

Stratigraphy of the Upper Cretaceous System in the Kril'on Peninsula, South Sakhalin, Russia

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Abstract The Upper Cretaceous System in the Kura and Gorbusha areas of the Kril'on Peninsula, South Sakhalin was investigated stratigraphically and paleontologically by the first Japanese-Russian expedition after the Second World War. The Upper Cretaceous System of the Kril'on Peninsula is divided into two formations, the Bykov and Krasnoyarka formations in upward sequence. The former is composed of dark gray massive mudstone, and is correlated to the "Upper Yezo Group" in Hokkaido. The later consists mainly of sandstone and sandy mudstone, being correlated to the "Hakobuchi Group". Inoceramid bivalves, pachydiscid and gaudryceratid ammonites are abundant throughout the sequence, in which six inoceramid zones were recognized successively, i.e., *Inoceramus amakusensis*, *Platyceramus japonicus*, *Sphenoceramus schmidt*, *Inoceramus balticus*, *Mytiloides shimanukii*, and *Inoceramus shikotanensis* zones in ascending order. These zones suggest the Santonian to uppermost Campanian or lowest Maastrichtian stages.

Key words: ammonites, inoceramids, Kril'on Peninsula, South Sakhalin, stratigraphy, Upper Cretaceous

Introduction

The Cretaceous Yezo Group consists of fore-arc basin clastic deposits (Okada, 1979, 1983). It is widely distributed in the central zone of Hokkaido and western zone of Sakhalin. Numerous ammonite and inoceramid species have been described from the Yezo Group by previous authors (e.g. Yokoyama, 1890; Jimbo, 1892; Yabe, 1903, 1904; Nagao & Matsumoto, 1939, 1940; see Matsumoto, 1975) and, based on these ammonoids and inoceramids, a biostratigraphic scheme for the Cretaceous System in Hokkaido has been well established (Matsumoto, 1942, 1943, 1954, 1959, 1977; Toshimitsu *et al.*, 1995a, 1995b).

A complete succession of marine fossil assemblages spanning the Campanian-Maastrichtian is not recorded in Hokkaido, because regressive deltaic facies become predominant in the uppermost part of the Cretaceous System there (Matsumoto,

1954; Maeda, 1986). In contrast, fossiliferous mudstone facies is still dominated in the uppermost part of the Cretaceous System of South Sakhalin, and stratigraphic and faunal successions are readily observable toward the top of the sequence (Vereshchagin *et al.*, 1965; Vereshchagin, 1970, 1977; Fursenko, 1974).

The stratotype of the Cretaceous System in South Sakhalin is located in the Naiba River area, and the megafossil zonation has been attempted by many authors (Kawada, 1929; Shimizu, 1929; Matsumoto, 1942, 1943, 1954; Vereshchagin, 1961, 1963; Vereshchagin & Salinikov, 1968; Pergament, 1974; Zonova, 1974; Zakharov *et al.*, 1981, 1984, 1996; Zonova, 1987; Mirolubov, 1987; Zonova *et al.*, 1993; Yazykova, 1994; Alabushev & Wiedmann, 1997).

In addition to the stratotype locality, the Kura and Gorbusha areas in the Kril'on Peninsula (Fig. 1) provide one of the best reference sections of the Upper Cretaceous of South Sakhalin (Vereshchagin, 1961; Vereshchagin, 1970, 1977). No detailed geological maps, columnar sections, or route maps of the peninsula have been published for this area.

To establish the up-to-date biostratigraphic zonation for the Upper Cretaceous System of Sakhalin, a field expedition was carried out by the authors in 1996 along

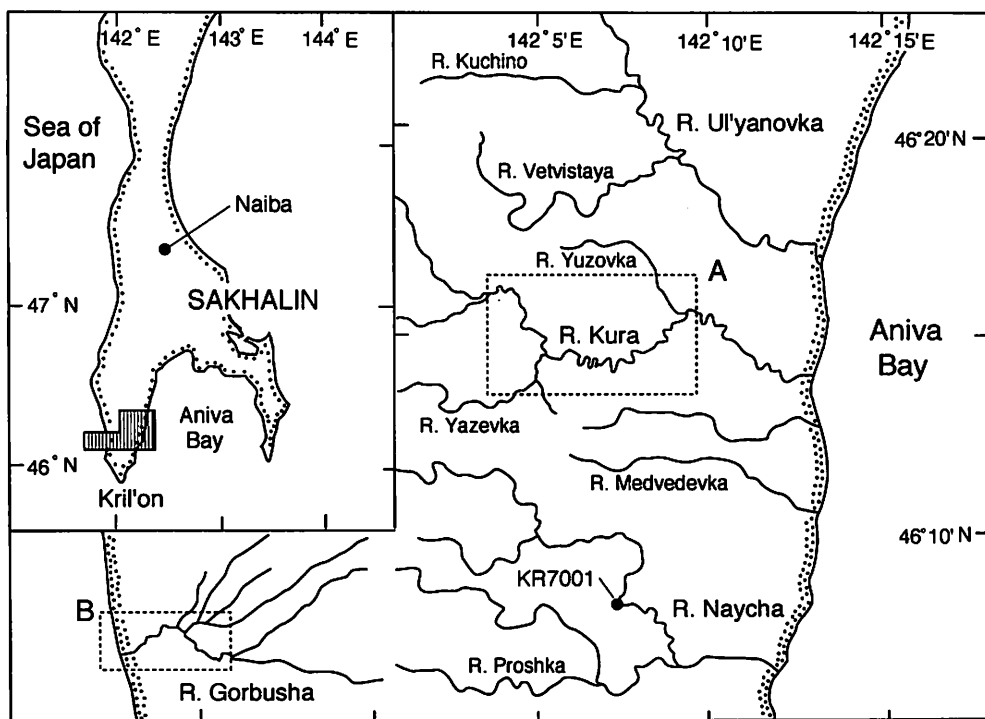


Fig. 1. Map showing the study area in the eastern part of the Kril'on peninsula, South Sakhalin.
A: Kura area, B: Gorbusha area.

the Kura and Gorbusha rivers (Fig. 1). This was the first geological expedition by a joint Japanese-Russian research team to the Kril'on Peninsula since the Second World War.

Previous Studies of the Kril'on Area

During the mid 19th to early 20th centuries, a few Russian and Japanese geologists undertook a geological expedition in the Kril'on Peninsula, and discovered Cretaceous deposits and fossils there (Hirano & Tsurumaru, 1908; see Vereshchagin, 1977). In the 1930's, Murayama (1933) made a geological survey in the Dorokawa (=Ul'yanovka) area, and described the Dorokawa Formation, consisting of black shale and green sandstone containing many Cretaceous ammonites and inoceramids. In the western part of the Kril'on Peninsula, Ishizaki and Sakakura (1937) described the Cretaceous rocks as the Togushi Black Shale and the Togushi Green Sandstone formations.

After the Second World War, many Russian geologists conducted a geological survey in the Kril'on Peninsula, and the megafossil assemblage and stratigraphy of the Cretaceous System were summarized by Vereshchagin (1970, 1977) and Furensenko (1974). They divided the Cretaceous deposits into the Bykov and Krasnoyarka formations in upward sequence, as in those of the type section in the Naiba area. Subsequently, ammonites and inoceramids from these formations have been partly described by Zonova (1993) and Yazykova (1992, 1994).

Stratigraphy in the Kura Area

The Yezo Group is widely exposed along the upper course of the Kura River. The strata strike N10–85°E, and dip 15–30° westward and are unconformably overlain by the Neogene deposits. The Cretaceous sequence are partly exposed repeatedly in the middle course of the river by faults (Figs. 2, 3).

