4018	
Shahmaticeramus kusiroensis (Nagao & Matsumoto)		4018	
Crustacea			
Linuparus sp.		4018	2030, 2036, 4035

K1 Unit

Exposures: Locs. MK2014–2019 along the middle course of the Acacia R. (typical section); middle course of the Victoria R., Rechidtsa R., and Gruzdovka R.

Thickness: 250–270 m.

Stratigraphic relationship: The K1 Unit conformably overlies the B4 Unit of the Bykov Formation, and conformably underlies the K2 Unit.

Lithology: The lowermost part of the K1 Unit consists of greenish gray, intensely bioturbated or mottled muddy sandstone, which contains many large calcareous concretions (Loc. MK2014; Fig. 9). It grades upward into greenish gray, dark poorly sorted, coarse, sandstone interbedded with gray, mottled, sandy mudstone in the main part of the K1 Unit (Locs. MK2014–2019). The sandstone varies in thickness from 50 to 500 cm, and is rich in andesitic volcanic rock fragments. *Phycosiphon* occurs in the sandy mudstone as well as much larger burrows oriented obliquely to the bedding plane. The sandy mudstone also contains huge (50–100 cm in diameter) spherical calcareous nodules, some of which are fossiliferous. A few vitric tuff beds varying in thickness from 2 to 5 cm are intercalated in the upper part (Locs. MK2018, 2019).

Microfossils: *Cyclagelosphaera* sp. and *Watznaueria biporta* Bukry occur in samples 018 and 017, respectively.

Megafossils: *Canadoceras multicostatum* Matsumoto (Fig. 12) is the characteristic ammonoid in the lower part of the K1 Unit, but *Tetragonites popetensis* Yabe (Fig. 44), *Menuites soyaensis* (Matsumoto and Miyauchi) (Fig. 13), and *Pseudomenuites* sp. (Fig. 13) are also common (Table 3). Relatively few fossils were found in the upper part of the K1 Unit.

K2 Unit

Exposures: Locs. MK4012–4019 along the middle course of the Victoria R. (typical section); middle course of the Acacia R., and Gruzdovka R.

Thickness: 200–500 m.

Stratigraphic relationship: The K2 Unit conformably overlies the K1 Unit, and conformably underlies the K3 Unit.

Lithology: The lower part of the K2 Unit consists of gray to light greenish gray, cross-stratified, coarse to medium grained sandstone. Most of the cross-stratification can be classified as trough-type displaying a gentle angle, while a few beds exhibit features that are characteristic of hummocky cross-stratification (HCS). Occasionally, the top-most beds of these structures show current ripples suggesting a north to south paleocurrent (Loc. MK4013). A key, widely traceable 30 cm thick, yellowish gray, vitric tuff bed occurs in the basal part of the unit (Loc. MK4013).

The upper part of the K2 Unit becomes fine grained and is mainly comprised of dark gray, intensely bioturbated coarse mudstone, containing ellipsoidal calcareous concretions 20–40 cm in diameter.

Microfossils: No nannofossils were found in the K2 Unit.

Megafossils: The basal sandstone yields no fossils, but the overlying sandy mudstone is quite fossiliferous (Table 3). *Gaudryceras tombetsense* Matsumoto (Figs. 26–31) is the characteristic ammonoid in the lower part of the unit, but *Pseudophyllites indra* (Forbes) (Figs. 46–50) and *Anagaudryceras matsumotoi* Morozumi (Fig. 39) are also common in the lower and middle parts. *Sphenoceramus hetonaianus* (Matsumoto) (Fig. 18) is frequently found in the lower and middle parts. A form of *Pachydiscus gracilis* Matsumoto (Fig. 14) that is much more compressed than the holotype, frequently occurs in the middle part of the unit. A lobster (*Linuparus* sp., Fig. 10) and *Cidaris* sp. are also common in the middle part. *Gaudryceras hamanakense* Matsumoto and Yoshida (Fig. 32) is found in the upper part. A specimen of *Zelandites varuna* (Forbes) (Fig. 38) was obtained from a float calcareous nodule at Loc. MK3031 along the Gruzovka River. Although the exact horizon from which the nodule came is uncertain, judging from the locality and lithology, it almost without doubt came from the upper part o the unit.

K3 Unit

Exposures: Locs. MK2023–2040 along the middle course of the Acacia R. (typical section); middle course of the Victoria R., and Gruzdovka R.

Thickness: 400–500 m.

Stratigraphic relationship: The K3 Unit conformably overlies the K2 Unit, and conformably underlies the K4a Subunit.

Lithology: The lower part of the K3 Unit consists of gray, coarse to medium grained, bedded sandstone varying in thickness from 50 to 250 cm. Relatively few mudstone intercalations are present in this sandstone. Alternating beds of sandstone and sandy mudstone comprise the middle part of the unit. The sandstone beds sometimes show parallel lami-

Fig. 9. 1, A distant view of Loc. MK2014 along the Acacia River. The exposure is the Upper Campanian bedded muddy sandstone of the K1 Unit, Krasnoyarka Formation. 2, A view of Loc. MK2036 along the Acacia River. Maastrichtian muddy sandstone of the K3 Unit yields many calcareous nodules. The second author (Y.S.) is shown trying to excavate one of the nodules. 3, A calcareous nodule, found in the river at Loc. MK 2025, containing a 15 cm in diameter specimen of *Pachydiscus flexuosus* Matsumoto. Specimen deposited in DGMKU.

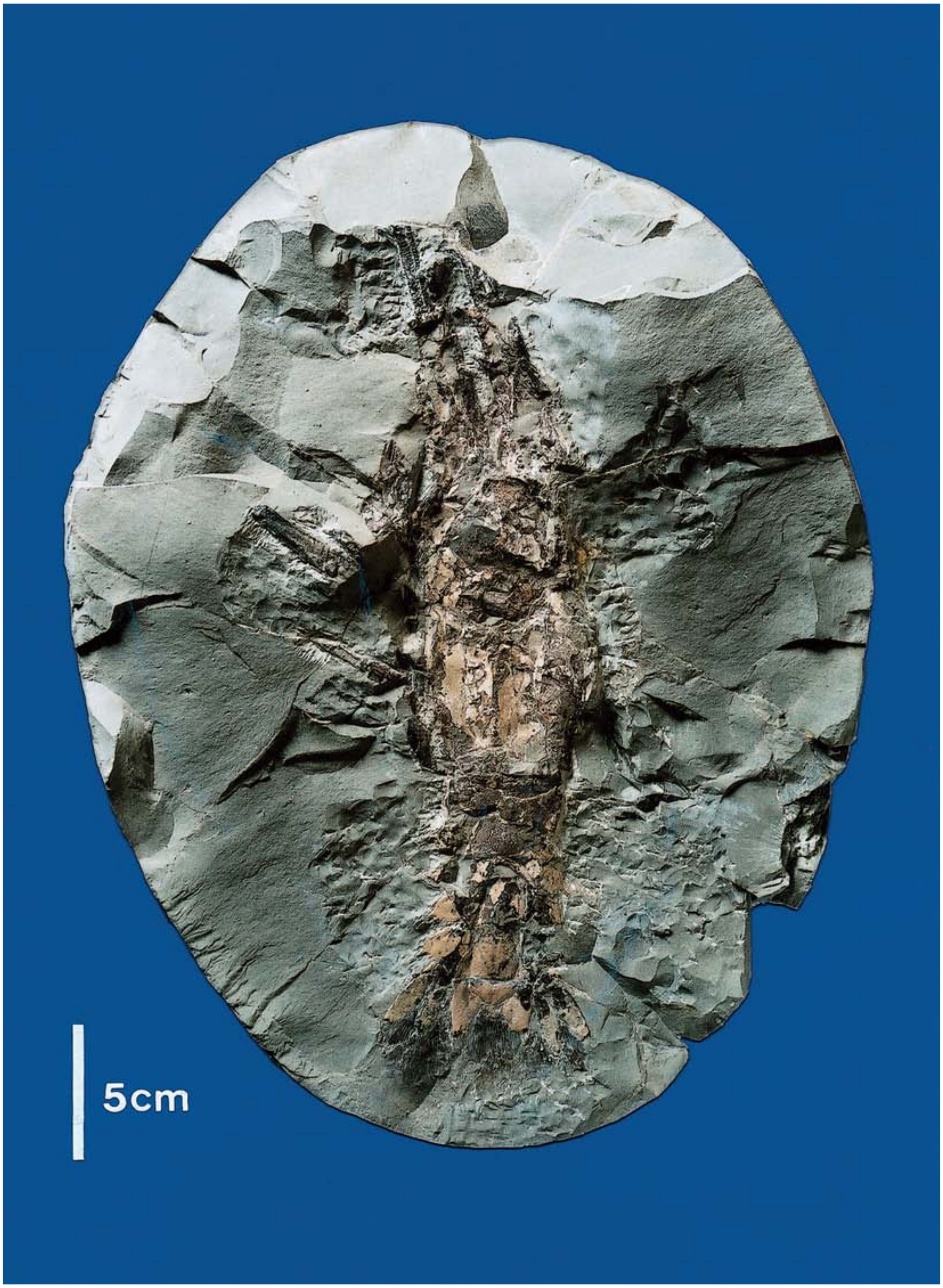

Fig. 10. A large calcareous nodule containing *Linuparus* sp. from the K2 Unit at Loc. MK4018. Note that the antennae and appendages are preserved *in situ* even though the carapace is crushed. Specimen deposited in DGMKU. Scale bar = 5 cm.

nations. In the upper part of the unit, dark greenish gray, intensely bioturbated sandstone is dominant. Spherical calcareous nodules are common in the sandy mudstone (Fig. 9).

In addition, a key, widely traceable, 90 to 120 cm thick, yellowish gray, fine grained, vitric tuff bed, displaying parallel laminations, is intercalated in the sandy mudstone (Loc. MK2027).

Microfossils: No nannofossils were found in the K3 Unit.

Megafossils: *Pachydiscus flexuosus* Matsumoto (Fig. 15) and *Gaudryceras makarovense* Shigeta and Maeda sp. nov. (Figs. 15, 33–37) are abundant in the middle part of the K3 Unit. An identical assemblage is typically found in the Pugachevo area (see Maeda & Shigeta, 2005; another article in this volume). *P. flexuosus*, *Glyptoxoceras* sp. (Fig. 51), *Nanonavis* sp. and *Linuparus* sp. occur sporadically in the upper part of the unit.

K4 Unit

The sedimentological features of the K4 Unit, which is the uppermost lithostratigraphic unit of the Krasnoyarka Formation, are somewhat different from those of the three underlying units. Unlike the lower units of the formation, the K4 Unit exhibits a coarsening-upward sequence, which resembles a deltaic sequence (Walker & James, 1992). The K4 Unit is subdivided into two distinct subunits, K4a and K4b, which are described separately.

K4a Subunit

Exposures: Locs. MK2041–2049 along the upper course of the Acacia R. (typical section); upper course of the Victoria R.

Thickness: 200–500 m.

Stratigraphic relationship: The K4a Subunit conformably overlies the K3 Unit, and conformably underlies the K4b Subunit.

Lithology: The K4a Subunit consists mainly of gray to light gray, cross-stratified, medium to fine grained sandstone. For the Yezo Group, the sandstone is exceptionally well-sorted, thus indicating probable deposition under relatively strong wave action and/or currents. Low-angle cross-stratified, fine grained sandstones, whose margins converge on the surrounding beds, are dominant in the lower part (Loc. MK2044). The distinctive features of these beds suggest that they can be classified as hummocky cross-stratified sandstone (HCS) formed by storm events. In the upper part of the unit, medium-grained sandstones displaying trough-type cross-stratification are dominant (Loc. MK2048).

In the section along the Victoria River, the lithology is highly variable, and many different sediment types are intercalated in the K4a Subunit. These include dark gray sandy mudstone (Loc. MK4040), a pebble conglomerate bed 10–30 cm thick (Loc. MK4045 etc.), a medium-grained sandstone displaying tabular cross-stratification (Loc. MK4046), coal seams 5–12 cm thick (Loc. MK4048), and andesitic volcanic breccia 10 m thick (Loc. MK4042).

Microfossils: No nannofossils were found in the K4a Subunit.

Megafossils: No fossils were found in the cross-stratified sandstones. Only rare specimens of *Nanonavis* sp. were found in the sandy mudstone in the Victoria section.

K4b Subunit

Exposures: Locs. MK2050–2061 along the upper course of the Acacia River (typical section).

Thickness: Greater than 450 m.

Stratigraphic relationship: The K4b Subunit conformably overlies the K4a Subunit. The top portion is in fault contact with the Bykov Formation, which is again exposed along the axis of an anticline in the western part of the area.

Lithology: The unit consists mainly of poorly sorted, mottled, sandy mudstone intercalated in thin sandstone beds and beds of vitric tuff.

Microfossils: No nannofossils were found in the K4b Subunit.

Megafossils: No fossils were found except allochthonous shell fragments of bivalves which have accumulated as debris in the sandstone along with pebbles and patches of shale.

Correlation

We propose a provisional stratigraphic correlation of the Cretaceous deposits in the Makarov area based on the biostratigraphy of ammonoids, inoceramids and calcareous nannofossils. Then, once all currently ongoing investigations have been completed, the results as well as a comprehensive discussion of our conclusions will be published elsewhere. Investigations still in progress include magnetostratigraphy, and oxygen and carbon isotope stratigraphy.

The Cretaceous deposits in the Makarov area are similar lithologically to those of the stratotype section in the Naiba area. More specifically, the Bykov Formation is equivalent to the Upper Yezo Group, while the Krasnoyarka Formation can be correlated with the Hakobuchi Group in Hokkaido, Japan (Matsumoto, 1942d, 1954; Shigeta *et al.*, 1999; Kodama *et al.*, 2002).

Based on ammonoid assemblages (Matsumoto, 1942d, 1954, 1959a; Poyarkova, 1987; Zonova *et al.*, 1993; Toshimitsu *et al.*, 1995 etc.), the B1 Unit of the Bykov Formation is supposed to be of Coniacian or Santonian age, whereas the occurrence of *Gaudryceras tenuiliratum* Yabe in the lower and middle part of the B3 Unit indicates that these sediments are of Santonian age.

A change in the fossil assemblage in the upper part of the B3 Unit, in which *Menuites naumanni* and *Sphenoceramus orientalis* are common, suggests that this portion of the unit is correlated to the uppermost Santonian or lowermost Campanian stage (Matsumoto, 1959a; Kanie, 1966). The overlying B4 Unit yields *Sphenoceramus schmidti*, the index fossil of the widely traceable, 100 m thick *S. schmidti* Zone, which is the Lower Campanian stage.

Based on the occurrence of nannofossil species *Reinhardtites anthophorus*, *R. levis* and *Arkhangelskiella cymbiformis*, the B4 Unit ranges from the Lower to Upper Campanian stage, which is equivalent to nannofossil zones NC17–20 of Roth (1978), CC17–22 of Sissingh (1977, 1978) and UC13–15 of Burnett (1998). Both *A. cymbiformis* and *R. levis* have their FOs in the Lower Campanian (UC13 and UC14, respectively), while *R. anthophorus* has its LO in the Upper Campanian (upper boundary marker for UC15). According to Burnett (1998), the Campanian–Santonian boundary occurs slightly below the FO of *A. cymbiformis* (lower boundary marker for UC13). Therefore, the occurrence of *A. cymbiformis* in the lower part of the B4 Unit suggests that the Campanian–Santonian boundary should lie within the basal part of the B4 Unit or the upper part of the B3 Unit.

The overlying K1 Unit of the Krasnoyarka Formation is the Upper Campanian stage as indicated by the presence of *Canadoceras multicostatum* and associated fauna, e.g., *Menuites soyaensis*. This assemblage is also known as the "Soya Fauna" (see Matsumoto & Miyauchi, 1984). Although one of the diagnostic species, *Metaplacenticeras subtilistriatum* (Jimbo), has not yet been reported from Sakhalin, the "Soya Fauna" is widely traceable throughout Hokkaido and southern Sakhalin (Shigeta *et al.*, 1999; Kodama *et al.*, 2002).

Lower Maastrichtian faunas first appear in the K2 Unit. Among these, *Sphenoceramus hetonaianus*, *Gaudryceras tombetsense*, and *Pachydiscus gracilis* are also known from the Hakobuchi Group of Hokkaido (Matsumoto 1984b; Matsumoto *et al.*, 1979, 1985; Toshimitsu *et al.*, 1995). The K3 Unit frequently yields *Pachydiscus flexuosus* and *Gaudryceras makarovense* sp. nov., an assemblage that typically can be found in the Pugachevo area, about 50 km south of the Makarov area (see another paper in this volume). *P. flexuosus* is

Fig. 11. *Menuites naumanni* (Yokoyama) from the B3 Unit, Bykov Formation, along the upper course of the Victoria River. 1–2, NSM PM17268. 3, NSM PM17269. 4, NSM PM17270. Different views of the same specimen are linked by the white line (same as in Figs. 12, 13, and 15). Scale bar=5 cm.

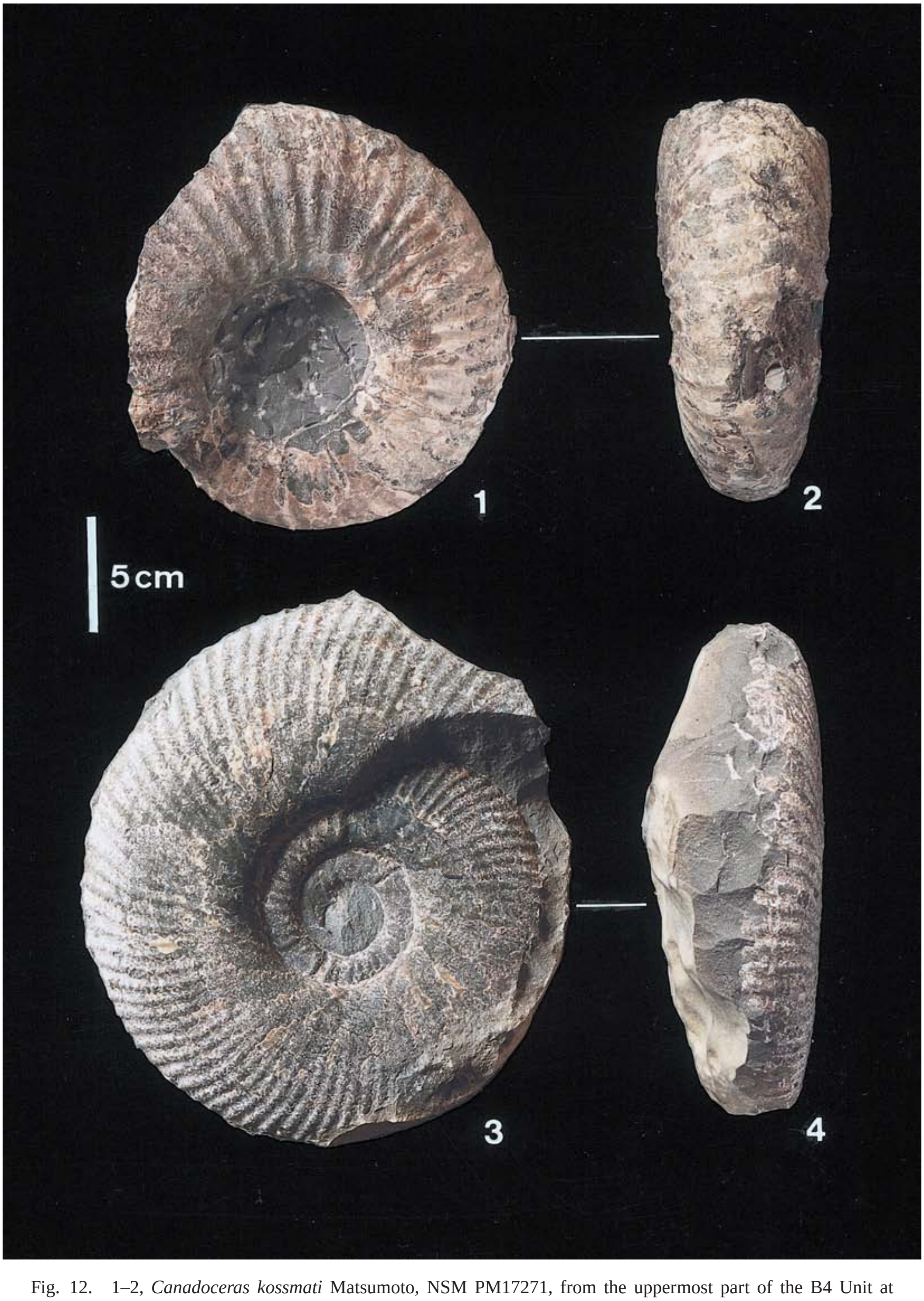

Fig. 12. 1–2, *Canadoceras kossmati* Matsumoto, NSM PM17271, from the uppermost part of the B4 Unit at Loc. MK4008. 3–4, *Canadoceras multicostatum* Matsumoto, NSM PM17272, from the basal part of the K1 Unit at Loc. MK2014. Scale bar = 5 cm.

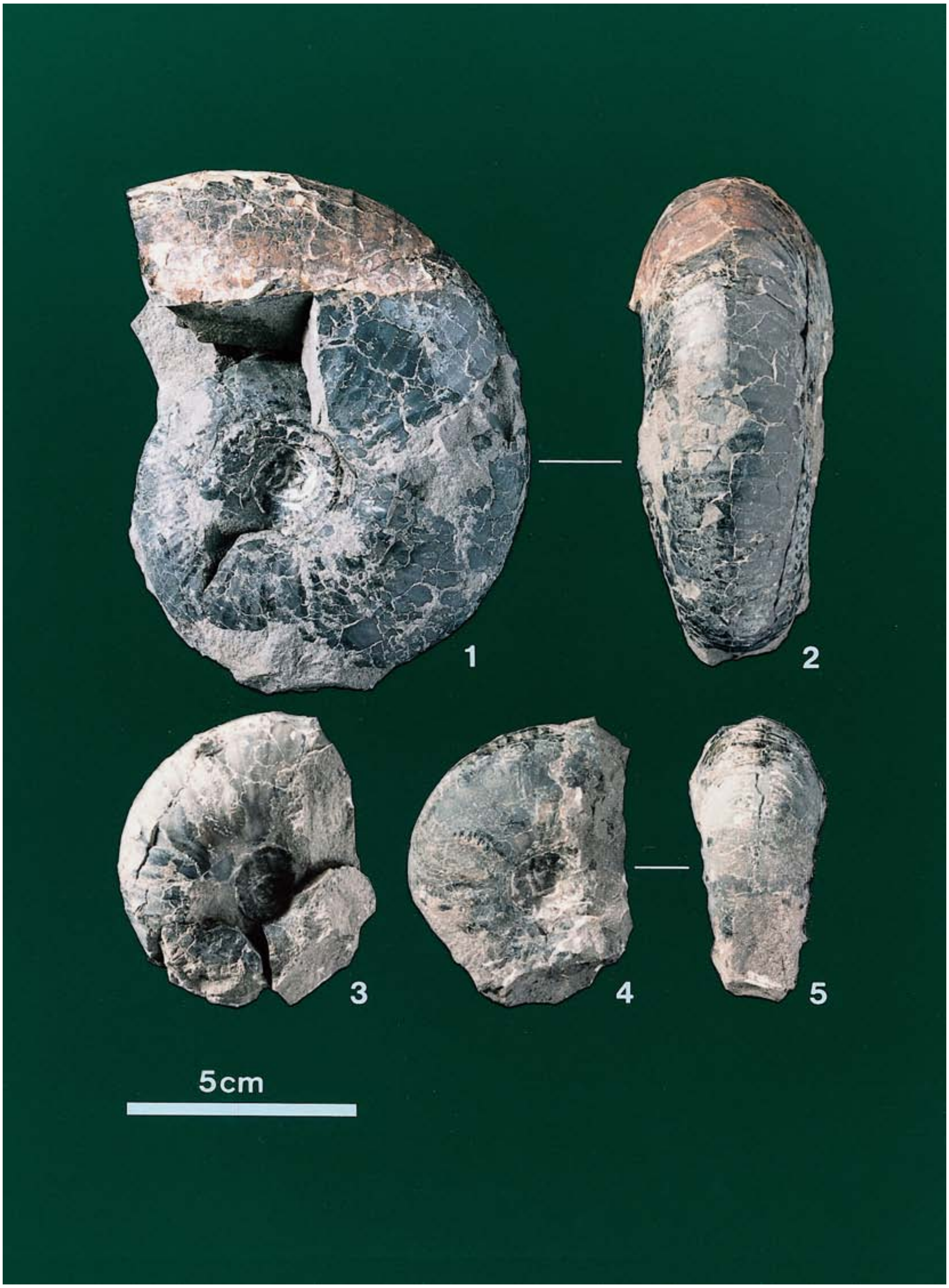

Fig. 13. 1–2, *Menuites soyaensis* (Matsumoto and Miyauchi), NSM PM17273, from the basal part of the K1 Unit at Loc. MK2014. 3–5, "*Pseudomenuites*" sp. from the same locality as *Menuites soyaensis*. 3, NSM PM17274. 4–5, NSM PM17275. Scale bar = 5 cm.

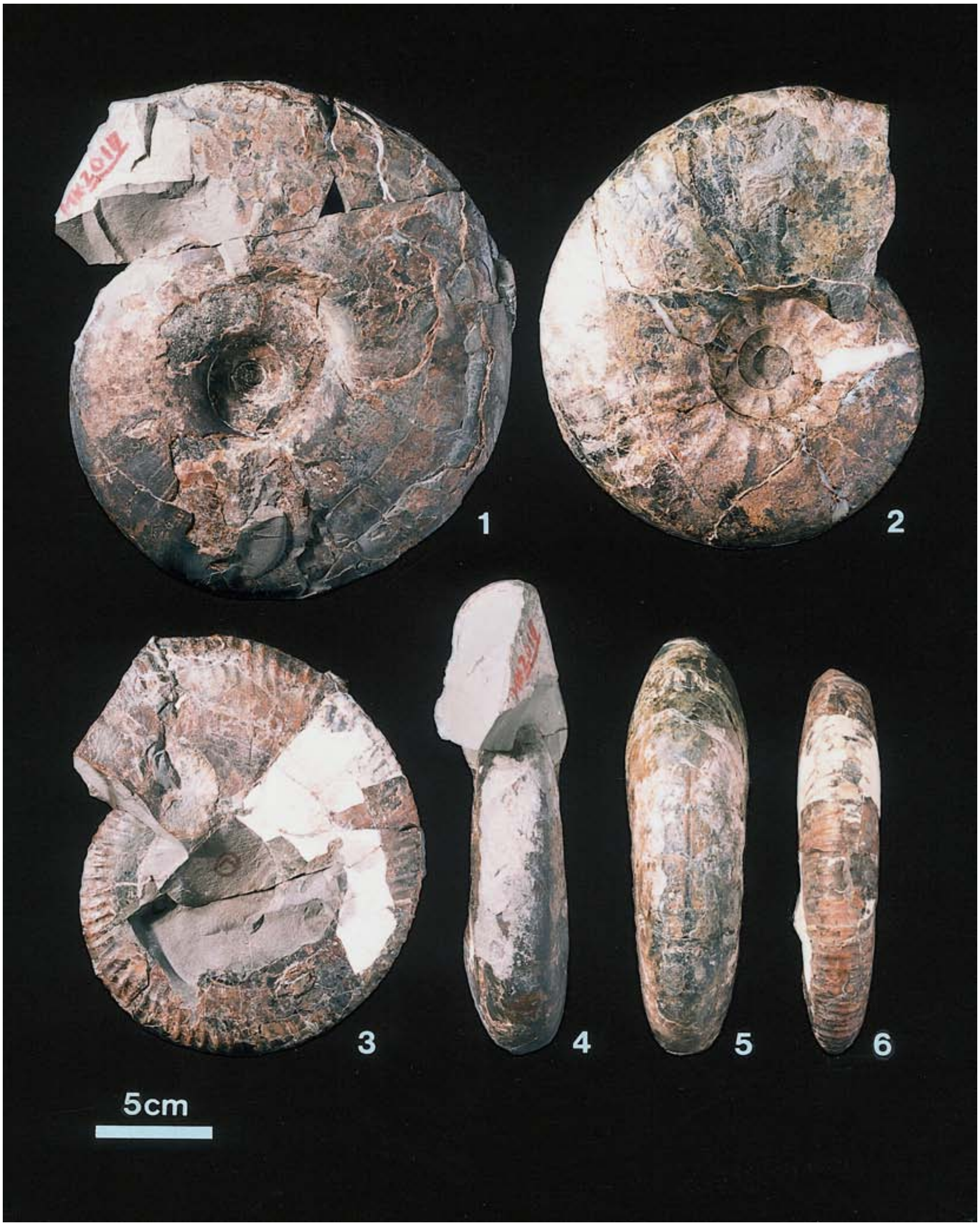

Fig. 14. Comparison of three Maastrichtian species of *Pachydiscus* from Sakhalin. 1, 4, *Pachydiscus gracilis* Matsumoto, NSM PM17276, from the K2 Unit at Loc. MK4017. 2, 5, Strongly ribbed morphotype of *Pachydiscus flexuosus* Matsumoto, NSM PM17277, from the Krasnoyarka Formation at Loc. PC1002 along the Pugachevka River, Pugachevo area (Maeda & Shigeta, 2005). 3, 6, *Pachydiscus subcompressus* Matsumoto, DGMKU specimen, from the Krasnoyarka Formation at Loc. NB7024 along the Seim River, Naiba area (this specimen is figured in Kodama *et al.*, 2002, p. 378, fig. 8H). Note that *P. subcompressus* has a compressed discoidal shell whose sides are flat and parallel, and fine costae which are independent of the umbilical bullae. *P. flexuosus* shows a wide morphological variation. The strongly ribbed morphotype in the middle growth stage (2, 5) could be mistakenly identified as *Canadoceras*. Scale bar=5 cm.

Fig. 15. Upper Maastrichtian ammonoids from the K3 Unit along the Victoria River. 1, 2, 4, 5, *Pachydiscus flexuosus* Matsumoto. 1, NSM PM17278, from Loc. MK4029. 2, DGMKU specimen, from Loc. MK4028. 4–5, NSM PM17279, from Loc. MK4030. 3, *Gaudryceras makarovense* Shigeta and Maeda, sp. nov., NSM PM17206, paratype, from Loc. MK4030. Each scale bar=5 cm. Upper scale bar—1, 2, 4 and 5; lower scale bar—3.

normally indicative of the lower Upper Maastrichtian stage (Matsumoto *et al.*, 1979; Toshimitsu *et al.*, 1995), but its stratigraphic range is apparently much greater than we formerly anticipated.

The geological age of the K4a and K4b subunits remains uncertain because no direct, age diagnostic evidence has been found. The Sinegorsk Fauna, which would apparently suggest a Danian age (Kalishevich & Posylny, 1958; Kalishevich *et al.*, 1981; Poyarkova, 1987), was not found during this study.

Among the calcareous nannofossils found in the B3 and B4 units, *Repagulum parvidentatum* is the most common. The occurrence of this normally high latitude index species suggests that the B3 and B4 units were deposited during Campanian time under the influence of cold water conditions (Crux, 1991).

Discussion

The significance of the Cretaceous section in the Makarov area (Makarov section) can be summarized as follows.

1) A fossiliferous section in the northern part of southern Sakhalin, ranging in age from Santonian to Maastrichtian has been discovered.

2) A complete succession of the *Sphenoceramus schmidti* Zone, which is rarely found in other areas, is documented.

3) The mode of occurrence of a characteristic Maastrichtian fossil assemblage represented by *Pachydiscus flexuosus* is documented.

The Position of the Makarov section in the "Yezo Basin"

The sedimentary features of the Cretaceous Yezo Group (=Supergroup) are similar throughout southern Sakhalin and the eastern central zone of Hokkaido: e.g., Wakkanai (Matsumoto & Miyauchi, 1984), Nakatonbetsu (Matsumoto *et al.*, 1980; Ando *et al.*, 2001), Hidaka (Obata *et al.*, 1973; Kawaguchi & Kanie, 1985) and Urakawa areas (Kanie, 1966). Monotonous mudstone facies, indicative of a deep offshore environment, predominate throughout the main part of the group. Then, the mudstone facies gradually give way to a shallowing-upward sequence in both Sakhalin and Hokkaido. Such remarkable sedimentary continuity and uniformity are characteristic of the deposits in the extensive "Yezo Basin" (see Shigeta & Maeda, 2005 in this volume).

Although slight differences exist at certain localities, a regressive deltaic facies finally appears in the uppermost part of the group (approx. the Lower Campanian stage) at many places in Hokkaido (Matsumoto, 1954; Maeda, 1986; Takahashi *et al.*, 2003 etc.). Sedimentation becomes intermittent because of erosion by strong wave and current action, and certain fossil zones of the Campanian–Maastrichtian stage are not recorded there.

In contrast, the typical deltaic facies consisting of a series of coarsening-upward sequences does not appear in the Krasnoyarka Formation except in the uppermost part in southern Sakhalin. In this area, marine sedimentation appears to be continuous even in the regressive phase of Campanian–Maastrichtian age. This facies may be the result of deposition under a much deeper and quieter environment than that in Hokkaido. Therefore, stratigraphic and faunal successions are exceptionally well preserved in southern Sakhalin (Matsumoto, 1942d, 1954; Poyarkova, 1987; Shigeta *et al.*, 1999; Kodama *et al.*, 2002).

