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Stratigraphy and Paleontology of the Cretaceous in the Ishikari Province, Central Hokkaido
Part 2. Stratigraphy of the Cretaceous in the Northern Areas

By

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Abstract The Cretaceous Middle and Upper Yezo Groups of the Naie, Bibai and Ashibetsu areas in the northern Ishikari province, central Hokkaido are described litho- and bio-stratigraphically. The strata are composed mainly of sandstone, siltstone, mudstone, shale and alternating beds of sandstone and mudstone units containing fossiliferous calcareous nodules, and are of late Albian to Santonian in age.

Stratigraphic changes of the ammonite fauna and lithofacies of the Middle to Upper Yezo Group in the Ishikari province are discussed. As the result, a peak of regression during the sedimentation of the Middle to Upper Yezo Group is in early to middle Turonian age. The different occurrences of index ammonites in these areas are reflected by the lithofacies change of the sediments from the late Albian to middle Turonian ages, but is not clear in those of the in late Turonian age.

The useful Turonian zonation in this province is established on the basis of the succession of collignoniceratid ammonites such as *Collignoniceras*, *Subprionocyclus*, *Lymaniceras* and *Reesidites* species. Thus the Turonian Stage in Hokkaido is reasonably divided into three ammonite zones, in ascending stratigraphic order, *Mammites costatus* Zone, *Collignoniceras bravaisianum* Zone and *Subprionocyclus neptuni* Zone.

Introduction

The Cretaceous System in the Ishikari province was divided into four divisions, the Lower Yezo, Middle Yezo, Upper Yezo and Hakobuchi Groups in ascending order (MATSUMOTO, 1954). In these sediments, well-preserved, marine invertebrate fossils are contained abundantly and successively, which have been the subjects for many biostratigraphic and paleontologic works since YABE (1903–4).

In order to accomplish the more precise biostratigraphic zonation of the Middle and Upper Cretaceous, the detailed field survey has been made in the seven areas of the Ishikari province. In Part 1, I described the lithostratigraphy and ammonite biostratigraphy in the southern part of the Ishikari province (FUTAKAMI, 1986). The present report is the continuation from Part 1, and deals with the litho- and bio-stratigraphy in the northern part, namely the Naie, Bibai and Ashibetsu areas. On this ground, the stratigraphic and geographic distributions of the lithofacies and ammonite fauna in both the southern and northern parts are discussed. Special emphasis is given to the

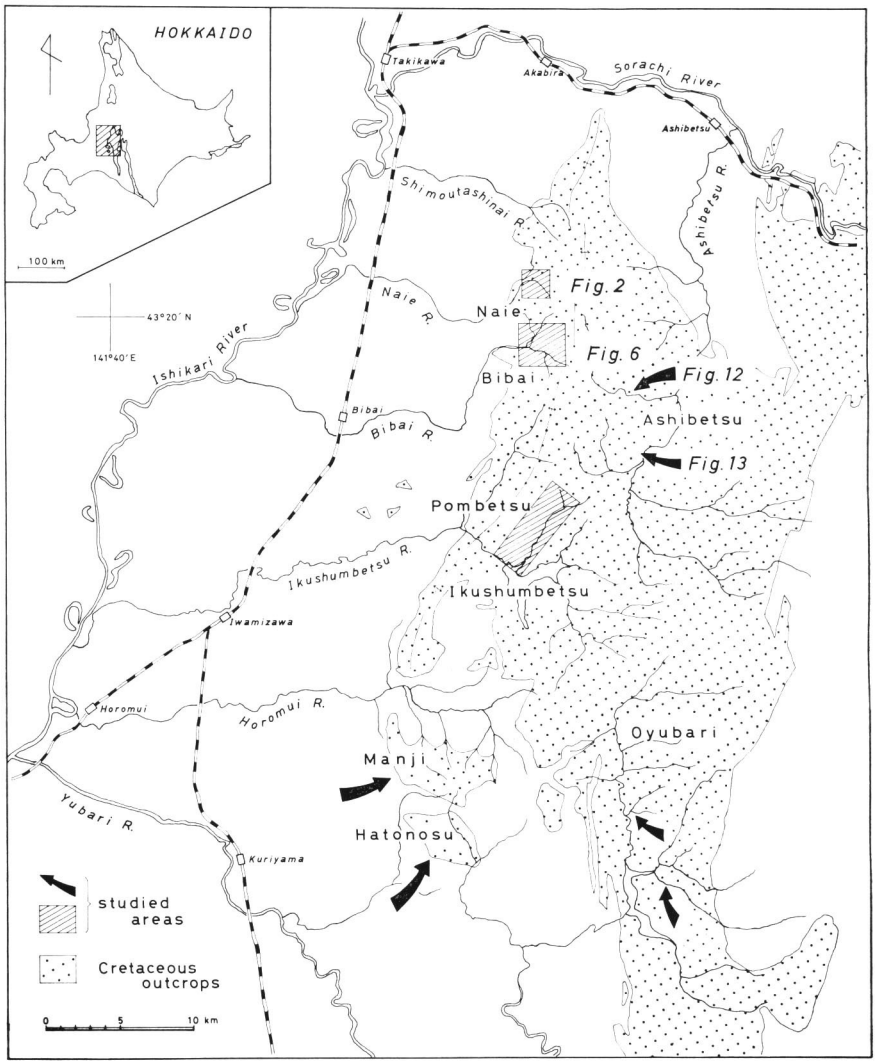


Fig. 1. Index map of the Ishikari province in central Hokkaido.

Turonian biostratigraphic zonation based on the collignoniceratid ammonite species, and proposed three ammonite zones for the Turonian sequence.

The Naie Area

The Cretaceous sequence in the Naie area is exposed in the western part of the Sorachi anticline (TASHIRO, 1951), and shows a relatively simple geological structure. On the Cretaceous formations in this area, a few reports have been provisionally published (SHIMIZU *et al.*, 1953; MATSUMOTO, 1954; TANAKA, 1959).

Stratigraphic Description

The Cretaceous formations exposed in this area are lithologically divided into three groups, the Middle Yezo Group (Mikasa Formation), the Upper Yezo Group and the Hakobuchi Group in ascending order. However, emphasis was put on the study of the Middle and Upper Yezo Groups distributed in the upper stream and its branches of the Naie River (Fig. 1). The geologic map, the generalized columnar section, the columnar sections and the geologic route map are shown in Figs. 2–5.

Middle Yezo Group: Mikasa Formation

This group represents stratigraphically the lowest part in the Naie area, and consists primarily of coarse-grained clastic sediments. The lower limit is not clear because of insufficient exposure for the detailed study.

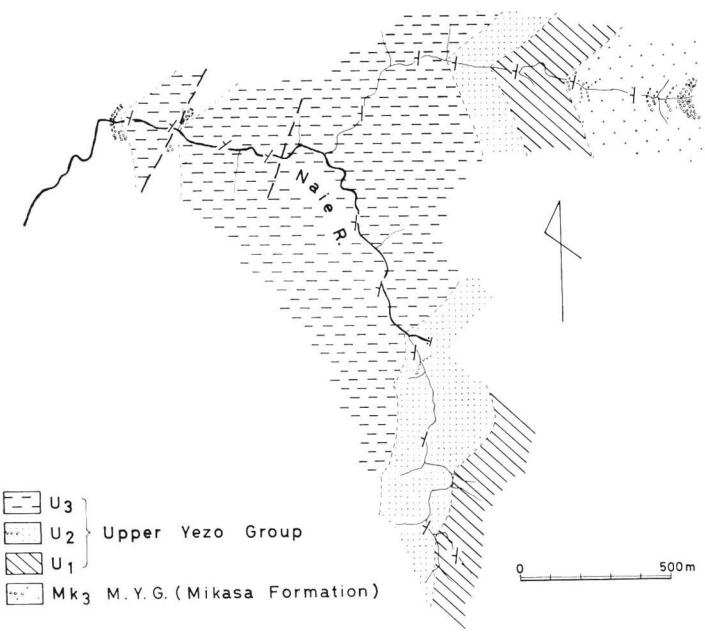


Fig. 2. The geologic map of the Naie area, central Hokkaido.

Member Mk_2

Distribution: Upper stream of the Kita-zawa, a branch of the Naie River.

Thickness: 225+ meters

Lithology: In the lower part of this member, the conglomerate is about 40–50 meters thick and is composed mainly of well rounded pebbles, occasionally of cobbles, of older sandstone, porphyrite and chart. The middle to upper part of this member consists primarily of massive fine- to medium-grained sandstone which sometimes develops cross lamination, contains thin layers (5–100 cm.) of pebble-conglomerate

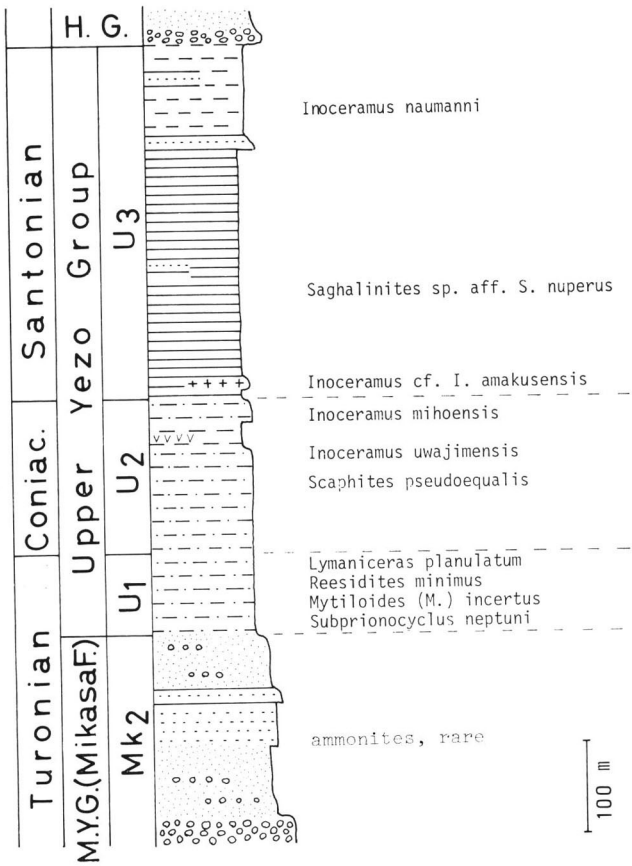


Fig. 3. The generalized columnar section of the Naie area, central Hokkaido. Rock symbols are the same as in Fig. 4.

especially in its lower and upper parts, and also intercalates with the alternating beds of medium-grained sandstone and siltstone in its middle part. Molluscan fossils are scarcely found in this member.