The Yezo Group along the Kura River can be divided into two units, the Bykov and Krasnoyarka formations in upward sequence, as defined by Vereshchagin (1961) along the Naiba River (Figs. 4, 5). These are respectively equivalent to the Upper Yezo and the Hakobuchi groups of Hokkaido.

Bykov Formation (Vereshchagin, 1961)

Stratotype: Naiba River, South Sakhalin.

Localities: Middle course of the Kura River (Locs. KR6049–6052); the Yazevka River (Locs. KR6213–6223).

Thickness: Greater than 60 m.

Lithology: Only the uppermost part is exposed. It is composed mainly of dark gray, intensely bioturbated mudstone. Lenticular calcareous nodules, 30–60 cm in di-

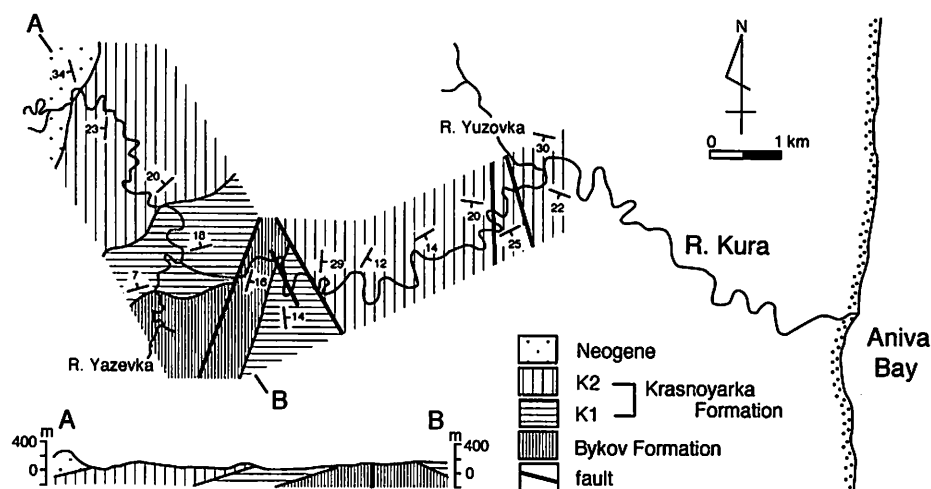


Fig. 2. Geological map and profile along the Kura River.

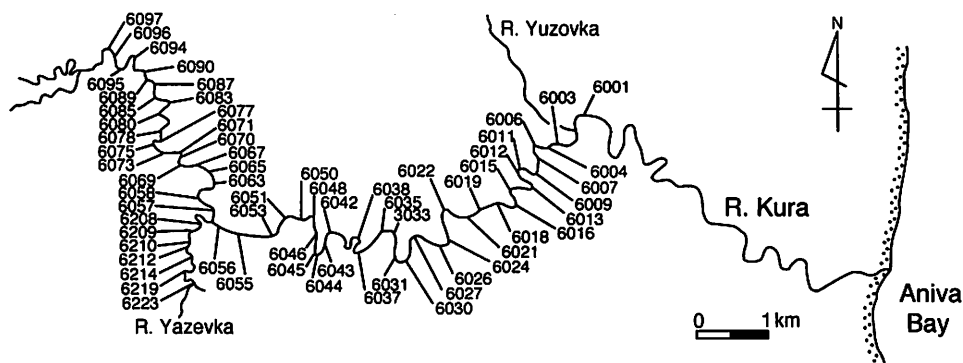


Fig. 3. Locality map along the Kura River. Prefix KR is omitted for each locality number.

ameter, are commonly embedded in the mudstone.

Fossil: *Eupachydiscus haradai* (Jimbo) is abundant, and occurs both from calcareous nodules and from the host rock. Specimens are usually adult forms, and attain more than 30 cm in diameter.

Krasnoyarka Formation (Vereshchagin, 1961)

This formation consists mainly of sandstone and sandy mudstone, and the total thickness attains to about 1,060 m. It conformably covers the Bykov Formation, and is subdivided into two members, K1 and K2 in ascending order.

Stratotype: Krasnoyarka River, a branch of the Naiba River, South Sakhalin.

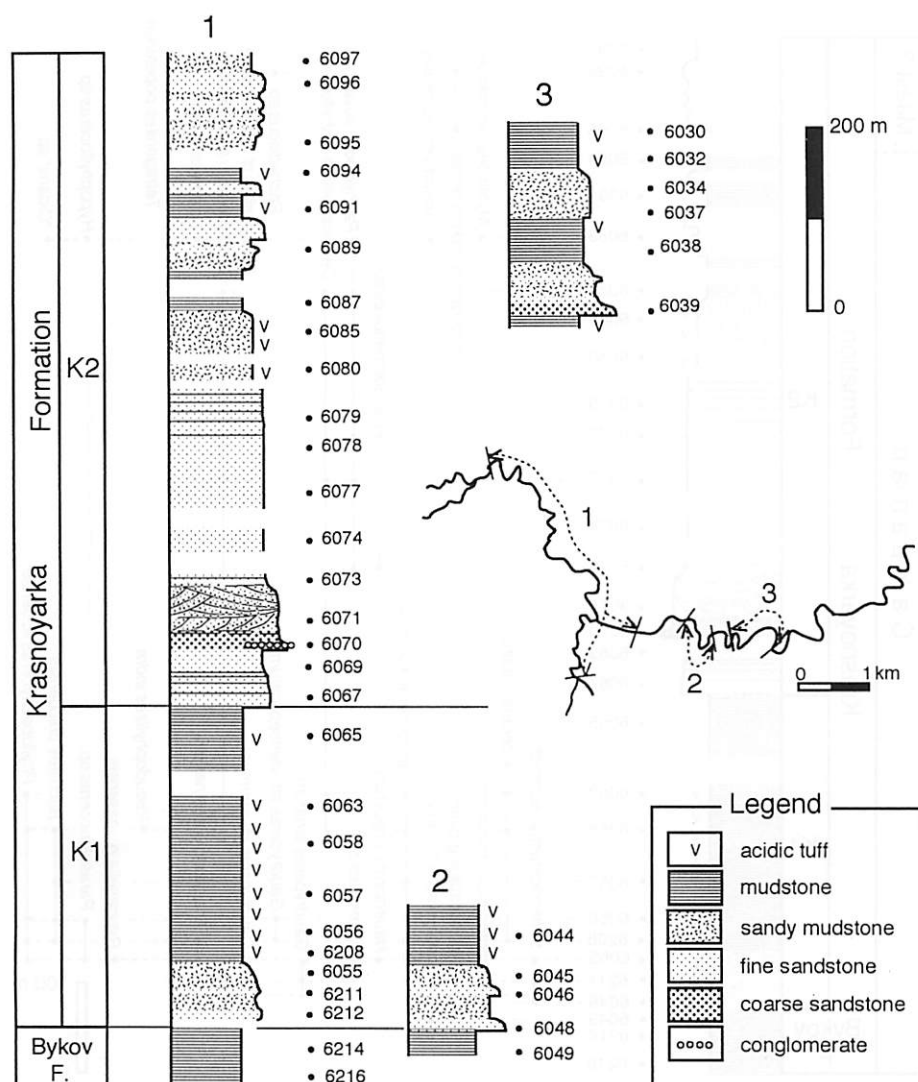


Fig. 4. Columnar section of the Upper Cretaceous along the Kura River. Localities can be found on the locality map (Fig. 3).