The lithology of the Cretaceous strata in the Makarov area is similar in detail to that of the type section in the Naiba area (Poyarkova, 1987; Kodama *et al.*, 2002). For example, in the Naiba section the lithological transition from the Bykov Formation to the overlying Krasnoyarka Formation is identical to that in the Makarov section located 200 km to the north. The succession consists of, in ascending order: 1) massive mudstone, 2) greenish gray,

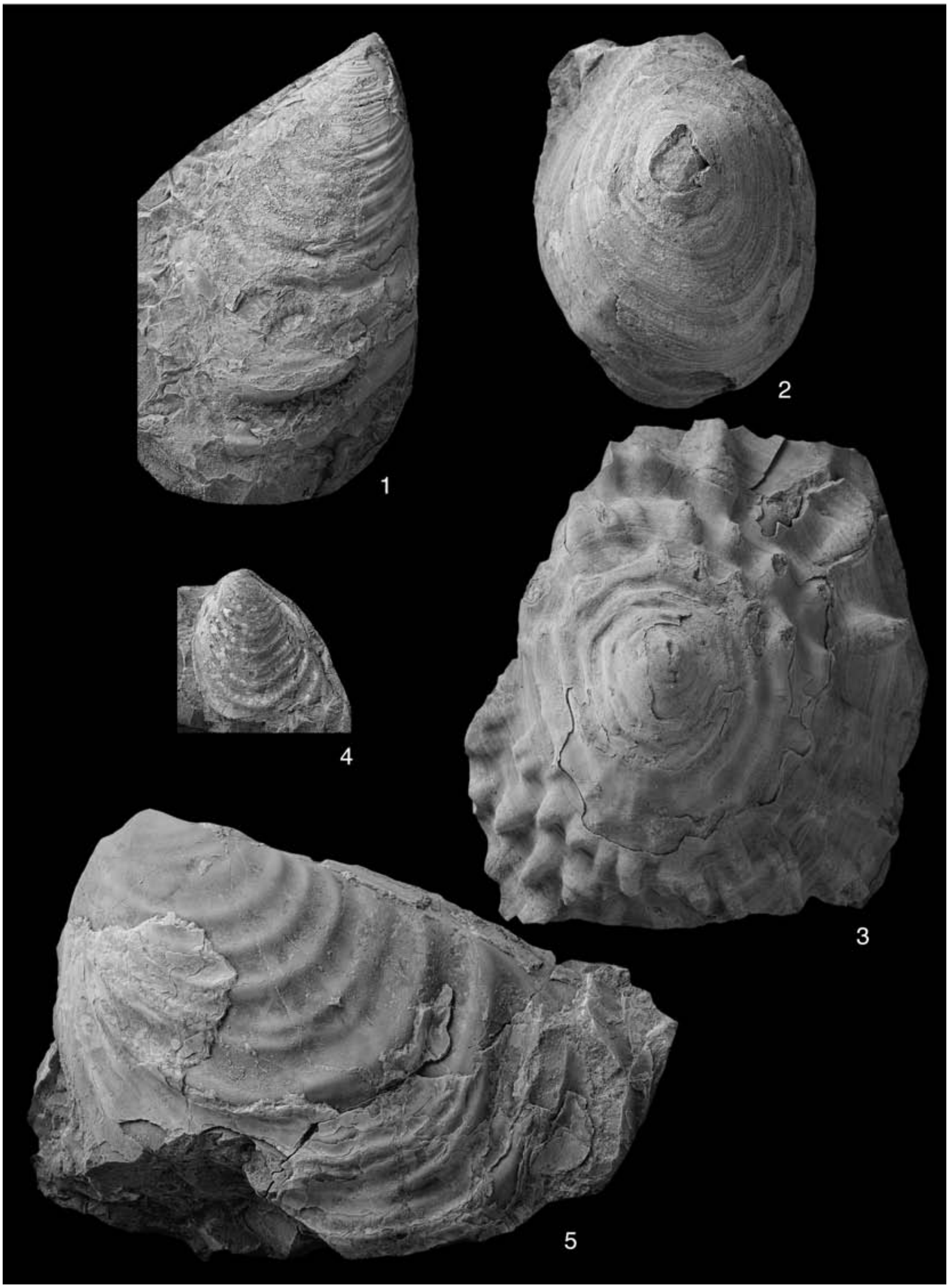

Fig. 16. 1, *Sphenoceramus nagaoi* (Matsumoto and Ueda), NSM PM17280, from the B3 Unit at Loc. MK2008, ×1.0. 2, *Anisomyon cassidarius* (Yokoyama), NSM PM17281, from the B3 Unit at Loc. MK2008, ×1.0. 3, "*Gigantocaplus*" *transformis* (Dundo), NSM PM17282, from the uppermost part of the B3 Unit at Loc. MK2062, ×1.0. 4–5, *Sphenoceramus orientalis* (Sokolov), from the uppermost part of the B3 Unit at Loc. MK2062. 4, NSM PM17283, ×1.0. 5, NSM PM17284, ×1.0.

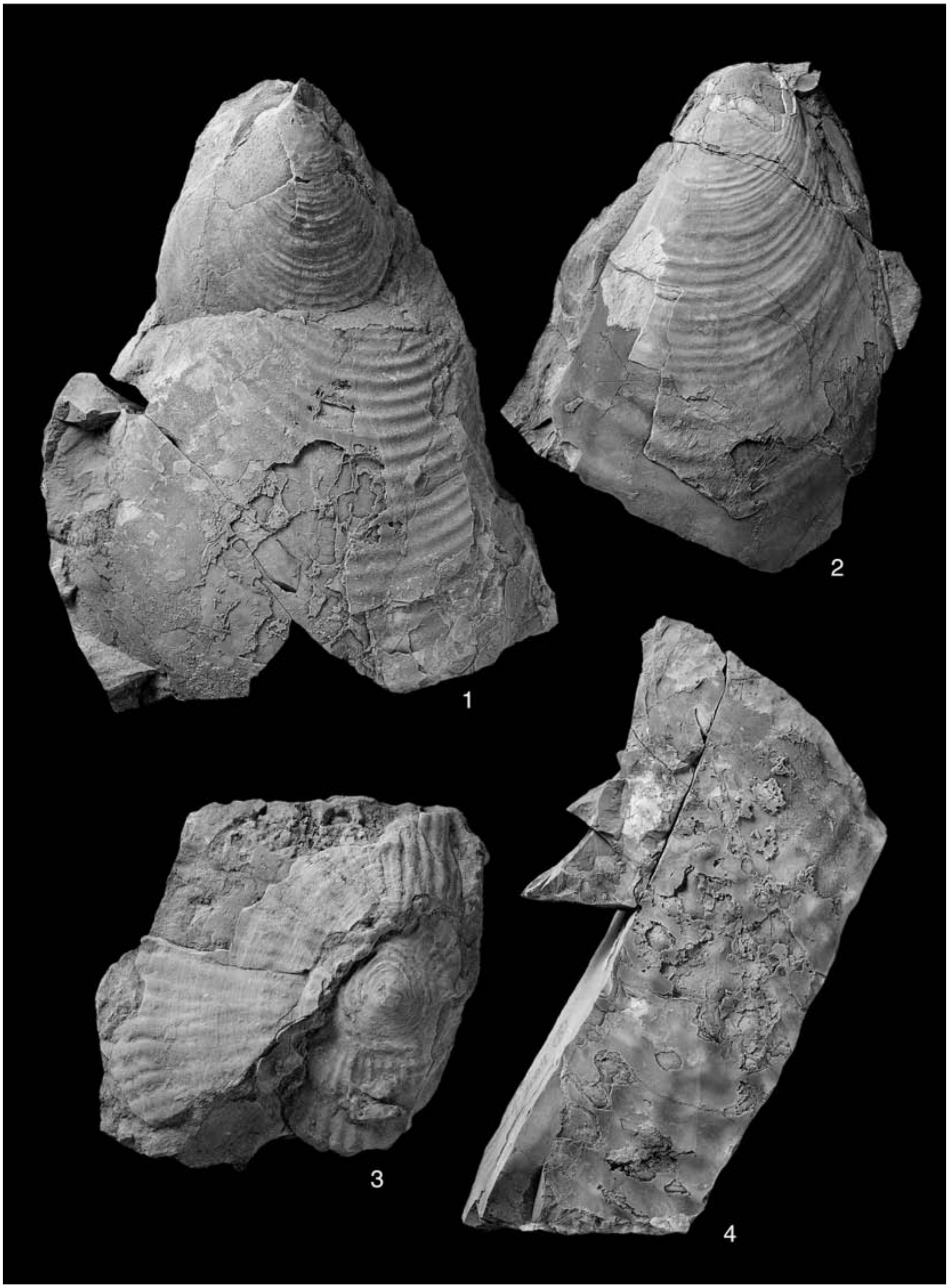

Fig. 17. 1, 2, 4, *Sphenoceramus schmidti* (Michael), from the B4 Unit at Loc. MK2009. 1, NSM PM17285, from the upper part of the *S. schmidti* Zone, ×0.4. 2, NSM PM17286, from the upper part of the *S. schmidti* Zone, ×0.4. 4, NSM PM17288, from the basal part of the *S. schmidti* Zone, ×0.4. 3, *Gigantocaplus giganteus* (Schmidt), NSM PM17287, from the basal part of the B4 Unit (=basal part of the *S. schmidti* Zone) at Loc. MK2009, ×0.4.

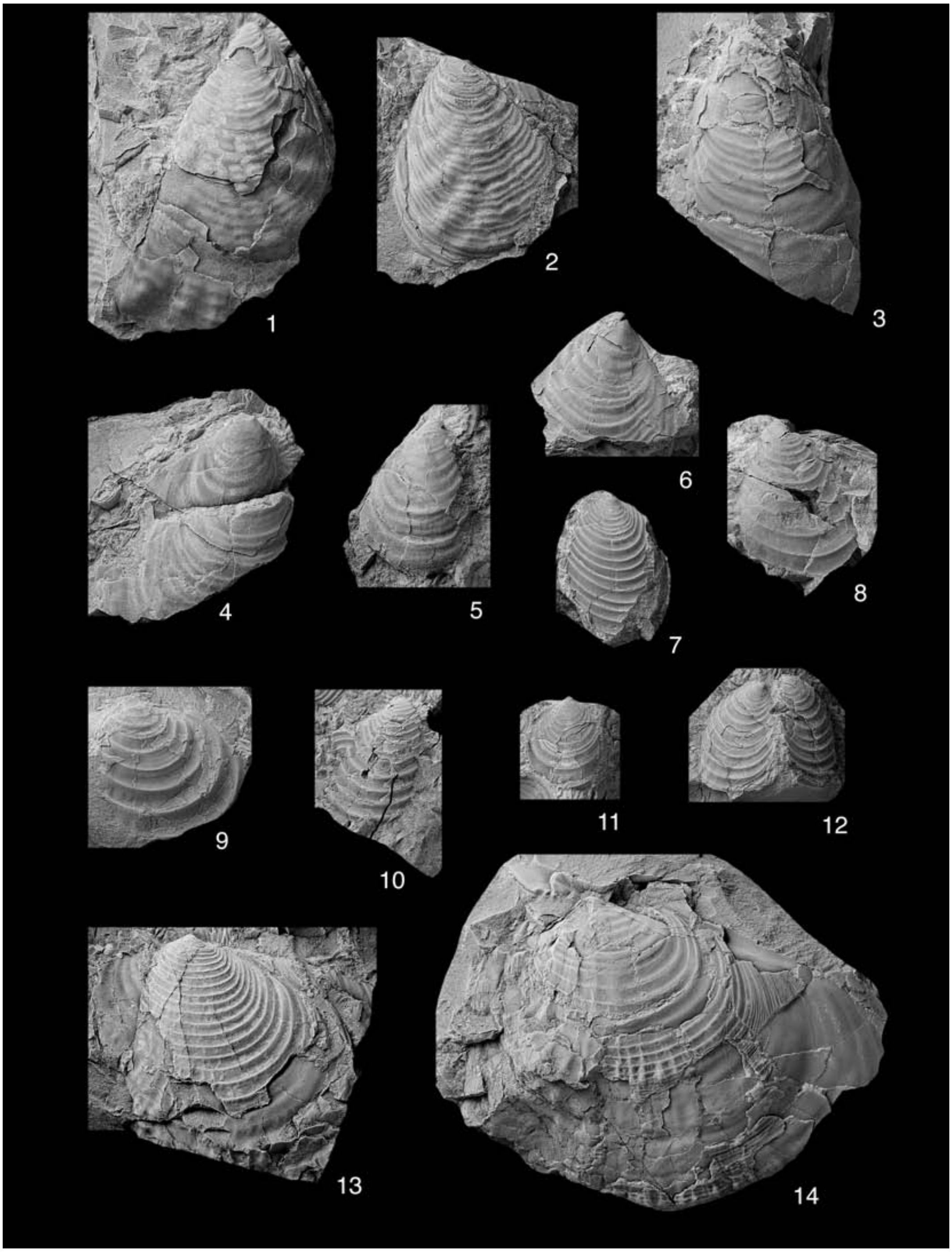

Fig. 18. 1–3, *Sphenoceramus schmidti* (Michael), from the basal part of the B4 Unit at Loc. MK2009. 1, NSM PM17289, ×1.0. 2, NSM PM17290, ×1.0. 3, NSM PM17291, ×1.0. 4–6, *Sphenoceramus hetonaianus* (Matsumoto), from the K2 Unit at Loc. MK2021. 4, NSM PM17292, ×1.0. 5, NSM PM17293, ×1.0. 6, NSM PM17294, ×1.0. 7–12, *Shahmaticeramus shahmati* (Salnikova and Zonova) from the K2 Unit. 7, NSM PM17295 from Loc. MK2021, ×1.0. 8, NSM PM17296 from Loc. MK2021, ×1.0. 9. NSM PM17297 from Loc. MK4016, ×1.0. 10. NSM PM17298 from Loc. MK4018, ×1.0. 11. NSM PM17299 from Loc. MK4018, ×1.0. 12. NSM PM17300 from Loc. MK4018, ×1.0. 13, 14, *Shahmaticeramus kusiroensis* (Nagao and Matsumoto) from the K2 Unit at Loc. MK4018. 13, NSM PM17301, ×1.0. 14, NSM PM17302, ×1.0.

mottled muddy sandstone containing many calcareous nodules, 3) dark greenish-gray, poorly sorted, bedded coarse sandstone composed of andesitic volcaniclasts, and 4) alternating beds of greenish gray sandstone and sandy mudstone in an upward sequence. One of the remarkable characteristics of the Yezo Group is its uniformity and continuity of lithofacies and biofacies, extending over a distance of 200 km or more along an active plate margin.

However, in spite of the lithological similarity of the Cretaceous System throughout southern Sakhalin, it is obvious that the datum planes of a few fossil zones extend across some lithostratigraphic boundaries. For example, in the Naiba section, the Lower Campanian *Sphenoceramus schmidti* Zone is intercalated in the basal part of the Krasnoyarka Formation (Matsumoto, 1942d; Zakharov *et al.*, 1984; Poyarkova, 1987; Kodama *et al.*, 2002). On the other hand, in the Makarov section, the *S. schmidti* Zone exists within the sandy mudstone of the B4 Unit of the Bykov Formation. More specifically, in the Makarov area, the FAD of *S. schmidti* is about 150 m below the base of the Krasnoyarka Formation (Figs. 5, 6). These features aptly demonstrate the important problems inherent with chronological correlation between lithofacies and biofacies.

A Complete succession of the *Sphenoceramus schmidti* Zone

Sphenoceramus schmidti is a well known and a long established fossil taxon within the Yezo Group. It usually occurs in traceable shellbeds which represent the *S. schmidti* Zone. Many workers have been interested in the various aspects of this species because of its abundant occurrence and peculiar morphology of divergent ribs, e.g., biostratigraphy (Pergament, 1974), taxonomy (Zonova, 1987; Zonova *et al.*, 1993; Tashiro *et al.*, 1995), and paleoecology (Hayami & Kanie, 1980; Tashiro *et al.*, 1995).

However, the *S. schmidti* Zone is incomplete in nearly all sections in Hokkaido and southern Sakhalin because of an increasing influx of sands during the regressive phase (discussed above). The FAD of *S. schmidti*, or the basal part of the *S. schmidti* Zone, is observable in various sections. However, the LAD of *S. schmidti*, or upper part of the *S. schmidti* Zone, is rarely preserved. The top part is not clearly recognizable, even in the Naiba section. Our studies reveal that in most cases, the so-called "*S. schmidti* Zone" discussed in various literature, actually represents only the basal part of the zone.

In contrast, the Makarov section is a rare example in which a complete, 100 m thick, succession of the *S. schmidti* Zone is preserved (Figs. 5, 6, 19). In the basal part of the *S. schmidti* Zone, the morphotype possessing diagnostic divergent ribs in the adult stage is abundant. At this level, *Gigantocapulus giganteus* is closely associated with this particular morphotype (Fig. 17; Locs. MK3003, 4005). This association of *S. schmidti* and *G. giganteus* has led us to, hypothesize that the two species lived in a symbiotic relationship, with the latter species attached to the shell-surface of the former (Hayami & Kanie, 1980). This hypothesis still appears to be valid, and our observations reveal the following two points, which will be utilized to test the principle in further studies.

1) *G. giganteus* only occurs in the basal part of the zone in association with the morphotype possessing divergent ribbing. *G. giganteus* completely disappears above the basal part of the *S. schmidti* Zone (Fig. 19).

2) Without exception, *G. giganteus* attaches itself to the lower valve of *S. schmidti*, and is always in the upside down position.

In the upper part of the *S. schmidti* Zone, smooth morphotypes, in which the divergent ribs appear only in the early growth stage, become dominant (Figs. 17, 19; discussed later). Several morphotypes, including the smooth type, were needlessly divided into several species by some authors (Pergament, 1974;

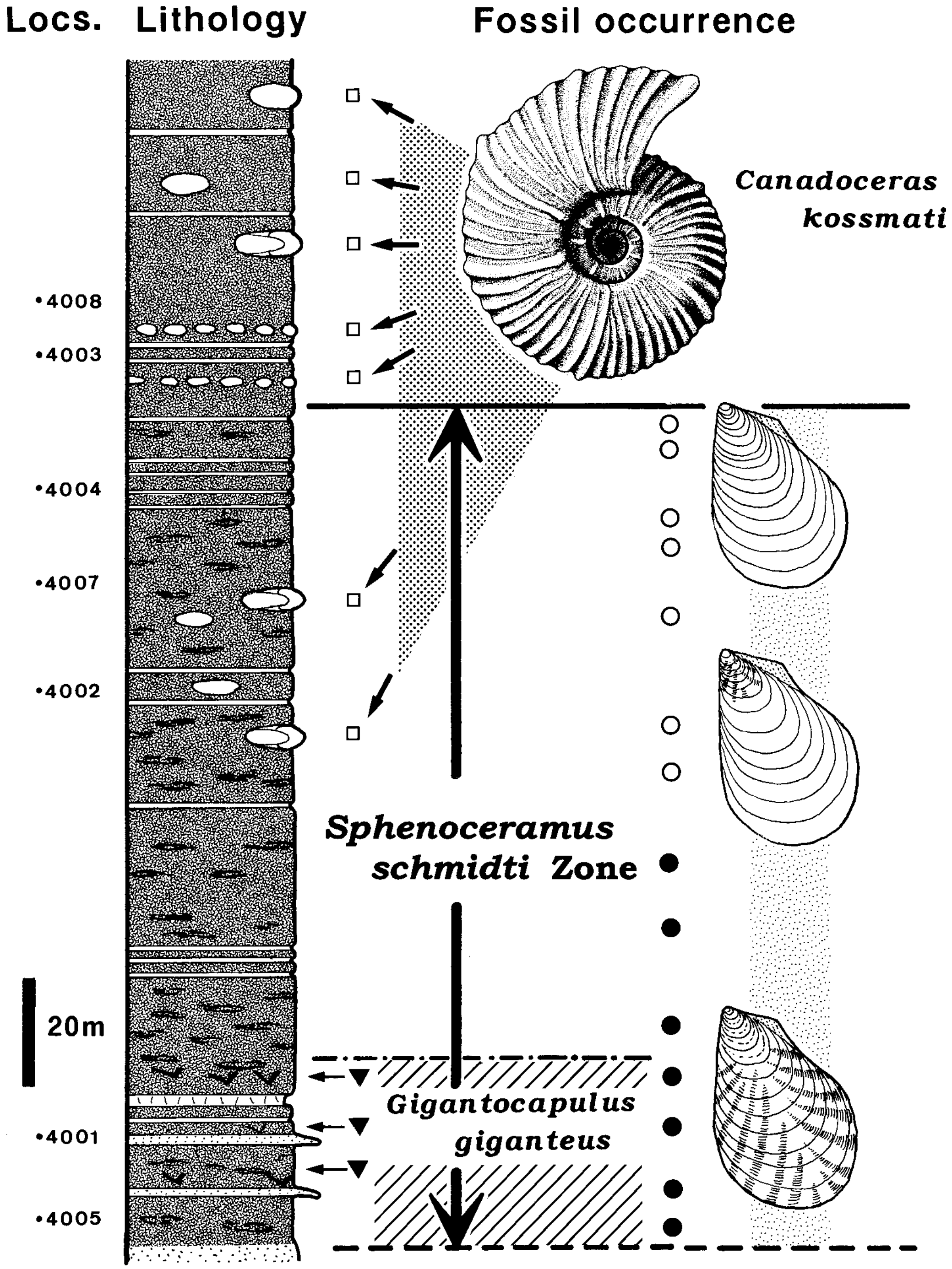

Fig. 19. Columnar section showing detailed occurrences of key species of the *Sphenoceramus schmidti* Zone in the B4 Unit of the Bykov Formation along the Victoria River. A complete succession of the *S. schmidti* Zone is well observable. Solid circle: occurrence of morphotype possessing divergent ribs in adult shells; open circle: morphotype possessing smooth adult shells. Note that *Gigantocapulus giganteus* (solid triangle) is associated only with the former morphotype, and occurs restrictedly from the basal part of the *S. schmidti* Zone.

Zonova, 1987; Zonova *et al.*, 1993). However, it is now known that *S. schmidti* exhibits a very wide range of morphological variation. The successive change of morphotypes shown in Fig. 19 can also be explained by heterochrony within a single evolutional biospecies, i.e., the timing of the appearance of divergent ribs has been ontogenetically accelerated. Therefore, we herein include all of the morphotypes within the synonymy of *S. schmidti*.

The discovery of a complete succession of the *S. schmidti* Zone in the Makarov area is very important for further research. Furthermore, Japanese workers must be mindful that a complete succession of the *S. schmidti* Zone does not exist on Hokkaido. For this reason, we attach even greater importance to the Makarov section. Failure to recognize that the *S. schmidti* Zone in Hokkaido consists of only partial successions, will merely lead to false assumptions and conclusions about the zone.

Aspects of the Maastrichtian faunas

The Maastrichtian assemblages in the Makarov area, which consist of *Pachydiscus*, *Gaudryceras*, *Linuparus*, and *Cidaris*, resemble those in the Pugachevo, Manui, and Kril'on areas in southern Sakhalin (Zonova *et al.*, 1993; Yazikova, 1994; Shigeta *et al.*, 1999) and the Nakatonbetsu and Hobetsu areas in Hokkaido (Matsumoto *et al.*, 1979, 1980; Ando *et al.*, 2001). The faunal contents are also similar to those of the Izumi Group in southwest Japan (Matsumoto & Morozumi, 1980; Morozumi, 1985). Among the various pachydiscid species, *P. flexuosus* (Fig. 15) frequently occurs in the Makarov area. Our observations reveal that *P. flexuosus* is widely distributed in Maastrichtian successions throughout southern Sakhalin and Hokkaido. *P. flexuosus* may be indigenous to the North Pacific Realm, and it has several related species.

In contrast, the well-known species *Pachydiscus subcompressus* Matsumoto occurs in the Krasnoyarka Formation in the Naiba and Sinegorsk areas (Fig. 14; Matsumoto, 1942d, 1954; Kodama *et al.*, 2002, table 3, fig. 8). However, it is not found in the Makarov area, even though several specimens mistakenly identified as *P. subcompressus* have been listed in various papers.

P. subcompressus is clearly distinguishable morphologically from *P. flexuosus* and its related species. *P. subcompressus* has very compressed whorls, whose flanks are nearly flat, and shell ornamentation is clearly distinguished by umbilical bullae and short, separate ventrolateral ribs (Fig. 14). These features closely resemble those of the European type species, *P. neubergicus* (Hauer) and the Indian species: *P. compressus* Spath (Kossmat, 1895–1898).

In the Naiba section, *P. subcompressus* is usually associated with *Zelandites varuna*, another important element of the Indian Maastrichtian fauna (Kodama *et al.*, 2002, fig. 8). This volume of evidence suggests that *P. subcompressus* is not indigenous to the North Pacific Realm, but is actually a "foreign species", which migrated northward from the Indian province.

Systematic Paleontology

(By Y. Shigeta and H. Maeda)

Abbreviations: D=shell diameter; U=umbilical diameter; H=whorl height; B=whorl width.

Suborder Phylloceratina Arkell, 1950

Superfamily Phylloceratoidea Zittel, 1884

Family Phylloceratidae Zittel, 1884

Genus ***Hypophylloceras*** Salfeld, 1924

Subgenus ***Neophylloceras*** Shimizu, 1934

Type species: *Ammonites* (*Scaphites*?) *ramosus* Meek, 1857.

Remarks: *Neophylloceras* was established by Shimizu (1934, p. 61 in Shimizu and

Obata), and has been regarded as either within the synonymy of *Hypophylloceras*, as a subgenus of *Hypophylloceras* or *Phylloceras*, or an independent genus. We herein follow Wright *et al*. (1996) and treat *Neophylloceras* as a subgenus of *Hypophylloceras*.

Hypophylloceras (***Neophylloceras***) ***victriense*** sp. nov.

Figs. 20–23

Type: Holotype, NSM PM17171, is from Loc. MK4018 along the Victoria River, and consists mostly of the phragmocone of a large shell.

Material (*Paratypes*): Three specimens, NSM PM17172–17174, from Loc. MK4016, and three specimens, NSM PM17175–17177, from Loc. MK4018 along the Victoria River.

Diagnosis: Very involute, large-sized *Neophylloceras* with compressed whorl section and nearly smooth or very weak ribs on later whorls. Suture is as for *Neophylloceras*.

Dimensions: See Table 4.

Description: Early whorls (up to 20 mm in diameter). Involute shell characterized by a very narrow umbilicus with a very steep umbilical wall, and a compressed oval whorl section with gently rounded flanks and rounded venter, with the greatest width occurring at mid-flank. Ornamentation consists of fine, dense, lirae, which arise at the umbilical seam, sweep gently forward across the inner flank, and then pass straight across the mid-flank and venter.

Middle and later whorls (over 20 mm in diameter). As size increases, the whorl section becomes more compressed, with nearly parallel flanks and rounded venter, with the greatest width occurring at mid-flank. The umbilicus is narrow with a very steep wall and abruptly rounded shoulder. On later whorls the lirae gradually become distant, barely raised ribs, while the internal mold becomes almost smooth. The suture is barely visible, but obviously consists of numerous deeply incised elements with phylloid terminals.

Comparison: *Hypophylloceras* (*Neophylloceras*) *victriense* sp. nov. closely resembles some Maastrichtian species of *Hypophylloceras* such as *H.* (*N.*) *nera* (Forbes, 1846, p. 106), *H.* (*N.*) *surya* (Forbes, 1846, p. 106) and *H.* (*N.*) *groelandicum* (Birkelund, 1965, p. 23), but it is distinguished from the latter by having very weak lirae or a nearly smooth shell surface at middle to later growth stages.

Etymology: This species is named for the Victoria River, which is the type locality.

Occurrence: The described specimens were collected from a bed in which *Sphenoceramus hetonaianus* and *Shahmaticeramus kushiroensis* occur, in the K2 Unit of the Krasnoyarka Formation in the Makarov area, Sakhalin. This level is upper Lower to lower Upper Maastrichtian.

Hypophylloceras (***Neophylloceras***) cf. ***nera*** (Forbes, 1846)

Fig. 24.1–24.4

cf. *Ammonites Nera* Forbes, 1846, p. 106, pl. 8, fig. 7.

cf. *Phylloceras nera* (Forbes). Kossmat, 1895, p. 109, 160, pl. 16, fig. 2.

cf. *Phylloceras* (*Neophylloceras*) *nera* (Forbes). Kennedy and Henderson, 1992, p. 389, pl. 1, figs. 10–12, pl. 15, figs. 1–2, text-fig. 3A; Matsumoto and Toshimitsu, 1996, p. 3, pls. 1–2.

Tabe 4. Measurements (in mm) of *Hypophylloceras victriense* Shigeta and Maeda sp. nov. at the last preserved septum.

Specimen	D	U	H	B	U/D	B/H
NSM PM17171	147.7	8.4	83.8	36.0	0.06	0.43
NSM PM17176	93.0	6.5	52.4	23.8	0.07	0.45
NSM PM17175	74.1	4.6	43.1	19.7	0.06	0.46
NSM PM17173	50.0	3.3	29.2	15.0	0.07	0.51

Fig. 20. *Hypophylloceras* (*Neophylloceras*) *victriense* Shigeta and Maeda, sp. nov. 1–4, NSM PM17171, holotype, from Loc. MK4018. Scale bar=5 cm.

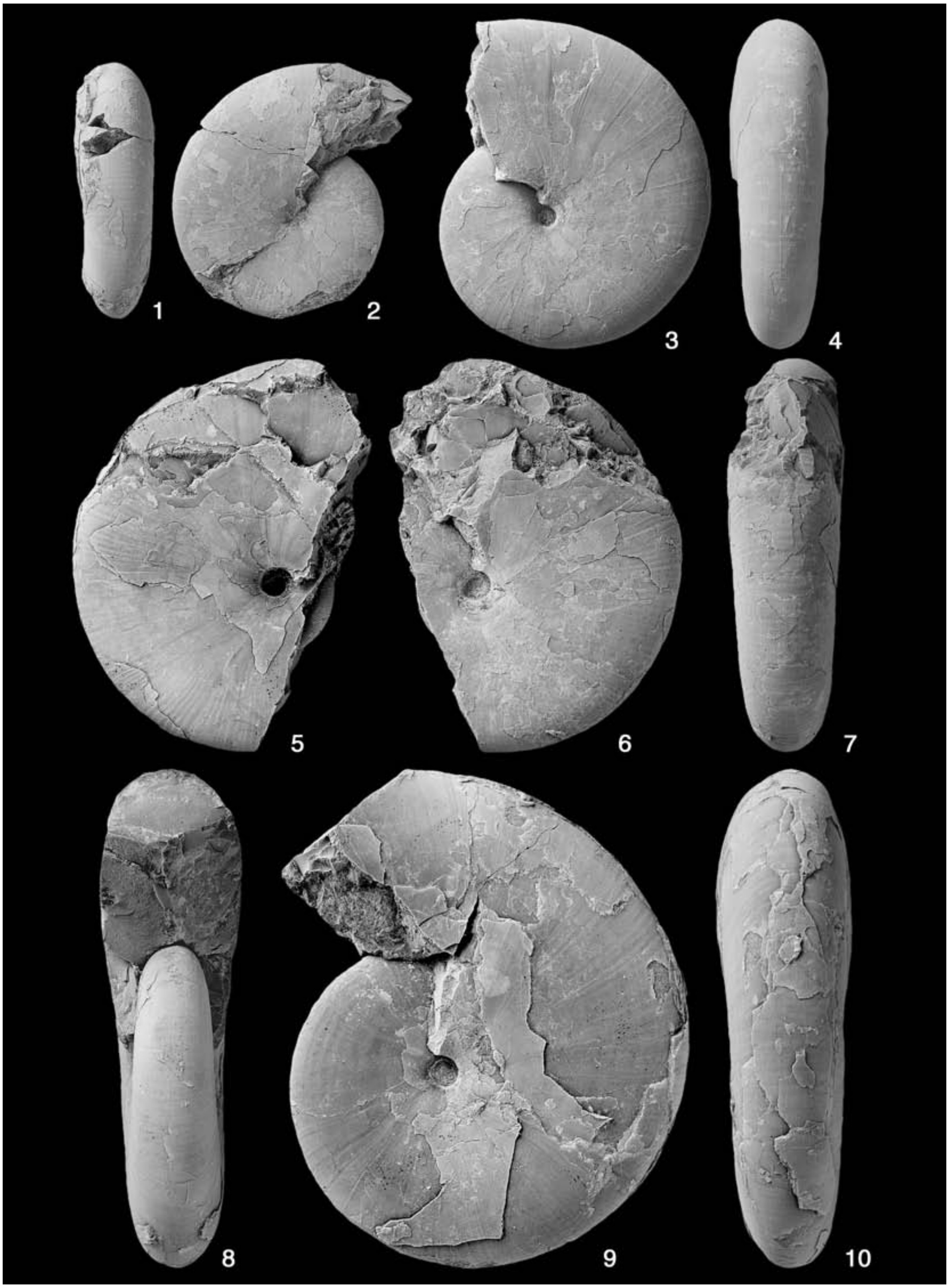

Fig. 21. *Hypophylloceras* (*Neophylloceras*) *victriense* Shigeta and Maeda, sp. nov. 1–2, NSM PM17172, paratype, from Loc. MK4016, ×1.0. 3–4, NSM PM17173, paratype, from Loc. MK4016, ×1.0. 5–7, NSM PM17174, paratype, from Loc. MK4016, ×1.0. 8–10, NSM PM17175, paratype, from Loc. MK4018, ×1.0.

Fig. 22. *Hypophylloceras* (*Neophylloceras*) *victriense* Shigeta and Maeda, sp. nov. 1–4, NSM PM17176, paratype, from Loc. MK4018, ×1.0.