Upper Yezo Group

This group consists primarily of fine-grained clastic sediments, and gradually becomes finer from the lower upward. It conformably overlies the Mikasa Formation, the Middle Yezo Group, and is conformably coverlain by basal pebble- to cobble-conglomerate of the Hakobuchi Group which is about 30–40 meters thick. The Upper Yezo Group is lithologically and biostratigraphically subdivided into three members, U_1, U_2 and U_3 in ascending order.

Member U_1

Distribution: Middle stream of the Kita-zawa and the middle stream of the

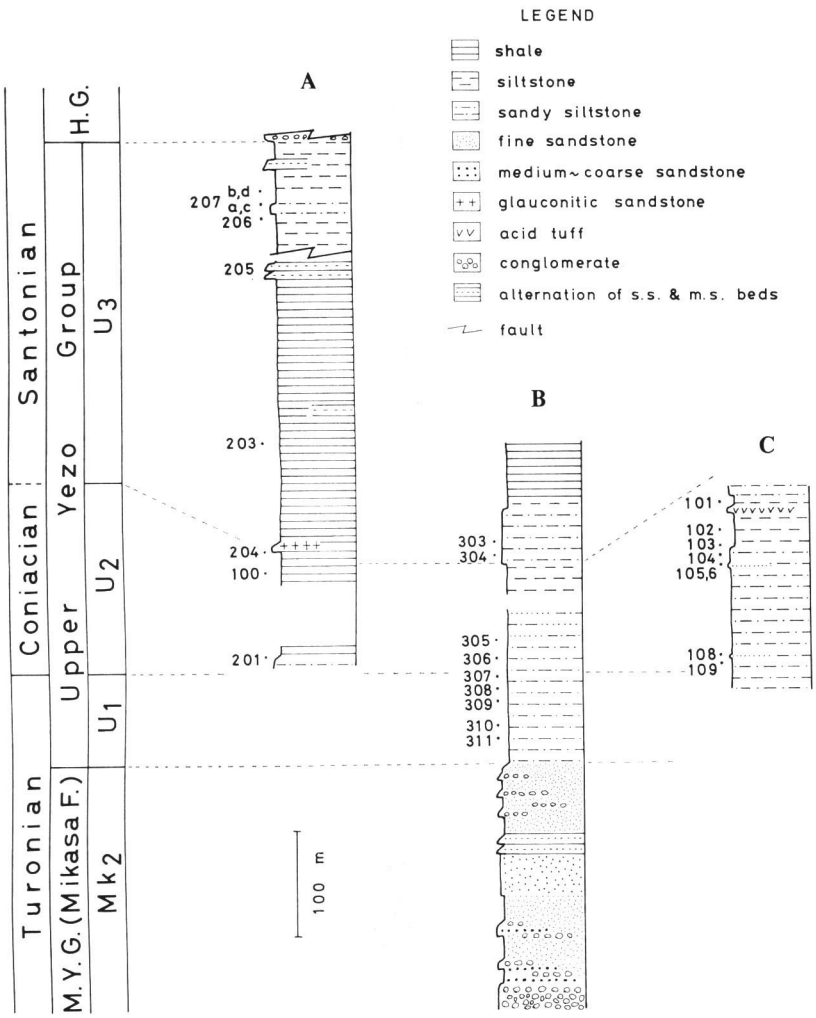


Fig. 4. The columnar sections in the Naie area, central Hokkaido. A: the main stream of the Naie River, B: the Kita-zawa, C: the Minami-zawa.

Minami-zawa, the branches of the Naie River.

Thickness: 90 meters

Lithology: This member comprises well bedded sandy siltstone, and contains many calcareous nodules which are about 5–50 cm. in size. In these nodules the ammonoids and inoceramids occur commonly. Among them *Inoceramus tenuistriatus* occurs characteristically.

Member U_2

Distribution: Middle stream of the Kita-zawa and the upper stream of the

Minami-zawa, the branches of the Naie River, and the upper stream of the Naie.

Thickness: 168 meters

Lithology: This member is composed mainly of sandy siltstone, and is intercalated with a thin layer of silty sandstone in the middle part. In the upper part, it consists of siltstone and shale with an intercalation of thin sandy siltstone which contains glauconite in abundance in the upper part. In the Minami-zawa, at least an acid fuff, about 20 cm. thick, is intercalated. The calcareous nodules, about 30–100 cm. in size, are often included, and they contain ammonoids and inoceramids, including *Scaphites pseudoequalis*, *Baculites* sp. and *I. uwajimensis*.

Member U_3

Distribution: Lower stream of the Kita-zawa, and the upper stream of the Naie River.

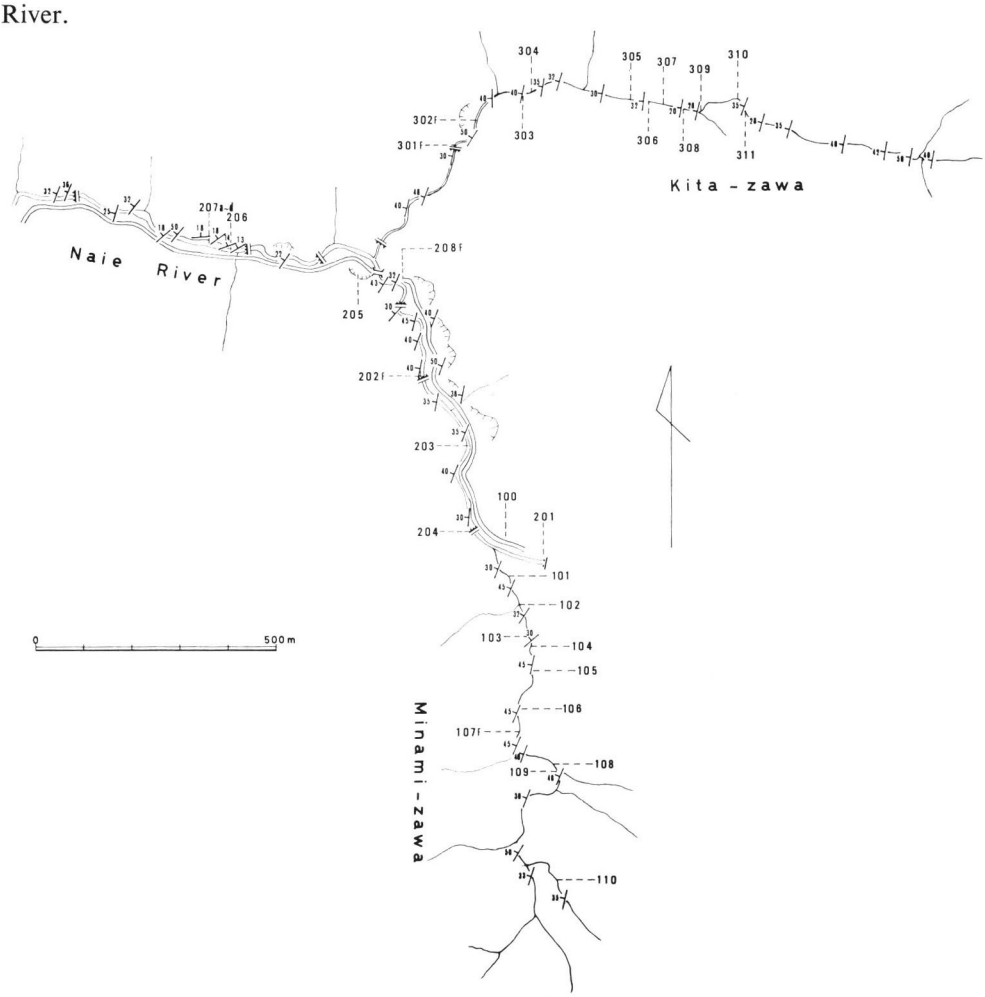


Fig. 5. The geologic route map of the Naie area, central Hokkaido.

Thickness: 388 meters

Lithology: The lower to middle of this member consists mainly of shale which is often characterized by parallel lamination, and a silty sandstone layer, 1 meter thick, which includes abundant glauconite, develops in the lower part at the Naie River. In the middle part, there are two alternating beds of mudstone and fine-grained sandstone characterized by cross lamination, which are several meters thick respectively. In the upper part of the Member U_3 is composed primarily of siltstone and shale. The stratigraphic relationship with the overlying Hakobuchi Group is mentioned above. The calcareous nodules are included aboundantly in the lower and upper parts. The megafossils, ammonoids and inoceramids, especially *I. naumanni*, occur commonly in the Member U_3

Biostratigraphy and Geological Age

The list of fossils from the Middle and Upper Yezo Groups of this area is shown in Table 1.

From the Member Mk_2, fossil-molluscs were not obtained in this investigation. The lithology of this member is similar to that of the middle member of the Mikasa Formation in the Bibai, Pombetsu, Ikushumbetsu, Manji and Hatonosu areas. Among them the Member Mk_2 closely resembles the Mikasa Formation of the upper stream of the Bibai River in which the ammonoids, inoceramids and others are scarcely found and the conglomerate is very thick. In the other areas, *Inoceramus hobetsensis*, a zonal index of the middle Turonian in Japan occurs commonly from the sandstone with thick conglomerate beds (MATSUMOTO, 1965; OBATA and FUTAKAMI, 1975; FUTAKAMI, 1982). Thus, Member Mk_2 is probably assigned to the Middle Turonian.

The Member U_1 is characterized by the common occurrence of *Inoceramus tenuistriatus*. In addition to *Mytiloides* (*M.*) *incertus*, *Subprionocyclus neptuni* which is a Tethian species and ranges from the Upper Turonian occurred from the lower part of this member in the middle stream of the Kita-zawa. *Reesidites minimus* occurred from a rolled nodule which probably came from this member in the Naie River near the Kita-zawa, and also young collignoniceratid gen. et sp. indet. (probably *R. minimus*) from a rolled nodule on the Minami-zawa. *Lymaniceras planulatum* was obtained from a rolled nodule on the middle stream of the Kita-zawa. Accordingly, the Member U_1 is assigned to the Upper Turonian.

From the Member U_2, *Scaphites pseudoequalis* of early Coniacian age and *Inoceramus uwajimensis* of early and middle Coniacian age in Japan occur commonly. At the top of the member, *Inoceramus mihoensis* of late Coniacian age was found. From the composition of species mentioned above, the Member U_2 is considered equivalent to the Lower to Upper Coniacian.

From the Member U_3, a weakly ornate ammonite, *Saghalinites* sp. aff. *S. nuperus* was obtained from the lower part. *S. nuperus* has been reported to occur from the Upper Santonian to the Lower Campanian in Pondoland and from the Lower to Middle Santonian in Madagascar (KENNEDY and KLINGER, 1977). In addition to *S. nuperus*, *I.*

Table 1. List of molluscan fossils from the Upper Yezo Group in the Naie area, central Hokkaido.