K1 Member

Localities: Upper course of the Kura River (Locs. KR6053-6066, typical section); middle course of the Kura River (Locs. KR6042-6048); the Yazevka River (Locs. KR6201-6212)

Thickness: 350 m.

Lithology: This member rests on the Bykov Formation, and conformably under-

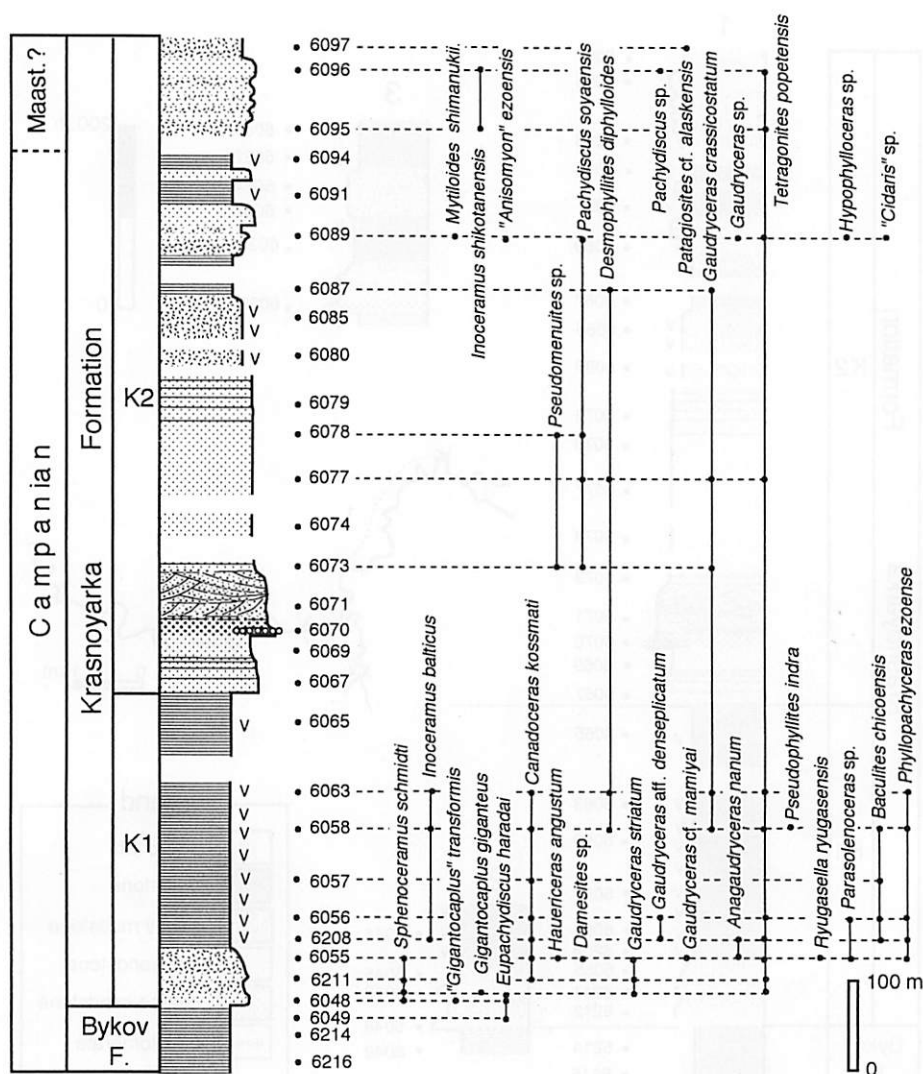


Fig. 5. Stratigraphic occurrences of ammonites, inoceramids and other invertebrates along the Kura River. Legend is shown in Figure 4.

lies the K2 Member. The basal part of the K1 consists of greenish gray and poorly sorted bedded sandstone, and rich in andesitic volcanic rock fragments. It changes upward to intensely bioturbated massive sandy mudstone and mudstone interbedded with thin tuff beds in the middle and upper parts. Spherical or lenticular calcareous nodules, which contain abundant fossils, are common particularly in the lower and middle parts.

Fossils: The entire member is fossiliferous. In the basal part, *Sphenoceras*

schmidt Michael, *Eupachydiscus haradai* (Pl. 2, fig. 1), and large pattelliform gastropods, "*Gigantocapulus*" *transformis* (Dundo) (Pl. 1, fig. 4) and *Gigantocapulus giganteus* (Schmidt) (Pl. 1, fig. 5) are found in abundance, both from calcareous nodules and host rock.

The muddy sandstone at approximately 50 m above the base of the K1 Member is particularly fossiliferous, and the following ammonites and inoceramid bivalve were found at Loc. KR6055: *Canadoceras kossmati* Matsumoto, *Damesites* sp., *Hauericeras angustum* Yabe, *Ryugasella ryugasensis* Wright & Matsumoto, *Parasolenoceras* sp., *Tetragonites popetensis* Yabe, *Gaudryceras striatum* (Jimbo), *Gaudryceras* cf. *mamiyai* Matsumoto & Miyauch, *Anagaudryceras nanum* Matsumoto, *Phyllopachyceras ezoense* (Yokoyama), and *Sphenocerasmus schmidt* (Pl. 1, fig. 2). Small brachiopods are also found in cluster, together with ammonites in calcareous nodules.

The faunal composition changes toward the upward sequence within the middle part of the K1 Member. In the lower middle part of the member, *Baculites chicoensis* Trask (Pl. 1, fig. 1), *Parasolenoceras* sp., and *Gaudryceras* aff. *denseplicatum* Jimbo are common, while *Desmophyllites diphylloides* (Forbes), *Gaudryceras crassicastratum* Jimbo, and *Pseudophyllites indra* (Forbes) are abundant in the upper middle part. These ammonites occur mostly from calcareous nodules. In addition, *Inoceramus balticus* Böhm, *C. kossmati* (Pl. 3, fig. 1), *T. popetensis*, and *P. ezoense* are common in calcareous nodules, in association with plant remains. *C. kossmati* in the upper middle part tends to possess dense ribs in adult stage, resembling *Canadoceras multicastratum* Matsumoto.

No fossils were found in the upper part of the member.

K2 Member

Localities: Upper course of the Kura River (Locs. KR6067–6097, typical section); middle course of the Kura River (Locs. KR6001–6041).

Thickness: 710 m.

Lithology: The member conformably overlies the K1 Member, and conformably underlies the Neogene deposits. The lowest part of the member consists of greenish gray, fine- to medium-grained, bedded sandstone and changes upward to greenish gray, medium- to coarse-grained sandstone interbedded with a thin conglomerate bed. This conglomerate bed consists mainly of angular to subrounded pebbles of andestic volcanic rock. Higher still, the lithology changes upward to greenish gray, trough-cross-stratified, coarse- to medium-grained sandstone, and further changes to dark, intensely bioturbated muddy sandstone. The middle to upper parts of the member consist of dark greenish gray, intensely bioturbated sandy mudstone and muddy sandstone interbedded with thin tuff beds.

Fossils: The cross-stratified sandstone and conglomerate in the lowest part of the K2 Member lack megafossils, but the overlying fine-grained sandstone is fossilif-

Table 1. List of ammonites, inoceramids and other invertebrates from the Krasnoyarka Formation along the Kura River.