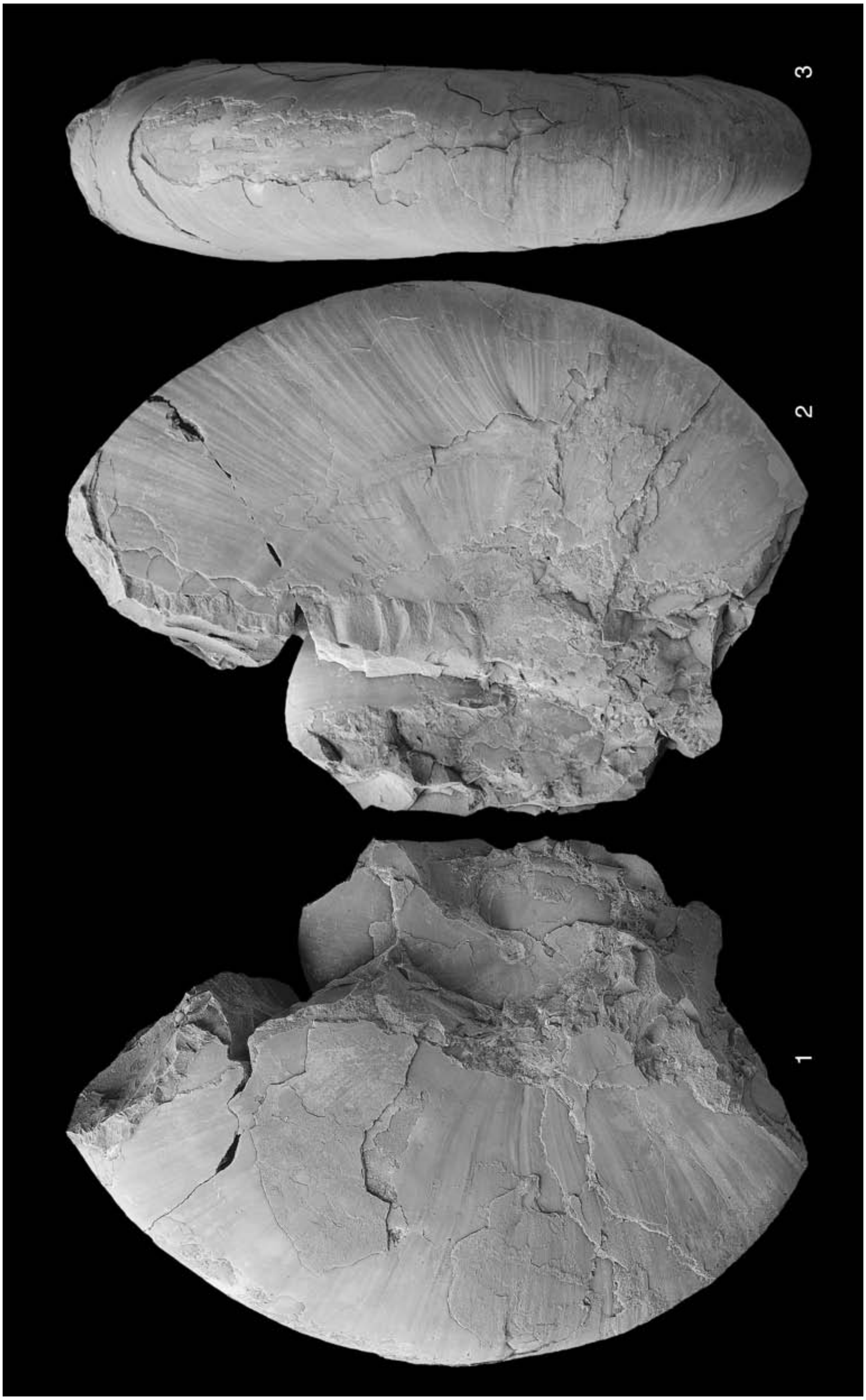

Fig. 23. *Hypophylloceras* (*Neophylloceras*) *victriense* Shigeta and Maeda, sp. nov. 1–3, NSM PM17177, paratype, from Loc. MK4018, ×0.7.

Material: Two specimens, NSM PM17178, 17179, from Loc. MK4016 along the Victoria River.

Description: Very involute shell distinguished by a compressed oval whorl section with nearly parallel flanks and rounded venter, with the greatest width occurring at mid-flank. The umbilicus is narrow with a very steep wall and rounded shoulder. Ornamentation consists of fine, dense lirae, which arise at the umbilical seam, sweep gently forward across the inner flank, and then pass straight across midflanks to the venter. Flanks of inner whorls are ornamented by broad undulations.

Although the suture is not completely exposed on the present specimens, the visible portions are deeply incised and finely divided.

Discussion: *Hypophylloceras* (*Neophylloceras*) *nera* was established for a small, apparently immature specimen from the Maastrichtian of southern India. However, Matsumoto and Toshimitsu (1996) provided a revised diagnosis for the species based on three larger specimens and a smaller one collected from the *Sphenoceramus hetonaianus-Pachydiscus gracilis* Zone (upper Lower Maastrichtian) in the Hobetsu area, central Hokkaido. Consequently, the distinctive features of the present specimens enable us to identify them with reasonable confidence as *H.* (*N.*) *nera*.

Occurrence: The described specimens were found in the same bed in which *Sphenoceramus hetonaianus* occurs in the K2 Unit of the Krasnoyarka Formation in the Makarov area, Sakhalin. This level is upper Lower to lower Upper Maastrichtian.

Genus ***Phyllopachyceras*** Spath, 1925

Type species: *Ammonites infundibulum* d'Orbigny 1841.

Phyllopachyceras ezoense (Yokoyama, 1890)

Fig. 24.5–24.11

Phylloceras ezoense Yokoyama, 1890, p. 178, pl. 19, fig. 2; Yabe and Shimizu, 1921, p. 54, pl. 8, fig. 2.

Phyllopachyceras ezoense (Yokoyama). Matsumoto, 1942c, p. 674; Matsumoto and Obata, 1955, pl. 30, fig. 3; Matsumoto and Miyauchi, 1984, p. 38, pl. 10, figs. 3–4; Alabushev and Wiedmann, 1997, p. 6, pl. 1, figs. 3–5.

Type: Repository of the holotype (Yokoyama, 1890, p. 178, pl. 19, fig. 2), from the Yezo Group in the Urakawa area, south central Hokkaido, is the Bavarian State Collection of Palaeontology and Geology in Munich, Germany. Its exact collection locality and horizon are unknown.

Material: Two specimens, NSM PM17180, 17181, from Loc. MK2062 along the Acacia River. NSM PM17182, from Loc. MK2015 along the Acacia River.

Description: Very involute shell, characterized by a very narrow, deep, funnel-shaped umbilicus and a slightly inflated, sub-circular whorl section with a moderately arched venter. The greatest width occurs at mid-flank. Ornamentation consists of dense, very fine prorsiradiate lirae that cross the flanks and then become slightly sinuous on the ventrolateral shoulders, before crossing the venter in a broad convex arch. Mature whorls are ornamented by frequent, strong, rounded, prorsiradiate ribs which originate low on the flank and cross the venter in a moderately broad convex arch. The suture line is not exposed.

Occurrence: The described specimens were collected in the *Sphenoceramus orientalis* and *Canadoceras kossmati* bearing beds in the B3 and B4 units of the Bykov Formation, in the Makarov area, Sakhalin. These levels are equivalent to the upper Lower Campanian, but the species is abundant in beds of Turonian to Campanian age in Hokkaido and Sakhalin (Toshimitsu & Hirano, 2000).

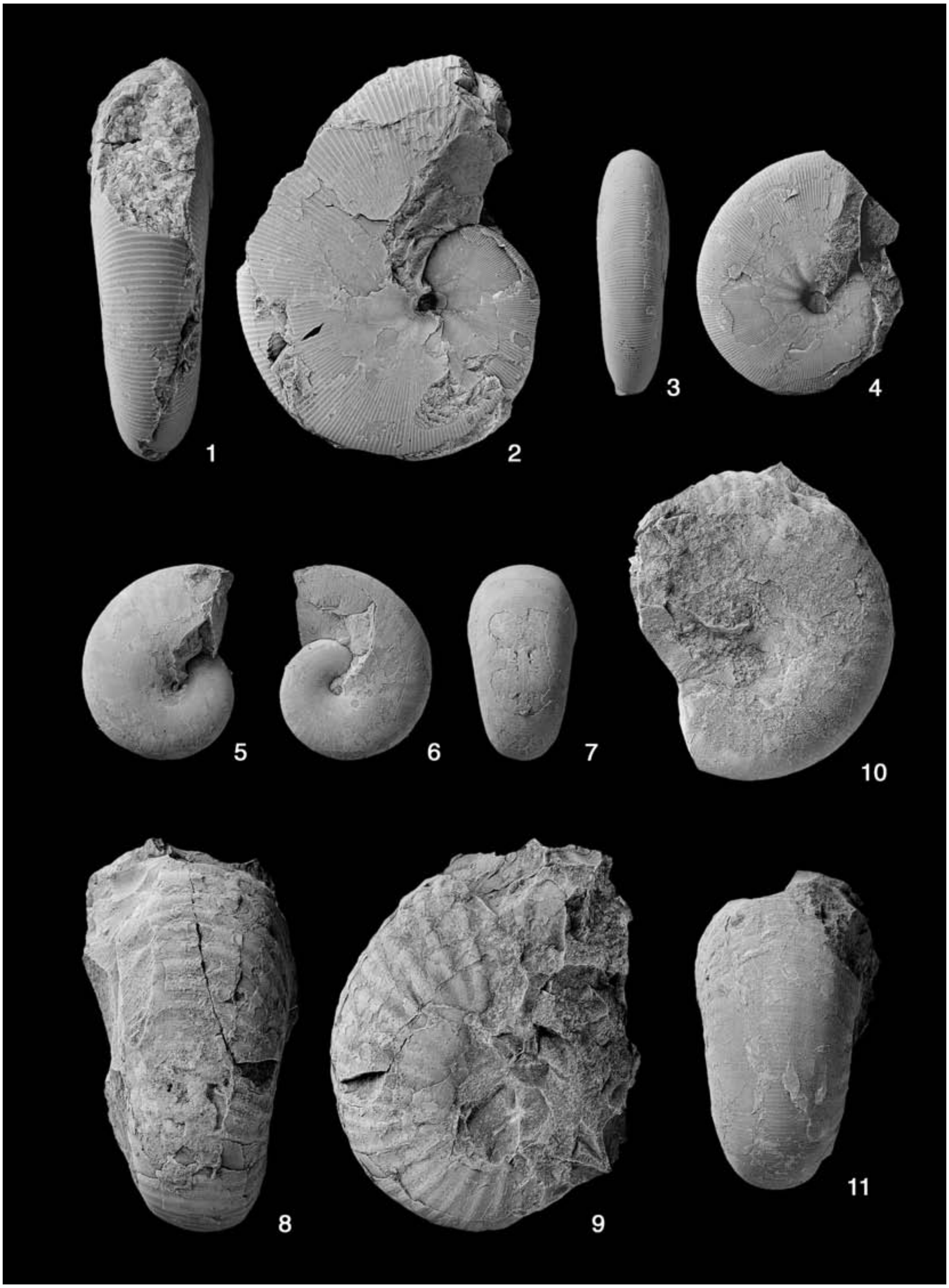

Fig. 24. 1–4, *Hypophylloceras* (*Neophylloceras*) cf. *nera* (Forbes). 1–2, NSM PM17178, from Loc. MK4016, ×1.0. 3–4, NSM PM17179, from Loc. MK4016, ×1.0. 5–11, *Phyllopachyceras ezoense* (Yokoyama). 5–7, NSM PM17180, from Loc. MK2062, ×1.0. 8–9, NSM PM17182, from Loc. MK2015, ×1.0. 10–11, NSM PM17181, from Loc. MK2062, ×1.0.

Suborder Lytoceratina Hyatt, 1889

Superfamily Tetragonitoidea Hyatt, 1990

Family Gaudryceratidae Spath, 1927

Genus ***Gaudryceras*** de Grossouvre, 1894

Type species: *Ammonites mitis* Hauer, 1866.

Gaudryceras striatum (Jimbo, 1894)
Fig. 25.1–25.3

Lytoceras striatum Jimbo, 1894, p. 181, pl. 22, fig. 6.
Gaudryceras striatum (Jimbo). Yabe, 1903, p. 31, pl. 4, fig. 5; Haggart, 1989, p. 189, pl. 8.2, figs. 1–11.
Gaudryceras striatum (Jimbo) var. *picta* Yabe, 1903, p. 33, pl. 4, fig. 6.

Type: Holotype, UMUT. MM7493 (Jimbo, 1894, p. 181, pl. 22, fig. 6), is from the Yezo Group in the Nakagawa area, northern Hokkaido. Its exact collection locality and horizon are unknown.

Material: NSM PM17183, from Loc. MK2062 along the Acacia River.

Description: Very evolute shell, characterized by a rounded but slightly depressed whorl section, with the greatest width occurring slightly below mid-flank, and a wide, shallow umbilicus with a rounded wall. The whorl sides and venter are rounded. Ornamentation consists of fine, dense lirae, which arise at the umbilical seam and become quite sinuous, approaching a sigmoidal pattern, before culminating on the venter in a broad, convex arch. Most of these lirae arise at, or just above the umbilical seam but a few are intercalated on the inner flanks. In addition to the lirae, narrow, rounded, variable close or distant, collar-like ribs, parallel to the lirae, occur on all whorls. The suture line, with large, incised, bifid lobes and saddles, is typical of gaudryceratids.

Remarks: Jimbo (1894, p. 181) provided a diagnosis of the species based on a single specimen 47 mm in diameter, and then Yabe (1903, p. 31) revised and supplemented the diagnosis with an additional specimen, 72 mm in diameter, from the type locality. The present specimen exhibits no appreciable differences from the holotype or from the inner whorl of Yabe's specimen, and it also closely matches the specimens described as *Gaudryceras striatum* by Haggart (1989) from British Columbia. As Haggart (1989) noted, Yabe's variety of *Gaudryceras striatum* var. *picta* is nearly identical to *G. striatum* in most details of morphology and ornamentation, and therefore, he included it within *Gaudryceras striatum*.

G. striatum closely resembles *G. tenuiliratum* Yabe (1903, p. 19), which occurs in Coniacian to lower Lower Campanian sediments of Hokkaido and Sakhalin, in size, shape and general pattern of ornamentation, but it is distinguished by its finer and denser lirae. This species is also very similar to the phragmocones of the Upper Campanian species *Gaudryceras crassicostatum* (Jimbo, 1894, p. 182) and the three Maastrichtian species *Gaudryceras hamanakense* Matsumoto and Yoshida (1979, p. 68), *Gaudryceras tombetsense* Matsumoto (1984b, p. 2) and *Gaudryceras venustum* Matsumoto (1984b, p. 5) from Hokkaido, in having not only fine lirae, but the lirae on the younger species are bifurcated and intercalated with finer and denser lirae on the outer flank and venter. Also, the lirae of the Maastrichtian species is distinctly coarser in the area of the umbilical shoulder than in *G. striatum*.

Occurrence: The described specimen was found in a bed with *Sphenoceramus orientalis* (upper Lower Campanian), just below the *Sphenoceramus schmidti* bearing bed (upper Lower Campanian) in the B3 Unit of the Bykov Formation in the Makarov area, Sakhalin. The exact horizon from which the holotype of *Gaudryceras striatum* was collected is unknown, but the species is common in the *S. orientalis* and *S. schmidti* bearing beds in Hokkaido and Sakhalin (Matsumoto, 1995). This species also occurs in the *S. schmidti* bearing bed in British Columbia, Canada.

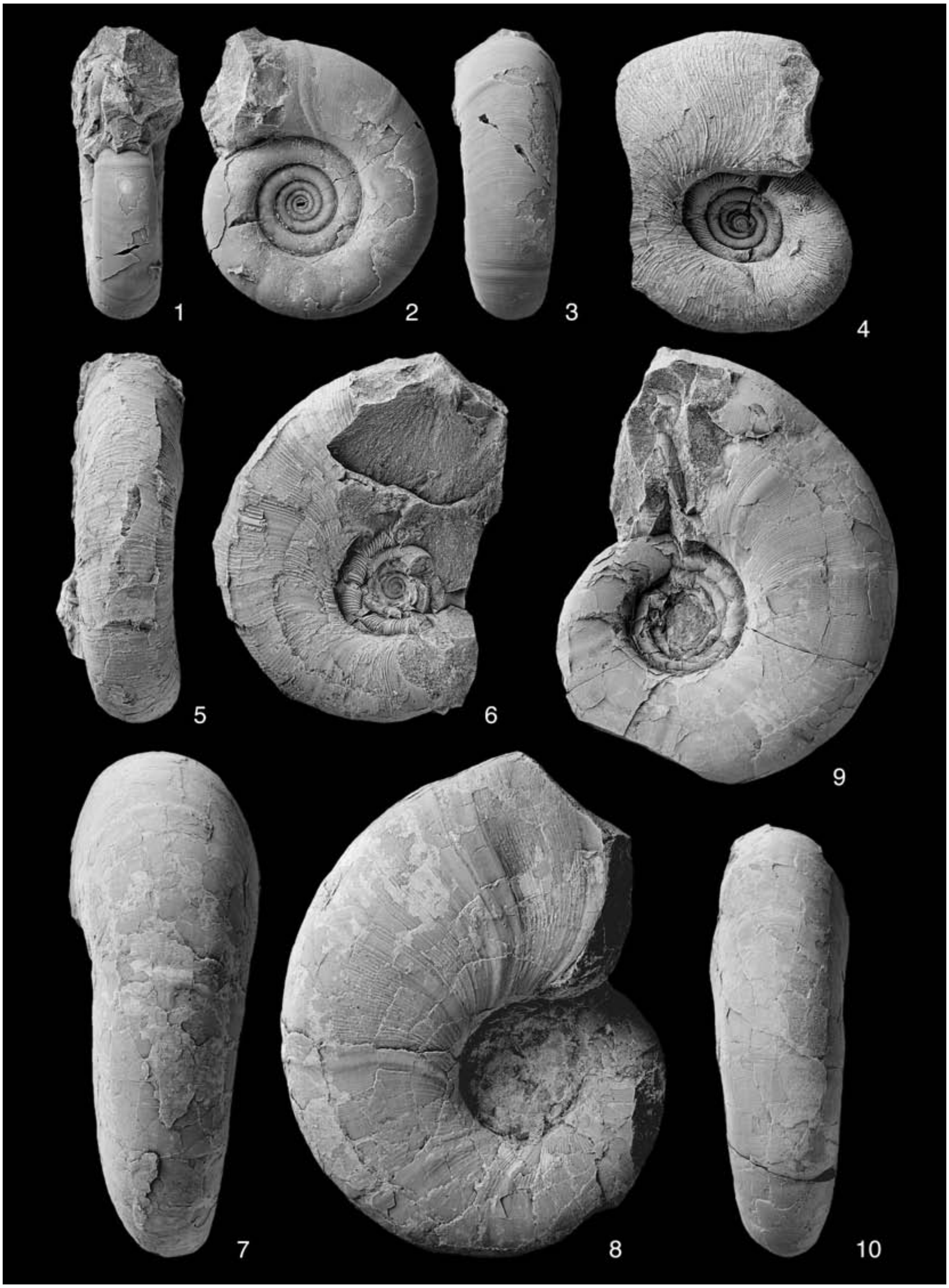

Fig. 25. 1–3, *Gaudryceras striatum* (Jimbo), NSM PM17183, from Loc. MK2062, ×1.0. 4–6, *Gaudryceras* cf. *mamiyai* Matsumoto and Miyauchi. 4, NSM PM17184, from Loc. MK2015, ×1.0. 5–6, NSM PM17185, from Loc. MK2015, ×1.0. 7–10, *Gaudryceras crassicostatum* (Jimbo). 7–8, NSM PM17186, from Loc. MK2014, ×1.0. 9–10, NSM PM17187, from Loc. MK2014, ×1.0.

Gaudryceras mamiyai Matsumoto and Miyauchi, 1984

Fig. 26.1, 26.2

Gaudryceras mamiyai Matsumoto and Miyauchi, 1984, p. 55, pl. 24, fig. 1.

Type: Holotype, GK. H5974 (Matsumoto & Miyauch, 1984, p. 55, pl. 24, fig. 1), is from the Upper Campanian beds around the fishing harbor of Kiyohama-II in the Soya area, northern Hokkaido.

Material: NSM PM17188, from Loc. MK-2009 along the Acacia River. This specimen, consisting of a somewhat crushed phragmocone and a portion of the body chamber, is 107 mm in diameter at the last preserved septum. If complete it would approach 160 mm in diameter.

Description: During the early growth stage the shell is evolute with slowly expanding whorls and a rounded, slightly depressed whorl section, but as growth approaches maturity it becomes moderately evolute with rapidly expanding whorls and a somewhat compressed whorl section. The umbilicus is of medium size with a steep umbilical wall.

Ornamentation on the phragmocone consists of fine, slightly distant, raised ribs, which originate just above the umbilical seam and become moderately sinuous, approaching a sigmoidal pattern, before culminating on the venter in a moderately broad, convex arch. A few of these ribs branch and intercalate at a point low on the umbilical shoulder. Body chamber ornamentation also consists of sinuous ribs that tend toward a sigmoidal form, but they are more distinct and slightly more distant than those on the phragmocone. Most of the ribs are sharply raised with a gently sloping adoral face and an abrupt, very steep adapical face, and quite frequently some of them are of such size and intensity that they have the appearance of major ribs.

The suture line is only partly exposed but large, incised, bifid lobes and saddles typical of gaudryceratids are visible.

Remarks: *Gaudryceras mamiyai* closely resembles *Gaudryceras denmanense* Whiteaves (1901, p. 32) from the Upper Campanian of British Columbia and southeast Alaska in having narrowly raised ribs, but it is distinguished from the latter by having more frequent major ribs on the adult body chamber. This species is also similar to *Gaudryceras tenuiliratum* Yabe (1903, p. 19), of Coniacian to Campanian age from Hokkaido and Sakhalin, in shell shape and general configuration of ornament, but it is clearly distinguished from the latter by having coarser ribs.

Occurrence: The described specimen was found in a bed associated with *Spenoceramus schmidti* (upper Lower Campanian) in the B4 Unit of the Bykov Formation in the Makarov area, Sakhalin, while the holotype of *Gaudryceras mamiyai* was found in a calcareous nodule of greenish, dark grey, sandy siltstone, in a pile of dredged rocks immediately northeast of the fishing harbor of Kiyohama-II in the Soya area, northern Hokkaido. The exact horizon from which the nodule came is uncertain, but judging from its locality and lithology, the holotype probably came from the bed in which *Schlueterella kawadai* (Upper Campanian) occurs. Shigeta *et al.* (1999) reported the occurrence of *Gaudryceras* cf. *mamiyai* from the *S. schmidti* bearing bed along the Kura River in the Kril'on Peninsula, southern Sakhalin.

Gaudryceras cf. **_mamiyai_** Matsumoto and Miyauchi, 1984

Fig. 25.4–25.6

cf. *Gaudryceras mamiyai* Matsumoto and Miyauchi, 1984, p. 55, pl. 24, fig. 1.

Material: Two specimens, NSM PM17184, 17185, from Loc. MK2015 along the Acacia River. Both specimens are partly deformed.

Description: Evolute shell, with a somewhat depressed whorl section during early growth stage but becoming slightly compressed as diameter increases. The umbilicus is broad and shallow, with a steep initial wall

Fig. 26. 1–2, *Gaudryceras mamiyai* Matsumoto and Miyauchi, NSM PM17188, from Loc. MK2009, ×0.75. 3, *Gaudryceras tombetsense* Matsumoto, NSM PM17196, from Loc. MK4015, ×0.75.

and broadly rounded shoulder. Flanks are slightly rounded and venter is broadly rounded. Ornamentation consists of fine, dense lirae, which arise at the umbilical seam, become sinuous, approaching a sigmoidal pattern, and sweep across the venter in a broad, convex arch. A few lirae branch at or just above the umbilical seam, while several intercalate on the flank. The suture line is not exposed.

Discussion: Although the present specimens are partly deformed, their distinctive features enable us to identify them with reasonable confidence as *Gaudryceras mamiyai*.

Occurrence: The present specimens were collected from a bed in which *Canadoceras kossmati* (upper Lower Campanian) occurs, just below the *Schlueterella kawadai* bearing bed (Upper Campanian) in the uppermost part of the B4 Unit of the Bykov Formation in the Makarov area, Sakhalin.

Gaudryceras crassicostatum (Jimbo, 1894)

Fig. 25.7–25.10

Lytoceras crassicostatum Jimbo, 1894, p. 182, pl. 22, fig. 7.

Gaudryceras crassicostatum (Jimbo). Yabe, 1903, p. 29, pl. 4, fig. 4; Matsumoto, 1984b, p. 6, pl. 4, figs. 1–3, pl. 5, figs. 1–2; Matsumoto *et. al.*, 1985, p. 20, pl. 1, figs. 1–3, pl. 2, figs. 1–4, pl. 3, figs. 7–10.

Type: Holotype, UMUT. MM7492 (Jimbo, 1894, p. 182, pl. 22, fig. 7), is from the Yezo Group in the Soya area, northern Hokkaido. Its exact collection locality and horizon are unknown.

Material: Two specimens, NSM PM17186, 17187, from Loc. MK2014 along the Acacia River. Both specimens are slightly crushed and deformed.

Description: Evolute shell with slowly expanding whorls and a slightly compressed, but somewhat inflated whorl section. The umbilicus is broad and shallow with a steep wall and a broadly rounded shoulder. Ornamentation consists of very fine flexuous lirae, which arise at the umbilical seam and sweep over the shell in a near sigmoidal form and culminate on the venter in a broad convex arch. In addition, the ventrolateral shoulder and venter are covered with extremely fine, dense lirae resulting from multiple branching and intercalation of the normal lirae. All whorls bear moderately strong, variable close or distant, fold-like ribs that parallel the lirae. The suture lines are not preserved.

Remarks: The phragmocone of *Gaudryceras crassicostatum* is very similar to *G. striatum* (Jimbo, 1894, p. 181) from the upper Lower Campanian of Hokkaido and Sakhalin in having fine lirae and periodic ribs, but is distinguished from the latter by having numerous, much finer lirae on the venter.

Occurrence: The present specimens were associated with *Schlueterella kawadai* (Upper Campanian) in a bed in the lower part of the K1 Unit of the Krasnoyarka Formation in the Makarov area, Sakhalin. *Gaudryceras crassicostatum* has also been reported from the *S. kawadai* bearing bed in the Naiba area, southern Sakhalin, and the Soya area, northern Hokkaido.

Gaudryceras tombetsense Matsumoto, 1984b

Figs. 26.3, 27–31

Gaudryceras tombetsense Matsumoto, 1984b, p. 2, pl. 1, figs, 1–2, pl. 2, figs. 1–4; Shigeta *et al.*, 1999, pl. 6, fig. 1.

Gaudryceras hamanakense Matsumoto and Yoshida. Yazykova, 1992, p. 196, pl. 111, figs. 1–2; Yazikova, 1994, p. 292, pl. 3, figs. 2–3.

Gaudryceras denmanense Whiteaves. Yazykova, 1993, p. 153, pl. 88, fig. 2; Yazikova, 1994, p. 291, pl. 6, fig. 3.

Type: Holotype, GK. H5991 (Matsumoto, 1984b, p. 2, pl. 1, figs. 1–2), is from the Yezo Group in the Nakatombetsu area, northern Hokkaido.

Material: NSM PM17262, from Loc. MK-2022 along the Acacia River. Seven specimens, NSM PM17189–17195, from Loc. MK-4014, and seven specimens, PM17196–17202, from Loc. MK4015 along the Victoria River.

Description: Early whorls (up to 50 mm). Very evolute shell, characterized by a moderately inflated whorl section with rounded sides and venter, and a wide, shallow umbilicus with a rounded wall. Ornamentation consists of very fine, dense, slightly sinuous lirae, which arise at the umbilical seam and pass over the venter in a broad convex arch. Bifurcation and intercalation of the lirae occurs on the umbilical shoulder and lower flank. Each whorl has variable close or distant, rounded, collar-like or fold-like ribs, running parallel to the lirae, and each rib is immediately followed by a shallow constriction. The collar-like ribs and constrictions are covered with very fine lirae.

Middle whorls (50–100 mm in diameter). As size increases, the whorl section tends to become slightly compressed, and the umbilical width becomes smaller. The lirae gradually develop into slightly more distant, narrowly raised ribs, which increase in strength as diameter increases. These ribs follow the same pattern as on the earlier whorls but they tend to become more sinuous as diameter increases. A few ribs bifurcate at or just above the umbilical seam and a few intercalatory ribs arise on the flanks. Shallow, periodic constrictions are present, and each constriction is accompanied by an adjacent, parallel collar-like or fold-like rib.

Later whorls (over 100 mm in diameter). As the shell grows larger the whorl expansion rate increases and the whorl section becomes more compressed while the umbilical width becomes progressively smaller. As the shell matures the ribs generally become much coarser and more distant, with alternating ribs varying somewhat in intensity, and the collar-like ribs become more frequent. The suture line with its large, incised and bifid lobes and saddles is typical of gaudryceratids.

Remarks: The morphology of *Gaudryceras tombetsense* is now recognized as being distinctly different during the early, middle and later growth stages. Yazykova (1992) and Yazikova (1994) assigned a small gaudryceratid from the Maastrichtian of the Makarov area to *Gaudryceras hamanakense* Matsumoto and Yoshida (1979, p. 68), but this specimen is identical to the juvenile shell of *G. tombetsense*. Yazykova (1993) and Yazikova (1994) also assigned a large gaudryceratid of Maastrichtian age from the Nerpichya area, eastern Sakhalin, to *Gaudryceras denmanense* Whiteaves (1901, p. 32), but this specimen closely matches the adult shell of *G. tombetsense*.

Occurrence: The present specimens were collected from a bed in which *Sphenoceramus hetonaianus* occurs in the K2 Unit of the Krasnoyarka Formation in the Makarov area, Sakhalin. The holotype of *Gaudryceras tombetsense* was obtained from the lower course of the Kikusui-gawa River, a tributary of the Tombetsu River, while the paratype was collected from a float calcareous nodule in the Heitaro-zawa River, a tributary of the Tombetsu River. Both localities are in the Nakatombetsu area, northern Hokkaido. Although the exact horizon which yielded the type specimens is uncertain, judging from their respective localities and matrix lithology, they probably came from the bed in which *S. hetonaianus* (Ando *et al.*, 2001) occurs. Shigeta *et al.* (1999) reported the occurrence of this species from the *S. hetonaianus* bearing bed along the Naycha River in the Kril'on Peninsula, southern Sakhalin. *S. hetonaianus* is diagnostic of the upper Lower to lower Upper Maastrichtian.

Gaudryceras cf. ***tombetsense*** Matsumoto, 1984b

Fig. 40.1–40.3

cf. *Gaudryceras tombetsense* Matsumoto, 1984b, p. 2, pl. 1, figs. 1–2, pl. 2, figs. 1–4.

Material: NSM PM17251, from Loc. MK-4016 along the Victoria River.

Description: Very evolute shell, characterized by a slightly depressed and rounded whorl section, with the greatest width at mid-flank, and a wide, shallow umbilicus with a broadly

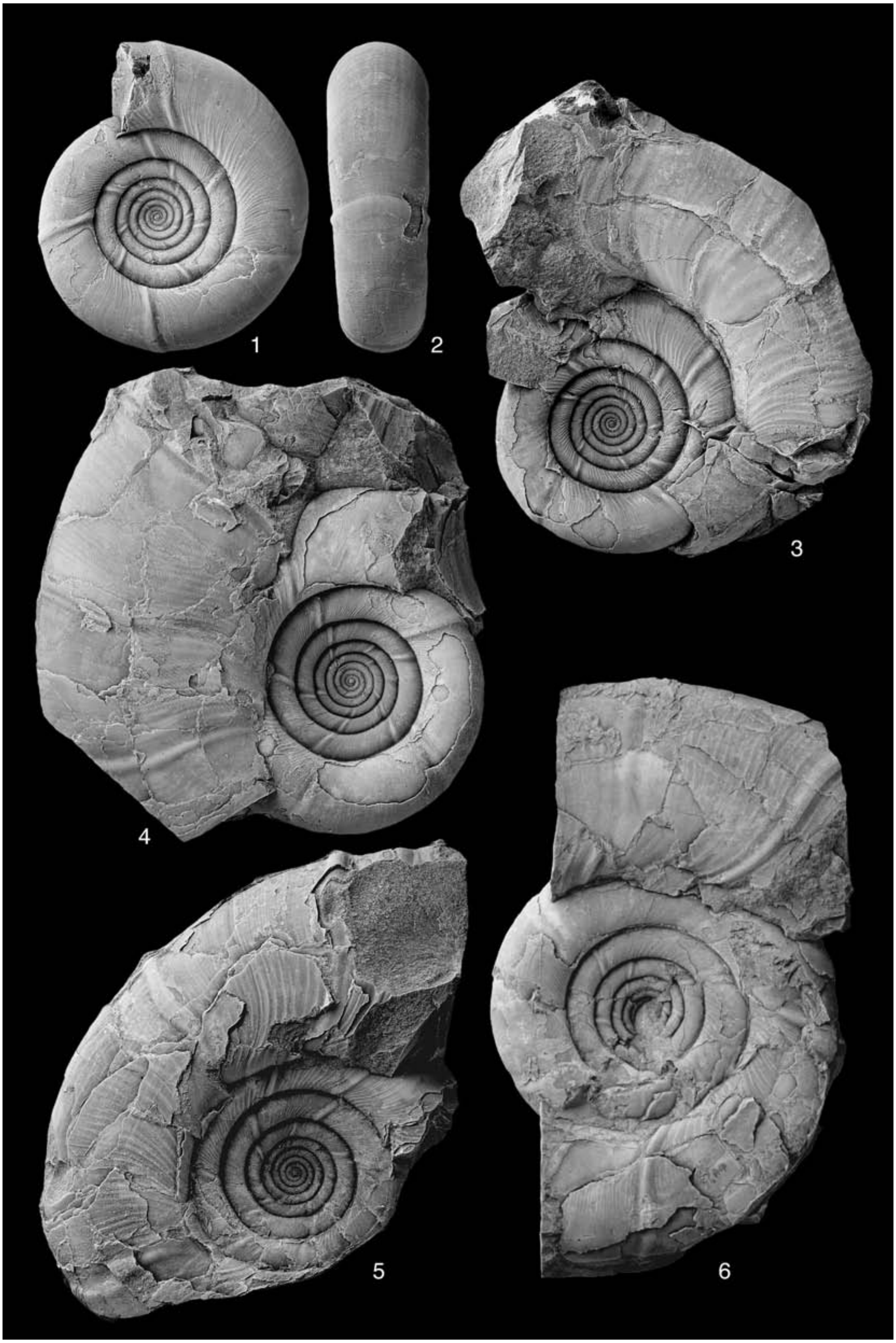
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Fig. 28. *Gaudryceras tombetsense* Matsumoto. 1–2, NSM PM17199, from Loc. MK4015, ×1.0. 3–4, NSM PM17200, from Loc. MK4015, ×1.0.