Species \ Member	U_1	U_2	U_3
Neophylloceras subramosum SHIMIZU			207d
N. sp.		100	
Damesitea sp.	107F		205, 206, 207d
Tetragonites sp.			206, 207d, 301F
Saghalinites sp. aff. *S. nuperus* (HOEPEN)			203
Gaudryceras sp.		100, 105	206, 207d
Anagaudryceras limatum (YABE)	110	105, 306	
Lymaniceras planulatum MATSUMOTO	302F		
Reesidites minimus (HAYASAKA et FUKADA)	208F		
Subprionocyclus neptuni (GEINITZ)	311		
Collignoniceratid gen. et sp. indet.	107F		
Polyptychoceras pseudogaultinum (YOKOYAMA)			203
P. sp.			207a,b
Diplomoceratid gen. et sp. indet.		100	
Eubostrychoceras (?) sp.		105	
Scaphites pseudoequalis YABE		102, 103, 208F	
Otoscaphites (*O.*) *puerculus* (JIMBO)		109	
O.(*Hyposcaphites*) *perrini* (ANDERSON)	202F		
O. sp.		105, 208F	
Baculites sp.		201	
aptychi			207a,d
Inoceramus naumanni YOKOYAMA			204, 207b,d, 304
I. cf. *amakusensis* NAGAO et MATSUMOTO			303
I. mihoensis MATSUMOTO		100	
I. uwajimensis (YEHARA)		102, 103, 108, 305	
I. tenuistriatus NAGAO et MATSUMOTO	107F, 202F, 307, 308		
Mytiloides (*M.*) *incertus* (JIMBO)	311		
I. n. sp.		102	
I. sp.	310	101, 201	
Nanonavis sp.			301F
Acira sp.		201	

naumanni occurred commonly in this member, and *I.* cf. *I. amakusensis* was obtained from the lower part of the member in the lower stream of the Kita-zawa. *I. amakusensis* is a zonal index of the Lower Santonian in Japan. At a cliff of the forestry road along the Naie River, fragments of shell which seem to be those of *I. japonicus* are rarely found in the host rock of this member. From the composition of these species mentioned above, the Member U_3 is possibly regarded to range from the Lower to Upper Santonian or further to the Lower Campanian.

The Bibai Area

The Cretaceous in the Bibai area is situated on southern part of the Naie area above mentioned, and is exposed in the western part of the Sorachi anticline. The Cretaceous sequence has been studied by some authors (SHIMIZU *et al*, 1953; MATSUMOTO, 1954; TANAKA, 1959; MAEDA, 1986). Among them, MAEDA (1986) has reported on characteristics of the sedimentary facies and molluscan fauna especially. On the other hand, systematic descriptions of some ammonites obtained from this area have been studied by MATSUMOTO (1965, 1969).

Stratigraphic Description

An object of my study in this area is the Cretaceous which is exposed in the upper stream and its tributary of the Bibai River. Its geologic structure is relatively simple. The Cretaceous is lithostratigraphically divided into three groups, the Middle and Upper Yezo Groups and the Hakobuchi Group in ascending order. Furthermore, the Middle Yezo Group is subdivided into the Main part which is composed of fine-grained clastic sediments and the Mikasa Formation of coarser sediments. The boundaries between these groups are observed on the cliffs along the Shimomata-zawa and Bibai forestry roads (Figs. 7, 8). The geological map, the generalized columnar section, columnar sections and the geological route map of the Cretaceous in this area are shown in Figs. 6, 9–11.

Middle Yezo Group

Main part

The Main part is lithostratigraphically situated at the lowest part in this area, and consists mainly of fine-grained sediments. The lower limit is not clear because it is cut by a fault at the upper stream of the Bibai River, but its thickness exceeds at least 110 meters. The Main part is typically exposed along the creek of the upper steram of the Bibai River and its forestry road.

Member M

Distribution: Upper stream of the Bibai River, the forestry road along the Bibai and the upper stream of the Mae-sawa.

Thickness: 110+ meters

Lithology: Stratigraphic relation of this member with the lower member is not

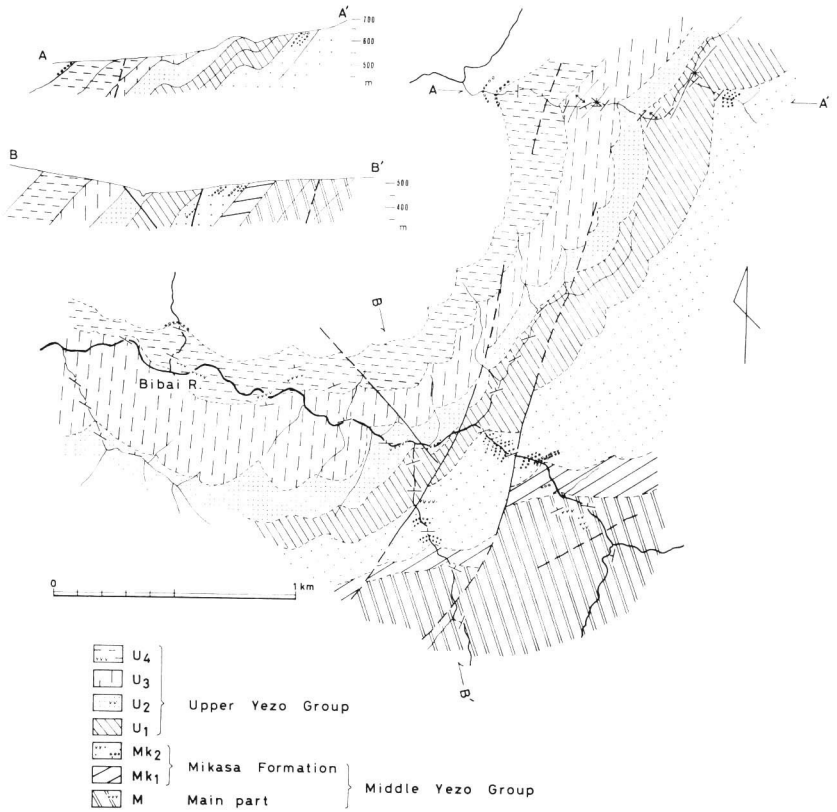


Fig. 6. The geologic map and sections of the Bibai area, central Hokkaido.

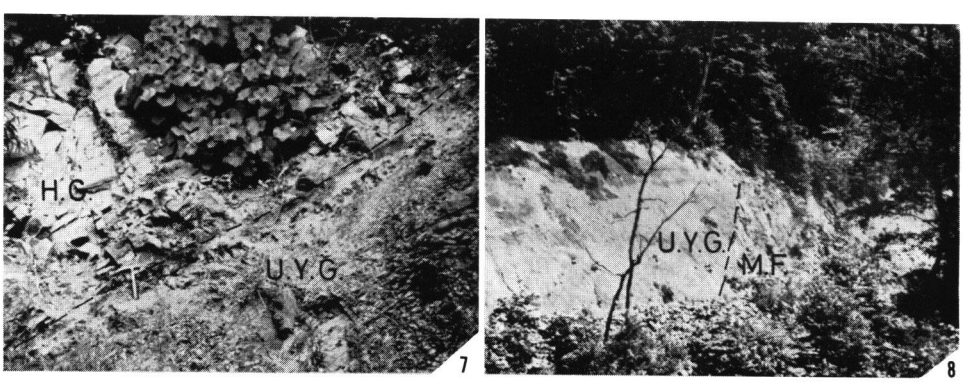


Fig. 7. A boundary of the Upper Yezo Group (U.Y.G.) and the Hakobuchi Group (H.G.) observed on a cliff along the Shimomata-zawa forestry road in Bibai.

Fig. 8. A boundary of the Mikasa Formation of the Middle Yezo Group (M.F.) and the Upper Yezo Group (U.Y.G.) observed on a cliff near loc. Bi310 along the Bibai forestry road in Bibai.

clear in this area because of truncation by a fault as mentioned above. This member consists mainly of dark bluish mudstone and is intercalated with thin layers of fine-grained sandstone in the upper part. These sandstone beds change into alternating beds with siltstone layers in the uppermost part, and are gradually increased in thickness from the lower upward. In the upper part of the alternation and mudstone part, acid tuffs, about 10–15 cm. thick, are intercalated at least at five horizons. The calcareous nodules and plant fragments are not found at all in this member.

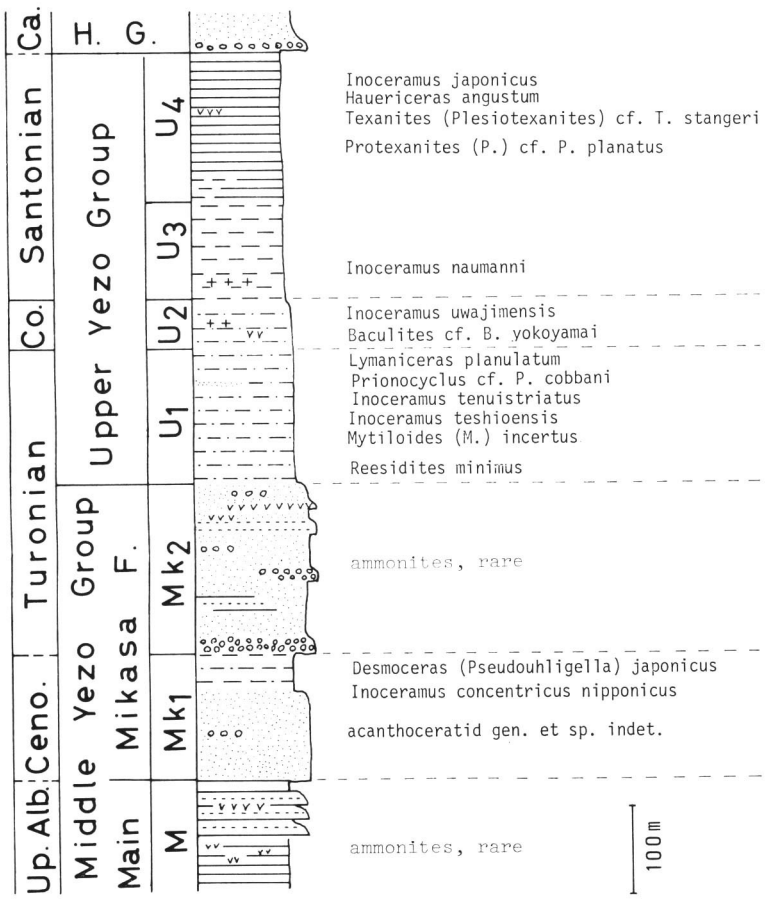


Fig. 9. The generalized columnar section of the Bibai area, central Hokkaido. Rock symbols are the same as in Fig. 10.