Species	Krasnoyarka Formation	
	K1 member	K2 member
Inoceramids		
<i>Sphenoceras schmidt</i> Michael	6043, 6045, 6046, 6048, 6053, 6054, 6055, 6210, 6211, 6212	
<i>Mytiloides shimanukii</i> Matsumoto & Noda		6015, 6022, 6089
<i>Inoceramus balticus</i> Böhm	6208, 6058, 6063	
<i>Inoceramus shikotanensis</i> Nagao & Matsumoto		6095, 6096
Gastropods		
" <i>Gigantocapulus</i> " <i>transformis</i> (Dundo)	6048	
<i>Gigantocapulus giganteus</i> (Schmidt)	6048	
" <i>Anisomyon</i> " <i>ezoensis</i> Nagao & Otatume		6089
Ammonites		
<i>Eupachydiscus haradai</i> (Jimbo)	6048, 6049	
<i>Canadoceras kossmati</i> Matsumoto	6042, 6043, 6044, 6045, 6054, 6055, 6056, 6057, 6058, 6063, 6201, 6207, 6208, 6209, 6210, 6211	
<i>Pachydiscus soyaensis</i> Matsumoto & Miyauchi		6073, 6077, 6078, 6089
<i>Pseudomenuites</i> sp.		6073, 6078
<i>Patagiosites</i> cf. <i>alaskensis</i> Jones		6097
<i>Pachydiscus</i> sp.		6096
<i>Hauericeras angustum</i> Yabe	6055	
<i>Damesites</i> sp.	6055	
<i>Desmophyllites diphylloides</i> (Forbes)	6058, 6063	6015, 6077, 6087
<i>Tetragonites popetensis</i> Yabe	6043, 6044, 6045, 6048, 6055, 6056, 6058, 6060, 6063, 6207, 6208, 6209, 6211	6077, 6089, 6095, 6096
<i>Pseudophyllites indra</i> (Forbes)	6058	6009
<i>Gaudryceras striatum</i> (Jimbo)	6043, 6048, 6055, 6211	
<i>Gaudryceras</i> cf. <i>mamiyai</i> Matsumoto & Miyauchi	6055	
<i>Gaudryceras</i> aff. <i>denseplicatum</i> Jimbo	6056, 6208, 6209	
<i>Gaudryceras crassicostatum</i> Jimbo	6058, 6063	6073, 6077, 6087
<i>Gaudryceras</i> sp.		6089
<i>Anagaudryceras nanum</i> Matsumoto	6042, 6055, 6208	
<i>Ryugasella ryugasensis</i> Wright & Matsumoto	6055	
<i>Parasolenoceras</i> sp.	6055, 6056	6015
<i>Diplomoceras</i> sp.		6015
<i>Baculites chicoensis</i> Trask	6044, 6056, 6057, 6058, 6207, 6208	
<i>Phyllopachyceras ezoense</i> (Yokoyama)	6043, 6044, 6055, 6056 6058, 6063, 6208	
<i>Hypophylloceras</i> sp.		6089
Echinoid		
" <i>Cidaris</i> " sp.		6089

erous; *Pachydiscus soyaensis* Matsumoto & Miyauchi (Pl. 4, figs.1–3), *Gaudryceras crassicostatum*, *Desmophyllites diphyloides*, and *Pseudomenuites* sp. (Pl. 5, figs.1, 2) are particularly abundant in the lower part. Fossils of *P. soyaensis* are represented by adult shells only, attaining 30–50 cm in diameter.

In the middle part of the member, *Mytiloides shimanukii* Matsumoto & Noda (Pl. 1, fig. 3), *Gaudryceras* sp., *P. soyaensis*, *T. popetensis*, *Hypophylloceras* sp., *Pseudophyllites indra*, *Diplompceras* sp., *Cidaris* sp., and “*Anisomyon*” *ezoensis* Nagao & Otatsume (Pl. 1, fig. 6) were found from calcareous nodules.

Inoceramus shikotanensis Nagao & Matsumoto is found in abundance both from calcareous nodules and host rock in the upper part of the K2 Member. It co-occurs with *Patagiosites* cf. *alaskensis* Jones (Pl. 5, figs.3, 4) and *T. popetensis*. This is the stratigraphically highest fauna in the Kura River area.

Stratigraphy in the Gorbusha Area

The Yezo Group along the lower course of the Gorbusha River is exposed in the north-northwest trending syncline area. The strata on the western limb strike N10–20°W and dip 20° eastward; those on the eastern limb strike N–S and dip 50–60° westward. They are unconformably covered by supposed Neogene deposits which consist chiefly of poorly-indurated sandstone, with basal conglomerate, and contain marine mollusks and rare plant megafossils, such as *Zelkova ungeri* (Ettingshausen) Kovats and silicified woods of *Taxodioxydon*, *Picea* and *Ulmus* (Figs. 6, 7).

The Cretaceous Yezo Group exposed along the Gorbusha River can be divided into the Bykov and Krasnoyarka formations in ascending order, as is the case of the Kura area in the eastern part of Kril'on Peninsula (Figs. 8, 9).

Bykov Formation (Vereshchagin, 1961)

Stratotype: Naiba River, South Sakhalin.

Localities: Middle course of the Gorbusha River (Locs. KR1016–1054).

Thickness: Greater than 770 m.

Lithology: Only the upper part is exposed, composing mainly of dark gray, intensely bioturbated mudstone interbedded with white vitric tuff layers ranging 5 to 20 cm thick. Lenticular or Spherical calcareous nodules, 30–60 cm in diameter, are commonly embedded in the mudstone.

Fossils: The formation is fossiliferous. In the lower to middle parts, *Inoceramus amakusensis* Nagao & Matsumoto, *Damesites damesi* (Jimbo), *Menuites sutneri* (Yokoyama), *Yokoyamaoceras ishikawai* (Jimbo), *Gaudryceras tenuiliratum* Yabe, *Tetragonites popetensis*, *Tetragonites glabrus* (Jimbo), *Hypophylloceras subramosum* (Shimizu), *Polyptychoceras obstrictum* (Jimbo), and *Subptychoceras yubarensense* (Yabe) were found from calcareous nodules.

Platyceramus japonicus (Nagao & Matsumoto) is found in abundance in the

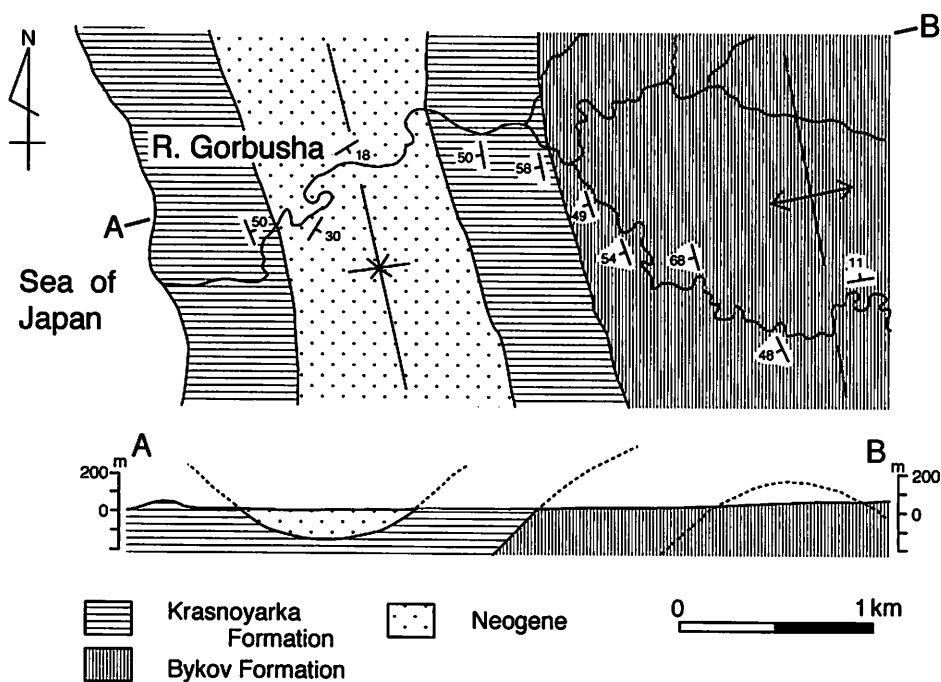


Fig. 6. Geological map and profile along the Gorbusha River.