←Fig. 27. *Gaudryceras tombetsense* Matsumoto. 1–2, NSM PM17189, from Loc. MK4014, ×1.0. 3, NSM PM17190, from Loc. MK4014, ×1.0. 4, NSM PM17197, from Loc. MK4015, ×1.0. 5, NSM PM17198, from Loc. MK4015, ×1.0. 6, NSM PM17191, from Loc. MK4014, ×1.0.

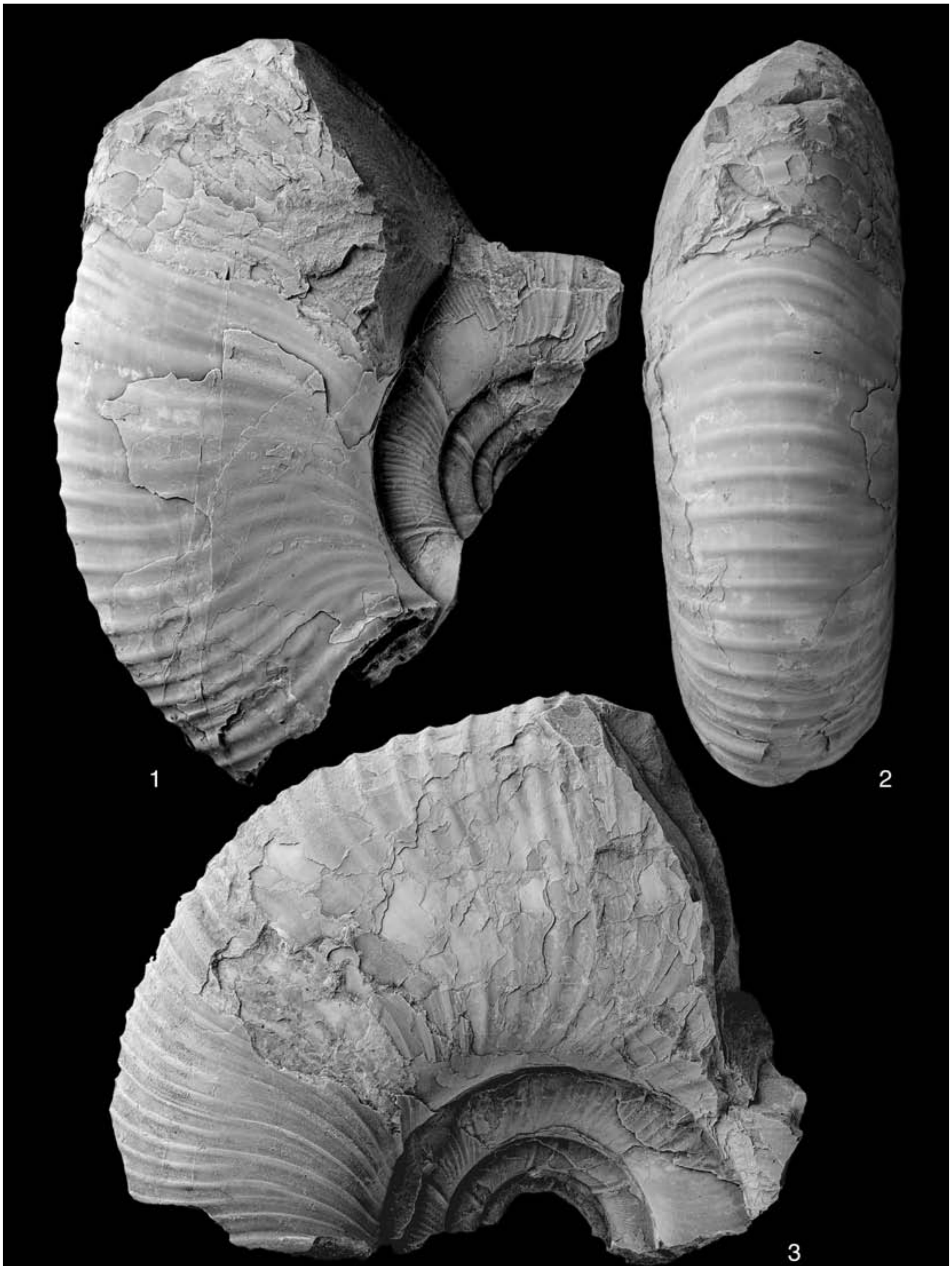

Fig. 29. *Gaudryceras tombetsense* Matsumoto. 1–2, NSM PM17202, from Loc. MK4015, ×0.85. 3, NSM PM17201, from Loc. MK4015, ×0.85.

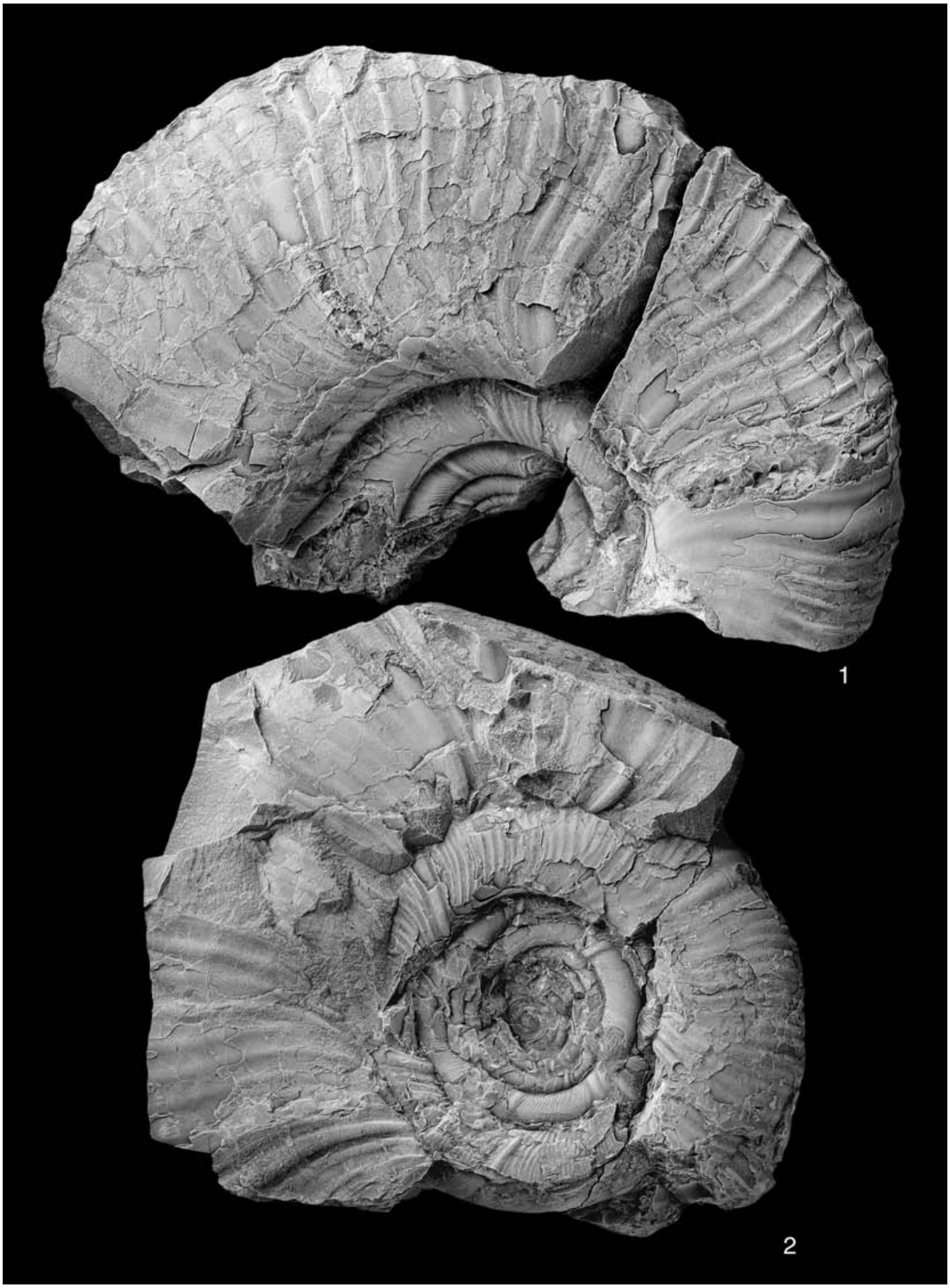

Fig. 30. *Gaudryceras tombetsense* Matsumoto. 1, NSM PM17192, from Loc. MK4014, ×0.85. 2, NSM PM17193, from Loc. MK4014, ×0.85.

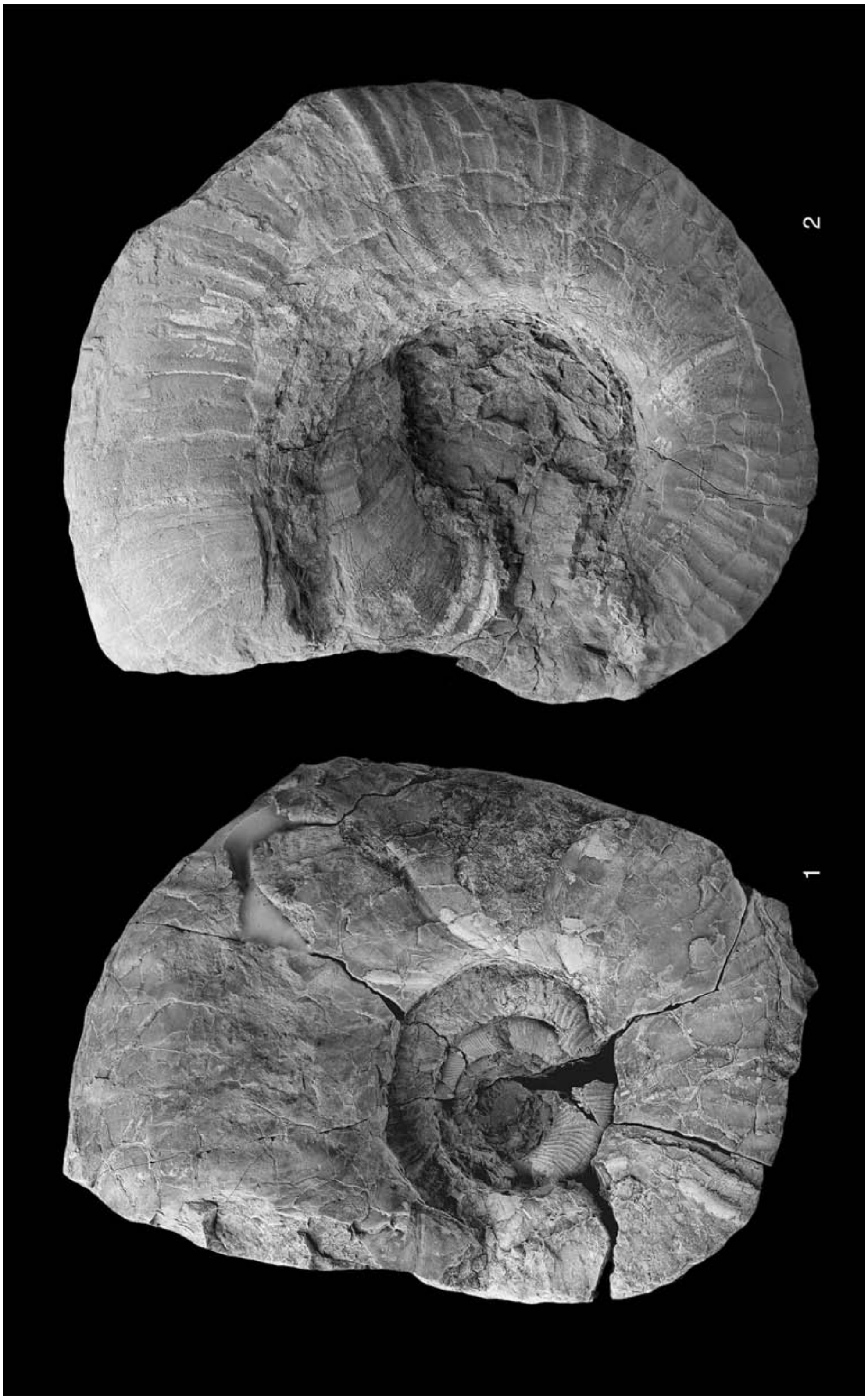

Fig. 31. *Gaudryceras tombetsense* Matsumoto. 1, NSM PM17195, from Loc. MK4014, ×0.5. 2, NSM PM17194, from Loc. MK4015, ×0.5.

rounded wall. Ornamentation consists of very fine, dense, moderately sinuous lirae, which arise at the umbilical seam and approach a sigmoidal pattern before passing over the venter in a broad convex arch. Although they are invisible to the naked eye, extremely fine, dense lirae resulting from multiple branching and intercalation of the normal lirae, cover the flanks and venter. In addition, periodic, narrow, rounded collar-like ribs, parallel to the lirae, occur on all whorls. The sutures are not fully exposed.

Discussion: Even though the present specimen is an immature shell, its distinctive ornamentation and shell shape enable us to identify it with probable confidence as *Gaudryceras tombetsense*.

Occurrence: The present specimen was collected from a bed in which *Sphenoceramus hetonaianus* (upper Lower to lower Upper Maastrichtian.) occurs in the K2 Unit of the Krasnoyarka Formation in the Makarov area, Sakhalin. This horizon is just above the *Gaudryceras tombetsense* bearing bed.

Gaudryceras hamanakense Matsumoto and Yoshida, 1979

Fig. 32.1–32.3

Gaudryceras hamanakense Matsumoto and Yoshida, 1979, p. 68, pl. 10, figs. 1–3, pl. 11, figs. 1–2, text-fig. 2.

Type: Holotype, GK. H5873 (Matsumoto & Yoshida, 1979, p. 68, pl. 10, fig. 1), came from the main part of the Akkeshi Formation of the Nemuro Group in the Hamanaka area, eastern Hokkaido.

Material: NSM PM17203, from Loc. MK-4019 along the Victoria River. NSM PM17204, from Loc. MK2023 along the Acacia River.

Description: Very evolute shell, with a low expansion rate, wide, shallow umbilicus, and a somewhat depressed whorl section in the younger stage, but becoming slightly compressed as diameter increases. Ornamentation consists of fine, dense lirae, which arise at the umbilical seam and sweep forward over the umbilical wall and shoulder, but then become slightly flexuous on the lower flank, before passing straight across the upper flank and venter. At about mid-flank they subdivide into numerous, extremely fine, dense lirae that are almost invisible to naked eye. In addition, periodic, narrow, rounded collar-like ribs parallel to the lirae, occur on all whorls. The suture line with its large, incised, bifid lobes and saddles is typical of gaudryceratids.

Remarks: Two specimens, described as *Gaudryceras hamanakense* by Yazikova (1994, p. 292, pl. 3, figs. 2–3, pl. 6, figs. 2–3) from the Makarova area, are referred by us to *Guadryceras tombetsense* Matsumoto (1984b, p. 2).

Occurrence: *Gaudryceras hamanakense* has been reported from the *Pachydiscus flexuosus* bearing bed, of late Maastrichtian age, in the Nakatombetsu area, northern Hokkaido (Ando *et al.*, 2001) and the Hamanaka area, eastern Hokkaido. The present specimens were collected from the *P. flexuosus* bearing bed in the uppermost part of the K2 Unit of the Krasnoyarka Formation in the Makarov area, Sakhalin.

Gaudryceras makarovense sp. nov.

Figs. 15.3, 32.4, 33–37

Gaudryceras denmanense Whiteaves. Yazykova, 1992, p. 195, pl. 111, fig. 3; Yazykova, 1993, p. 153, pl. 102, fig. 2; Yazikova, 1994, p. 291, pl. 8, fig. 2.

Gaudryceras hamanakense Matsumoto and Yoshida. Yazykova, 1992, p. 196, pl. 110, figs. 1–2; Yazykova, 1993, p. 154, pl. 88, fig. 1, pl. 99, fig. 2, pl. 104, fig. 2; Yazikova, 1994, p. 292, pl. 4, figs. 1–3.

Gaudryceras venustum Matsumoto. Yazykova, 1993, p. 152, pl. 87, fig. 1, pl. 102, fig. 1, pl. 103, fig. 3, pl. 104, fig. 1; Yazikova, 1994, p. 292, pl. 14, pl. 5, fig. 2.

Gaudryceras izumiense Matsumoto and Morozumi. Morozumi, 1985, p. 24, pl. 8, fig. 2.

Type: Holotype, NSM PM17205, is from Loc. MK4030 along the Victoria River.

Material (*Paratypes*): NSM PM17206, from Loc. MK4030 along the Victoria River. NSM PM17207, from Loc. MK2023, two specimens, NSM PM17208, 17209, from Loc.

Fig. 32. 1–3, *Gaudryceras hamanakense* Matsumoto and Yoshida. 1–2, NSM PM17203, from Loc. MK4019, ×1.0. 3, NSM PM17204, from the mudstone of the uppermost part of the K2 Unit of the Krasnoyarka Formation at Loc. MK2023, ×1.0. 4–5, *Gaudryceras makarovense* Shigeta and Maeda, sp. nov., NSM PM17207, paratype, from the sandstone of the lowest part of the K3 Unit of the Krasnoyarka Formation at Loc. MK2023, ×1.0.

MK2025, three specimens, NSM PM17210–17212, from Loc. MK2029, and four specimens, NSM PM17213–17216, from Loc. MK2031 along the Acacia River.

Diagnosis: Large-sized *Gaudryceras* with fine lirae on early whorls, narrowly raised ribs with gently sloping adoral face and nearly vertical adapical face on middle whorls, and dense ribbing with frequent collar-like ribs that are adjacent to constrictions, on later whorls.

Dimensions: See Table 5.

Description: Early whorls (up to 50 mm). Very evolute shell, with slowly expanding whorls, a slightly depressed whorl section, rounded whorl sides and venter, and a wide, shallow umbilicus with an abruptly rounded shoulder. Ornamentation consists of fine, dense lirae, which arise at the umbilical seam and become flexuous, approaching a sigmoidal pattern, before crossing over the venter in a broad, convex arch. The ventrolateral shoulders and venter are also covered with extremely fine, dense lirae resulting from multiple branching and intercalation of the regular lirae. In addition, periodic, strengthened, fold-like ribs, parallel to the lirae, occur on all whorls.

Middle whorls (50–100 mm in diameter). As the shell grows, the whorl expansion rate increases, the whorl section become progressively less depressed, and the umbilicus becomes smaller in width and somewhat deeper. Lirae become narrowly raised ribs, which increase in strength with increasing diameter, and they are distinguished by a gently sloping adoral face and nearly vertical adapical face. These ribs follow the same flexuous, near sigmoidal pattern as those on the earlier whorls, and they culminate on the venter in a broad, convex arch. A few of the ribs branch and intercalate at the umbilicus. Periodic constrictions, parallel to the lirae, are present but are occasionally invisible to the naked eye.

Later whorls (over 100 mm in diameter). As the shell matures, the whorl expansion rate continues to increase and the whorl cross section becomes slightly more compressed, resulting in an umbilicus that becomes progressively deeper and smaller in width. Ribs become denser, and collar-like ribs become frequent.

The suture line, with large, incised, bifid lobes and saddles, is typical of gaudryceratids.

Comparison: *Gaudryceras makarovense* sp. nov. closely resembles *Gaudryceras denmanense* Whiteaves (1901, p. 32) from the Upper Campanian of British Columbia and southeast Alaska, and *Gaudryceras mamiyai* Matsumoto and Miyauchi (1984, p. 55) from the Campanian of Hokkaido and Sakhalin, in having narrowly raised ribs with a gently sloping adoral face and nearly vertical adapical face on the middle whorls. It is distinguished from the latter by having denser ribs and more frequent collar-like ribs on the adult body chamber.

Yazykova (1992, 1993) and Yazikova (1994) described several gaudryceratids from the Maastrichtian of the Makarov and Pugachevo areas, and assigned them to *Gaudryceras venustum* Matsumoto (1984b, p. 5), *Gaudryceras hamanakense* Matsumoro and Yoshida (1979, p. 68) or *G. denmanense* Whiteaves (1901, p. 32), but these specimens are identical to *G. makarovense* sp. nov., with respect to whorl section, mode of coiling, and ornamentation.

Etymology: This species is named for

Tabe 5. Measurements (in mm) of *Gaudryceras makarovense* Shigeta and Maeda sp. nov. at the last preserved septum.

Specimen	D	U	H	B	U/D	B/H
NSM PM17205	108.0	38.2	46.0	36.0	0.35	0.78
NSM PM17213	39.0	17.0	13.8	14.4	0.44	1.04
NSM PM17215	35.4	17.7	10.3	12.0	0.50	1.17

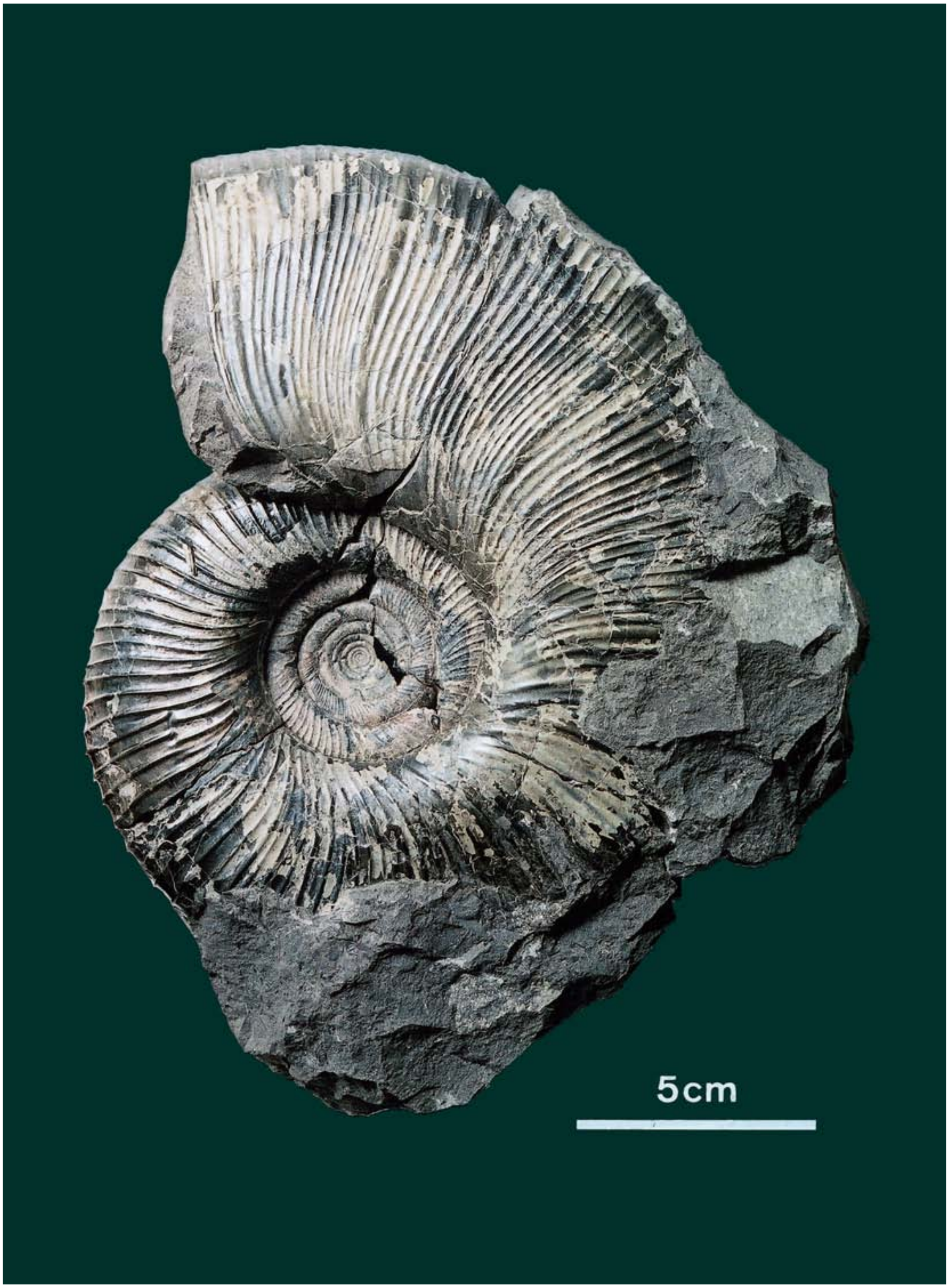

Fig. 33. *Gaudryceras makarovense* Shigeta and Maeda, sp. nov., NSM PM17205, holotype, from Loc. MK4030. Scale bar=5 cm.

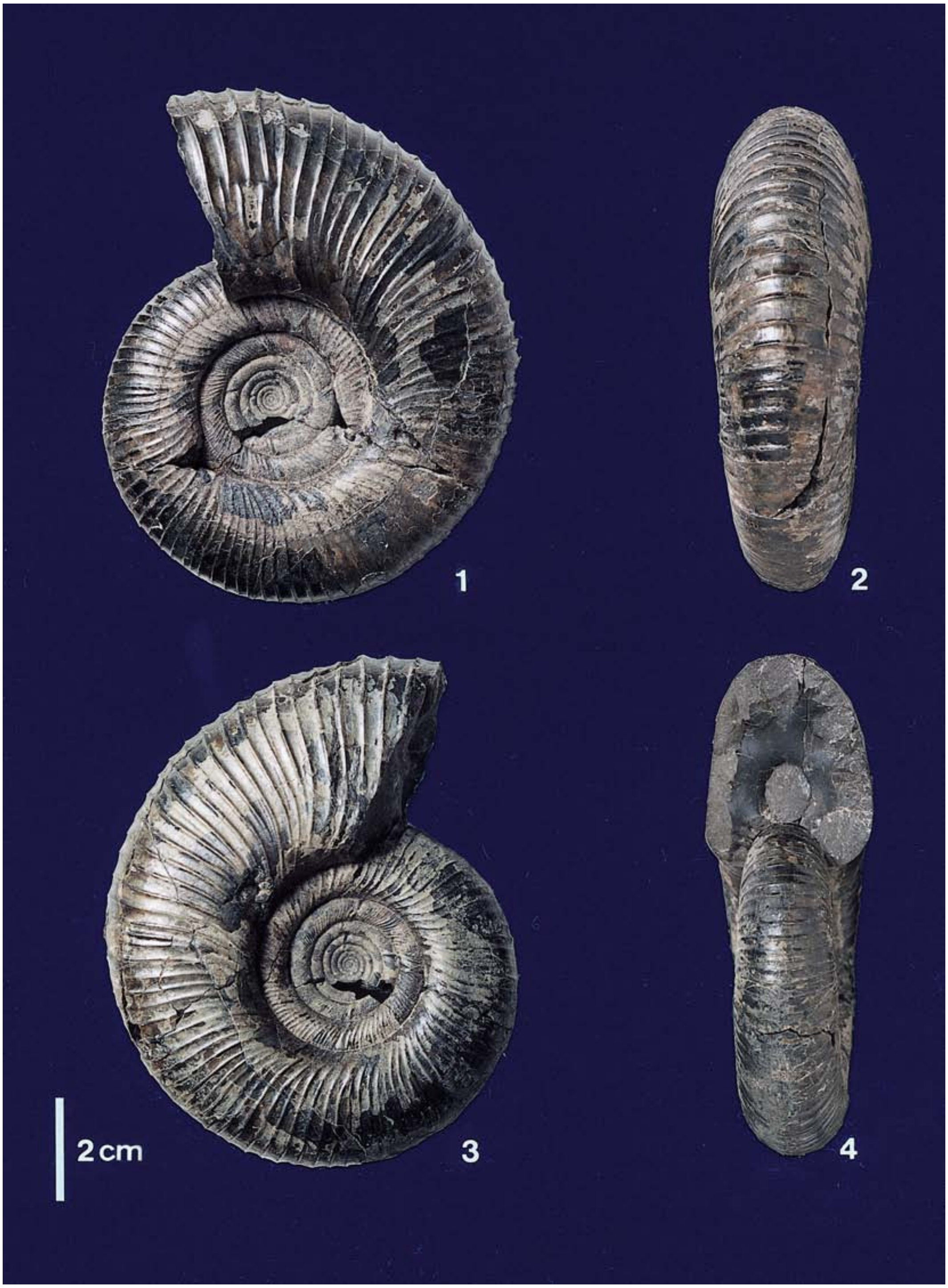

Fig. 34. *Gaudryceras makarovense* Shigeta and Maeda, sp. nov. 1–4, Inner whorls of the holotype (NSM PM17205, Fig. 33), from at Loc. MK4030. Scale bar = 2 cm.

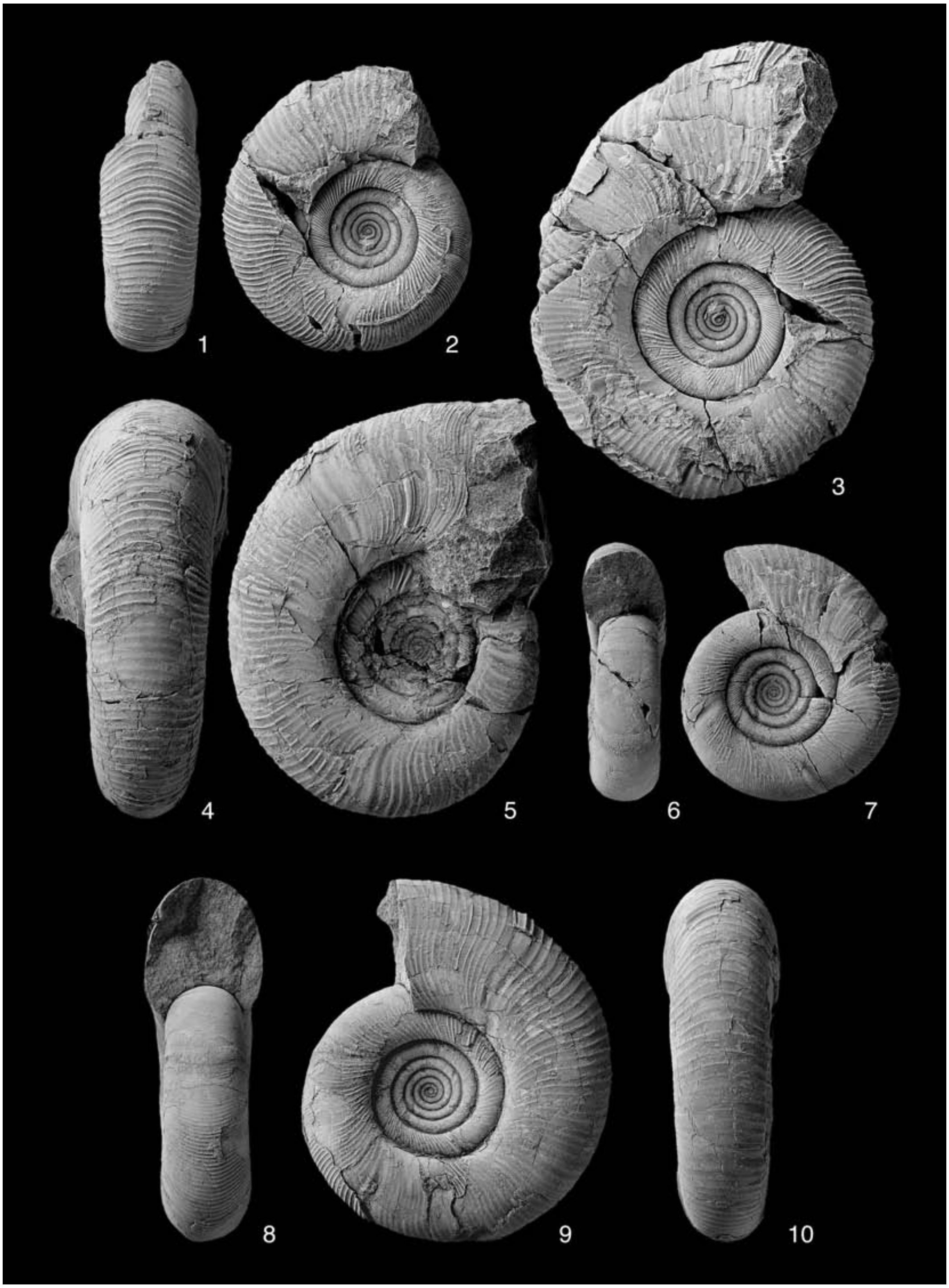

Fig. 35. *Gaudryceras makarovense* Shigeta and Maeda, sp. nov. 1–2, Inner whorls of NSM PM17213, paratype, from Loc. MK2031, ×1.0. 3, NSM PM17213, paratype, from Loc. MK2031, ×1.0. 4–5, NSM PM17214, paratype, from Loc. MK2031, ×1.0. 6–7, NSM PM17215, paratype, from Loc. MK2031, ×1.0. 8–10, NSM PM17216, paratype, from Loc. MK2031, ×1.0.

