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 paleontolo-
gically 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 com-
posed 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 cor-
related to the “Hakobuchi Group”. Inoceramid bivalves, pachydiscid and gaudrycer-
atid ammonites are abundant throughout the sequence, in which six inoceramid
zones were recognized successively, i.e., *Inoceramus amakusensis*, *Platyceramus
japonicus*, *Sphenoceramus Schmidtii*, *Inoceramus balticus*, *Mytiloides shimamukii*,
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, stratig-
raphy, 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 Sys-
tem 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,
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; Mirolyubov, 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

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**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 Furesenko (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-
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-
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*
schmidtii 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 *Sphenoceramus schmidtii* (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 crassicostatum* 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 multicosatum* 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 andesitic 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.

<table>
<thead>
<tr>
<th>Species</th>
<th>Krasnoyarka Formation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>K1 member</td>
</tr>
<tr>
<td>Inoceramids</td>
<td></td>
</tr>
<tr>
<td><em>Sphenoceramus schmidtii</em> Michael</td>
<td>6043, 6045, 6046, 6048, 6053, 6054, 6055, 6210, 6211, 6212</td>
</tr>
<tr>
<td><em>Mytiloides shimanukii</em> Matsumoto &amp; Noda</td>
<td>6208, 6058, 6063</td>
</tr>
<tr>
<td><em>Inoceramus balticus</em> Böhm</td>
<td></td>
</tr>
<tr>
<td><em>Inoceramus shikotanensis</em> Nagao &amp; Matsumoto</td>
<td></td>
</tr>
<tr>
<td>Gastropods</td>
<td></td>
</tr>
<tr>
<td>“Gigantocapulus” transformis (Dundo)</td>
<td>6048</td>
</tr>
<tr>
<td><em>Gigantocapulus giganteus</em> (Schmidt)</td>
<td>6048</td>
</tr>
<tr>
<td>“<em>Amitonony</em>” ezoensis Nagao &amp; Otatume</td>
<td></td>
</tr>
<tr>
<td>Ammonites</td>
<td></td>
</tr>
<tr>
<td><em>Eupachydiscus haradai</em> (Jimbo)</td>
<td>6048, 6049</td>
</tr>
<tr>
<td><em>Canadoceras kossmati</em> Matsumoto</td>
<td>6042, 6043, 6044, 6045, 6054, 6055, 6056, 6057, 6058, 6063, 6201, 6207, 6208, 6209, 6210, 6211</td>
</tr>
<tr>
<td><em>Pachydiscus soyaensis</em> Matsumoto &amp; Miyauchi</td>
<td></td>
</tr>
<tr>
<td><em>Pseudomenuites</em> sp.</td>
<td></td>
</tr>
<tr>
<td><em>Patagiosites cf. alaskensis</em> Jones</td>
<td>6097</td>
</tr>
<tr>
<td><em>Pachydiscus</em> sp.</td>
<td>6096</td>
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<tr>
<td><em>Hauericeras angustum</em> Yabe</td>
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<tr>
<td><em>Damesites</em> sp.</td>
<td>6055</td>
</tr>
<tr>
<td><em>Demosphyllites diphylloides</em> (Forbes)</td>
<td>6058, 6063</td>
</tr>
<tr>
<td><em>Tetragonites popetensis</em> Yabe</td>
<td>6043, 6044, 6045, 6048, 6055, 6056, 6058, 6060, 6063, 6207, 6208, 6209, 6211</td>
</tr>
<tr>
<td><em>Pseudophyllites indra</em> (Forbes)</td>
<td>6058</td>
</tr>
<tr>
<td><em>Gaudryceras striatum</em> (Jimbo)</td>
<td>6043, 6048, 6055, 6211</td>
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<tr>
<td><em>Gaudryceras cf. maniayi</em> Matsumoto &amp; Miyauchi</td>
<td>6055</td>
</tr>
<tr>
<td><em>Gaudryceras aff. denseplicatum</em> Jimbo</td>
<td>6056, 6208, 6209</td>
</tr>
<tr>
<td><em>Gaudryceras crassicostatum</em> Jimbo</td>
<td>6058, 6063</td>
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<tr>
<td><em>Gaudryceras</em> sp.</td>
<td></td>
</tr>
<tr>
<td><em>Anagaudryceras nanum</em> Matsumoto</td>
<td>6042, 6055, 6208</td>
</tr>
<tr>
<td><em>Ryugasella ryugasensis</em> Wright &amp; Matsumoto</td>
<td>6055</td>
</tr>
<tr>
<td><em>Parasolenoceras</em> sp.</td>
<td>6055, 6056</td>
</tr>
<tr>
<td><em>Diplomoceras</em> sp.</td>
<td></td>
</tr>
<tr>
<td><em>Baculites chicoensis</em> Trask</td>
<td>6044, 6056, 6057, 6058, 6207, 6208</td>
</tr>
<tr>
<td><em>Phyllophycyaceras ezoense</em> (Yokoyama)</td>
<td>6043, 6044, 6055, 6056, 6058, 6063, 6208</td>
</tr>
<tr>
<td><em>Hypophylloceras</em> sp.</td>
<td></td>
</tr>
<tr>
<td>“<em>Cidaris</em>” sp.</td>
<td></td>
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</tbody>
</table>
Stratigraphy of the Upper Cretaceous System in the Kril' on Peninsula