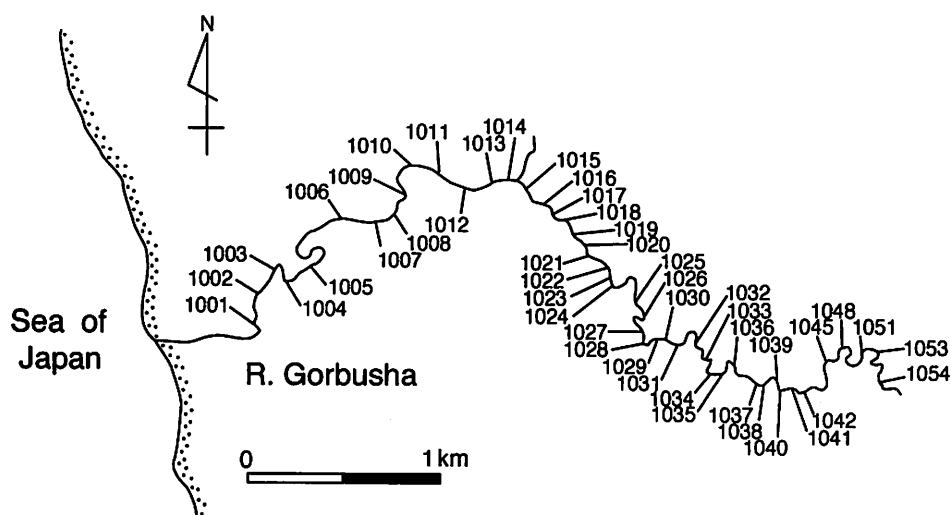


Fig. 7. Locality map along the Gorbusha River. Prefix KR is omitted for each locality number.

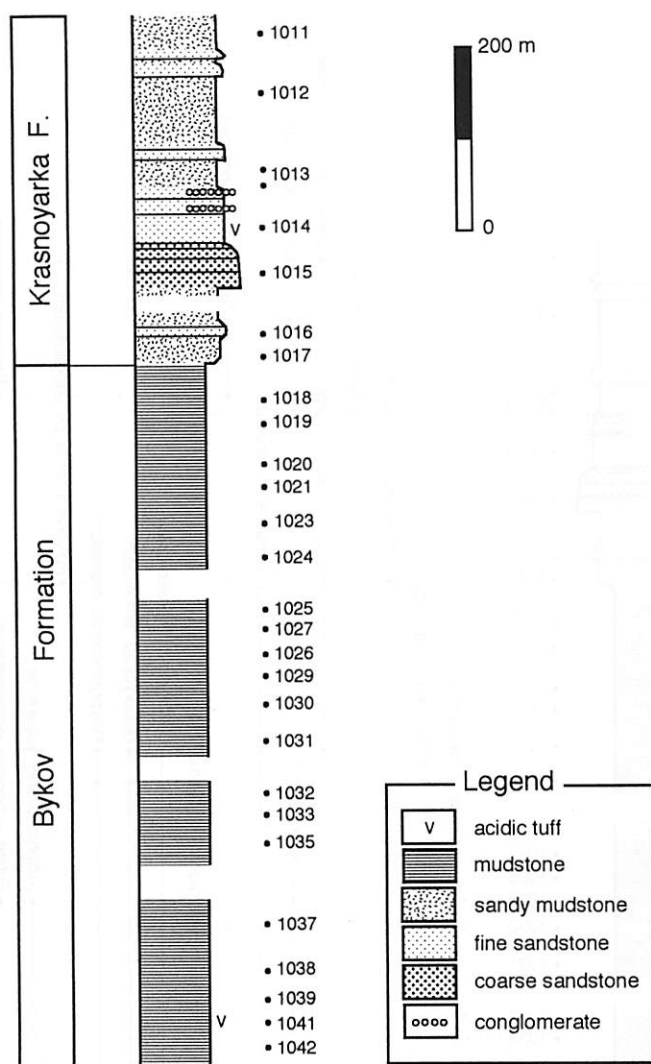


Fig. 8. Columnar section of the Upper Cretaceous along the Gorbusha River. Localities can be found on the locality map (Fig. 7).

upper part of the formation. It commonly co-occurs with *Eubostrychoceras densicostus* Matsumoto, *Gaudryceras densiplicatum* Jimbo, *G. tenuiliratum*, *T. poptetensis*, *T. glabrus*, *Y. ishikawai*, *Hauericeras angustum*, *P. obstrictum*, and *S. yubarensis*.

Krasnoyarka Formation (Vereshchagin, 1961)

The Krasnoyarka Formation consists mainly of sandstone and sandy mudstone, rich in andesitic volcanic rock fragments. It conformably overlies the Bykov Forma-