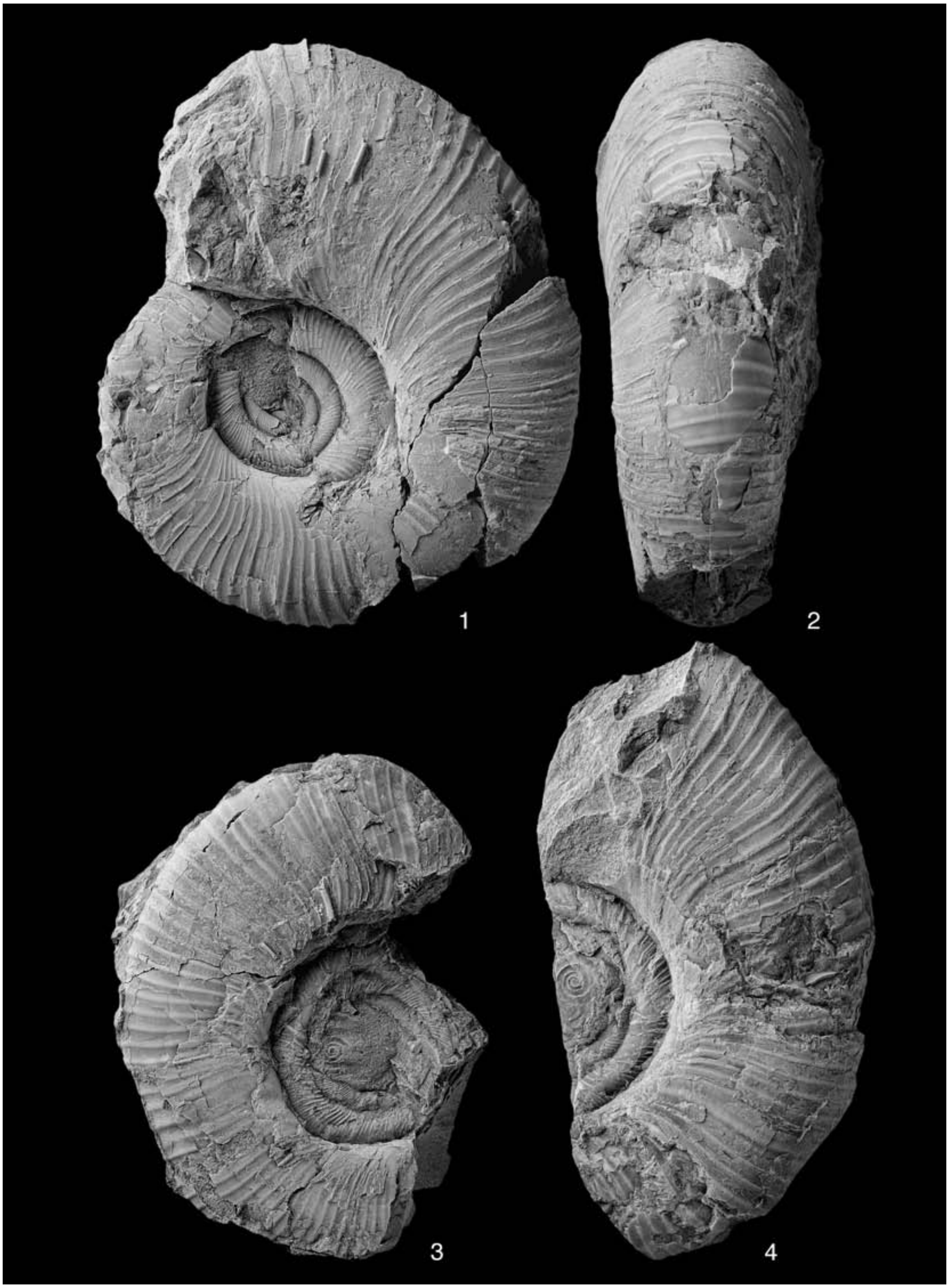

Fig. 36. *Gaudryceras makarovense* Shigeta and Maeda, sp. nov. 1–2, NSM PM17210, paratype, from Loc. MK2029, ×1.0. 3, NSM PM17208, paratype, from Loc. MK2025, ×1.0. 4, NSM PM17209, paratype, from Loc. MK2025, ×1.0.

Fig. 37. *Gaudryceras makarovense* Shigeta and Maeda, sp. nov. 1–2, NSM PM17211, paratype, from Loc. MK2029, ×0.5. 3–4, NSM PM17212, paratype, from Loc. MK2029, ×0.5.

Makarov, its type locality.

Occurrence: The present specimens were associated with *Pachydiscus flexuosus* in a bed in the K3 Unit (Upper Maastrichtian) of the Krasnoyarka Formation in the Makarov area, Sakhalin. Specimens referable to *Gaudryceras makarovense* sp. nov. were collected from the Maastrichtian of the Pugachevo area, southern Sakhalin, and from a float nodule probably derived from the Shimonada Formation of Maastrichtian age on Awaji Island, southwest Japan.

Genus ***Anagaudryceras*** Shimizu 1934

Type species: *Ammonites sacya* Forbes, 1846.

Anagaudryceras nanum Matsumoto, 1985

Fig. 38.5–38.8

Anagaudryceras nanum Matsumoto, 1985, p. 25, pl. 5, figs. 1–4.

Type: Holotype, GK H3124 (Matsumoto, 1986, p. 25, pl. 5, figs. 1–4), is from the Campanian of the Urakawa area, central Hokkaido.

Material: NSM PM17218, from Loc. MK2062 along the Acacia River.

Description: Very evolute shell, with a whorl section that varies from slightly depressed during the early growth stage to slightly compressed as the shell matures, and a wide, shallow umbilicus with a rounded shoulder. Flanks are rounded during the early growth stages, but tend to flatten during later growth stages, and the venter remains broadly rounded throughout shell growth. Ornamentation consists of very fine lirae which arise at the umbilical seam and become sinuous, approaching a slightly sigmoidal form, before crossing over the venter in a broad, convex arch. In addition, the last whorl is ornamented with low, broad, gently flexed band-like ribs which are separated by narrow constrictions. The suture lines are not exposed.

Occurrence: The holotype of *Anagaudryceras nanum* was found in the *Sphenoceramus schmidti* Zone, of late Early Campanian age, in the Urakawa area, central Hokkaido. The present specimen was obtained from the *Sphenoceramus orientalis* bearing bed, just below the *Sphenoceramus schmidt* bearing bed, in the B3 Unit of the Bykov Formation in the Makarov area, Sakhalin.

Anagaudryceras matsumotoi Morozumi, 1985

Fig. 39

Anagaudryceras matsumotoi Morozumi, 1985, p. 29, pl. 9, fig. 1, text-fig. 7; Matsumoto, 1985, p. 27, pl. 4, figs. 1–10; Matsumoto, 1988, p 183, pl. 51, fig. 3.

Zelandites varuna (Forbes). Yazikova, 1994, p. 289, pl. 1, fig. 8.

Type: Holotype, GK. H6882 (Morozumi, 1985, p. 29, pl. 9, fig. 1), is from the Upper Maastrichtian on Awaji Island, southwest Japan.

Material: NSM PM17219, from Loc. MK2021 and NSM PM17263, from Loc. MK2022 along the Acacia River. NSM PM17264, from Loc. MK4014, NSM PM-17265, from Loc. MK4015, four specimens, NSM PM17220–17223, from Loc. MK4016, and NSM PM17266, from Loc. MK4018 along the Victoria River. Three specimens, NSM PM17224–17226, from a float calcareous nodule in the upper course of a small tributary flowing into the Acatia River at MK2029.

Description: Species is distinguished by a small sized mature shell, less than 60 mm in diameter. Moderately involute shell, characterized by a slightly depressed, rounded whorl section during earlier growth stages, with the greatest width occurring some distance below mid-flank. The umbilicus is of moderate width with a rounded umbilical wall. As growth proceeds the whorl section tends to become slightly compressed with the last whorl being moderately compressed. Ornamentation consists of very fine lirae, which arise at the umbilical seam, sweep gently forwards across the umbilical wall, shoulder and flanks, and then pass straight across the venter. In addition, the last whorl is ornamented with low, broad, gently flexed band-like ribs, which are separated by constrictions of variable width. The suture line is not exposed.

Remarks: Yazikova (1994) assigned a small gaudryceratid from the *Pachydiscus flexuosus* Zone in the Pugachevo area to *Zelandites varuna* (Forbes), but the specimen is identical to *Anagaudryceras matsumotoi* with respect to whorl section, mode of coiling, and ornamentation.

Occurrence: *Gaudryceras matsumotoi* occurs in the *Zelandites varuna* bearing bed (Upper Maastrichtian) in the Naiba and Pugachevo areas, southern Sakhalin, and on Awaji Island, southwest Japan. The species has also been reported from the *Pachydiscus flexuosus* bearing bed (Upper Maastrichtian) in the Nakatombetsu area, northern Hokkaido (Ando *et al.*, 2001), and Nemuro-Kushiro area, eastern Hokkaido.

The present specimens were found in the *Sphenoceramus hetonaianus* (upper Lower Maastrichtian) and *Gaudryceras makarovense* sp. nov. (Upper Maastrichtian) bearing beds in the K2 and K3 units of the Krasnoyarka Formation in the Makarov area, Sakhalin.

Anagaudryceras seymouriense Macellari, 1986

Figs. 40.4–40.6, 41

Anagaudryceras seymouriense Macellari, 1986, p. 10, figs. 9.1–9.6, 10.1–10.4.

Anagaudryceras cf. *seymouriense* Macellari. Matsumoto, 1988, p. 183, pl. 51, fig. 2, pl. 53, fig. 1.

Type: Holotype, OSU38333 (Macellari, 1986, p. 10, fig. 9.1–9.2), is from the Upper Maastrichtian of Seymour Island in the Antarctic Peninsula.

Material: NSM PM17238, from Loc. MK-4016 along the Victoria River in the Makarov area.

Description: Very evolute shell, distinguished by slowly expanding whorls, and a slightly depressed whorl section during the early growth stages, but becoming moderately compressed upon reaching maturity, and a wide, shallow umbilicus with a steep wall and moderately rounded shoulder. The sides are slightly flattened and the venter is rounded. Ornamentation consists of very fine lirae, which arise at the umbilical seam and become slightly flexuous, approaching a slightly sigmoidal form, before passing over the venter in a broad, convex arch. In addition, periodic narrow, rounded collar-like or fold-like ribs occur on the mature whorls. The suture lines are not exposed.

Occurrence: Macellari (1986) originally described *Anagaudryceras seymouriense*, of late Maestrichtian age, from a level just below the horizon at which *Zelandites varuna* occurs on Seymour Island. Matsumoto (1988) also described a specimen comparable to the present species, from the Rdy Member of the Ryugase Group, from a locality in the Naiba area, southern Sakhalin. Although the Ryugase Group is no longer recognized, the Rdy Member is equivalent to the K4 Unit of the Krasnoyarka Formation, as defined by Kodama *et al.* (2002), and it includes the *Z. varuna* bearing bed in the Naiba area, southern Sakhalin.

The present specimens were found in the *Sphenoceramus hetonaianus* bearing bed in the K2 Unit of the Krasnoyarka Formation, which is equivalent to the upper Lower to lower Upper Maastrichtian, in the Makarov area, Sakhalin.

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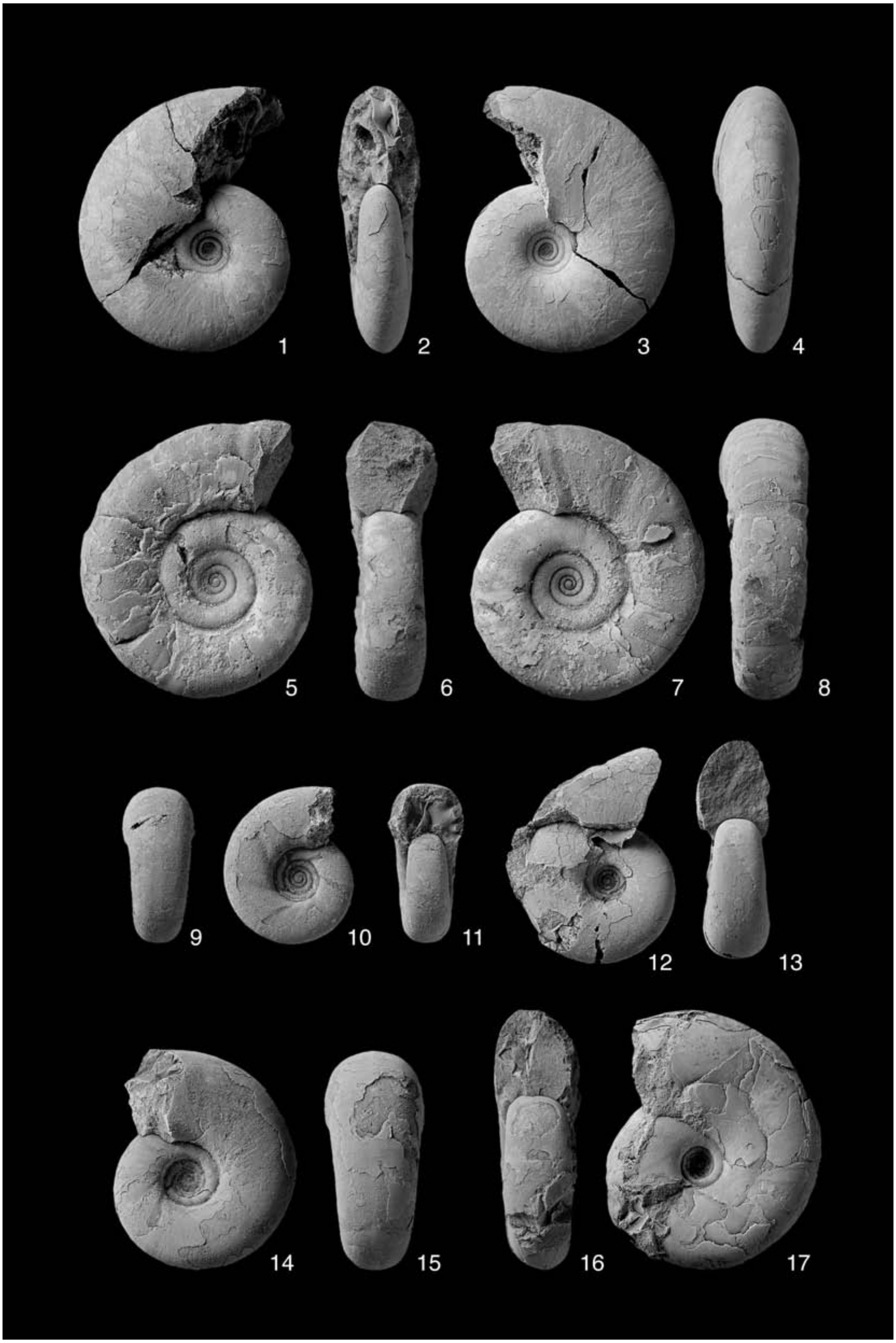
Fig. 38. 1–4, *Zelandites varuna* (Forbes), NSM PM17217, from a float calcareous nodule at Loc. MK3031, ×2.0. The specimen is almost certainly from the mudstone of the K2 Unit of the Krasnoyarka Formation. 5–8, *Anagaudryceras nanum* Matsumoto, NSM PM17218, from Loc. MK2062, ×2.0. 9–11, 14–15, *Tetragonites popetensis* Yabe. 9–11, NSM PM17230, from Loc. MK2021, ×2.0. 14–15, NSM PM17236, from Loc. MK4014, ×2.0. 12–13, 16–17, *Pseudophyllites indra* (Forbes). 12–13, NSM PM17247, from Loc. MK2031, ×2.0. 16–17, NSM PM17242, from Loc. MK4016, ×2.0.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Genus ***Zelandites*** Marshall, 1926

Type species: *Zelandites kaiparaensis* Marshall, 1926.

Zelandites varuna (Forbes, 1846)

Fig. 38.1–38.4

Ammonites varuna Forbes, 1846, p. 107, pl. 8, fig. 5.
Lytoceras (*Gaudryceras*) *varuna* (Forbes). Kossmat, 1895, p. 161, pl. 16, fig. 4, pl. 17, fig. 8.
Lytoceras varuna (Forbes). Steinmann, 1895, p. 84, pl. 5, fig. 2, text-fig. 7.
Zelandites varuna (Forbes) var. *japonica* Matsumoto, 1938, p. 140, pl. 14, figs. 5–7, text-fig. 1.
Zelandites cf. *varuna* (Forbes). Morozumi, 1985, p. 32, pl. 9, fig. 2, text-fig. 8.
Zelamdites varuna (Forbes). Stinnisbeck, 1986, p. 195, pl. 8, figs. 5–6, text-fig. 20; Macellari, 1986, p. 14, text-figs. 11.11, 11.12, 12; Matsumoto, 1988, p. 184, pl. 51, fig. 4; Kennedy and Henderson, 1992, p. 404, pl. 5, figs. 13–15, pl. 17, figs. 2–3.
Zelandites japonicus Matsumoto. Yazikova, 1994, p. 290, pl. 1, figs. 1–4, pl. 2, figs. 1–18; Alabushev and Wiedmann, 1997, p. 11, pl. 2, fig. 6, text-fig. 2.

Type: Lectotype, designated by Matsumoto (1988, p. 184), is BMNH C51059, the original of Forbes (1846, p. 107, pl. 8, fig. 5) from the Upper Maastrichtian of Pondicherry, southern India.

Material: NSM PM17217, extracted from a float calcareous nodule at Loc. MK3031 along the Gruzovka River.

Description: Very involute shell, characterized by a compressed whorl section, with the greatest width below mid-flank, and a narrow umbilicus with a low, rounded wall. The inner flanks are broadly rounded, and the outer flanks converge to a narrowly rounded venter. The specimen retains none of the original ornamentation. The suture line is not exposed.

Occurrence: *Zelandites varuna* occurs in the Upper Maastrichtian of southern India, Chili, Seymour Island in Antarctica and Awaji Island in Southwest Japan. It also occurs in the *Pachydiscus subcompressus* bearing bed (Upper Maastrichtian) in the Nakatombetsu area, northern Hokkaido (Ando *et al.*, 2001) and the Naiba area, southern Sakhalin.

The present specimen was obtained from a float calcareous nodule at Loc. MK3031 along the Gruzovka River in the Makarov area, Sakhalin. Although the exact horizon from which the nodule came is uncertain, judging from the locality and the lithology, it almost without doubt came from the mudstone in the K2 Unit of the Krasnoyarka Formation. This horizon probably occurs between the *Sphenoceramus hetonaianus* bearing bed (upper Lower Maastrichtian) and the *Gaudryceras makarovense* sp. nov. bearing bed (Upper Maastrichtian).

Family Tetragonitidae Hyatt, 1900

Genus ***Tetragonites*** Kossmat, 1895

Type species: *Ammonites timotheanus* Pictet, 1848.

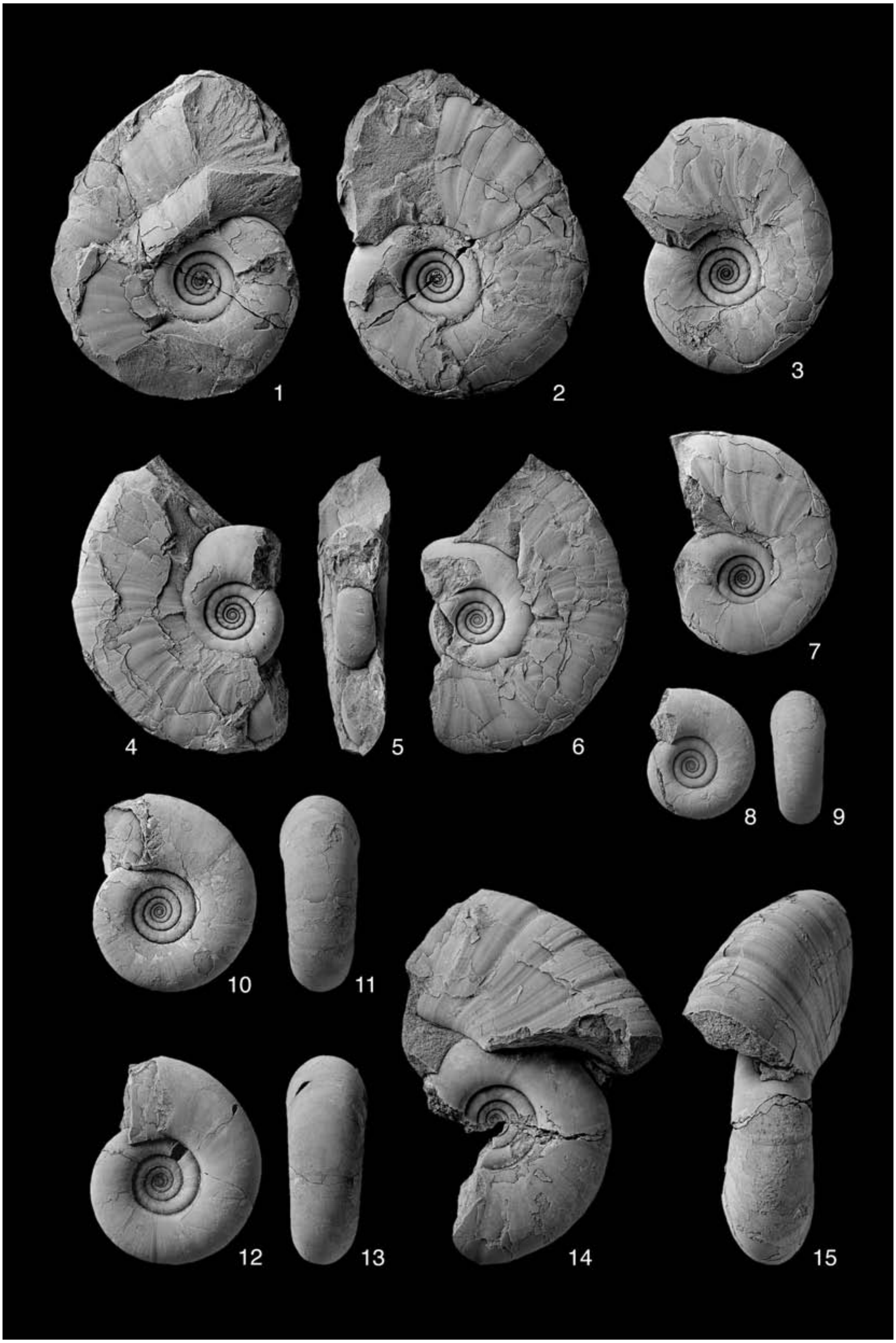
Tetragonites glabrus (Jimbo, 1894)

Fig. 42.1–42.4

Lytoceras glabrum Jimbo, 1894, p. 180, pl. 22, fig. 2.
Lytoceras sphaeronotum Jimbo, 1894, p. 181, pl. 22, fig. 4.
Lytoceras crassum Jimbo, 1894, p. 181, pl. 22, fig. 5.
Tetragonites glabrus (Jimbo). Yabe, 1903, p. 43, pl. 7, figs. 2, 5; Matsumoto, 1959b, p. 149, pl. 39, figs. 2–3, text-figs. 72–73; Tanabe and Kanie, 1978, p. 8, pl. 1, fig. 2; Shigeta, 1989, p. 334, text-fig. 12 (1–2).
Tetragonites sphaeronotus (Jimbo). Yabe, 1903, p. 45, pl. 7, fig. 1.

→

Fig. 39. *Anagaudryceras matsumotoi* Morozumi. 1–2, NSM PM17220, from Loc. MK4016, ×1.0. 3, NSM PM17221, from Loc. MK4016, ×1.0. 4–6, NSM PM17222, from Loc. MK4016, ×1.0. 7, NSM PM17223, from Loc. MK4016, ×1.0. 8–9, NSM PM17219, from Loc. MK2021, ×1.0. 10–11, NSM PM17224, from a float calcareous nodule in the upper course of a small tributary flowing into the Acatia River at Loc. MK2029, ×1.0. 12–13, NSM PM17225, from the same nodule as NSM PM17224, ×1.0. 14–15, NSM PM17226, from a floated calcareous nodule in the upper course of a small tributary flowing into the Acatia River at Loc. MK2029, ×1.0.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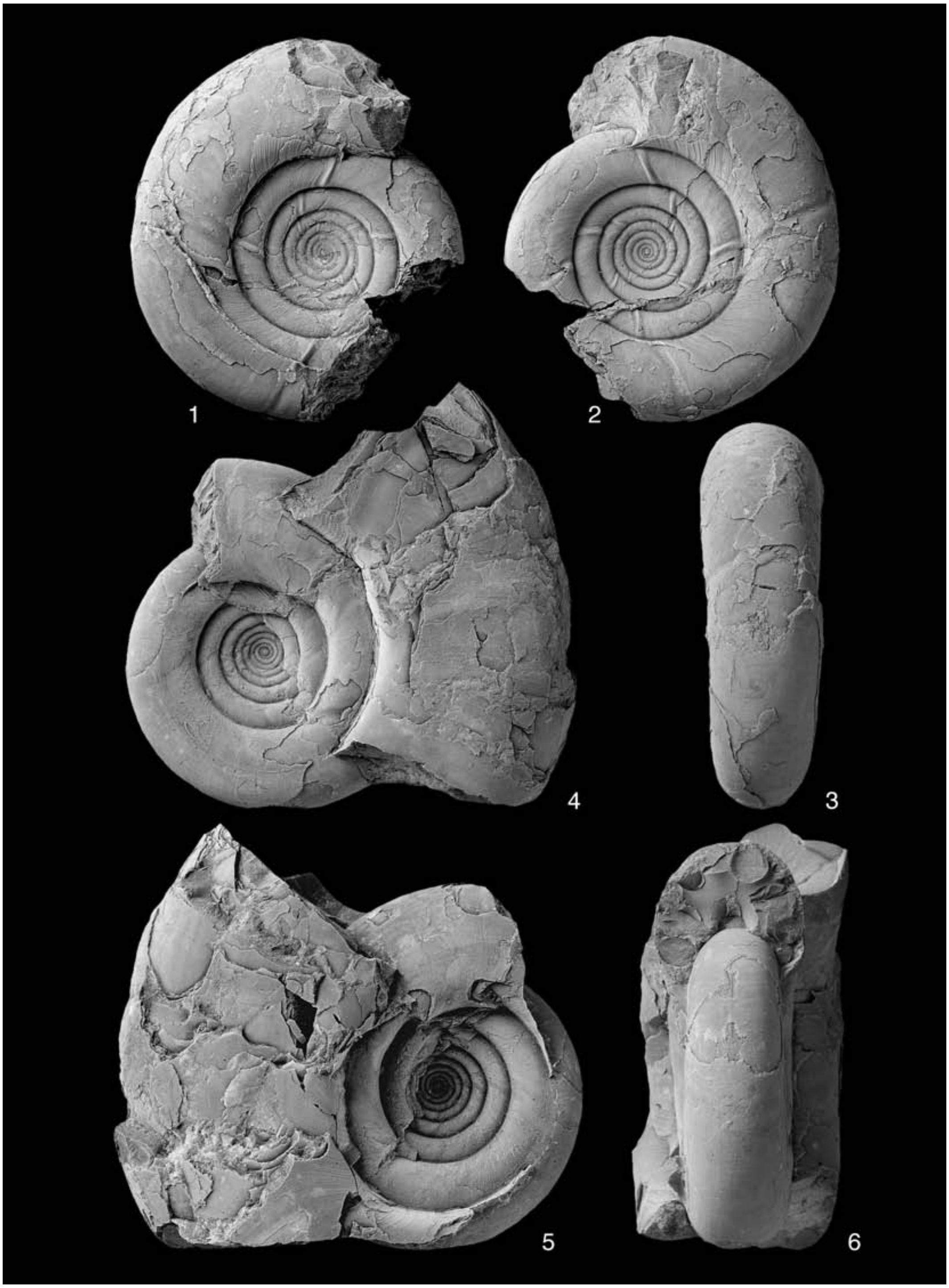

Fig. 40. 1–3, *Gaudryceras* cf. *tombetsense* Matsumoto, NSM PM17251, from Loc. MK4016, ×1.0. 4–6, *Anagaudryceras seymouriense* Macellari, inner whorls of NSM PM17238, from Loc. MK4016, ×1.0.

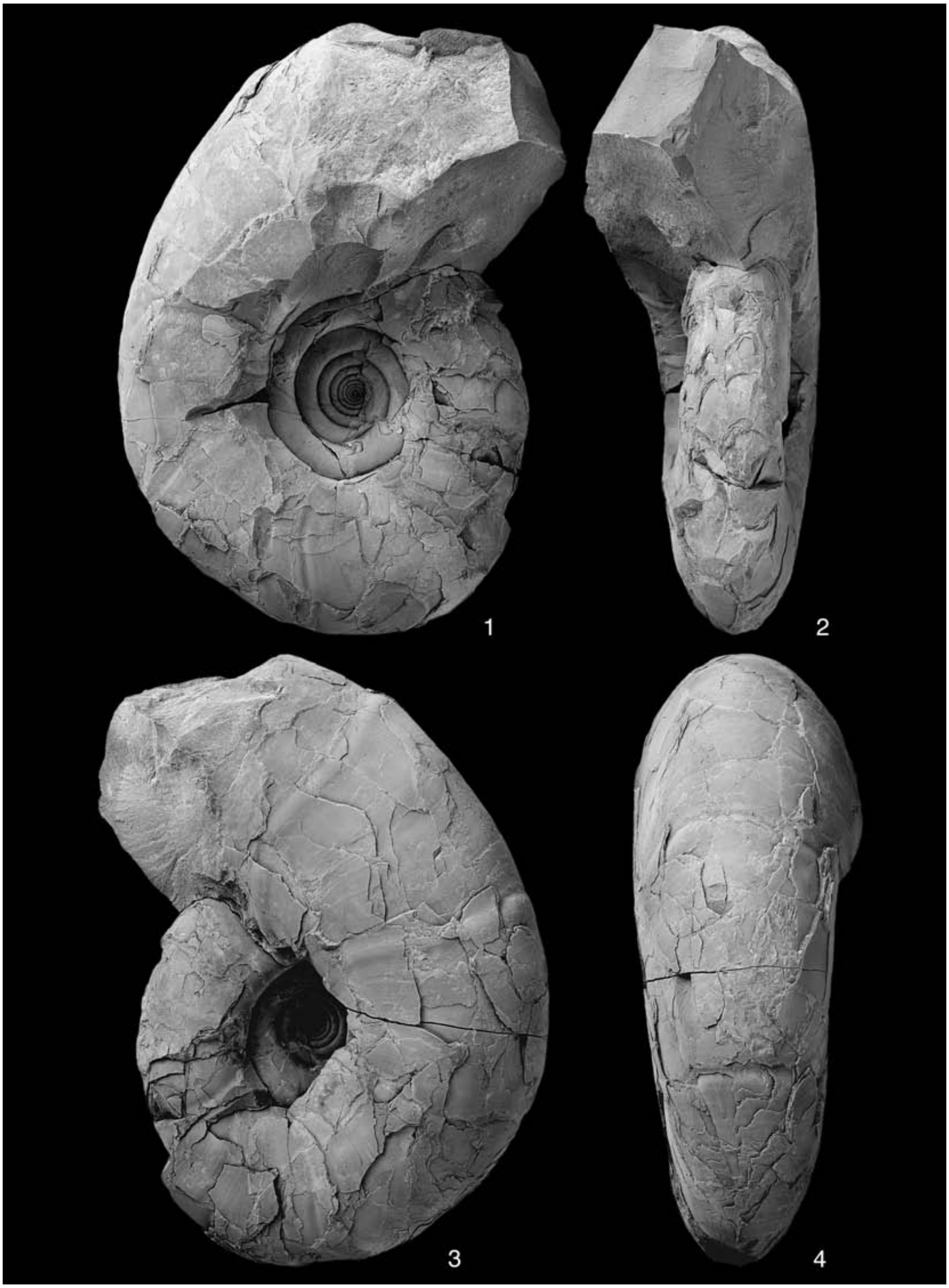

Fig. 41. *Anagaudryceras seymouriense* Macellari. 1–4, NSM PM17238, from Loc. MK4016, ×0.55.

Tetragonites cf. *epigonus* Kossmat. Yabe, 1903, p. 49, pl. 7, fig. 3.

Epigoniceras glabrum (Jimbo) var. *problematica* Matsumoto, 1942b, p. 672, fig. 1.

Epigoniceras epigonum (Kossmat). Alabushev and Wiedmann, 1997, p. 8, pl. 1, figs. 8–11, text-fig. 1.

Type: Holotype, UMUT MM7513 (Jimbo, 1894, p. 180, pl. 22, fig. 2), from the Upper Cretaceous of Ikandai in the Urakawa area, central Hokkaido.

Material: NSM PM17227, from Loc. MK-2062 along the Acacia River.

Description: Involute shell, characterized by moderately expanding whorls, a slightly depressed, sub-quadrate whorl section, and a narrow, deep umbilicus with a steep wall and an abruptly rounded shoulder on younger whorls, becoming more rounded on mature whorls. The flanks are gently rounded, merging with rounded ventrolateral shoulders and a broadly rounded venter. Although the shell surface is nearly smooth, it does have very fine, prorsiradiate growth lines and parallel, infrequent, conspicuous rib-like elevations that pass over the inner part of the umbilical wall and flanks, before becoming slightly flexuous at the ventrolateral shoulder and passing over the venter in a broad, adapical facing curve. The suture line is not exposed.