...fossiliferous; *Pachydiscus soyaensis* Matsumoto & Miyauch (Pl. 4, figs. 1–3), *Gaudryceras crassicoostatum*, *Desmophyllites diphyloides*, and *Pseudomenites* 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*, *Hypophyllloceras* sp., *Pseudophyllites indra*, *Diplompeceras* 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 *Taxodiumylon*, *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.


*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), *Menites sutneri* (Yokoyama), *Yokoyamaoceras ishikawai* (Jimbo), *Gaudryceras tenuiliratum* Yabe, *Tetragonites popetensis*, *Tetragonites glabrus* (Jimbo), *Hypophyllloceras subramosum* (Shimizu), *Polyphtychoceras obstrictum* (Jimbo), and *Subptychoceras yubarense* (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.

**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.

<table>
<thead>
<tr>
<th>Species</th>
<th>Bykov Formation</th>
<th>Krasnoyarka Formation</th>
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</thead>
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<tr>
<td>Inoceramids</td>
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<td></td>
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<tr>
<td><em>Inoceramus amakusensis</em> Nagao &amp; Matsumoto</td>
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</tr>
<tr>
<td><em>Platyceramus japonicus</em> (Nagao &amp; Matsumoto)</td>
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</tr>
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<td><em>Sphenoceramus naumanni</em> (Yokoyama)</td>
<td></td>
<td>1017</td>
</tr>
<tr>
<td><em>Sphenoceramus schmidtii</em> Michael</td>
<td></td>
<td>1013</td>
</tr>
<tr>
<td>Gastropod</td>
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<td></td>
</tr>
<tr>
<td><em>Gigantocaphus giganteus</em> (Schmidt)</td>
<td></td>
<td>1013</td>
</tr>
<tr>
<td>Ammonites</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Damesites damesi</em> (Jimbo)</td>
<td>1042, 1039</td>
<td>1011</td>
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<tr>
<td><em>Desmoxyphylites diphyloides</em> (Forbes)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Menites sutneri</em> (Yokoyama)</td>
<td>1032, 1029</td>
<td></td>
</tr>
<tr>
<td><em>Eupachycoides haradai</em> (Jimbo)</td>
<td>1023</td>
<td>1017</td>
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<tr>
<td><em>Canadoceras kossmati</em> Matsumoto</td>
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<td><em>Yokoyamaoceras ishikawai</em> (Jimbo)</td>
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<td><em>Tetragonites glabrus</em> (Jimbo)</td>
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<td><em>Tetragonites popetensis</em> Yabe</td>
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<td>1013, 1012</td>
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<td><em>Gaudryceras densiplicatum</em> (Jimbo)</td>
<td>1035, 1023</td>
<td></td>
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<tr>
<td><em>Gaudryceras tenuiratatum</em> Yabe</td>
<td>1039, 1024, 1023</td>
<td></td>
</tr>
<tr>
<td><em>Gaudryceras crassicostatum</em> Jimbo</td>
<td></td>
<td>1011</td>
</tr>
<tr>
<td><em>Polyptychoceras obstrictum</em> (Jimbo)</td>
<td>1042, 1024, 1023</td>
<td></td>
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<tr>
<td><em>Polyptychoceras pseudogauffitiium</em> (Yokoyama)</td>
<td></td>
<td>1017</td>
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<tr>
<td><em>Subptychoceras yubarense</em> (Yabe)</td>
<td>1035, 1029</td>
<td></td>
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<tr>
<td><em>Eusbychoceras densicostatum</em> Matsumoto</td>
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<td><em>Baculites chicoensis</em> Trask</td>
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<td><em>Hypophylloceras subramosum</em> (Shimizu)</td>
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<tr>
<td><em>Phyllochoceras eozense</em> (Yokoyama)</td>
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<tr>
<td>Crustacea</td>
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<td></td>
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<tr>
<td><em>Limaparus</em> sp.</td>
<td></td>
<td>1017</td>
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</table>