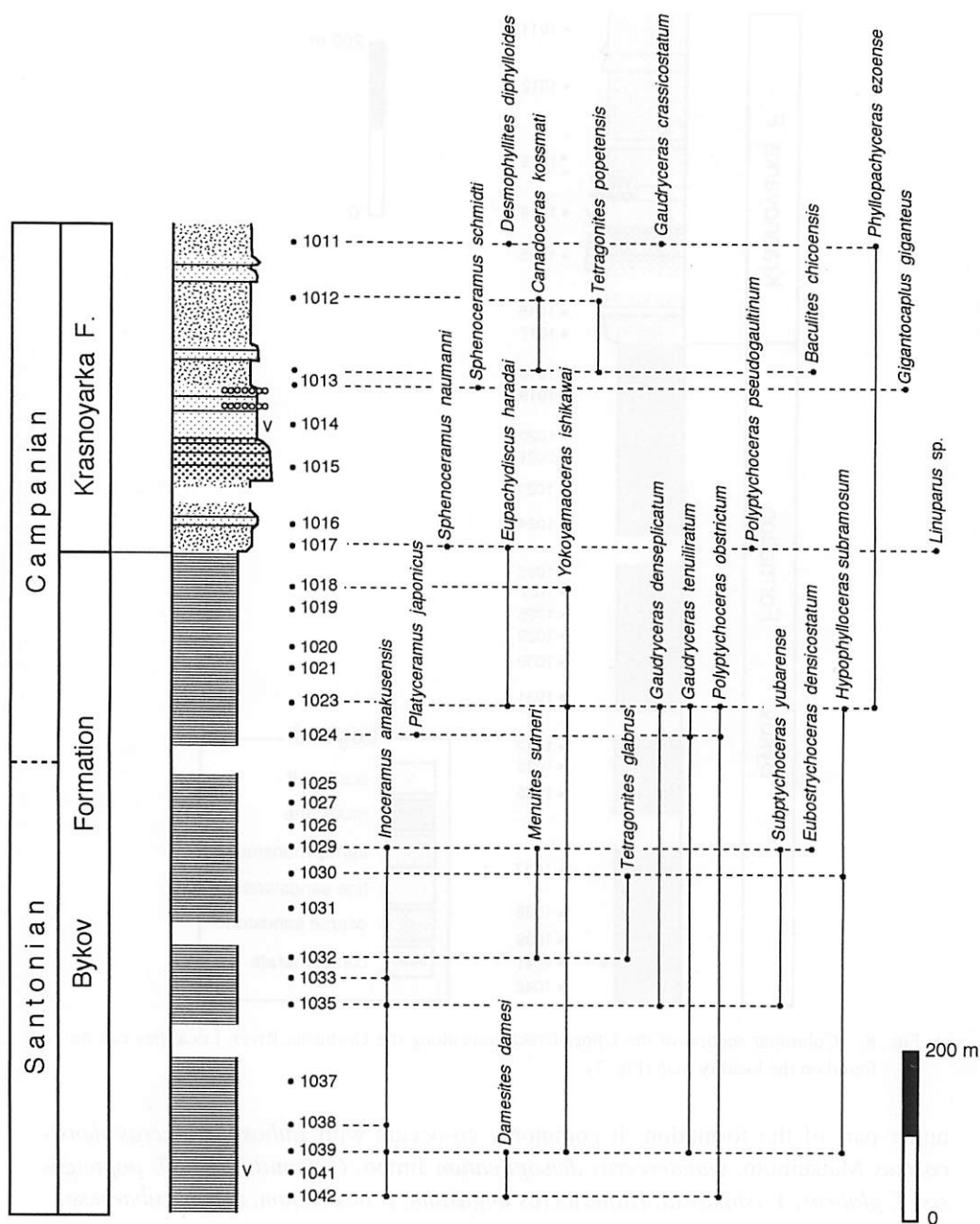


Fig. 9. Stratigraphic occurrences of ammonites, inoceramids and other invertebrates along the Gorbusha River. Legend is shown in Figure 8.

Table 2. List of ammonites, inoceramids and other invertebrates from the Bykov and Krasnoyarka formations along the Gorbusha River.

Species	Bykov Formation	Krasnoyarka Formation
Inoceramids		
<i>Inoceramus amakusensis</i> Nagao & Matsumoto	1042, 1039, 1038, 1035, 1033, 1029	
<i>Platyceramus japonicus</i> (Nagao & Matsumoto)	1024	
<i>Sphenoceramus naumanni</i> (Yokoyama)		1017
<i>Sphenoceramus schmidtii</i> Michael		1013
Gastropod		
<i>Gigantocapulus giganteus</i> (Schmidt)		1013
Ammonites		
<i>Damesites damesi</i> (Jimbo)	1042, 1039	
<i>Desmophyllites diphylloides</i> (Forbes)		1011
<i>Menuites sutneri</i> (Yokoyama)	1032, 1029	
<i>Eupachydiscus haradai</i> (Jimbo)	1023	1017
<i>Canadoceras kossmati</i> Matsumoto		1013, 1012
<i>Yokoyamaoceras ishikawai</i> (Jimbo)	1039, 1023, 1018	
<i>Tetragonites glabrus</i> (Jimbo)	1032, 1030	
<i>Tetragonites popetensis</i> Yabe		1013, 1012
<i>Gaudryceras denseplicatum</i> (Jimbo)	1035, 1023	
<i>Gaudryceras tenuiliratum</i> Yabe	1039, 1024, 1023	
<i>Gaudryceras crassicosatum</i> Jimbo		1011
<i>Polyptychoceras obstrictum</i> (Jimbo)	1042, 1024, 1023	
<i>Polyptychoceras pseudogaultinum</i> (Yokoyama)		1017
<i>Subptychoceras yubarens</i> (Yabe)	1035, 1029	
<i>Eubostrychoceras densicostatum</i> Matsumoto	1029	
<i>Baculites chicoensis</i> Trask		1013
<i>Hypophylloceras subramosum</i> (Shimizu)	1039, 1030, 1023	
<i>Phyllopachyceras ezoense</i> (Yokoyama)	1023	1011
Crustacea		
<i>Linuparus</i> sp.		1017

tion.

Stratotype: Krasnoyarka River, a branch of the Naiba River, South Sakhalin.

Localities: Middle course of the Gorbusha River (Locs. KR1011–1017); mouth of the Gorbusha River (Locs. KR1001, 1002).

Thickness: 380 m.

Lithology: The lower part of the formation consists of greenish gray, poorly-sorted, bedded, fine- to coarse-grained sandstone and muddy sandstone. The formation changes upward to intensely bioturbated massive muddy sandstone interbedded with conglomerate in the middle part and to fine-grained sandstone in the upper part. Sandy mudstone often contains spherical calcareous concretion, about 30–50 cm in diameter, and some of them are fossiliferous.

Fossils: *Sphenoceras naumanni* (Yokoyama), *Eupachydiscus haradai*, *Polyp-tychoceras pseudogaultinum* (Yokoyama), and *Linuparus* sp. were found in muddy sandstone of the basal part of the formation. *Sphenoceras schmidt* and *Gigant-caplus giganteus* are found in the middle part, and *Canadoceras kossmati*, *Tetragonites poptensis*, and *Desmophyllites diphyloides* occur in the upper part. We also discovered *Pachydiscus soyaensis* from a floated calcareous nodule possible derived from the uppermost part of the Krasnoyarka Formation on the western limb of the syncline.

Correlation

Kura area

The ammonite and inoceramid zonation applied in the Kura area is based on the studies of Matsumoto (1942, 1954, 1959, 1984), Zonova *et al.* (1993), Yazykova & Zonova (1994), Yazykova (1994), and Toshimitsu *et al.* (1995). The presence of *Sphenoceras schmidt* and *Eupachydiscus haradai* in the basal part of the K1 Member of the Krasnoyarka Formation suggests the middle Lower Campanian. The middle part of the K1 Member is characterized by the presence of *Inoceramus balticus* and *Canadoceras kossmati*, and is correlated to the upper Lower Campanian.

Various Upper Campanian faunal elements, typically represented by *Pachydiscus soyaensis* occur from the K2 Member. *Mytiloides shimanukii* is also found in the lower to middle parts of the K2 Member. This species, together with *Metaplatenicerias subtilistriatum* (Jimbo) and *Hoplitoplatenicerias monju* Matsumoto, dominantly occur in the Upper Campanian of the Hakobuchi Group in Hokkaido (Matsumoto, 1984; Matsumoto & Noda, 1985); the latter two species, however, have not yet been found in Sakhalin.

The uppermost part of the K2 Member contains *Inoceramus shikotanensis* and *Patagiosites* cf. *alaskensis*. The former is an index of the lower Lower Maastrichtian, but comparable specimens occur from the Upper Campanian of the Izumi Group of Japan (Morozumi, 1985). *Patagiosites alaskensis* is one of the characteristic species of the *Pachydiscus kamishakensis* Zone in southern Alaska, and the age is probably latest Campanian or early Maastrichtian (Jones, 1963). Therefore, the uppermost part of the K2 Member is probably correlated to the uppermost Campanian or lower Lower Maastrichtian.