Remarks: Based on a large sample of specimens collected from the upper Campanian in the Soya area, Shigeta (1989) noted that *Tetragonites glabrus* exhibits a remarkable variation in shell form. However, at a later date Shigeta (1992) described *Pseudophyllites indra* (Forbes) from Hokkaido and Sakhalin, and pointed out that his Soya area specimens with the small umbilicus, that he assigned to *T. glabrus* in his 1989 paper, actually should be regarded as juvenile specimens of *P. indra*. Shigeta's sample (AW1001A) was heterogeneous and consisted of specimens of both *P. indra* and *Tetragonites* having a wide umbilicus, that are now referable to *T. popetensis*. Therefore, *T. glabrus* does not occur in the Upper Campanian of Hokkaido and Sakhalin, and the species, in fact, does not exhibit the enormous variation in shell form described above. However, as Shigeta (1989) concluded, the previously described species *Tetragonites sphaeronotus* (Jimbo, 1894), *Tetragonites crassus* (Jimbo, 1894), and *Tetragonites glaburus problematicus* (Matsumoto, 1942b) are identical to *T. glaburus* with respect to whorl section, mode of coiling, and ornamentation, and all should be regarded as synonyms of *T. glaburus*.

Occurrence: *Tetragonites glaburus* occurs in abundance from the Turonian to the Lower Campanian in Hokkaido and Sakhalin (Matsumoto, 1942d, 1943; Toshimitsu & Hirano, 2000). The species is also known from the Santonian to the Campanian of Northwestern Kamchatka.

The present specimens were found in the *Sphenoceramus orientalis* bearing bed (upper Lower Campanian) just below the *Sphenoceramus schmidti* bearing bed in the B3 Unit of the Bykov Formation in the Makarov area, Sakhalin.

Tetragonires popetensis Yabe, 1903

Figs. 38.9–38.11, 38.14–38.15, 42.5–42.11, 43, 44

Tetragonites popetensis Yabe, 1903, p. 48, pl. 7, figs. 4, 6; Matsumoto and Miyauchi, 1984, p. 52, pl. 23, fig. 3; Matsumoto, 1988, p. 178, pl. 50, figs, 3–4; Yazikova, 1994, p. 293, pl. 3, fig. 1.

Tetragonites glaburus (Jimbo). Shigeta, 1989, p. 334, text-fig. 12 (4–7).

Type: Holotype, UMUT MM7460 (Yabe, 1903, p. 48, pl. 7, fig. 4), is from the Upper Cretaceous of Sanushibe in the Hobetsu area, central Hokkaido.

Material: NSM PM17228, from Loc. MK-4004 and two specimens, NSM PM17236, 17237, from Loc. MK4014 along the Victoria River. PM17229, from a float calcareous nodule, (also containing *Sphenoceramus schmidti*), found along a small tributary flowing into the Victoria River at MK4047. Three specimens, NSM PM17231–17233, from

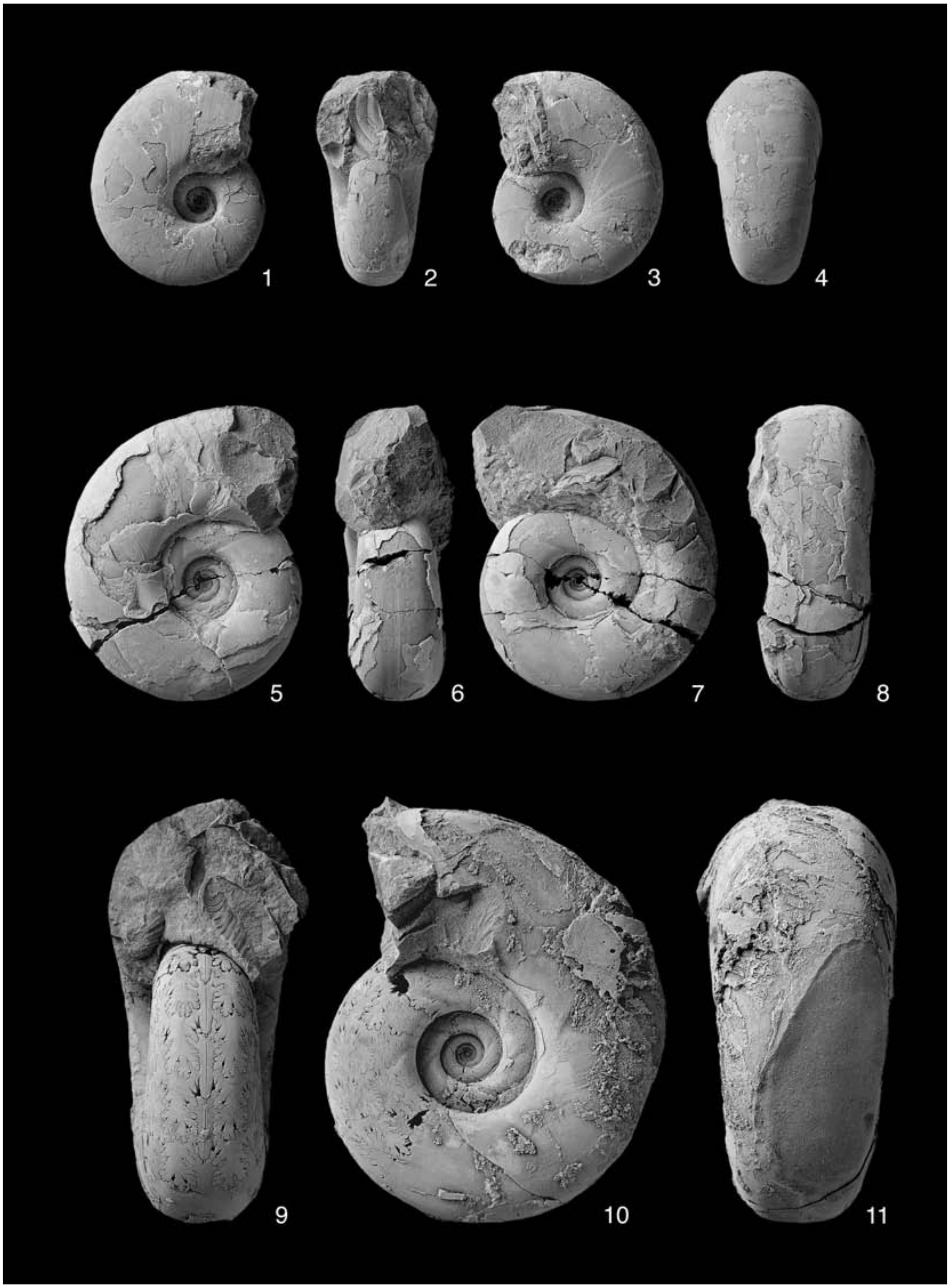

Fig. 42. 1–4, *Tetragonites glabrus* (Jimbo, 1894), NSM PM17227, from Loc. MK2062, ×1.0. 5–11, *Tetragonites popetensis* Yabe. 5–8, NSM PM17228, from Loc. MK4004, ×1.0. 9–11, NSM PM17229, associated with a specimen of *Sphenoceramus schmidti* (Michael) in a float calcareous nodule found along a small tributary flowing into the Victoria River at Loc. MK4047, ×1.0.

Loc. MK2015 and two specimens, NSM PM17234, 17235, from Loc. MK2014 along the Acacia River. NSM PM17230, from Loc MK2021 along the Acacia River.

Description: Moderately involute shell, characterized by moderately expanding whorls, a slightly depressed, rounded to sub-quadrate whorl section, and an umbilicus of moderate width with a very steep, moderately high wall and a rounded shoulder. Gently curved flanks and rounded ventrolateral shoulders merge with a broadly rounded venter. Very fine growth lines, visible on an otherwise nearly smooth shell surface, are prorsiradiate on the flanks, but become slightly sinuous at the ventrolateral shoulders, before passing across the venter in a broad, adapical facing curve. Periodic, conspicuous rib-like elevations (60–80°), parallel to the growth lines, also occur, but specimens NSM PM17231–17233 (Fig. 43) are unique in that the last constriction is very close (20°) to the aperture. The suture line, with its trifid major saddles and bifid lateral lobe, is typical of Tetragonitids.

Remarks: Shigeta (1989) regarded *Tetragonites popetensis* as a synonym of *Tetragonites glaburus*, but as discussed above in the remarks section for *T. glaburus*, both are sufficiently distinct so as to be considered different species.

Occurrence: *Tetragonites popetensis* occurs in abundance in sediments ranging in age from the Santonian to the Maastrichtian in Hokkaido and Sakhalin (Matsumoto, 1942d, 1943; Toshimitsu & Hirano, 2000). The present specimens were collected from the *Sphenoceramus schmidti* bearing bed in the B4 Unit of the Bykov Formation and the *Sphenoceramus hetonaianus* bearing bed in the K2 Unit of the Krasnoyarka Formation, as well as from several horizons in between, in the Makarov area, Sakhalin. They range in from the upper Lower Campanain to the upper Lower Maastrichtian.

Genus ***Saghalinites*** Wright and Matsumoto, 1954

Type species: *Ammonites cala* Forbes, 1846.

Saghalinites teshioensis Matsumoto, 1984a

Fig. 45

Saghalinites teshioensis Matsumoto, 1984a, p. 27, pl. 9, figs. 1–3; Matsumoto, 1988, p. 179, pl. 51, fig. 1.

Type: Holotype, GK. H5971 (Matsumoto, 1984a, p. 27, pl. 9, fig. 1), is from the Upper Campanian of Uttsu in the Teshio Mountains, northern Hokkaido.

Material: Three specimens, NSM PM-17239–17241, from Loc. MK2014 along the Acacia River. All specimens are slightly crushed and deformed.

Description: Very evolute shell, characterized by slowly expanding whorls, a slightly depressed whorl section during early growth stages, becoming slightly compressed as diameter increases, and a wide, shallow umbilicus with a low, rounded wall. On mature whorls, the flanks are gently rounded while the venter is more narrowly rounded. Fine growth lines, visible on a nearly smooth shell surface, arise at the umbilical seam and sweep forward over the inner flanks, become slightly sinuous at mid-flank, and then pass over the venter in a broad, adapical facing curve. Periodic, distant constrictions (60–80°) occur on the adult body chamber, but specimen NSM PM17239 is unique in that the last constriction is very close (20°) to the aperture. The suture line is not exposed.

Occurrence: *Saghalinites teshioensis* occurs in the *Schlueterella kawadai* bearing bed, of late Campanian age, in the Naiba area, Sakhalin and the Teshio Mountains, Hokkaido.

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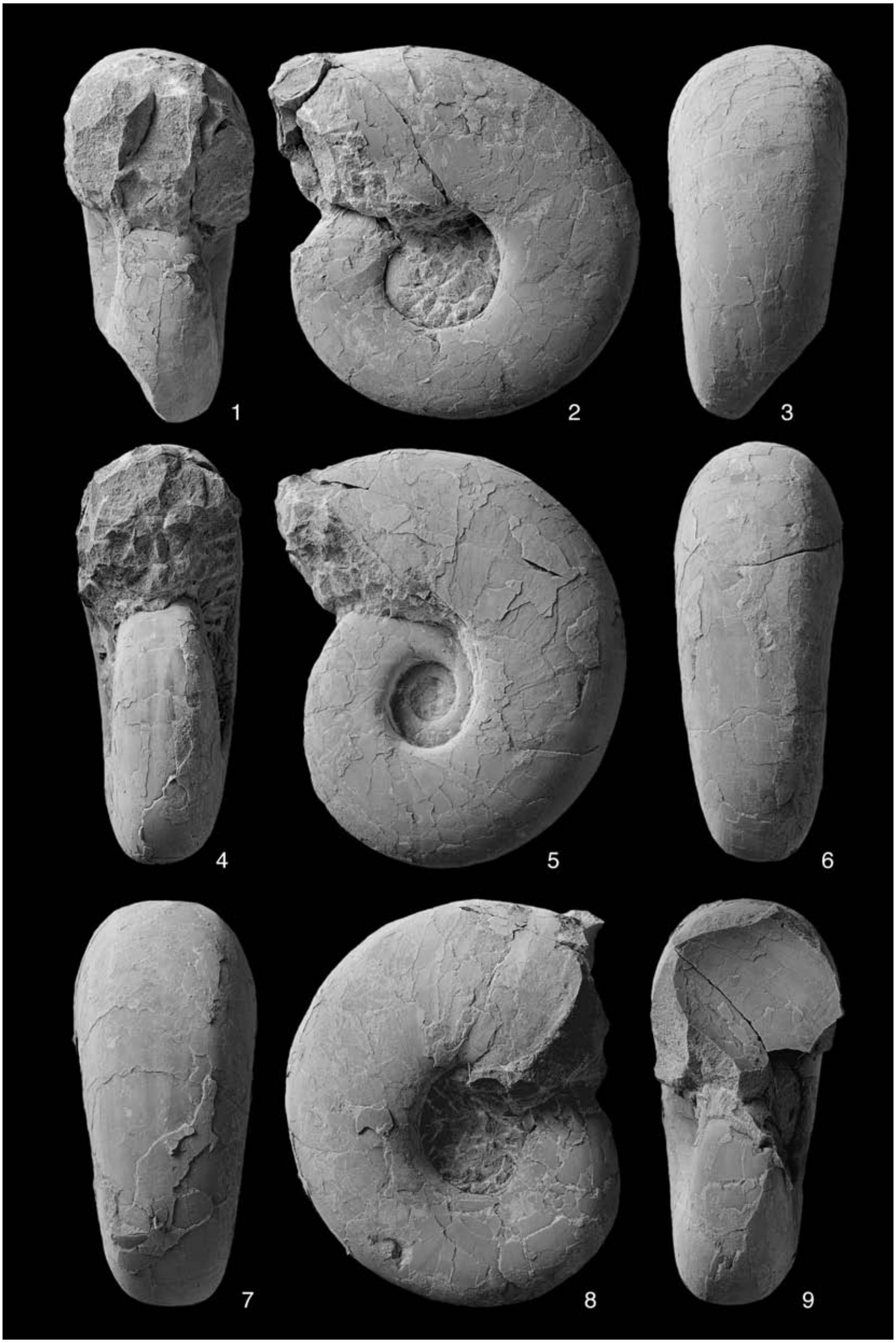
Fig. 43. *Tetragonites popetensis* Yabe. 1–3, NSM PM17231, from Loc. MK2015, ×1.0. 4–6, NSM PM17232, from Loc. MK2015, ×1.0. 7–9, NSM PM17233, from Loc. MK2015, ×1.0.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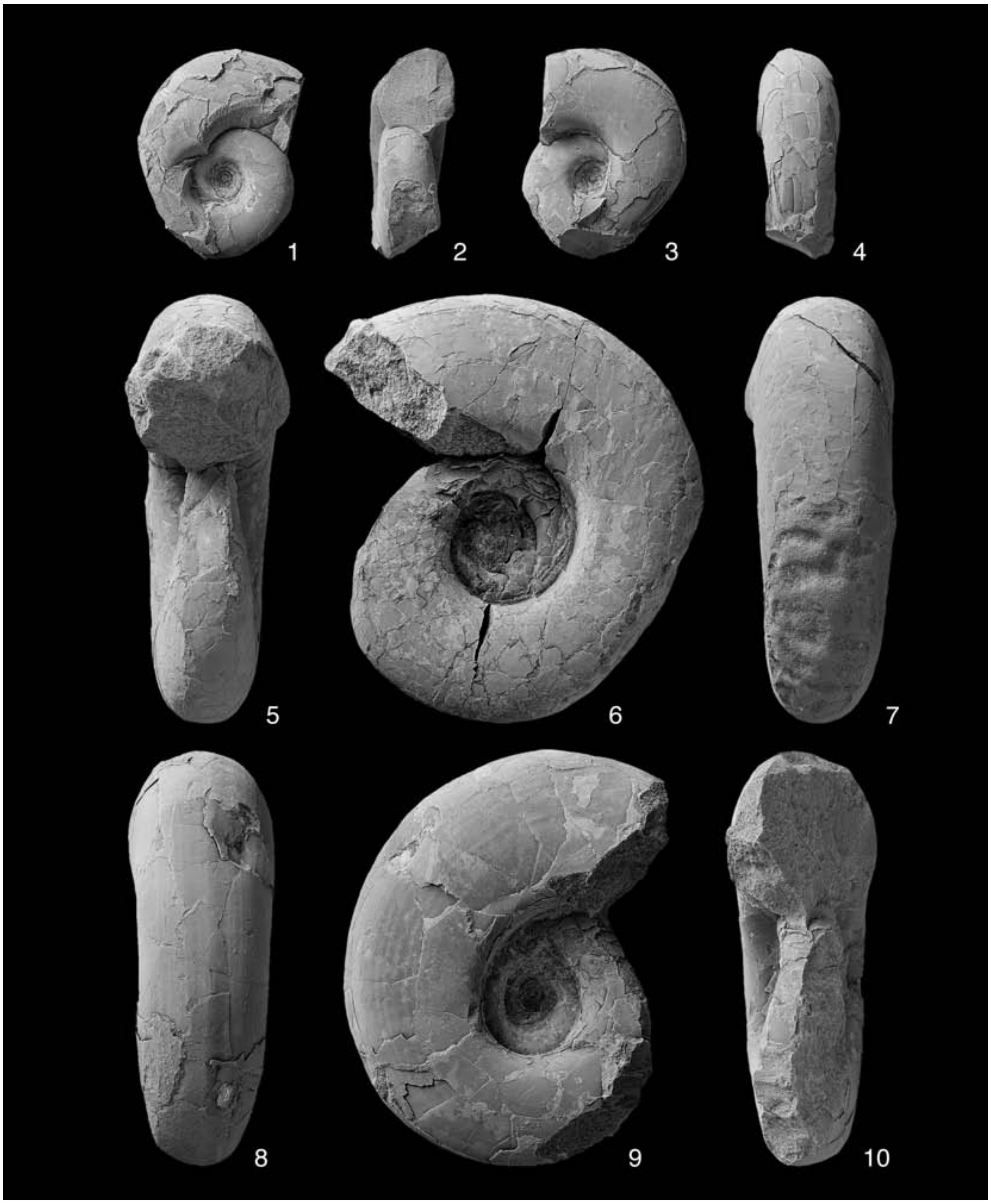

Fig. 44. *Tetragonites popetensis* Yabe. 1–4, NSM PM17237, from Loc. MK4014, ×1.0. 5–7, NSM PM17234, from Loc. MK2014, ×1.0. 8–10, NSM PM17235, from Loc. MK2014, ×1.0.

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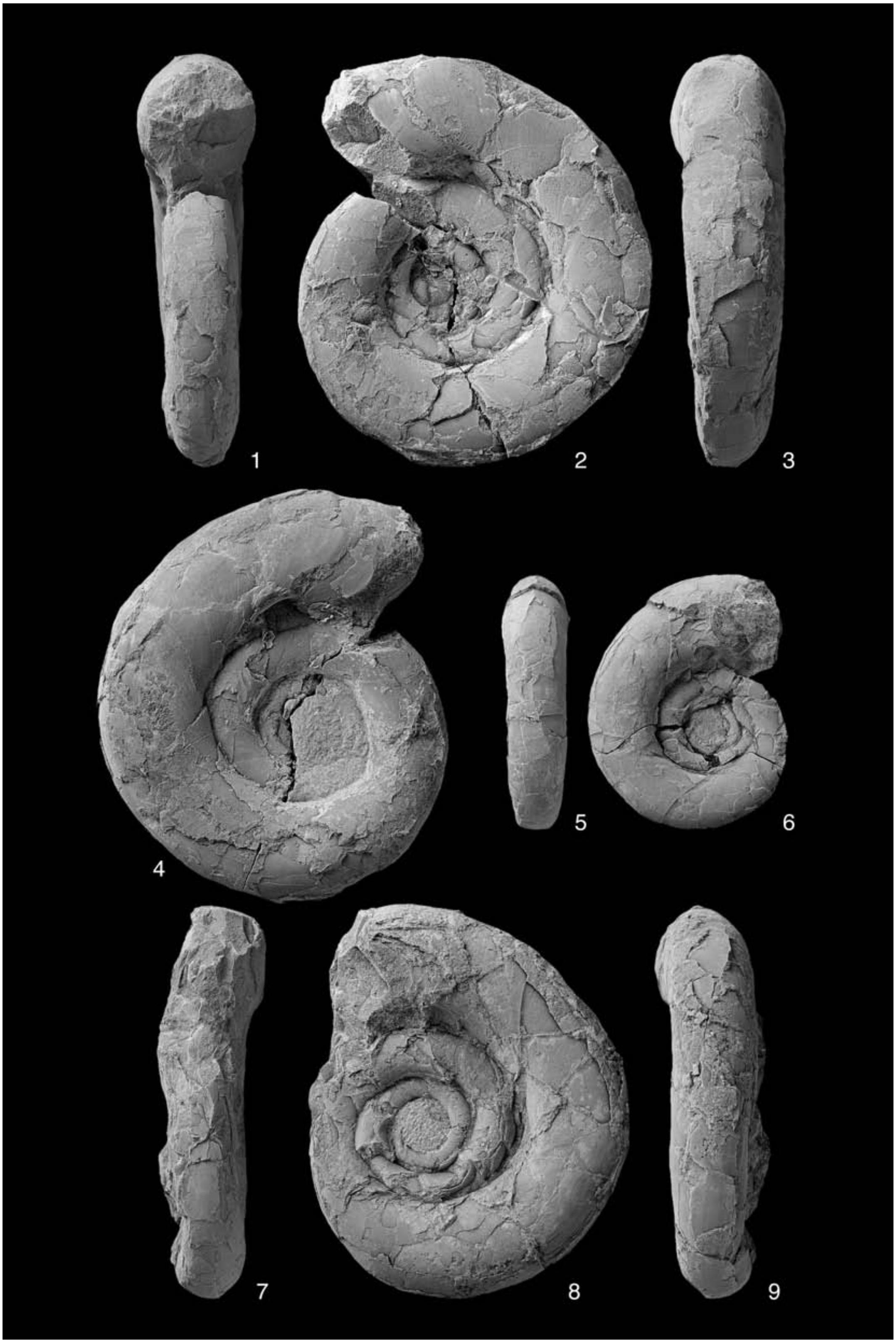
Fig. 45. *Saghalinites teshioensis* Matsumoto. 1–4, NSM PM17239, from Loc. MK2014, ×1.0. 5–6, NSM PM17240, from Loc. MK2014, ×1.0. 7–9, NSM PM17241, from Loc. MK2014, ×1.0.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The present specimens were associated with *S. kawadai* in a bed in the K1 Unit of the Krasnoyarka Formation in the Makarov area, Sakhalin.

Genus ***Pseudophyllites*** Kossmat, 1895

Type species: *Ammonites indra* Forbes, 1846.

Pseudophyllites indra (Forbes, 1846)

Figs. 38.12, 38.13, 38.16, 38.17, 46–50

Ammonites indra Forbes, 1846, p. 105, pl. 11, fig. 7; Stoliczka, 1865, p. 112, pl. 58, fig 2; Whiteaves 1879, p. 105, pl. 13, fig. 2.

Pseudophyllites indra (Forbes). Kossmat, 1895, p. 137, pl. 16, figs. 6–9, pl. 17, figs. 6–7, pl. 18, fig. 3; Whiteaves, 1903, p. 331; Woods, 1906, p. 334, pl. 41, fig. 6; Spath, 1922, p. 119; Collignon, 1938, p. 24, text-fig. E; Usher, 1952, p. 57, pl. 3, figs. 2–13, pl. 31, figs. 15–17; Collignon, 1956, p. 90; Matsumoto, 1959b, p. 134; Jones, 1963, p. 25, pl. 7, figs. 6–7, pl. 8, pl. 29, figs. 7–12, text-fig. 10; Collignon, 1969, p. 12, pl. 516, fig. 2032; Kennedy and Klinger, 1977, p. 182, text-figs. 19–22; Matsumoto and Miyauchi, 1984, p. 54, pl. 21, fig. 5; Henderson and McNamara, 1985, p. 50, pl. 2, figs. 7–8, pl. 3, figs. 4–5, text-fig. 5; Kennedy, 1986, p. 19, pl. 1, figs. 1–5, text-figs. 4e, 5a, 6a–e; Kennedy and Henderson, 1992, p. 398, pl. 3, figs. 7–9, 13–27, pl. 4, figs. 1–3; Shigeta, 1992, p. 1158, text-figs. 1–4.

Pseudophyllites cf. *indra* (Forbes). Kennedy and Summesberger, 1986, p. 187, pl. 1, figs. 1, 8, pl. 3, fig. 5, text-fig. 4.

Tetragonites glabrus (Jimbo). Shigeta, 1989, p. 334, text-fig. 12(3).

Type: Lectotype, designated by Kennedy and Klinger (1977, p. 182), is BMNH C51068, the original of Forbes (1846, p. 105, pl. 11, fig. 7) from the Upper Maastrichtian of the Valudavur Formation near Pondicherry, southern India.

Material: Three specimens, NSM PM-17248–17250, from Loc. MK4014, NSM PM-17267, from Loc. MK4015, two specimens, NSM PM17242, 17243, from Loc. MK4016, and three specimens, NSM PM17244–17246, from Loc. MK4018 along the Victoria River. NSM PM17247, from Loc. MK2031 along the Acacia River.

Description: Early whorls (up to 20 mm). Involute shell, characterized by moderately expanding whorls, a slightly depressed, subrounded to sub-quadrate whorl section, and a narrow, deep umbilicus with a very steep wall and rounded shoulder. Gently curved flanks merge with broadly rounded ventrolateral shoulders and a rounded venter. Fine, prorsiradiate growth lines arise on the umbilical wall and pass over the shoulder and the flanks before becoming slightly flexuous on the ventrolateral shoulders, and then pass over the venter in a broad, adapical facing curve.

Middle and later whorls (over 20 mm in diameter). As shell matures it becomes more involute and the whorl expansion rate increases significantly. Mature whorls are characterized by a rounded to sub-quadrate whorl section, with the greatest width at junction of umbilical shoulder and inner flank. Umbilicus becomes narrower and deeper, with a broadly rounded shoulder. Flanks are gently convex and merge with a broad, rounded venter. Fine growth lines, visible on the smooth shell surface, arise on the umbilical wall and become prorsiradiate as they pass over the umbilical shoulder and flanks, but become flexuous on the ventrolateral shoulders and then pass across the venter with a very broad adapical facing curve. As size increases, delicate folds appear on the flanks and venter, paralleling the growth lines. The suture is highly subdivided with a large, irregularly trifid, first lateral saddle, a smaller, bifid, second latertal saddle, a deeply incised, bifid lateral lobe, and a suspensive lobe with a large bifid first auxiliary saddle.

Occurrence: The present specimens were obtained from the *Sphenoceramus hetonaianus* bearing bed and the *Pachydiscus flexuosus* bearing bed in the K2 and K3 units of the Krasnoyarka Formation in the Makarov area, Sakhalin. These beds range from the upper Lower to the Upper Maastrichtian. Shigeta (1992) described *Pseudophyllites indra* from the Upper Campanian in the Soya area, northern Hokkaido, and the Naiba area, southern Sakhalin. However, this species has not been

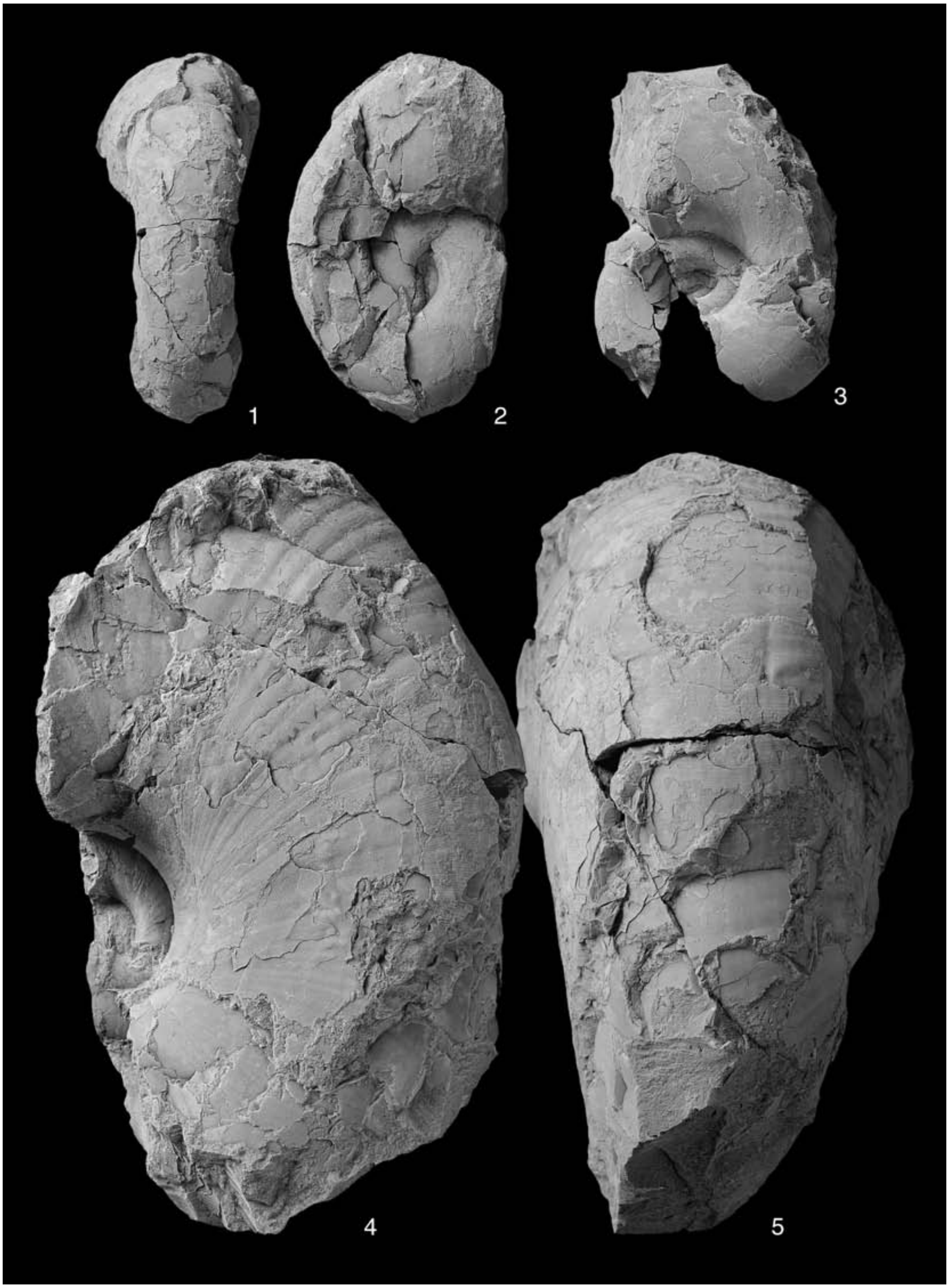

Fig. 46. *Pseudophyllites indra* (Forbes). 1–2, NSM PM17248, from Loc. MK4014, ×1.0. 3, NSM PM17249, from Loc. MK4014, ×1.0. 4–5, NSM PM17250, from Loc. MK4014, ×1.0.

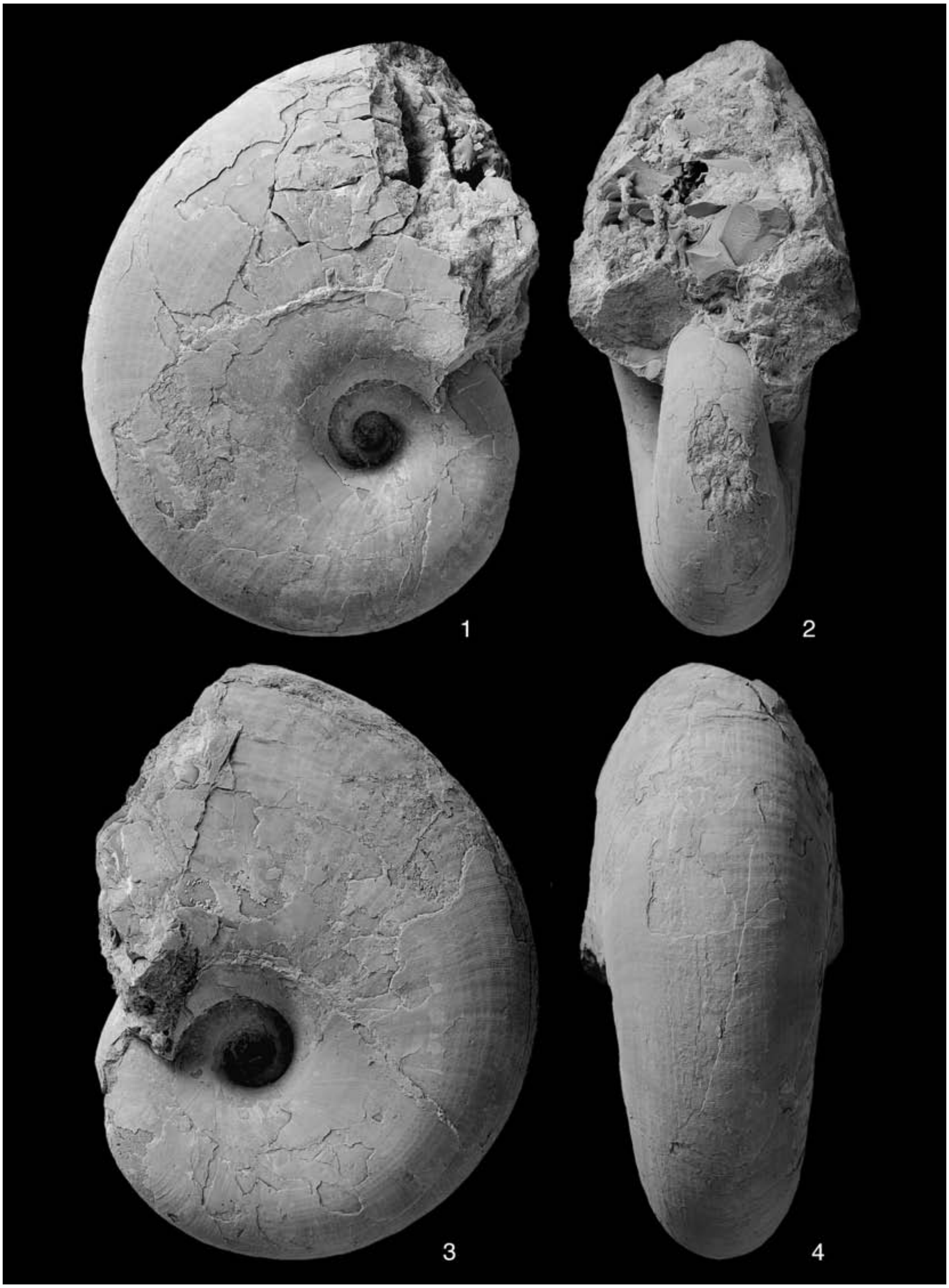

Fig. 47. *Pseudophyllites indra* (Forbes). 1–4, NSM PM17243, from Loc. MK4016, ×0.55.