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*, *Polyptychoceras pseudogaultinum* (Yokoyama), and *Linuparus* sp. were found in muddy sandstone of the basal part of the formation. *Sphenoceras schmidtii* and *Gigantocapulus giganteus* are found in the middle part, and *Canadoceras kossmati*, *Tetragnites poptensis*, and *Desmophyllites diphylloides* 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 schmidtii* 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 *Metaplacenticeras subtilistriatum* (Jimbo) and *Hoplitoplacenticeras monju* Matsumoto, dominantly occur in the Upper Campanian of the Hakobuchi Group in Hokkaido (Matsumoto, 1984; Matsumoto & Noda, 1985); the latter two, however, have not yet been found in Sakhalin.

The uppermost part of the K2 Member contains *Inoceramus shikotanensis* and *Patagosites 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). *Patagosites 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 *Platyceramus japonicus*, which indicates the lower part of the Lower Campanian. *Sphenoceras schmidtii* is found commonly in the middle part of the Krasnoyarka Formation; therefore the hori-
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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 *Sphenoceramus 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 (Kalishchevitch & Poslyn, 1958; Kalishchevitch 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 *Sphenoceramus hetaaniaus* (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 di-vided 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 biostrati-graphic 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 suc-cessions 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 there-fore 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. ×1.0.

Fig. 2. *Sphenoceras schmidtii* (Michael). NSM PM16111, left lateral view, from Loc. KR6055, along the Kura River. ×1.0.

Fig. 3. *Mytiloides shimanukii* Matsumoto & Noda, NSM PM16112, right lateral view, from the upper course of the Kura River. ×1.0.

Fig. 4. "*Gigantocapulus* transformis" (Dundo). NSM PM16113, apical view, from Loc. KR6048, along the Kura River. ×0.8.

Fig. 5. *Gigantocapulus giganteus* (Schmidt). NSM PM16114, apical view, from Loc. KR6048, along the Kura River. ×0.5.

Fig. 6. "*Anisomyon* ezoensis" Nagao & Otatsume. NSM PM16115, apical view, from Loc. KR6089, along the Kura River. ×2.0.

Plate 2.

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

Plate 3.

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

Plate 4.

Figs. 1–3. *Pachydiscus soyaeensis* Matsumoto and Miyauchi. NSM PM16119, ventral, left lateral and apertural views, from the upper course of the Kura River. ×0.3.

Plate 5.

Figs. 1, 2. *Pseudomenites* sp. NSM PM16120, ventral and left lateral views, from the upper course of the Kura River. ×0.7.

Figs. 3, 4. *Patagiosites* cf. *alaskensis* Jones. NSM PM16121, apertural and right lateral views, from Loc. KR6073, along the Kura River. ×0.55.

Plate 6.

Fig. 1. *Gaudryceras tombetswense* Matsumoto. NSM PM16122, left lateral view, from Loc. KR7001, along the Naycha River. ×0.8.
Plate 2