Mikasa Formation

This formation conformably overlies the Main part of the Middle Yezo Group with a rapid change of lithology as is confirmed at the upper stream of the Bibai River and its forestry road. This formation is composed mainly of coarse-grained clastic

sediments, and partly yields abundant bivalves including glycymerids and trigonids. It is lithologically and biostratigraphically subdivided into two members, Mk_1 and Mk_2 in ascending order.

Member Mk_1

Distribution: Upper stream of the Bibai River and its forestry road.

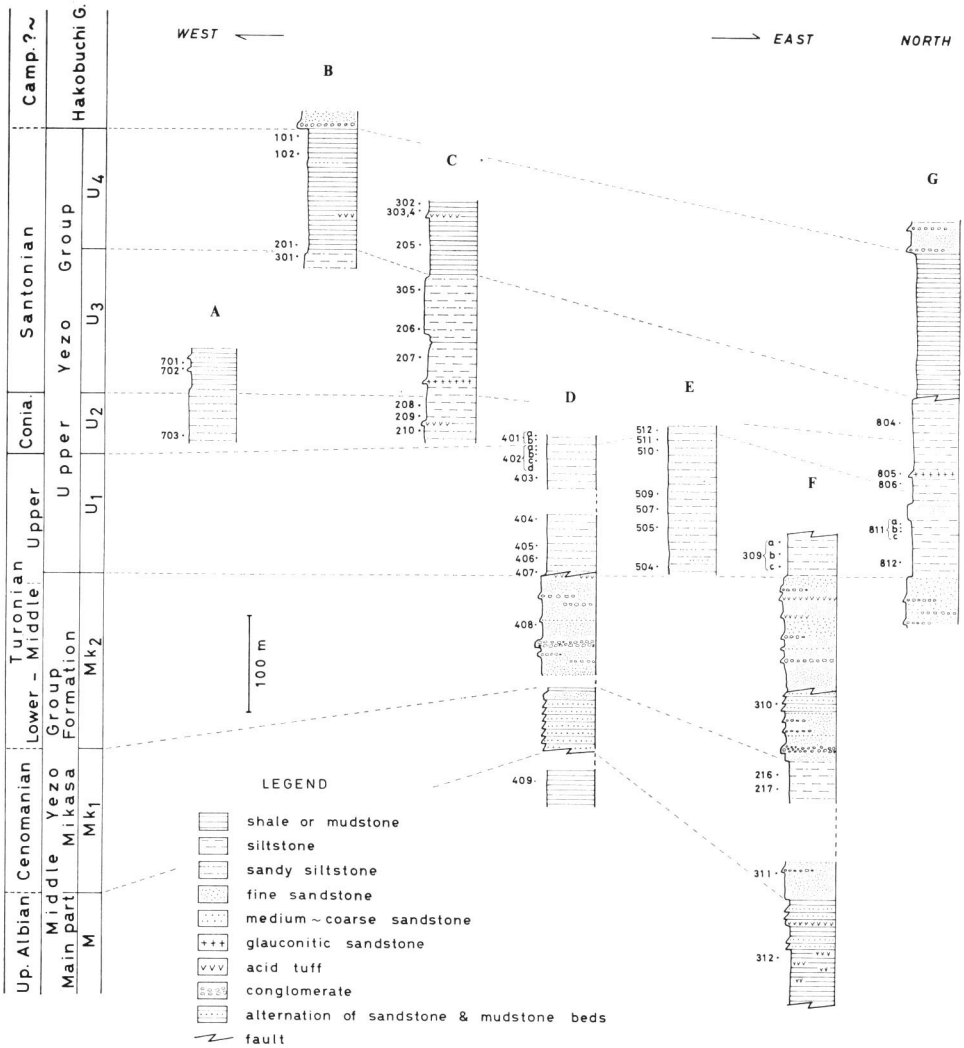


Fig. 10. The columnar sections in the Bibai area, central Hokkaido. A: the Suido-no-sawa, B: the lower stream of the Shimomata-zawa, C: the middle stream of the Bibai River and its forestry road, D: the Mae-sawa, E: the Kamisamata-zawa, F: the upper stream of the Bibai River and its forestry road, G: a branch of the upper stream of the Shimomata-zawa.

Thickness: 143+ meters

Lithology: This member generally becomes finer from the lower upward in grain size. The lower part consists primarily massive fine-grained sandstone and is intercalated with a thin layer (several centimeters in thickness) of pebble-conglomerate. In this sandstone the calcareous nodules, about 30–100 cm. in size, are often included, and they yield abundant such bivalves as *Pterotrigonia*, *Aphirodina*, *Ostrea*, etc., but rarely contain ammonites. The upper part of the member is composed mainly of sandy siltstone, in which the calcareous nodules, about 20–50 cm. in size, are included, and they contain ammonites and bivalves including inocerami.

Member Mk_2

Distribution: Upper stream of the Bibai River and its forestry road, the middle stream of the Mae-sawa, and the upper stream of the branch of the Shimomata-zawa.

Thickness: 190+ meters

Lithology: This member consists of the coarsest clastic sediments in the Cretaceous formations exposed in this area. It is composed mainly of massive fine-grained sandstone which is characterized by cross lamination. Mk_2 sometimes becomes well bedded sandstone in the upper part, and is intercalated with many conglomerate beds in the lower to upper part. In the basal part of this member, there is a conglomerate which is about 6 meters thick and is composed mainly of well rounded pebbles and rarely of cobbles of chart. In the middle part, the alternating beds of fine-grained sandstone and sandy siltstone, about 20 meters thick, is recognized and occasionally the calcareous nodules are included. In the upper part, thin layers, 5–30 cm. in thickness, of well rounded pebble-conglomerate are intercalated at several horizons, and they partly become the calcareous beds which contain commonly well preserved shells of *Pterotrigonia*, *Glycymeris*, *Ostrea*, *Aphirodina*, etc. And, two layers of acid tuff, 2 and 5 meters thick, are also intercalated.

Upper Yezo Group

This group is composed generally of fine-grained clastic sediments, and conformably overlies the Mikasa Formation of the Middle Yezo Group with a relatively rapid change of lithology. And, it is conformably coverlain by basal pebble- to cobble-conglomerate of the Hakobuchi Group, the uppermost Cretaceous. It consists primarily of siltstone, mudstone and shale, and becomes finer from the lower upward in grain size. This group is lithologically and biostratigraphically subdivided into four members, U_1, U_2, U_3 and U_4 in ascending order.

Member U_1

Distribution: Upper stream of the Bibai River and its forestry road, the lower stream of the Mae-sawa, the Kamisamata-zawa, and the middle stream of the branch of the Shimomata-zawa.

Thickness: 150 meters

Lithology: This member consists mainly of massive sandy siltstone, and often

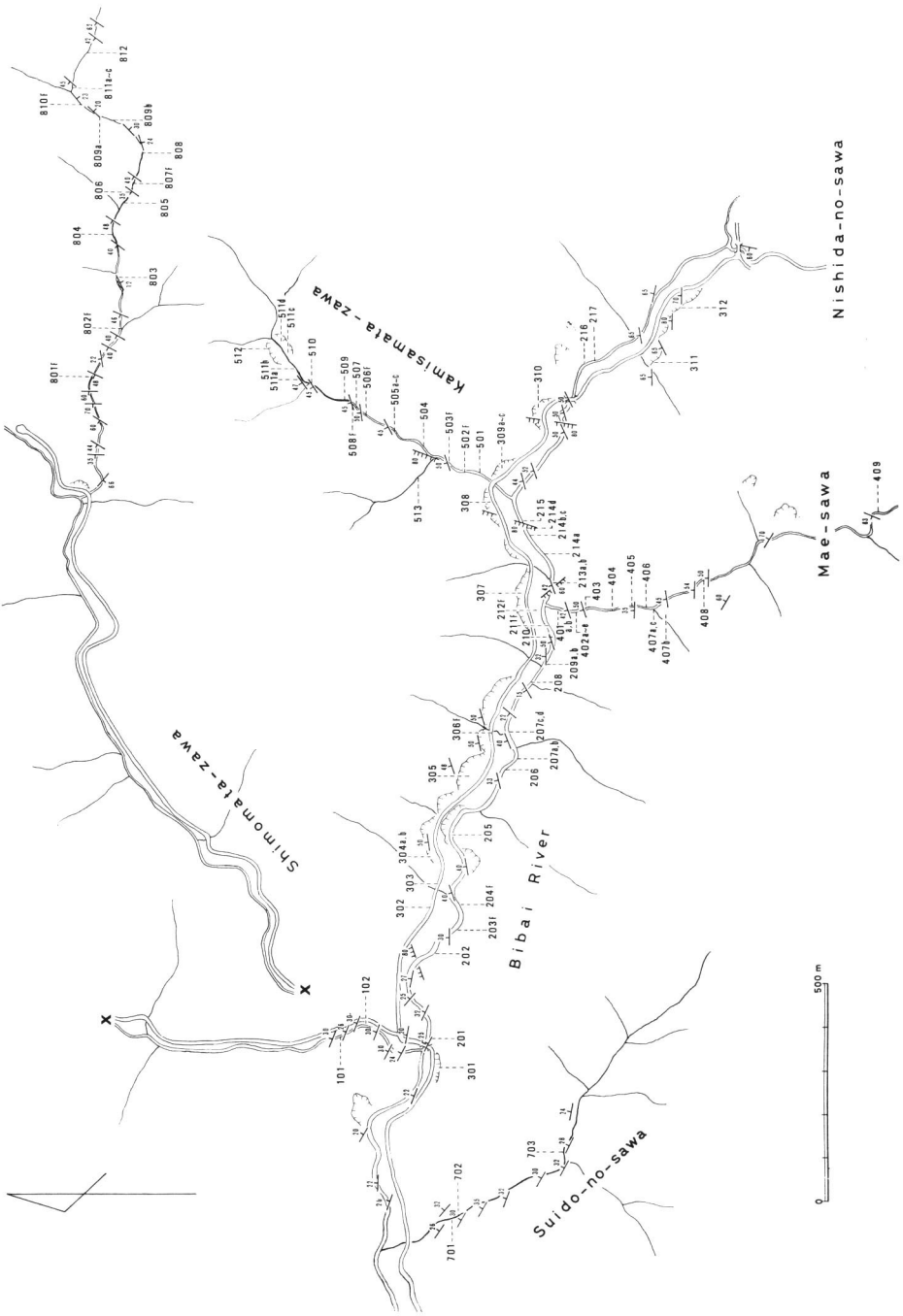


Fig. 11. The geologic route map of the Bibai area, central Hokkaido.

develops bedding planes in the lower and upper parts. In the Kamisamata-zawa thin layers of coarse-grained sandstone and medium-grained sandstone containing mudstone patches are recognized in the middle part. The calcareous nodules, 5–50 cm. in size, are commonly included in this member. Bioturbated structures are occasionally found in it. The mega-fossils occur commonly in the calcareous nodules and host rock in the lower and middle parts.