Gorbusha area

Inoceramus amakusensis, from the lower to middle parts of the Bykov Formation, shows the presence of the Lower Santonian stage in the Gorbusha area. The upper part of the Bykov Formation is characterized by *Platyceras japonicus*, which indicates the lower part of the Lower Campanian. *Sphenoceras schmidt* is found commonly in the middle part of the Krasnoyarka Formation; therefore the hori-

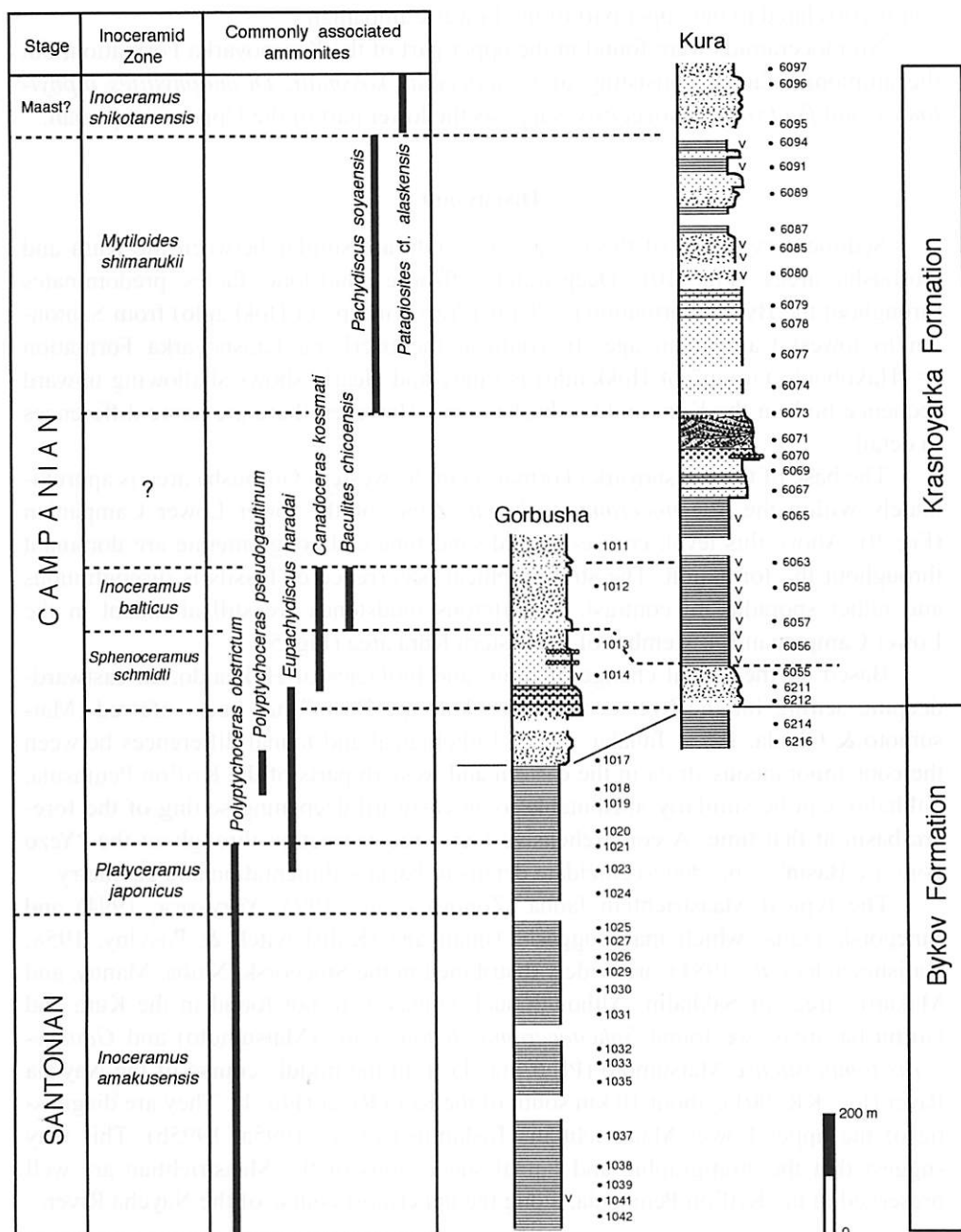


Fig. 10. Summary of biostratigraphy of the Cretaceous System in the Kril'on area.

zon is correlated to the upper part of the Lower Campanian.

No inoceramids were found in the upper part of the Krasnoyarka Formation, but the ammonite fauna, consisting of *Canadoceras kossmati*, *Desmophyllites diphylloides*, and *Pachydiscus soyaensis*, suggests the lower part of the Upper Campanian.

Discussion

Sedimentary facies of the Cretaceous strata are similar between the Kura and Gorbusha areas (Fig. 10). Deep-water, offshore mudstone facies predominates throughout the Bykov Formation (=“Upper Yezo Group” of Hokkaido) from Santonian to lowest Campanian age. In contrast, the overlying Krasnoyarka Formation (=“Hakobuchi Group” of Hokkaido) is sandy and clearly shows shallowing upward sequence both in the Kura and Gorbusha areas. However, there are some differences in detail.

The base of the Krasnoyarka Formation in the western Gorbusha area is approximately within the *Sphenoceras schmidtii* Zone, or the lower Lower Campanian (Fig. 9). Above this level, coarse-grained sandstone and conglomerate are dominant throughout the formation. The stratigraphical occurrence of fossils is discontinuous and rather sporadic. In contrast, fossiliferous mudstones are still abundant in the Lower Campanian K1 Member of the eastern Kura area (Fig. 5).

Based on the lateral change of litho- and biofacies of Hokkaido, an eastward-deepening setting for the Cretaceous “Yezo Fore-arc Basin” has been inferred (Matsumoto & Okada, 1971; Tanaka, 1977). Lithological and faunal differences between the contemporaneous strata in the eastern and western parts of the Kril'on Peninsula, Sakhalin, can be similarly attributable to an eastward-deepening setting of the fore-arc basin at that time. A comprehensive facies reconstruction throughout the “Yezo Fore-arc Basin” is needed to elucidate details of basin sedimentation and geometry.

The typical Maastrichtian fauna (Zonova *et al.*, 1993, Yazykova, 1994) and Sinegorsk fauna, which may suggest Danian age (Kalishevitch & Posylny, 1958; Kalishevitch *et al.*, 1981), are widely distributed in the Sinegorsk, Naiba, Manuy, and Makarov areas of Sakhalin. Although such faunas were not found in the Kura and Gorbusha areas, we found *Sphenoceras hetonaianus* (Matsumoto) and *Gaudryceras tombetsuense* Matsumoto (Pl. 6, fig. 1) from the middle course of the Naycha River (loc. KR7001), about 10 km south of the Kura River (Fig. 1). They are diagnostic of the upper Lower Maastrichtian (Toshimitsu *et al.*, 1995a, 1995b). This may suggest that the stratigraphic and faunal successions of the Maastrichtian are well preserved in the Kril'on Peninsula, along the uppermost course of the Naycha River.

Concluding Remarks

Similar to the Naiba section, the Cretaceous Yezo Group in the eastern Kura and

western Gorbusha areas in the Kril'on Peninsula, South Sakhalin, is lithologically divided into the Bykov and Krasnoyarka formations in ascending order. Although the lower part of the succession is not exposed in these areas, the age ranges from at least Santonian to uppermost Campanian or lowest Maastrichtian (Fig. 10).

Because of discontinuous and sporadic occurrence of megafossils, the biostratigraphic framework of the uppermost Cretaceous remains ambiguous in both Hokkaido and Sakhalin. Continuous sequences spanning into the Campanian-Maastrichtian are not observable even in the well-known reference sections of the Ikushumbetsu (Hokkaido) and Naiba (Sakhalin) areas. In contrast, stratigraphical and faunal successions of the Campanian are well preserved in the Kril'on Peninsula. Almost all megafossil assemblages known from the middle to Upper Campanian of Hokkaido and the Naiba area are found in a few sections in the Kura area. This area may therefore provide an important key to establish precise biostratigraphical framework of the Cretaceous in the Western Pacific region including Japan and Far Eastern Russia.