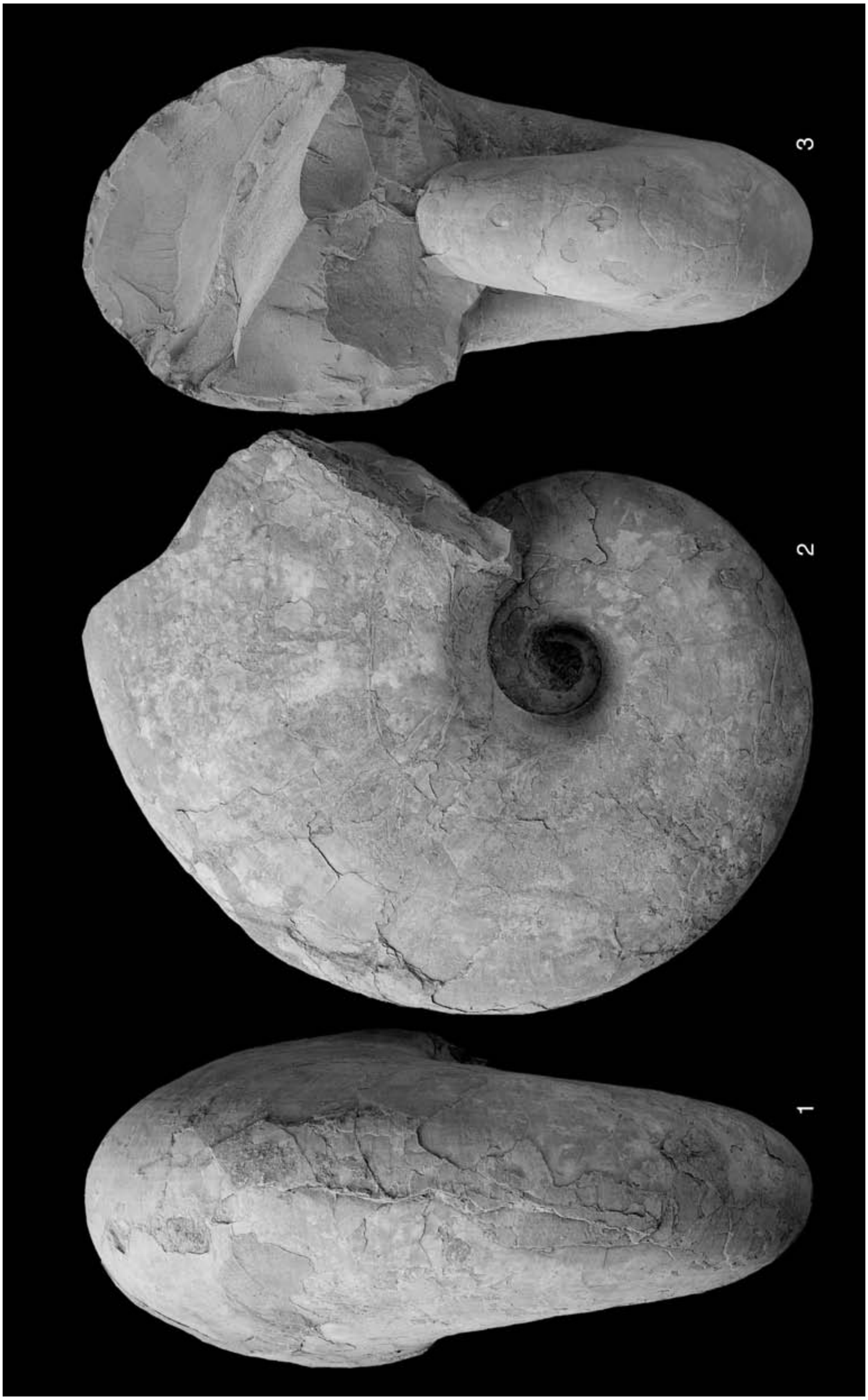

Fig. 48. *Pseudophyllites indra* (Forbes). 1–3, NSM PM17244, from Loc. MK4018, ×0.5.

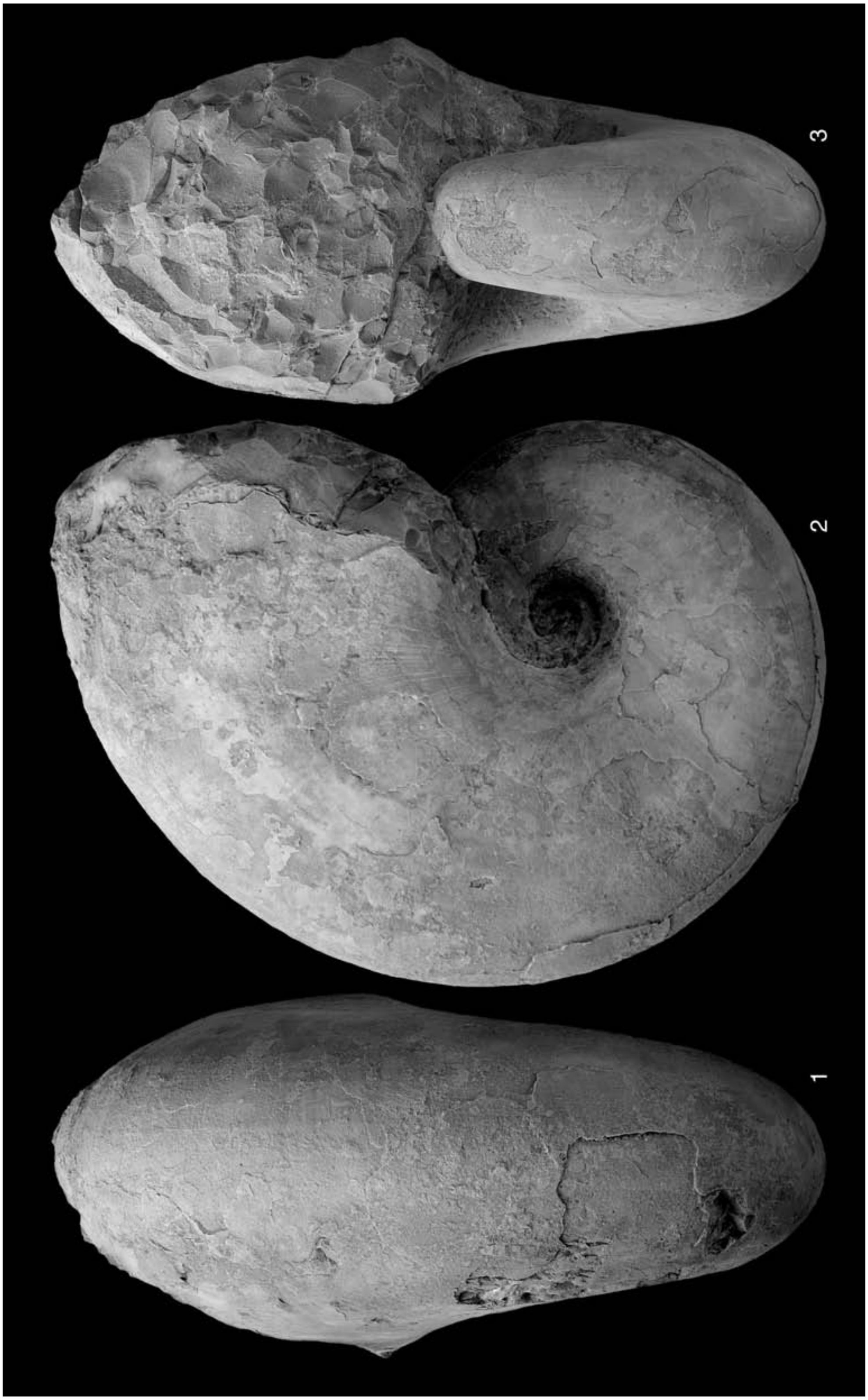

Fig. 49. *Pseudophyllites indra* (Forbes). 1–3, NSM PM17245, from Loc. MK4018, ×0.45.

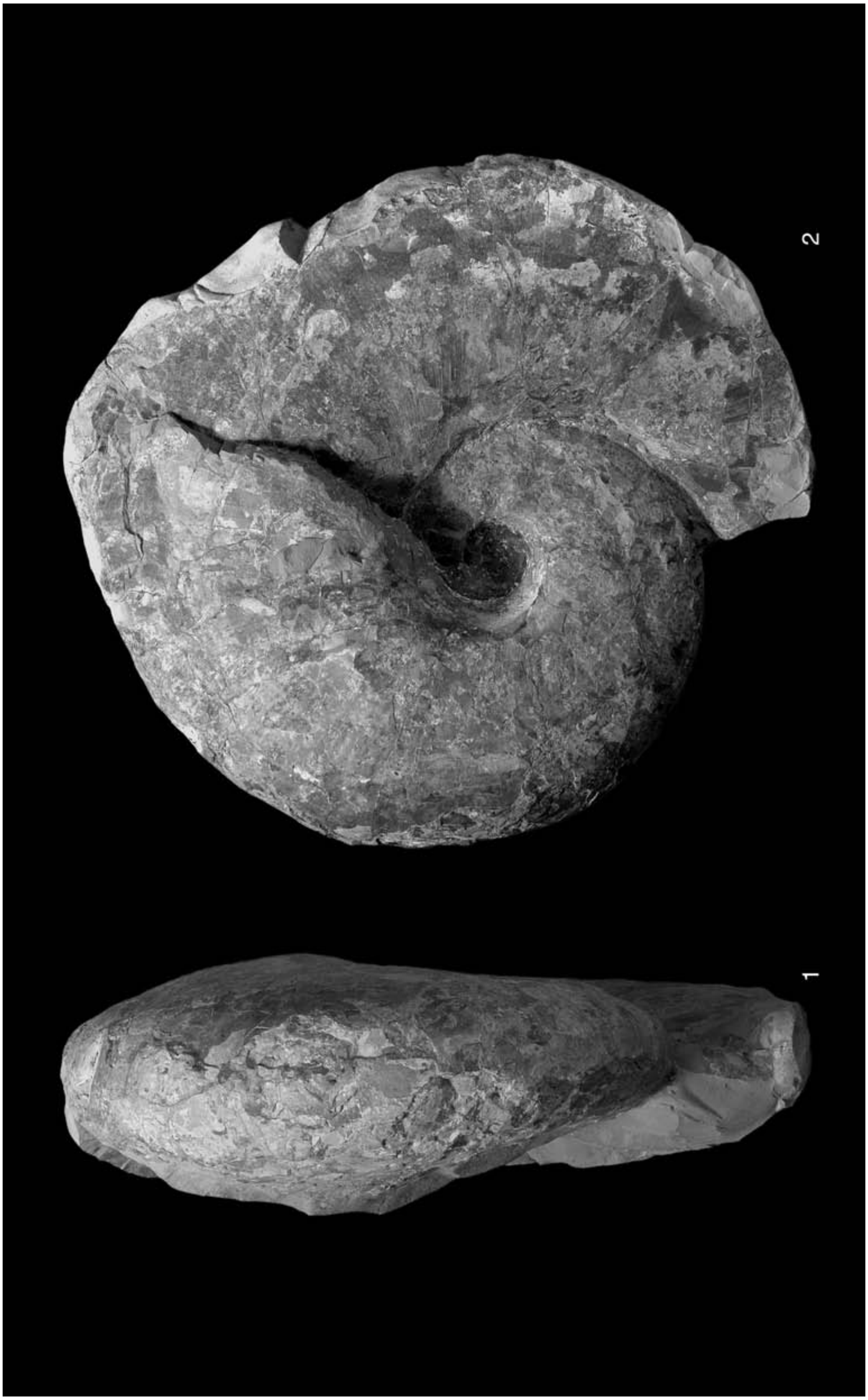

Fig. 50. *Pseudophyllites indra* (Forbes). 1–2, NSM PM17246, from Loc. MK4018, ×0.3.

reported from the *Inoceramus shikotanenus* Zone, of the lower Lower Maastrichtian in Hokkaido and Sakhalin, in spite of its rich ammonite fauna.

P. indra is a long ranging, cosmopolitan species known from the Santonian to Upper Maastrichtian in southern India, South Africa, Madagascar, Western Australia, Hokkaido, Sakhalin, Alaska, British Columbia, California, Chili, Poland, Austria and France.

Suborder Ancyloceratina, Wiedmann, 1966

Superfamily Turrilitoidea, Gill, 1871

Family Baculitidae Gill 1871

Genus ***Baculites*** Lamarck, 1799

Type species: *Baculites vertebralis* Lamarck, 1801

Baculites sp.

Fig. 51.4–51.7

Material: NSM PM17252, from the uppermost part of the Bykov Formation at Loc. MK2015 along the Acacia River. Specimen is a fragment of a body chamber.

Description: Slowly tapered shell, characterized by an oval whorl section, with a narrowly rounded venter and a broadly rounded dorsum, with the greatest width at a position just slightly dorsal of mid-flank. Shell surface is nearly smooth. Specific identification is impossible because of extremely poor preservation.

Occurrence: The present specimen was associated with *Canadoceras kossmati* (upper part of the Lower Campanian) in a bed just below the *Schlueterella kawadai* bearing bed (Upper Campanian) in the B4 Unit of the Bykov Formation in the Makarov area, Sakhalin.

Family *Diplomoceratidae* Spath, 1926

Genus ***Schlueterella*** Wiedmann, 1962

Type species: *Ancyloceras pseudoarmatum* Schlüter, 1872

Schlueterella kawadai Matsumoto and Miyauch, 1984

Fig. 51.8–51.13

Hamites cf. *amartus* Sowerby. Kawada, 1934, pl. 7, fig. 15, pl. 8, fig. 16.

Schlueterella kawadai Matsumoto and Miyauchi, 1984, p. 61, pl. 26, fig. 1, pl. 27, figs. 3–4, pl. 28, fig. 2, pl. 29, fig. 1, pl. 30, figs. 1–2, pl. 31, fig. 3, text-fig. 9.

Type: Holotype, GK. H5978 (Matsumoto & Miyauch, 1984, p. 61, pl. 26, fig. 1), is from Upper Campanian beds around the Soya fishing harbour in the Soya area, northern Hokkaido.

Material: Two specimens, NSM PM17253, 17254, from Loc. MK2014 along the Acacia River. PM17253 is a partly deformed, slightly curved portion of a phragmocone.

Description: Shell surface is ornamented with numerous ribs, which are slanted forward when viewed laterally. Periodic major ribs encircle the shell and each rib is ornamented with four spinose tubercles, one on each side of the ventral zone and one at mid-flank on each side. The sutures lines are only partly exposed on PM17253.

PM17254 is a curved portion of a large shell and it probably represents the hooked part of the body chamber. Only the ventral part is preserved, and two rows of tubercles are visible on the major ribs. Ornamentation on the ventral area is identical to that on the type material described by Matsumoto and

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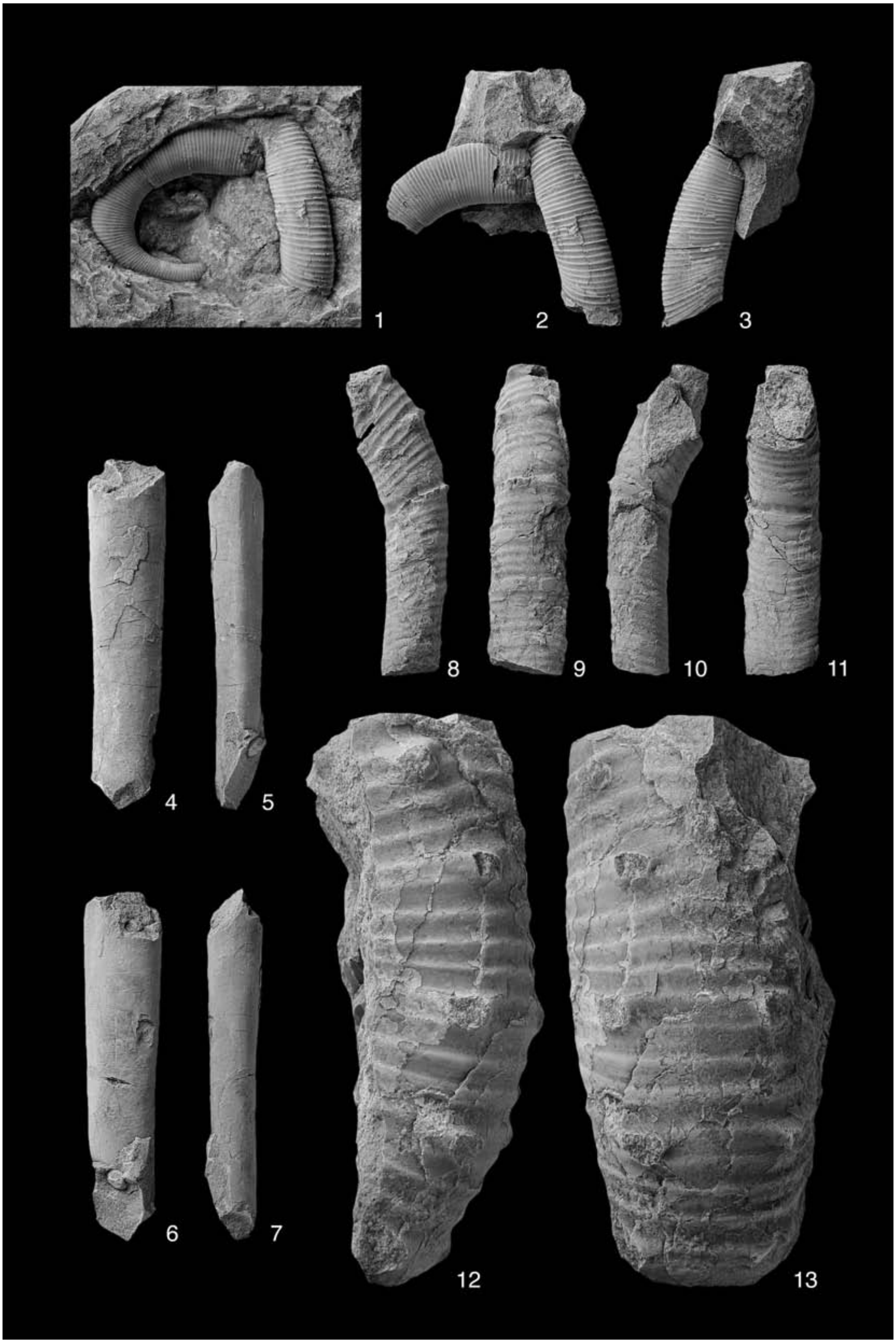
Fig. 51. 1–3, *Glyptoxoceras* sp., NSM PM17255, from Loc. MK2036, ×1.0. 1, Plaster cast from outer mould. 2, Lateral view. 3, Lateral view. 4–7, *Baculites* sp., NSM PM17252, from Loc. MK2015, ×1.0. 4, Lateral view. 5, Ventral view. 6, Lateral view. 7, Dorsal view. 8–13, *Schlueterella kawadai* Matsumoto and Miyauch. 8–11, NSM PM17253, from Loc. MK2014, ×1.0. 8, Lateral view. 9, Ventral view. 10, Lateral view. 11, Dorsal view. 12–13, NSM PM17254, from Loc. MK2014, ×1.0. 12, Lateral view. 13, Ventral view.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Miyauch (1984).

Occurrence: *Schlueterella kawadai* is abundant in the *Menuites soyaensis* bearing bed (Upper Campanian) in the Soya area, northern Hokkaido and the Naiba area, southern Sakhalin, as well as the *Metaplacenticeras subtilistriatum* bearing bed in the Teshio Mountains, northern Hokkaido. The present specimens were collected from the *M. soyaensis* bearing bed in the K1 Unit of the Krasnoyarka Formation in the Makarov area, Sakhalin.

Genus ***Diplomoceras*** Hyatt, 1900

Type species: *Baculites cylindracea* Defrance, 1816.

Diplomoceras cf. ***notabile*** Whiteaves, 1903

Fig. 52

cf. *Diplomoceras notabile* Whiteaves, 1903, p. 335, pl. 44, fig. 4; Usher, 1952, p. 109, pl. 29, fig. 2, pl. 30, fig. 1, pl. 31, figs. 26–27; Jones, 1963, p. 32, pl. 21, fig. 1, text-fig. 15.

cf. *Diplomoceras* cf. *notabile* Whiteaves. Matsumoto and Morozumi, 1980, p. 23, pl. 16, fig. 3.

Material: NSM PM17256, from Loc. MK-4030 along the Victoria River. Specimen is slightly flattened.

Description: PM17256 is a large portion of a body chamber approximately 330 mm long and 190 mm wide. It consists of two straight, nearly parallel shafts connected by U-curve. The whorl section is broadly oval with a nearly flattened dorsal side and a more narrowly rounded ventral side. Ornamentation consists of numerous, regularly spaced, encircling ribs, which vary from straight to strongly oblique.

Discussion: Although the present specimen is a partly deformed body chamber, its distinctive features enable us to identify it with probable confidence as *Diplomoceras notabile*.

Occurrence: *Diplomoceras notabile* is known from beds of late Campanian to Maastrichtian age in southwestern Japan, Alaska and British Columbia. The present specimens were associated with *Pachydiscus flexuosus* in a bed in the K3 Unit (lower Upper Maestrichtian) of the Krasnoyarka Formation in the Makarov area, Sakhalin.

Genus ***Glyptoxoceras*** Spath, 1925

Type species: *Hamites rugatus* Forbes, 1846.

Glyptoxoceras sp.

Fig. 51.1–51.3

Material: NSM PM17255, from Loc. MK-2036 along the Acacia River.

Description: The whorl is in the form of a very loose helix, with a slightly compressed, subcircular whorl section. Ornamentation consists of very fine, delicate ribs, which vary from straight to oblique. The suture lines are not exposed.

Occurrence: The present specimen was collected from the *Pachydiscus flexuosus* bearing bed in the K3 Unit (lower Upper Maastrichtian) of the Krasnoyarka Formation in the Makarov area, Sakhalin.

Suborder Ammonitina Hyatt, 1889

Superfamily Desmocerataceae Zittel, 1895

Family Desmoceratidae, 1895

Genus ***Damesites*** Matsumoto, 1942a

Type species: *Desmoceras damesi* Jimbo, 1894.

Damesites cf. ***sugata*** (Forbes, 1846)

Fig. 53.1–53.6

cf. *Ammonites sugata* Forbes, 1846, p. 113, pl. 10, fig. 2.

cf. *Damesites sugata* (Forbes). Matsumoto and Obata, 1955, p. 128, pl. 26, figs. 4–5, pl. 27, figs. 3–4; Haggart, 1989, p. 195, pl. 8.4, figs. 14–23.

Material: Two specimens, NSM PM17257, 17258, from the Bykov Formation at Loc. MK2062 along the Acacia River.

Description: Very involute shell, charac-

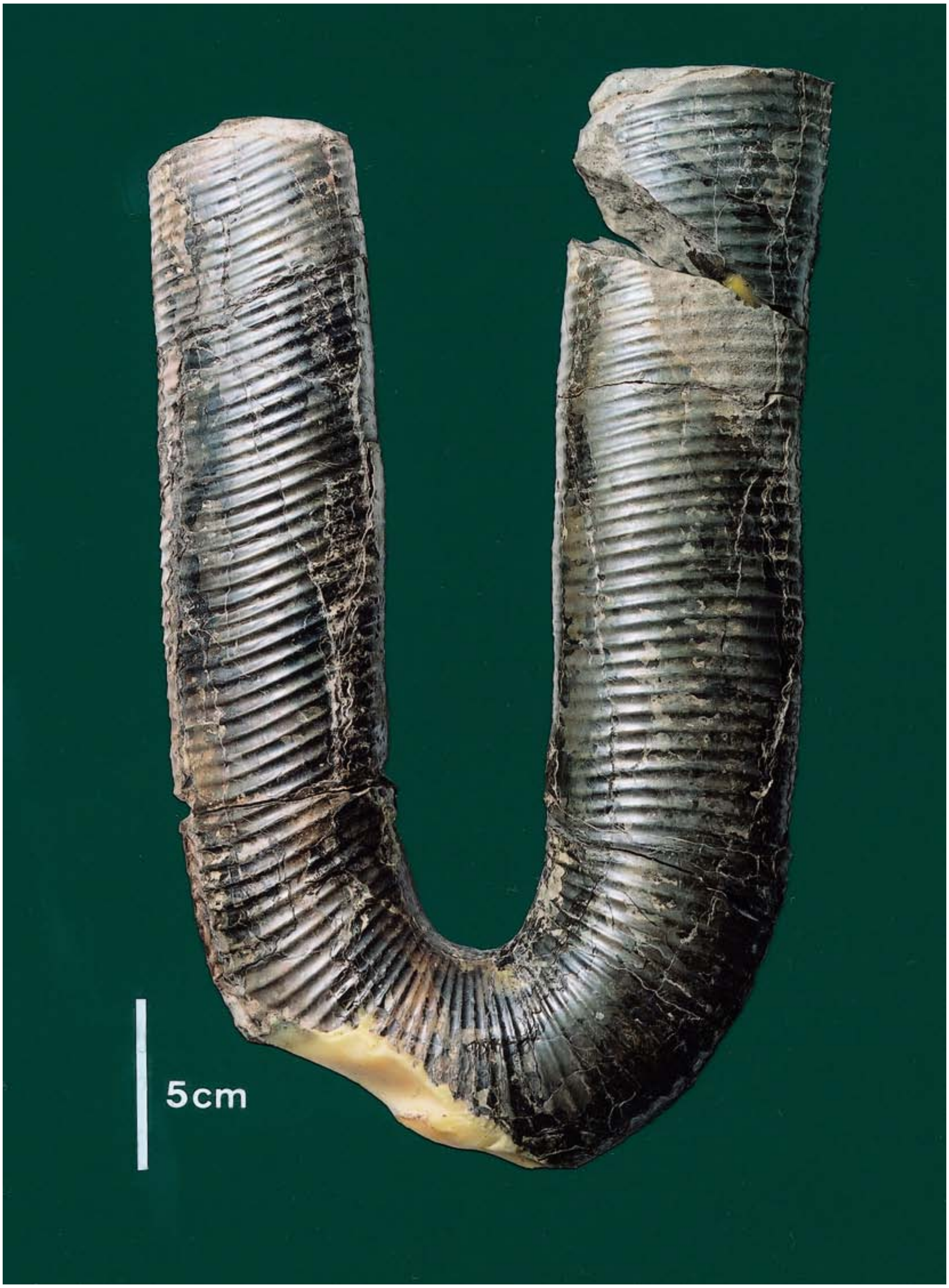

Fig. 52. *Diplomoceras* cf. *notabile* Whiteaves, NSM PM17256 from Loc. MK4030. Scale bar = 5 cm.

terized by an oval to sub-quadrate, slightly compressed whorl section, and weakly convex, nearly parallel flanks, with the greatest whorl width at about mid-flank, and a narrow, deep umbilicus with a vertical wall and rounded shoulder. The present specimens display very weak keel on a rounded venter. Fine, prorsiradiate growth lines, cover most of the flank, and flex forward at the ventrolateral shoulder, before crossing the venter with a narrow, convex arch. In addition, distant, periodic constrictions occur on all whorls. The suture line is typical of desmoceratids.

Discussion: Even though the present specimens are small, their distinctive features enable us to identify them with probable confidence as *Damesites sugata*.

Occurrence: The present specimens were found in the *Sphenoceramus orientalis* bearing bed (upper Lower Campanian) in the B3 Unit of the Bykov Formation in the Makarov area, Sakhalin. *Damesites sugata* is abundant in beds of Coniacian to Campanian age in Hokkaido, Sakhalin, British Columbia and southern India.

Genus ***Desmophyllites*** Spath, 1929

Type species: *Desmoceras larteti* Seunes, 1891.

Desmophyllites diphylloides (Forbes, 1846)

Fig. 53.7–53.14

Ammonites diphylloides Forbes, 1846, p. 105, pl. 8, fig. 8.

Desmophyllites diphylloides (Forbes). Matsumoto and Obata, 1955, p. 121, pl. 24, figs. 1–5, pl. 30, fig. 1, text-fig. 1; Matsumoto, 1959b, p. 9, pl. 3, fig. 3, text-fig. 2; Collignon, 1961, p. 61, pl. 25, figs. 1–2, text-fig. 2; Howarth, 1965, p. 388, pl. 11, fig. 3; Collignon, 1966, p. 84, pl. 498, fig. 1973; Collignon, 1971, p. 37, pl. 655, fig. 2415; Matsumoto, 1984a, p. 12, pl. 1, fig. 2; Henderson and McNamara, 1985, p. 54, pl. 4, figs. 1–4; Haggart, 1989, p. 193, pl. 8.4, figs. 1–13; Kennedy and Henderson, 1992, p. 405, pl. 6, figs. 1–9, pl. 16, figs. 1–3, 7–8, pl. 17, figs. 4–7, text-fig. 3F; Alabushev and Wiedmann, 1977, p. 22, pl. 6, figs. 3–5.

Type: Lectotype, designated by Matsumoto and Obata (1955, p. 122), is BMNH C22682, the original of Forbes (1846, p. 105, pl. 8, fig. 8) from the Maastrichtian (?) of Pondicherry, southern India.

Material: Three specimens, NSM PM-17259–17261, from Loc. MK2014 along the Acacia River. All specimens are slightly crushed and deformed.

Description: Very involute shell characterized by an oval to sub-quadrate, slightly compressed whorl section, a very narrow, deep umbilicus, and a moderately rounded venter at an early growth stage, but becoming narrowly rounded on mature whorls. Fine growth lines arise on the umbilical shoulder, become slightly sigmoidal in shape on the inner flank, and bend sharply forward on the outer flank before crossing venter in a narrow, convex arch. In addition, distant, periodic constrictions, parallel to the growth lines, occur on all whorls. The sutures lines are only partly exposed.

Occurrence: *Desmophyllites diphylloides* is known from beds of Santonian to late Maastrichtian age in southern India, western Australia, Madagascar and Angola, and it has also been reported from the *Schluterella kawadai* bearing bed (Upper Campanian) in southern Sakhalin and northern Hokkaido. The present specimens were associated with *Schluterella kawadai* in a bed in the K1 Unit of the Krasnoyarka Formation in the Makarov area, Sakhalin.

Concluding remarks

The Russian-Japanese joint investigation has delineated the detailed stratigraphy as well as the faunal succession in the Makarov area. Final conclusions regarding stratigraphic correlation will be presented after all analyses are completed and integrated.

The Cretaceous System in the Far East region is widely regarded as one of the world's standards (Matsumoto, 1977; Pergament, 1977). It reveals prolific information about

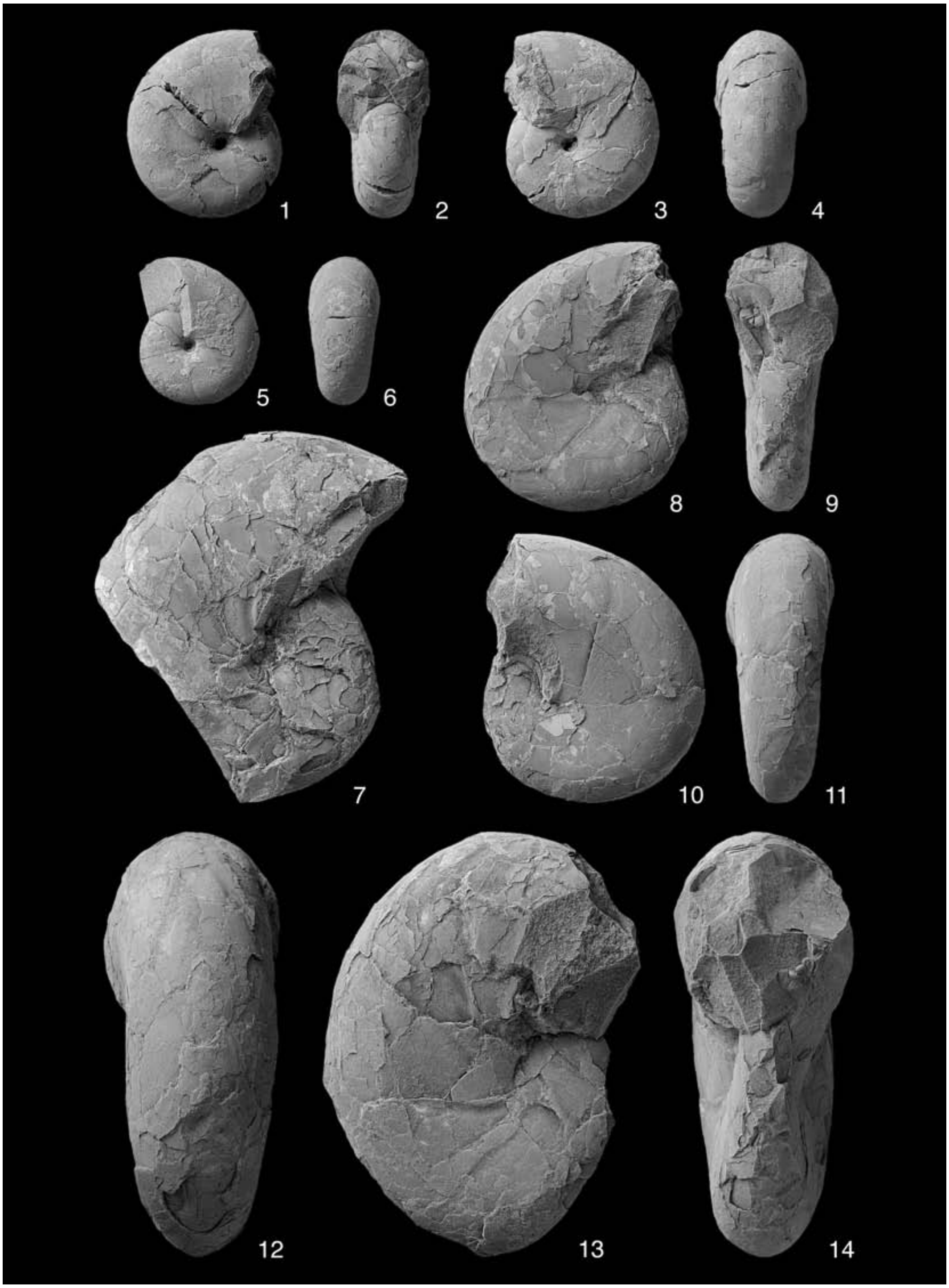

Fig. 53. 1–6, *Damesites* cf. *sugata* (Forbes). 1–4, NSM PM17257, fom Loc. MK2062, ×1.0. 5–6, NSM PM17258, fom Loc. MK2062, ×1.0. 7–14, *Desmophyllites diphylloides* (Forbes). 7, NSM PM17259, from Loc. MK2014, ×1.0. 8–11, NSM PM17260, from Loc. MK2014, ×1.0. 12–14, NSM PM17261, from Loc. MK2014, ×1.0.

biogeography as well as pandemic environmental changes during Cretaceous time, e.g., Oceanic Anoxic Events (Hirano *et al.*, 1991; Hirano, 1995). Several new paleoecological approaches have also arisen from observations of Cretaceous fossil assemblages from Hokkaido and Sakhalin (Kase *et al.*, 1994; Maeda, 1987, 1991, 1993; Shigeta, 1993). Therefore, much further progress is anticipated as a result of future efforts by the joint research team.