Member U_2

Distribution: Upper stream of the Bibai River and its forestry road, near the entrance of the Mae-sawa, the Upper stream of the Kamisamata-zawa, the lower stream of the branch of the Shimomata-zawa, and the middle stream of the Suido-no-sawa.

Thickness: 50 meters

Lithology: This member is composed mainly of sandy siltstone, and the upper part gradually changes into siltstone. In the lower part, an acid tuff bed, 30 cm. thick, and a *Zoophycos* bed are recognized in the Bibai River near the Mae-sawa, and a glauconitic medium-grained sandstone bed, 1 meter thick, is in the middle stream of the branch of the Shimomata-zawa. Fossiliferous calcareous nodules, 5–70 cm. in size, are commonly included in the lower to the middle part, but rarely in the upper part.

Member U_3

Distribution: Upper stream of the Bibai River and its forestry road, the middle stream of the branch of the Shimomata-zawa, and the lower stream of the Suido-no-sawa.

Thickness: 125 meters

Lithology: This member becomes coarser from the lower upward in grain size. Namely it consists of siltstone in the lower part, but gradually changes into sandy siltstone in the upper part. In the Bibai River a silty sandstone, about 1 meter thick, which contains glauconite in abundance, develops in the lower part. The maga-fossils occur commonly from the calcareous nodules and host rock, and especially *I. naumanni* occurs aboundantly, and *Damesites semicostatus*, a weakly ornate ammonite, occurs characteristically.

Member U_4

Distribution: Upper stream of the Bibai River and its forestry road, the lower stream of the Shimomata-zawa and the lower stream of its branch.

Thickness: 150 meters

Lithology: This member is composed mainly of mudstone in the lower part and of dark bluish shale in the upper part. In the middle part, there is an acid tuff bed, about 50–100 cm. thick, and stratigraphically 55 meters above this tuff, a thin layer, about 10–15 cm. thick, of fine-grained sandstone with cross lamination is also found. The uppermost part is conformably overlain by the basal conglomerate, about 50–60 cm. thick, of the Hakobuchi Group. The mega-fossils occur commonly from the calcareous nodules and host rock in the lower to middle part, but rarely from those in shale of the upper part.

Biostratigraphy and Geological Age

I investigated the mega-fossils obtained from the Bibai area in my field works in 1980–82. Table 2 shows the list of mega-fossils from the Middle and Upper Yezo Groups in this area.

Table 2. List of mega-fossils form the Middle and Upper Yezo Groups in the Bibai area, central Hokkaido.

Species \ Member	M	Mk_1	U_1	U_2	U_3	U_4
Neophylloceras sp.					306F	201a, 302, 305
Phyllopachyceras ezoense (YOKOYAMA)					306F	
Desmoceras japonicus MATSUMOTO		216b				
D. japonicus compressior MATSUMOTO		217				
Desmoceratid gen. et sp. indet.				213b		
Damesites semicostatus MATSUMOTO					206, 207b,c, 306F, 701	
D. ainuanus MATSUMOTO			509			
D. cf. ainuanus MATSUMOTO			215			
D. sp.			309b, 511b	212F, 807F	803, 804	
Anapachydiscus sp.						802F
Menuites pusillus MATSUMOTO						304a
Hauericeras angustum YABE						302, 303, 304d
Mesopuzosia pacifica MATSUMOTO			503F			
*M.*sp.			505b			
Puzosia (?) sp.	409					
Kitchinites (*Neopuzosia*) *ishikawai* (JIMBO)					306F	
K. (*N.*) *japonica* (SPATH)						201b
K. (*N.*) sp.				503F	207b, 305, 306F	304d
Yokoyamaoceras ornatum MATSUMOTO					401a	
Y. kotoi JIMBO				502F		
Tetragonites sp.			309b, 403a		207d, 306F, 702	201a, 304a
Gaudryceras denseplicatum (JIMBO)			309c	805		
G. tenuistriatum YABE				209b		204F, 205, 303
G. sp.				503F, 703	701	801F
Anagaudryceras limatum (YABE)			211F, 214b,c, 402a, 808	211F, 307		
A.cf. limatum (YABE)			402a, 809a	401b		
A. sp.			214a, 403a,b, 511d			
Texanites (*Plesiotexanites*) cf. *stanleri* (BAILY)						203F
Protexanites (*Protexanites*) cf. *planatus* (LASSWITZ)						304a
Lymanoceras planilatum MATSUMOTO			214d, 403a,c, 511d, 810F, 811a,c			
Reesidites minimus (HAYASAKA et FUKADA)			309a, 407a,b, 507			
Prionocyclus cf. *cobbani* MATSUMOTO			510, 511b			
Collignoniceratid gen. et sp. indet.			309a			
Acanthoceratid gen. et sp. indet.		311				
Poluptychoceras pseudogaultinum (YOKOYAMA)				209a	207b	304d
P. sp.				209b,c, 503F, 805	804	201a, 202, 205, 304c, 801F
Subptychoceras sp.					207c, 306F	201b
Huphantoceras cf. *heteromorphum* MATSUMOTO						302
Eubostrychoceras saxonicum (SCHLUTER)			309a, 403a, 511b			
Nipponites sp.			402a			
Scalarites sp.			309c, 406a,b, 506F, 812, 407a			
Scaphites pseudoequalis YABE			505a	209a, 212F		
S. planus (?) (YABE)				209a		
S. sp. aff. *S. subdelicatulus* COBBAN et GRYC			407b, 809			
S. sp.			407c			
Otoscaphites (*Otoscaphites*) *klamathensis* (ANDERSON)				208, 209a, 212F		
O. (*O.*) *puerculus* (JIMBO)			407c, 505b			
O. (*Hyposcaphites*) *matsumotoi* TANABE				703		
O. sp.			505b	502F		
Baculites cf. *yokoyamai* TOKUNAGA et SHIMIZU				212F		
B. sp.				502F		
Scipnoceras intermedium MATSUMOTO et OBATA			809a			
S. (?) sp.			309a			
aptichi					306F	304c
Coleoid gen. et sp. indet.					306F	304d
Inoceramus haumanni YOKOYAMA					206, 207b,d, 301, 306F, 701, 702, 803, 804	102, 201a,b, 202, 205, 303, 304a,c,d
I. japonicus NAGAO et MATSUMOTO						204F
I. orientalis nagaoi (?) MATSUMOTO et UEDA					207b	
I. uwajimensis (YEHARA)				208, 209a,b, 211F, 212F, 213a, 307, 401a, 502F, 508F, 512, 703F, 806		
I. cf. *uwajimensis* (YEHARA)				703, 805		
I. teshioensis NAGAO et MATSUMOTO			505b, 511a			
I. tenuistriatus NAGAO et MATSUMOTO			214a,b, 308, 309a,b, 402e, 403a,b, 404, 405, 406a,b, 407b,c, 505b, 506F, 507, 509, 511a,c, 810F, 811b,c, 812			
I. cf. *tenuistriatus* NAGAO et MATSUMOTO			809			
Mytiloides (*M.*) *incertus* (JIMBO)			203F, 309b, 404, 507, 511a			
I. inequivalvis SCHLUTER			309a			
I. concentricus nipponicus NAGAO et MATSUMOTO		216a				
I. concentricus costatus NAGAO et MATSUMOTO			505a			
I. sp.			309a,b, 402a, 403a, 504, 511b,d, 513	209c, 503F		
I. n. (?) sp.				209b, 805		
Didymotis akamatsui (YEHARA)				807F		
Pterotrigonia sp.		311				
Nanonavis (*Nanonavis*) *sachalinensis* (SCHMIDT)						304c
Aphirodina (?) sp.		311				
Parvamussium sp.						304c
"*Capulus*" *cassidarius* YOKOYAMA						201b, 204F
Ostrea sp.		311		209c		
Lynuparus japonicus NAGAO			308, 401b, 402e, 407b, 509, 812	401b		304c
chark teeth						303
fish scale					306F	201a

Puzosia (?) sp. was only found in the host rock of the Member M in the upper stream of the Mae-sawa. The lithology of this member is closely similar to that of the Main part of the Middle Yezo Group exposed in the southern Pombetsu and Ikushumbetsu areas. Accordingly the Member M of this area seems to represent a northern extension of the same member of the latter areas, where the index-fossils of the Upper Albian, *Mortoniceras* (*Cantabrigites*) *imaii* and *Ammonoceratites ezoensis* have been reported (MATSUMOTO, 1965). Thus the Member M is probably assigned to the Upper Albian.

From the Member Mk_1, a weakly ornate ammonite, *Desmoceras* (*Pseudouhligella*) *japonicus* occurs commonly. Acanthoceratid gen. et sp. indet. was found in the host rock of the lower part. In addition to these ammonites, *I. concentricus nipponicus* was obtained from the upper part. From the composition of the species mentioned above, the Member Mk_1 is assigned to the Cenomanian.

From the Member Mk_2, only the bivalves such as *Aphirodina* sp., *Pterotrigonia* sp., etc. were found, and the zonal indices including ammonoids and inoceramids were not obtained. Fortunately, SHIMIZU *et al.* (1953) reported *I. hobetsensis*, an index-fossil of the Middle Turonian in Japan, from the middle part of this member. Index of the Lower Turonian have not yet been found. Thus, from the evidence of fossils above mentioned and the stratigraphic position lying above the Member Mk_1, the Member Mk_2 is possibly referred to the Lower to Middle Turonian.

The Member U_1 is characterized by the common occurrence of *I. tenuistriatus*, and *Mytiloides* (*M.*) *incertus* in its lower to upper part. *I. inaequivalvis* occurs rarely. *Reesidites minimus*, an ornate ammonite, was obtained from the lower part and especially it occurs abundantly in the Mae-sawa. *Lymaniceras planulatum* occurs abundantly in the calcareous nodules of the middle to upper of the member in the Mae-sawa, the Bibai River and the branch of the upper stream of the Shimomata-zawa. *Prionocyclus* cf. *P. cobbani* was rarely obtained from the upper part. Thus, this member evidently represents the zone of *I. teshioensis* — *I. tenuistriatus* and is certainly equivalent to the Upper Turonian.

The Member U_2 is characterized by the common occurrence of *I. uwajimensis*. The Lower Coniacian scaphitid ammonites such as *Scaphites pseudoequalis*, *Otoscaphites* (*O.*) *klamathensis* and *O.* (*Hyposcaphites*) *matsumotoi* also occur commonly in U_2. Accordingly, the Member U_2 is assigned to the Lower Coniacian.