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Explanation of Plates

Plate 1.

- Fig. 1. Cluster occurrence of *Baculites chicoensis* Trask in a calcareous nodule. NSM PM16116, from Loc. KR6056, along the Kura River. $\times 1.0$.
- Fig. 2. *Sphenoceras schmidtii* (Michael). NSM PM16111, left lateral view, from Loc. KR6055, along the Kura River. $\times 1.0$.
- Fig. 3. *Mytiloides shimanukii* Matsumoto & Noda, NSM PM16112, right lateral view, from the upper course of the Kura River. $\times 1.0$.
- Fig. 4. "*Gigantocapulus*" *transformis* (Dundo). NSM PM16113, apical view, from Loc. KR6048, along the Kura River. $\times 0.8$.
- Fig. 5. *Gigantocapulus giganteus* (Schmidt). NSM PM16114, apical view, from Loc. KR6048, along the Kura River. $\times 0.5$.
- Fig. 6. "*Anisomyon*" *ezoensis* Nagao & Otatsumi. NSM PM16115, apical view, from Loc. KR6089, along the Kura River. $\times 2.0$.

Plate 2.

- Fig. 1. *Eupachydiscus haradai* (Jimbo). NSM PM16117, right lateral view, from Loc. KR6048, along the Kura River. $\times 1.0$.

Plate 3.

- Fig. 1. *Canadoceras kossmati* Matsumoto. NSM PM16118, right lateral view, from Loc. KR6057, along the Kura River. $\times 0.5$.

Plate 4.

- Figs. 1–3. *Pachydiscus soyaensis* Matsumoto and Miyauchi. NSM PM16119, ventral, left lateral and apertural views, from the upper course of the Kura River. $\times 0.3$.

Plate 5.

- Figs. 1, 2. *Pseudomenuites* sp. NSM PM16120, ventral and left lateral views, from the upper course of the Kura River. $\times 0.7$.
- Figs. 3, 4. *Patagiosites* cf. *alaskensis* Jones. NSM PM16121, apertural and right lateral views, from Loc. KR6073, along the Kura River. $\times 0.55$.

Plate 6.

- Fig. 1. *Gaudryceras tombetsuense* Matsumoto. NSM PM16122, left lateral view, from Loc. KR7001, along the Naycha River. $\times 0.8$.

Plate 1

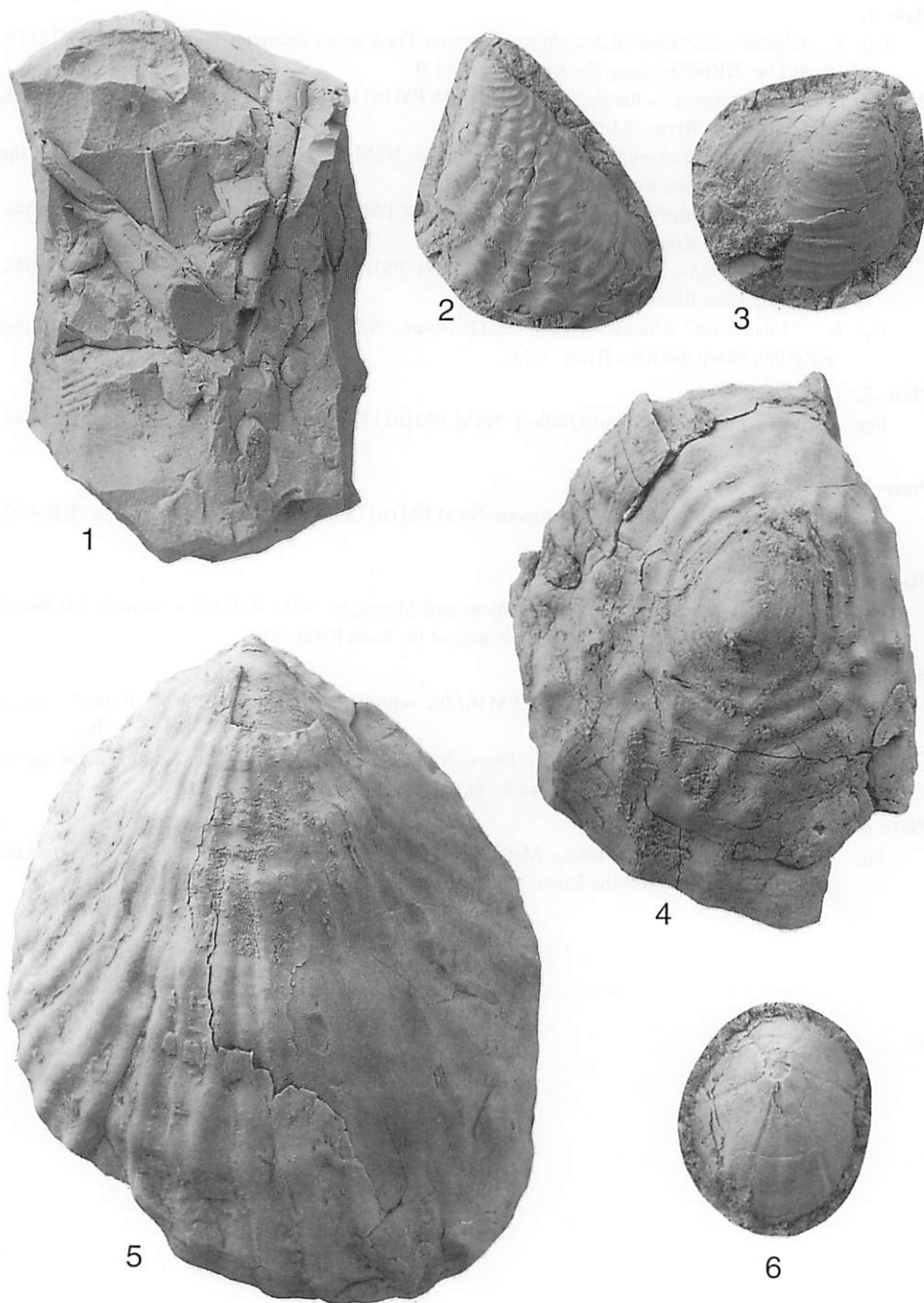


Plate 2





1

Plate 4



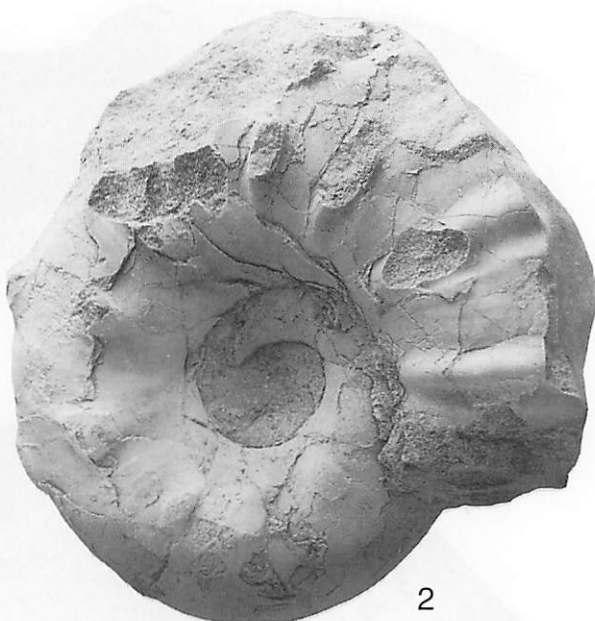


Plate 6



1