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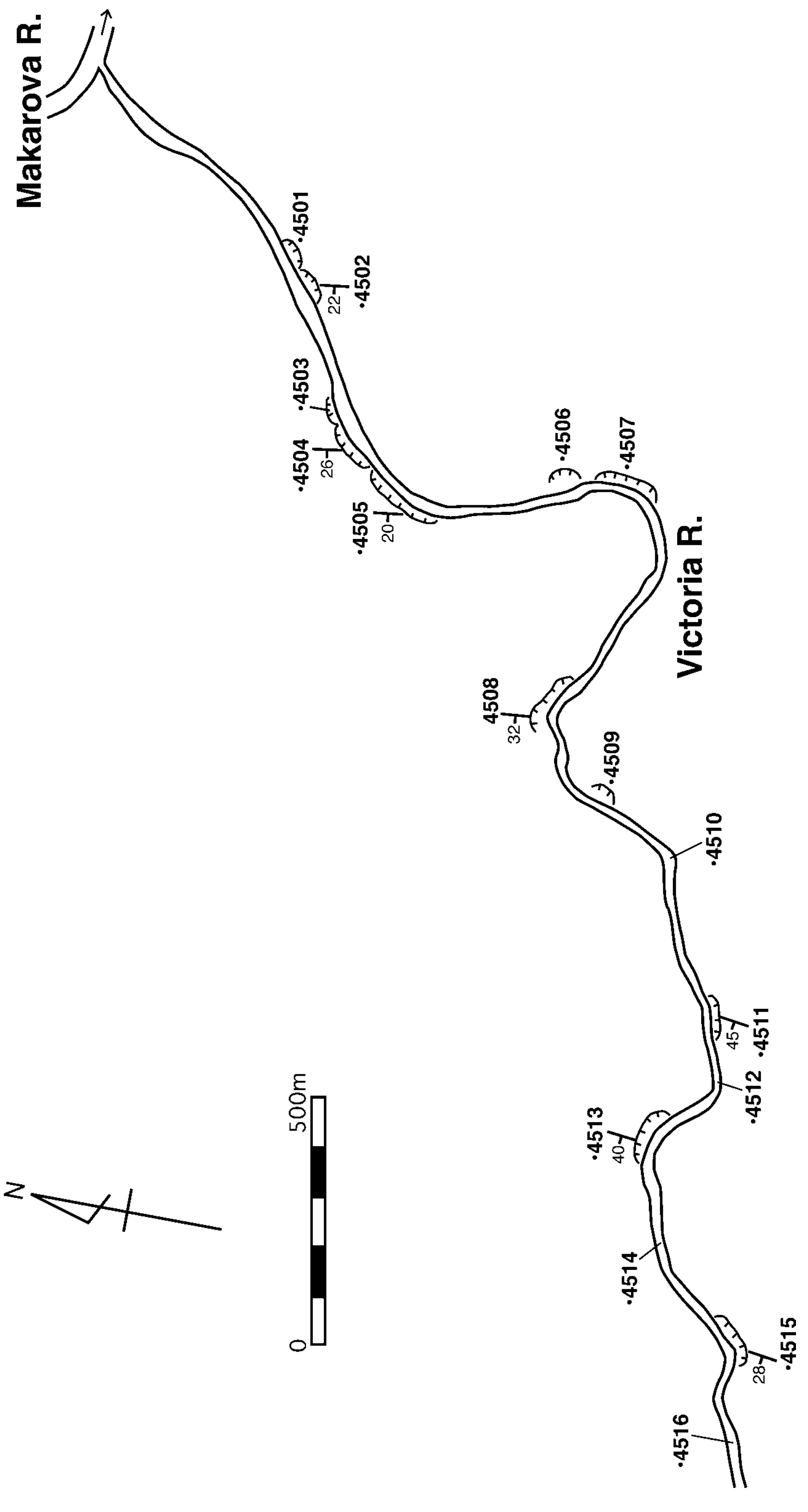
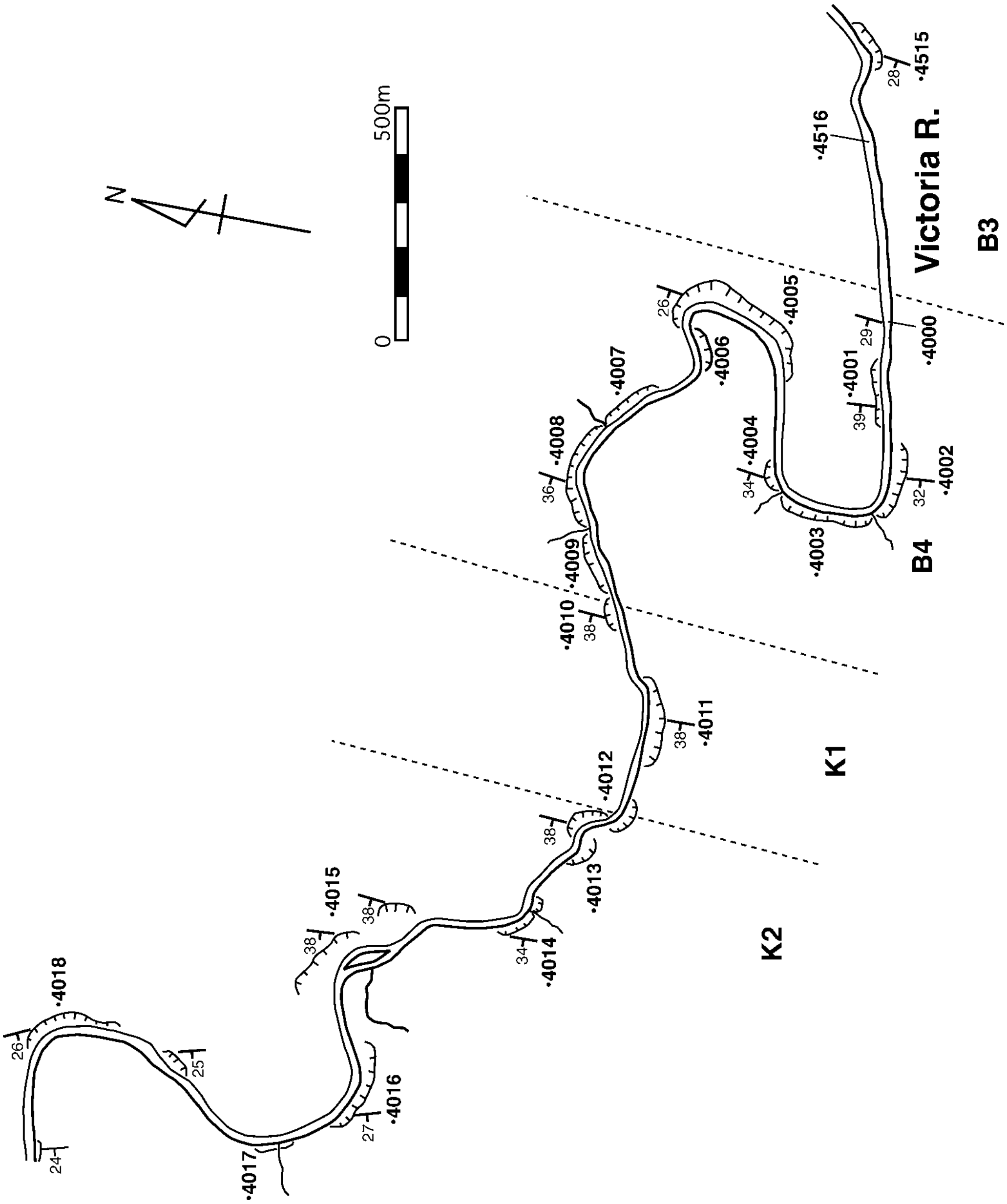
ロシア極東・サハリン南部・マカロフ地域の白亜系層序と化石群：マカロフ地域の白亜系蝦夷層群について，層序学および古生物学の視点から包括的な調査研究を行った．本地域に分布する蝦夷層群は，サントニアン期からマストリヒチアン期に及び，層厚は 2,500 m に達する．下位からブイコフ層とクラスノヤルカ層に区分される．ブイコフ層は主に沖合成の泥岩から成り，下位から B1~B4 の 4 岩相ユニットに区分される．一方，クラスノヤルカ層は主に沿岸成の砂岩やデルタ堆積物から成り，下位から K1~K4b の 5 岩相ユニットに区分される．クラスノヤルカ層の最上部を除き，化石は豊富に産出する．特に，パキディスクス科，テトラゴニテス科，ゴードリセラス科のアンモノイドが豊富に産出する．*Sphenoceramus schmidti*（カンパニアン期中期）も多産し，特徴的な化石帯として広く追跡できる．国際対比に有効な属種の産出は少ないが，カンパニアン期からマストリヒチアン期までのほぼ完全な化石群が連続的に観察できることは注目される．蝦夷層群の化石群の組成や泥岩の堆積学的な特徴はサハリン南部や北海道を通じて似ている．幾つかの化石帯は岩相層序境界と斜交するが，同一の岩相や生物相が南北 1,200 km にわたり分布する．このような堆積や動物群の均質性は蝦夷層群の著しい特徴である．本論文では，*Hypophylloceras* (*Neophylloceras*) *victriense* と *Gaudryceras makarovens* の 2 新種を含む 14 属 25 種のアンモノイドを記載した．

前田晴良・重田康成・ Allan Gil S. Fernando ・岡田尚武

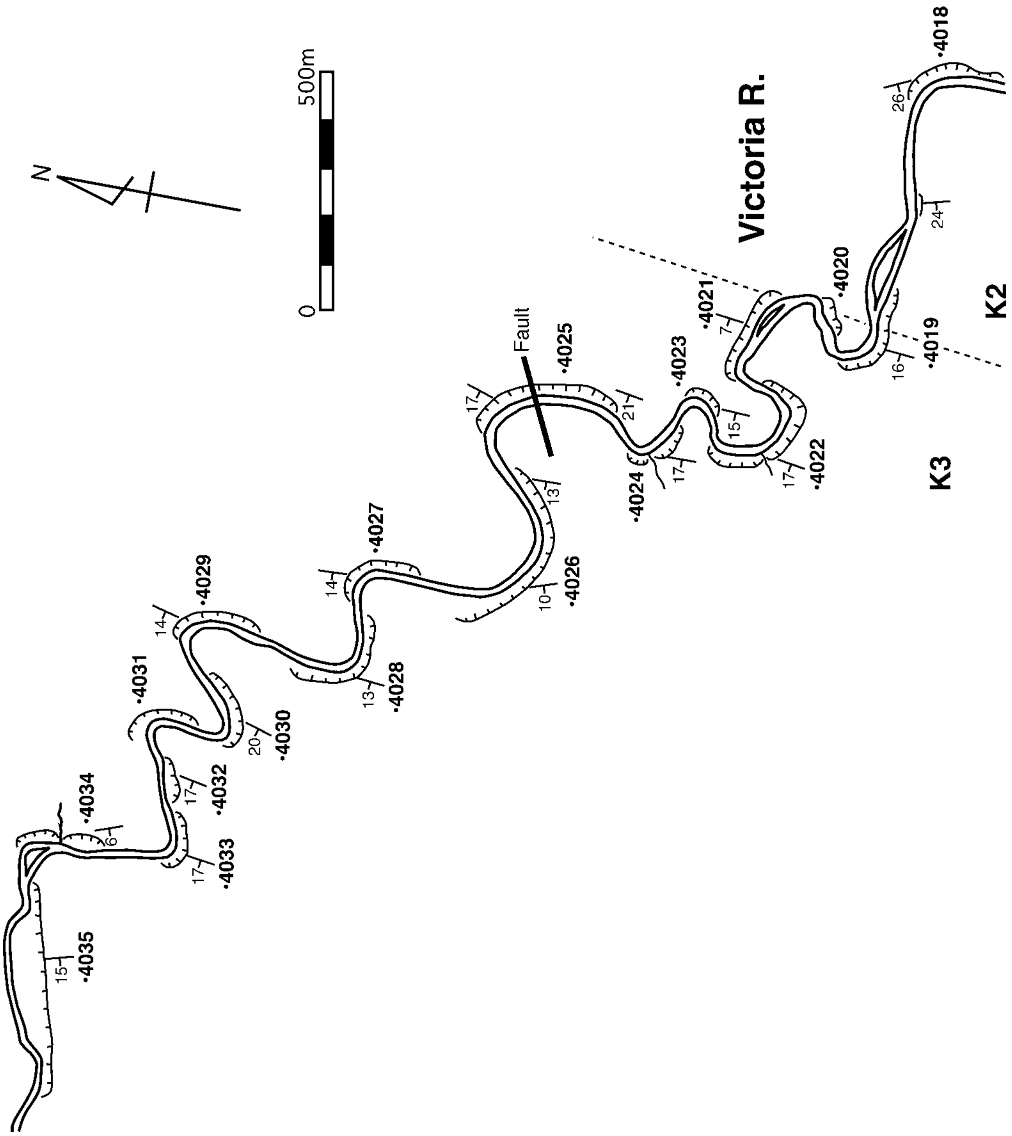
Appendices 1–8



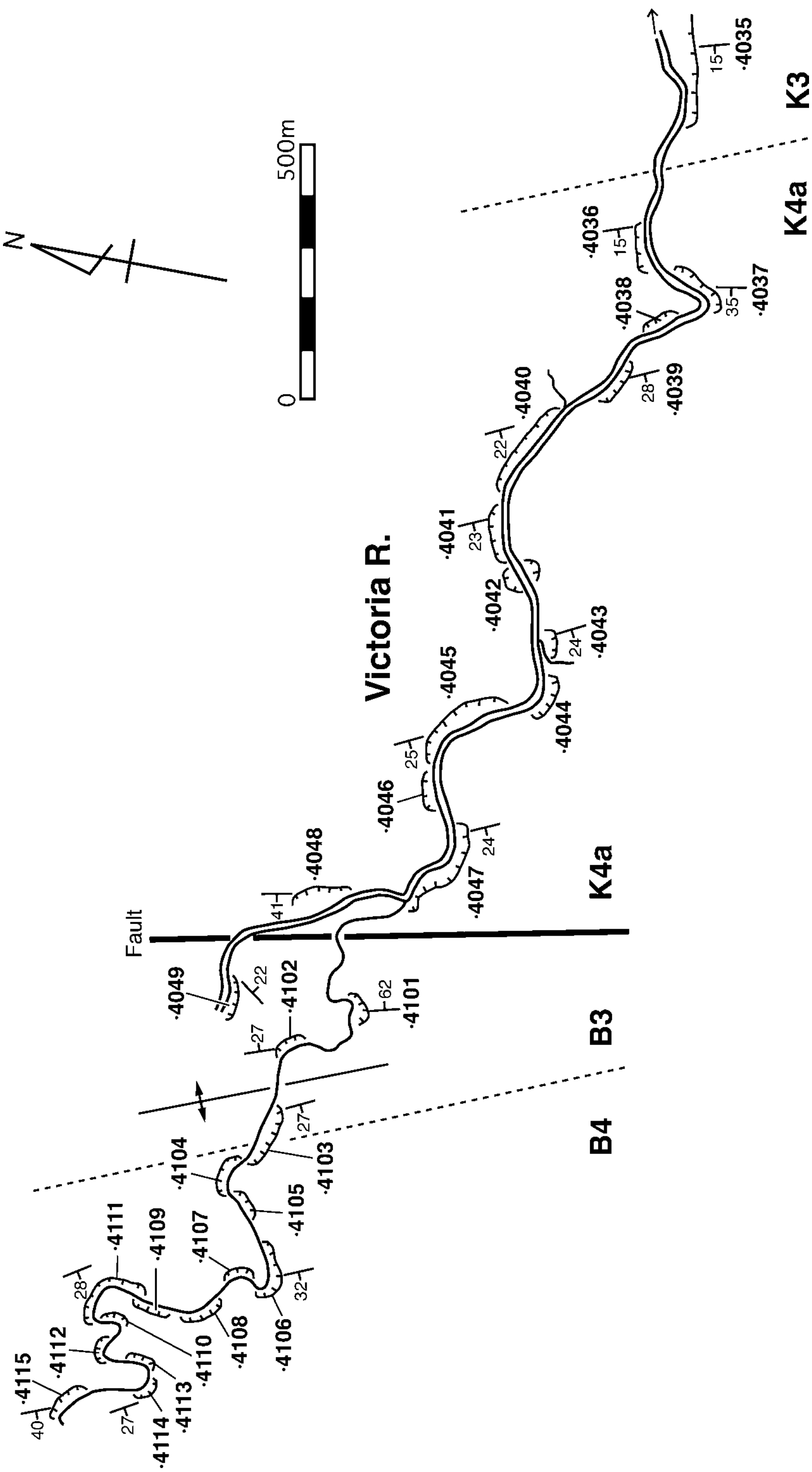
Appendix 1. Locality map along the Victoria River (part 1).



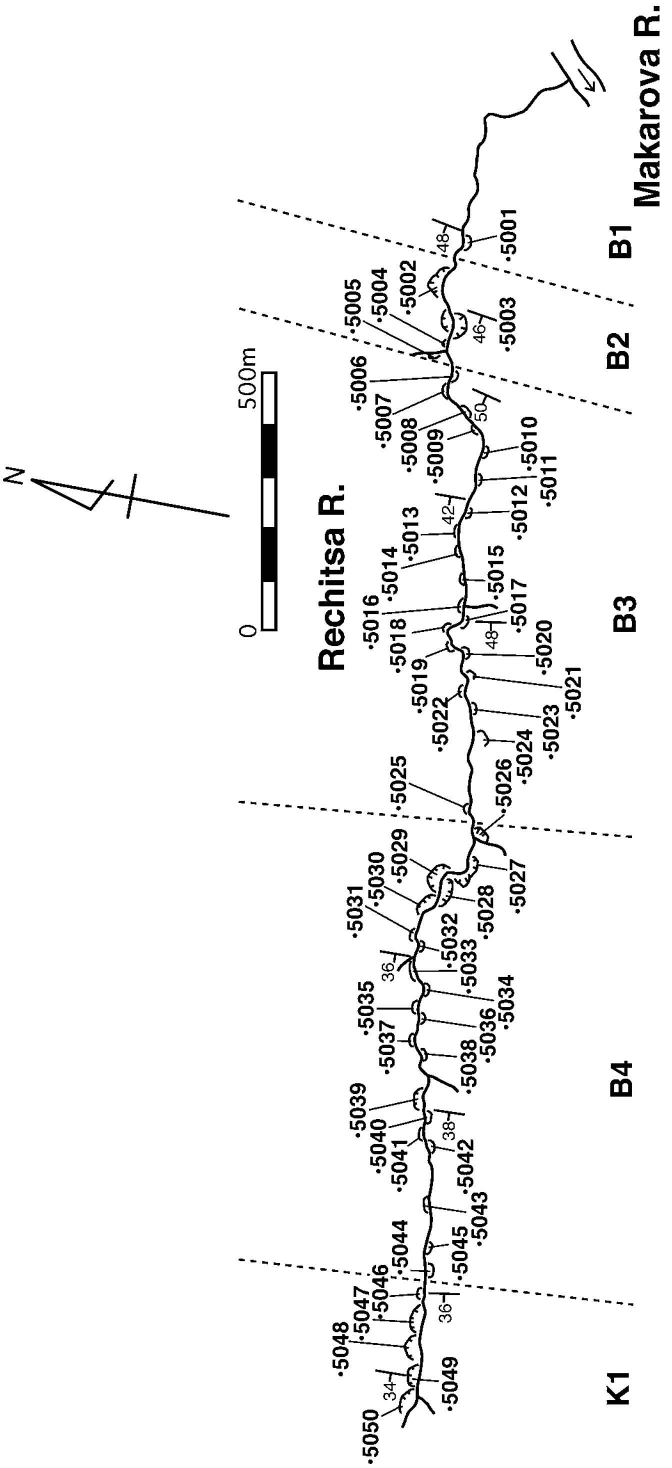
Appendix 2. Locality map along the Victoria River (part 2).



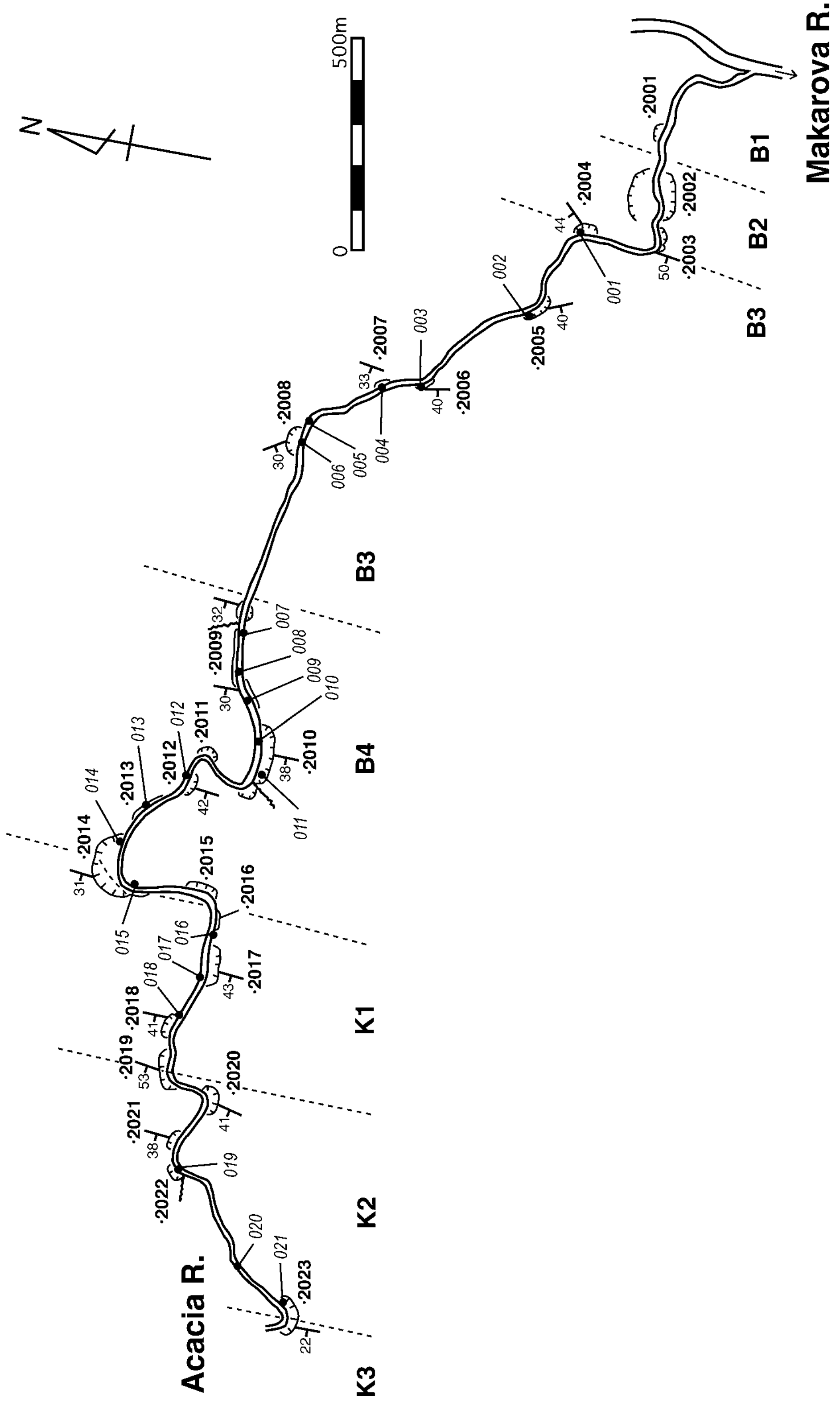
Appendix 3. Locality map along the Victoria River (part 3).



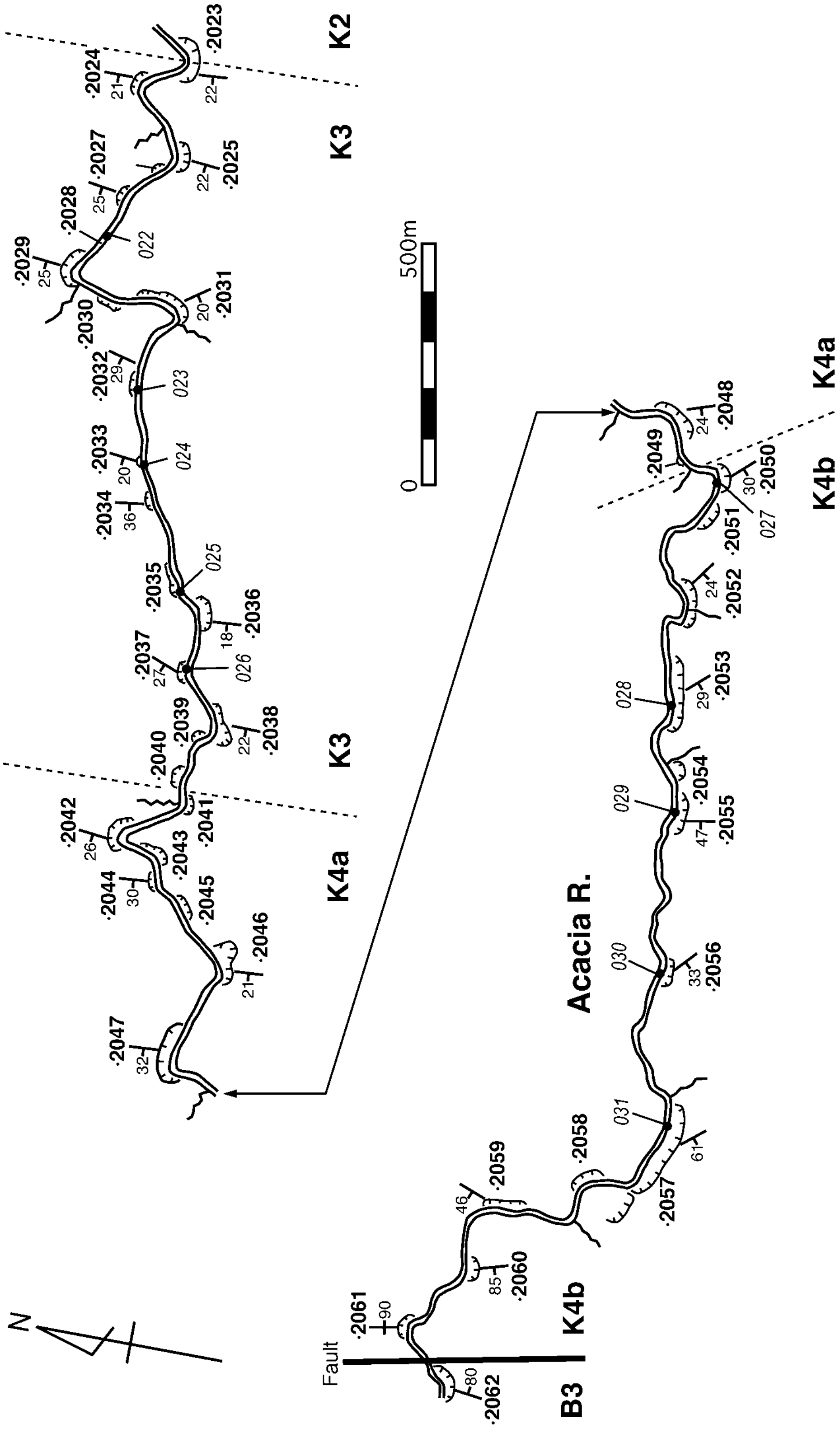
Appendix 4. Locality map along the Victoria River (part 4).



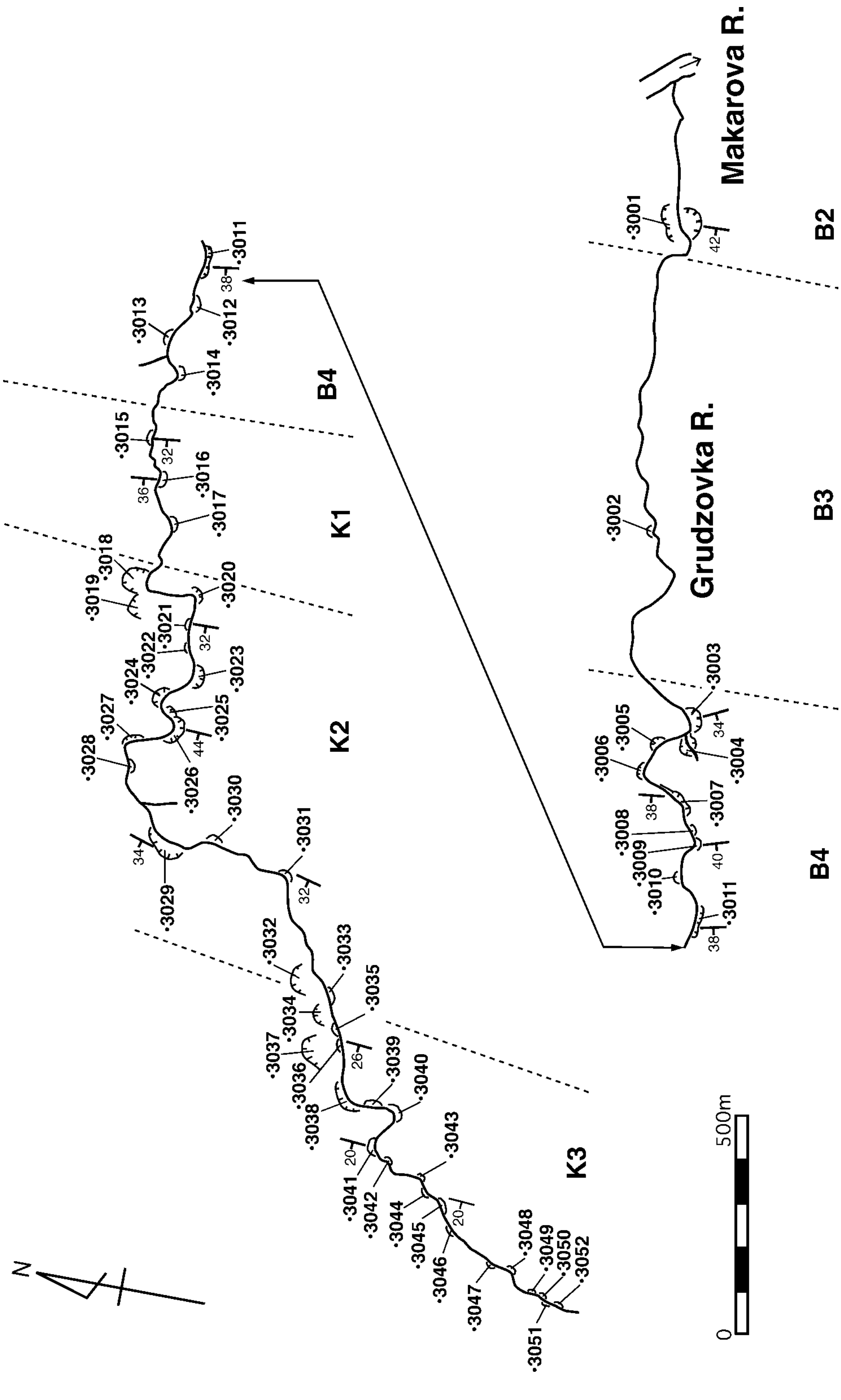
Appendix 5. Locality map along the Rechitsa River.



Appendix 6. Locality map along the Acacia River (part 1). 001–021: samples for calcareous nannofossil biostratigraphy.



Appendix 7. Locality map along the Acacia River (part 2). 022–031: samples for calcareous nannofossil biostratigraphy.



Appendix 8. Locality map along the Grudzovka River.