From the Member U_3 *Damesites semicostatus*, a weakly ornate ammonite, occurs abundantly from the middle part, which is commonly obtained from the Coniacian to the Santonian in Hokkaido. And, *I. naumanni* ranging from the Upper Coniacian to the Santonian in Japan occurs from this member characteristically. As mentioned above, the fossils which indicate the detailed age were not yet found. According to the evidence of fossils and the stratigraphic position, the Member U_3 seems to be referable to the Upper Coniacian to Lower Santonian.

In the Member U_4 *Protexanites* (*P.*) cf. *P. planatus*, an ornate ammonite, was obtained from a cliff on the forestry road along the Bibai River, and *Texanites* (*Plesiotex-*

anites) cf. *T. stangeri* from a rolled nodule on the main stream of the Bibai River near the Shimomata-zawa. The former species has been reported to occur from the Upper Coniacian in Texas by YOUNG (1963) and to occur from the Upper Coniacian to Lower Santonian in Hokkaido by MATSUMOTO (1970). The latter species has been reported to occur commonly from the lower part of the Upper Santonian in Pondoland and to occur with association of *I. naumanni* from the Santonian in the Chikubetsu area, northwestern Hokkaido by MATSUMOTO (1970). *Hauericeras angustum*, a weakly ornate ammonite, ranging from the Santonian to the Lower Campanian in Hokkaido (MATSUMOTO and OBATA, 1955) occurs commonly in the middle part of U_4. *I. naumanni* occurs commonly in the lower to middle part, and *I. japonicus*, an index of the Lower Santonian in Japan, from a rolled nodule on the main stream of the Bibai River. From the composition of the fossils mentioned above, the Member U_4 is assigned to the Santonian. Thus, the upper limit of the Upper Yezo Group in this area is referable to the Upper Santonian.

The Ashibetsu Area

The Cretaceous sequence of this area was reported by SHIMIZU *et al.* (1953), MATSUMOTO (1954), TANAKA (1959) and MATSUMOTO and OKADA (1973), and it has been regarded to represent an off-shore facies in the Cretaceous Yezo Group. Some ammonites from this area have been described by MATSUMOTO (1979 etc.) and MATSUMOTO and OBATA (1982). In this paper, the lithology and biostratigraphy of the middle stream of the Porokkoashibetsu River and the Kumami-zawa on about 500 meters

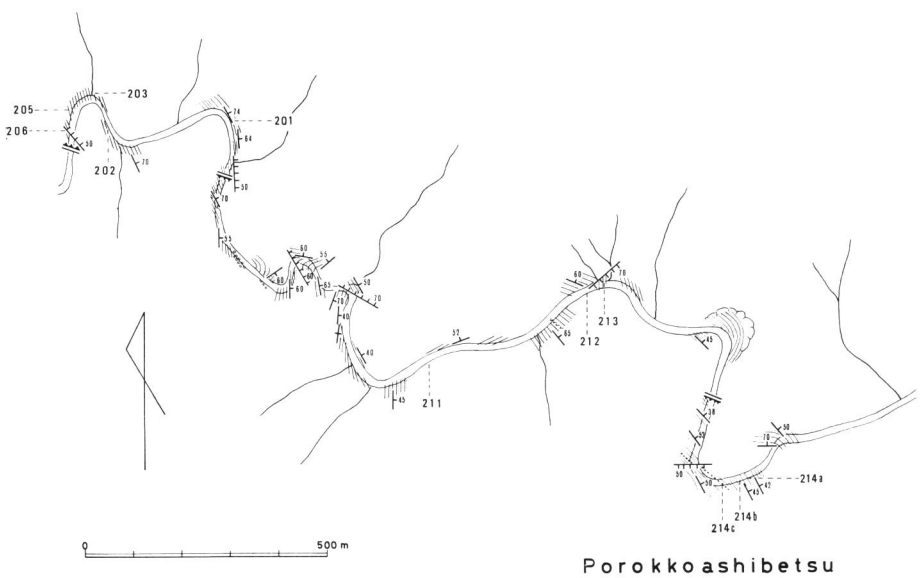


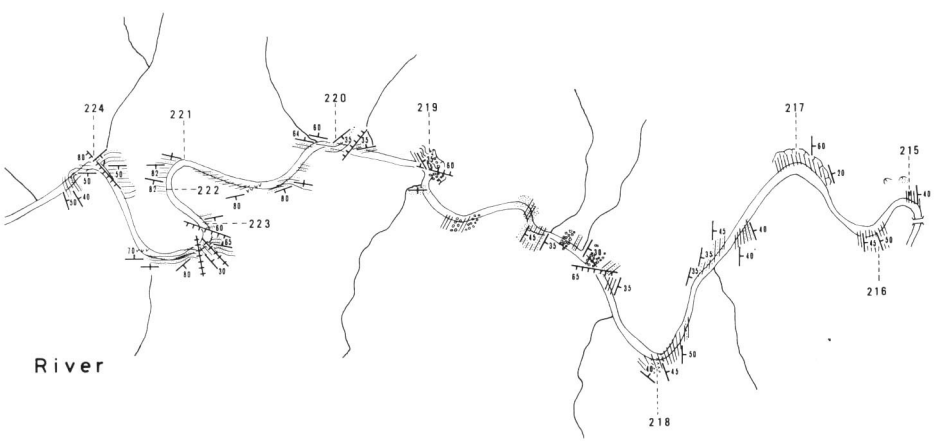
Fig. 12. The geologic route map of the middle stream of the

down the river from the Kimun Bridge, the tributaries of the Ashibetsu River are reported. The geologic route maps and the columnar sections are shown in Figs. 10–12, and the lists of megafossils from the Middle and Upper Yezo Groups are shown in Tables 3, 4.

The route of the Porokkoashibetsu River

The Cretaceous formations exposed in the middle strean of the Porokkoashibetsu River are lithologically divided into the Middle Yezo Group (the Saku Formation) and the Upper Yezo Group in ascending order.

The Saku Formation of the Middle Yezo Group consists primarily of shale and alternating beds of fine-grained sandstone and mudstone, and is sometimes intercalated with a few conglomerate beds which are about 20–30 centimeters in thickness and consist mainly of well rounded pebble of chart, sandstone and others. Three or more beds of the acid tuff of about 10–20 centimeters thick are recognized. *I. hobetsensis* occurs commonly from the lower to the middle part in the studied area. A fragmentary body chamber of *Yubariceras* sp., an ornate ammonite, was obtained from loc. As203. *Muramotoceras ezoense*, a heteromorph ammonite, is often found. Several species of *Mesopuzosia* and *Tetragonites*, the smooth or weakly ornate ammonites, occur commonly. The gigantic ammonites more than 50 centimeters in shell-size, which seem to belong to *Pachydesmoceras* and *Mesopuzosia*, are often found both in the host rock and calcareous nodules. In the upper part a specimen of *Lymaniceras planulatum*, which is not always well-preserved, was obtained from loc. As218. Accordingly, the Saku Formation of the Middle Yezo Group in the studied route is assigned to the



Porokkoashibetsu River in the Ashibetsu area, central Hokkaido.

Table 3. List of molluscan fossils from the Middle and Upper Yezo Groups in the middle stream of the Porokkoashibetsu River, Ashibetsu, central Hokkaido.

Species	Locality number (As)
Neophylloceras sp.	225
Desmoceras (*Pseudouhligella*) *ezoanum* MATSUMOTO	203F, 222
Desmoceras (?) sp.	201
Damesites ainuanus MATSUMOTO	211F
D. sp.	217
Mesopuzosia yubarensis (JIMBO)	223
M. pacifica MATSUMOTO	214b, 225b
M. sp.	214F, 223, 224c, 225
Lymaniceras planulatum MATSUMOTO	218
Yubariceras (?) sp.	213
Tetragonites glabrus (JIMBO)	214F
T. sp.	201, 220, 222, 224b
Gaudryceras sp.	211F
Anagaudryceras limatum (YABE)	203F, 205, 208F
A. sp.	202
Eubostrychoceras aff. *E. indicum* (STOLICZKA)	211F
Muramotoceras yezoense MATSUMOTO	211F, 214F
Scaphites sp.	206
Sciponoceras sp.	211F, 222, 224b
Inoceramus uwajimensis (YEHARA)	215, 216b, 217
I. tenuistriatus (?) NAGAO et MATSUMOTO	211F
I. hobetsensis NAGAO et MATSUMOTO	201, 204, 205, 206, 207, 208F, 211F, 219, 220, 221, 224b,c
I. cf. *labiatus* (SCHLOTHETM)	209
I. concentricus costatus NAGAO et MATSUMOTO	203F
I. sp.	212, 214F, 216, 218

Middle to Upper Turonian. In the uppermost part, about 10 meters stratigraphically above the horizon of *L. planulatum*, alternating beds of fine-grained sandstone and mudstone of about 100 meters thick are recognized (Fig. 14) and index-fossil was not found in it. As *L. planulatum* generally occurs abundantly form the uppermost part of the Upper Turonian in the Pombetsu and Bibai areas, this alternating beds may be possible assigned to the Coniacian.

The Upper Yezo Group is composed mainly of dark bluish shale, and *I. uwajimensis* occurs commonly from the host rock and calcareous nodules, although the occurrence of other molluscan fossils are few. Thus it is probably assigned to the Coniacian.

At the cliff of loc. As219, some large penecontemporaneous blocks of alternating beds and conglomerate bed are recognized in the mudstone. That suggests a tectonic movement during deposition. The strata of the *I. hobetsensis* Zone are complexly folded and faulted, while those of the *I. teshioensis* and *I. uwajimensis* Zones show a relatively simple geological structure.

The route of the Kumami-zawa

In the Kumami-zawa, a small branch of the Ashibetsu River, the Saku Formation of the Middle Yezo Group is exposed. It is composed mainly of sandy siltstone and alternating beds of fine-grained sandstone and mudstone in the middle to upper stream.

The Upper Yezo Group which consists mainly of shale with thin acid tuff beds of several centimeters thick is distributed in the lower stream.

I. hobetsensis occurs commonly from the Saku Formation. *Scaphiteuvpd sus*, a heteromorph ammonite, occurs abundantly from loc. As115 in the upper part of the Saku Formation together with *Jimboiceras* sp. Thus it is assigned to the Middle Turonian.

Reesidites minimus occurs abundantly form locs. As112, 113 in the lower part of the Upper Yezo Group. Together with *Damesites* cf. *D. ainuanus*, *Mesopuzosia* sp. and others, *Madagascarites ryu*, a heteromorph ammonite, occurs abundantly in the same nodules which include *R. minimus*. *Subprionocyclus normalis* was obtained from the rolled nodules on the entrance of the Kumami-zawa and its western small branch. *I. teshioensis* and *I. tenuistriatus* occur commonly and *I.* sp. aff. *I. uwajimensis* rarely

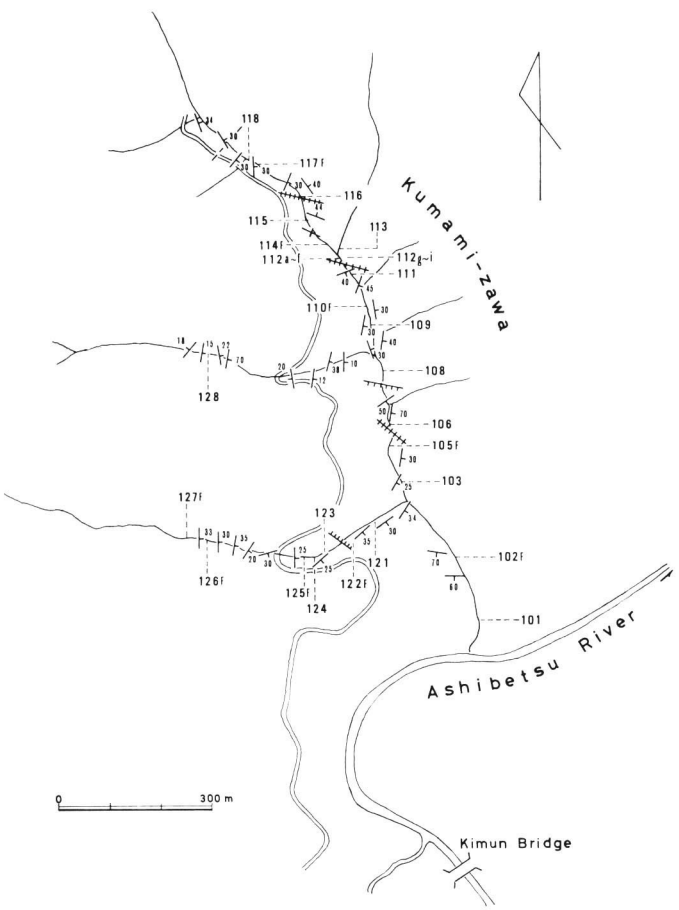


Fig. 13. The geologic route map of the Kumami-zawa in the Ashibetsu area, central Hokkaido.

occurs. Thus the lower part of the Upper Yezo Group in this route is assigned to the Upper Turonian. Its thickness is about 70 meters, and is thinner than that of the western marginal areas in the central zone of Cretaceous in Hokkaido, e.g. the Manji and Hatonosu areas. Above the *I. teshioensis* Zone, *I uwajimensis* and *Anagaudryceras limatum* occur commonly, and *I. naumanni* occurs from the host rock near the entrance of the Kumami-zawa. From the evidences of species mentioned above, the Upper Yezo Group of this route is probably assigned to the Upper Turonian to the Santonian.

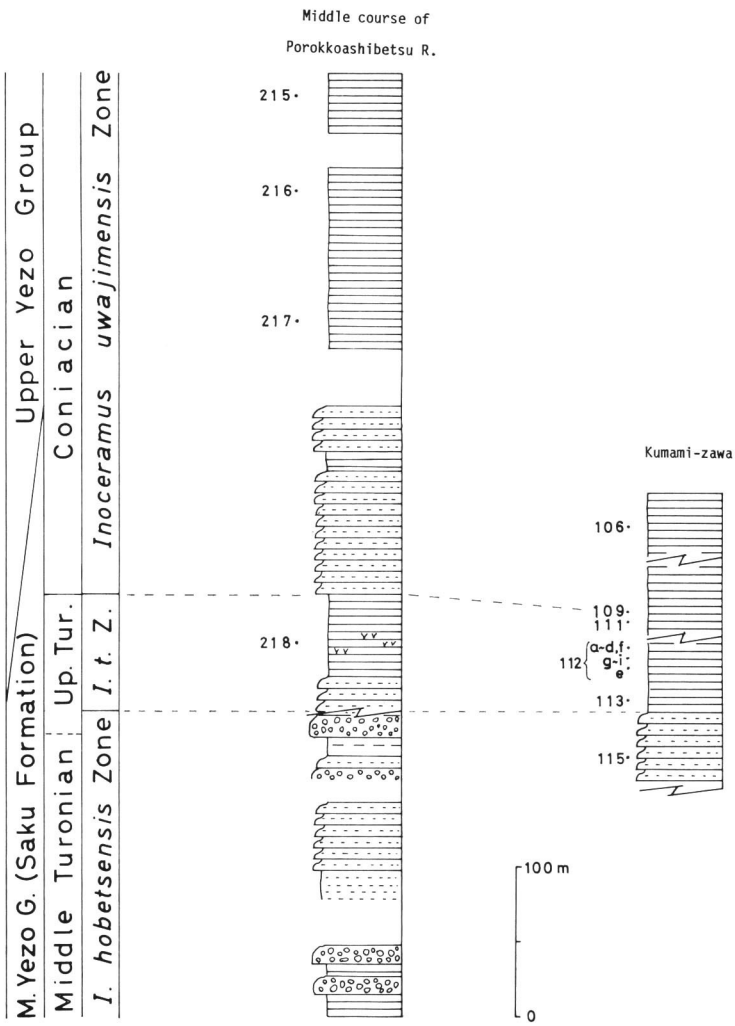


Fig. 14. The columnar sections of the Porokkoashibetsu River and the Kumami-zawa in the Ashibetsu area, central Hokkaido. Rock symbols are the same as in Fig. 10.

Table 4. List of molluscan fossils from the Middle and Upper Yezo Groups in the Kumami-zawa, a branch of the Ashibetsu River, Ashibetsu, central Hokkaido.

Species	Locality number (As)
Neophylloceras sp.	102F, 103, 105F, 115, 120F
Desmoceras sp.	118
Pachydesmoceras sp.	114F
Damesites cf. *ainuanus* MATSUMOTO	112
Damesites sp.	105F, 110F, 118, 119F, 126F, 127F, 125F
Mesopuzosia pacifica MATSUMOTO	112f, 125F
M. sp.	102F, 110F, 112a,b,i, 116, 120F, 129
Yokoyamaoceras kotoi (JIMBO)	102F
Tetragonites sp.	118, 126F, 112f, 129
Gaudryceras cf. *denseplicatum* (JIMBO)	112g
G. sp.	111, 112, 117F, 122F
Anagaudryceras limatum (YABE)	102F, 104F, 106, 109, 111, 119F, 122F
A. cf. *limatum* (YABE)	123, 126F
A. sp.	106, 107b
Jimboiceras (?) sp.	115
Reesidites minimus (HAYASAKA et FUKADA)	105F, 110F, 112f,h,i, 113
Subprionocyclus normalis (ANDERSON)	102F, 120F
Madagascarites ryu MATSUMOTO et MURAMOTO	105F, 110F, 112i
Scalarites sp.	112b,g, 119F
Scaphites aff. *S. pseudoequalis* YABE	110F
S. planus (YABE)	115
Sciponoceras intermedium MATSUMOTO et OBATA	112a
S. (?) sp.	112e,f, 125F
Eubostrychoceras cf. *saxonicum* (SCHLUTER)	126F
Inoceramus naumanni YOKOYAMA	101, 103
I. uwajimensis (YEHARA)	106, 128
I. aff. *I. uwajimensis* (YEHARA)	120F
I. teshioensis NAGAO et MATSUMOTO	107a, 112c
I. tenuistriatus NAGAO et MATSUMOTO	110F, 111, 112e, 122F
I. hobetsensis NAGAO et MATSUMOTO	114, 115, 117F, 129
I. sp.	102F, 105F, 108, 112b, 121
Nanonavis sachalinensis (SCHMIDT)	112e

It is noteworthy that well-preserved adult shells of *Anagaudryceras limatum* with the body chamber occurs frequently from the Turonian to Coniacian strata in the investigated routes along the Porokkoashibetsu River and the Kumami-zawa. The fact suggests that the species is autochthonous in this area in a broad sence.

Stratigraphic Change of Sediments and Ammonites of the Middle and Upper Yezo Groups

The sediments in the late Albian age represented by the strata in the Ishikari province are those of the Main part of the Middle Yezo Group which is composed mainly of mudstone with sandstone and alternating beds. From the Main part in the southern areas, e.g. Ikushumbetsu, Manji and Hatonosu, *Mortoniceras* (*Cantabrigites*) *imaii*, *M.* (*Deiradoceras*) sp., *Desmoceras* (*Pseudouhligella*) *dawsoni*, *Ammonoceratites ezoensis* and others are obtained (MATSUMOTO, 1965; OBATA and FUTAKAMI, 1975; FUTAKAMI,

1982). However, in the northern areas, e.g. Bibai and Ashibetsu, mega-fossils including ammonites are scarcely found in the Main part (Fig. 15). Such different occurrence of ammonites distinctly corresponds with the different lithofacies. Namely, rocks in the southern part are composed of coarser cross-laminated mudstone including plant fragments in comparison with those in the northern part, consisting of parallel-laminated mudstone. Therefore, the sedimentary environment in the late Albian age seems to have been deeper to the north.

Strata of Cenomanian age in the Ishikari province are lithologically divided into

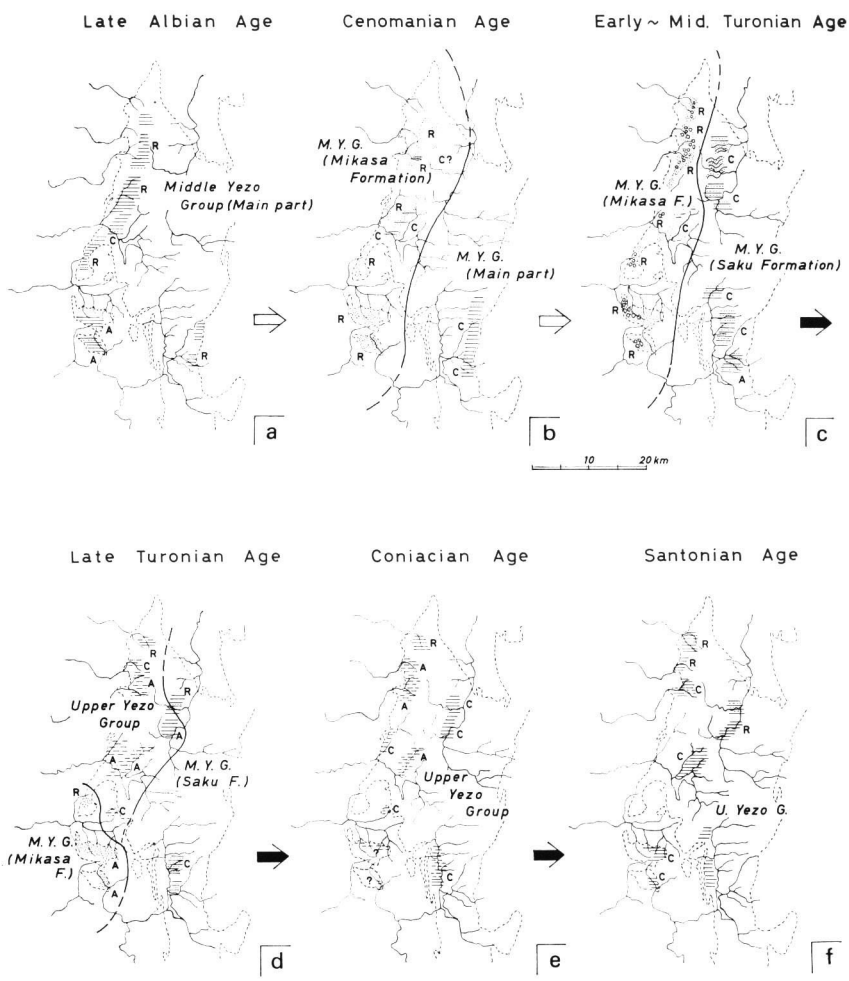


Fig. 15. Stratigraphic change of sediments and ammonites of the Middle and Upper Yezo Groups. The open arrows indicate the regression and the black arrows show the transgression. Rock symbols are the same as in Fig. 10. A: ammonites, abundant, C: ammonites, common, R: ammonites, rare.

two parts: the Mikasa Formation of the Middle Yezo Group in the western areas and the Main part of the Middle Yezo Group in the eastern area (Fig. 15). The Mikasa Formation consists of fine- to medium-grained sandstone with mudstone and conglomerate beds, and the Main part is composed of mudstone. These formations yield common ammonites such as *Acanthoceras takahashii*, *Mantelliceras japonicus*, *Calycoceras asiaticum*, *Desmoceras* (*Pseudouhligella*) *japonicus*, *Turrilites* sp. and others (MATSUMOTO *et al.*, 1957, 1969, etc.), although their occurrences are largely limited to the mudstone facies.

The early to middle Turonian Mikasa Formation distributed in the western part is composed of the coarsest sediments among those in the Middle and Upper Yezo Groups. Namely, the sedimentary rocks are cross-laminated medium- to coarse-grained sandstone and conglomerate, and are recognized as the beds which had been deposited in nonmarine and/or marine environments near the sea shoreline. The ammonoids are found few, sometimes only a few, in this formation. In the eastern part, i.e. Oyubari and Ashibetsu areas, the early to middle Turonian strata are the Saku Fromation of the Middle Yezo Group, which is composed of mudstone and alternating beds of sandstone and mudstone and often intercalates slump beds (Fig. 15c). Besides the common occurrence of *Scaphites planus*, *Otoscaphites puerculus*, *Tetragonites glabrus* and *Gaudryceras denseplicatum*, the occurrence of zonal indices such as *Mammites costatus*, *Yubariceras yubarense*, *Romanicers pseudodeverianum*, *Kamerunoceras* aff. *K. turoniense*, *Collignoniceras woollgari*, *C. bravaisianum* and others are known from this formation (MATSUMOTO *et al.*, 1957, 1969; HIRANO, 1986; FUTAKAMI, 1986 etc.). However, the investigation on just points of fossil locality is needed, because some of the specimens were obtained from rolled nodules and the Saku Formation has a complex geological structure.

The late Turonian sediments of the Mikasa Formation is limited in the southwestern areas, i.e. Poronai, Manji and Hatonosu, and consists of fine-grained sandstone and occasionally siltstone. In the northern areas the strata of that time are represented by the Upper Yezo Group which is composed of sandy siltstone, siltstone and shale. In the Oyubari area of eastern part there are the sediments of Saku Formation, accumulating from the preceding age (Fig. 15d). *Reesidites minimus*, *Subprionocyclus neptuni* and *S. normalis* are abundantly obtained from all these areas. *Lymaniceras planulatum*, *Prionocyclus cobbani*, *P. aberrans* and *P. novimexicanus* are found in the areas of northern part, i.e. Naie, Bibai, Pombetsu and Ashibetsu (Fig. 16).

The Coniacian rocks in this province are represented by the Upper Yezo Group which consists of siltstone and shale (Fig. 15e). In the Manji and Hatonosu areas, the sedimentary deposits which are distinctly assigned to the Coniacian age are rarely found. In additon to common occurrence of *Scaphites pseudoequalis*, *Baculites yokoyamai*, *Damesites damesi intermedius* and *Anagaudryceras limatum*, the zonal indices such as *Barroisiceras* (*B.*) *onilyense*, *B.* (*Basseoceras*) *inornatum*, *Forresteria* (*F.*) *alluaudi*, *F.* (*F.*) *armata*, *F.* (*Muramotoa*) *yezoensis* and *F.* (*M.*) *muramotoi* are obtained from this group (MATSUMOTO, 1965, 1969, 1971; FUTAKAMI, 1986).

The Santonian rocks of the Upper Yezo Group are represented by cross- and parallel-laminated black shale. Besides common occurrence of *Tetragonites glabrus*, *Damesites semicostatus*, *Polyptychoceras pseudogaultinum*, species of *Protexanites* and *Texanites* are often found. However, occurrence of mega-fossils in Naie and Shimo-utashinai areas is rarely known.

In short the deposits of the Middle Yezo Group except for the Main part grade laterally into finer sediments from west to east in the Ishikari province. Especially the lateral change of sedimentary facies from Cenomanian through Turonian age was remarkable in comparison with that in other ages. On the other hand, the deposits of the Upper Yezo Group gradually grade into finer sedimens to the east, to the north and to the upper in the Ishikari province. Accompanied with such changes of the sedimentary facies, the frequency of occurrence of mega-fossils decreases.

Turonian Zonation based on Ammonites

Concerning the Turonian zonation in Japan, six subzones have suggested by MATSUMOTO (1977), i.e. the *Fagesia thevestensis*, *Collignoniceras woollgari*, *Subprionocyclus neptuni*, *S. bravaisianus*, *S. normalis* and *Reesidites minimus* Subzones in ascending order. After that, MATSUMOTO (1984) has reported that *S. neptuni* has nearly the same vertical range as *R. minimus* in accordance with the records in the Manji area shown by OBATA and FUTAKAMI (1977). The present investigation, however, proved that the above mentioned collignoniceratids in the Ishikari province have a longer vertical range than the formerly accepted duration (Fig. 16). Vertical ranges of such collignoniceratids are within the middle to upper Turonian. On the other hand, MATSUMOTO *et al.* (1969) have reported that *Mammites costatus* was obtained from *Inoceramus* sp. aff. *I. saxonicus* Zone in the Oyubari area. As shown by HIRANO (1986), *I.* sp. aff. *I. saxonicus* is found in the basal part of the Turonian. The exact stratigraphic position of *M. costatus*, for example, is confirmed in the succession of the Kaneobetsu River in Oyubari. Thus, the Turonian in Japan is better divided into three concurrent range zones as follows:

Lower: *Mammites costatus* Zone [=*I.* sp. aff. *I. saxonicus* Zone]

Middle: *Collignoniceras bravaisianum* Zone (with *C. woollgrai*, *Romaniceras pseudodeverianum*, *R.* sp. aff. *R. deverianum* and *Yubariceras yubarense*) [=lower to middle part of *I. hobetsensis* Zone]

Upper: *Subprionocyclus neptuni* Zone (with *S. normalis*, *Reesidites minimus*, *Lymaniceras planulatum*, *Prionocyclus cobbani* and *P. aberrans*) [=upper part of *I. hobetsensis* Zone to *I. teshioensis* Zone]

These proposed zones are provided by the appearance of *Mammites costatus*, *Collignoniceras bravaisianum* and *Subprionocyclus neptuni* in ascending stratigraphic order.

At first sight, tripartite ammonite zones in the Turonian seems to be less precise than six-parted ones. But, the zonation is a reasonable result on the sound grounds,

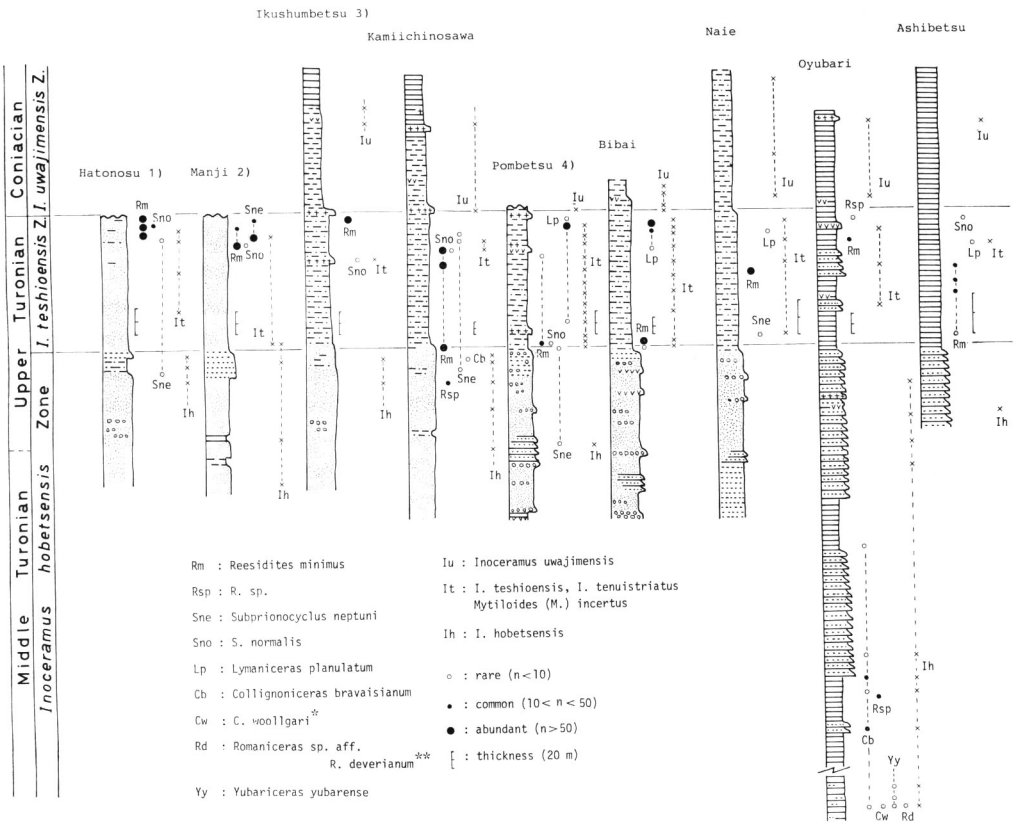


Fig. 16. The correlation of the Turonian in the Ishikari province, centarl Hokkaido. Rock symbols are the same as in Fig. 10. 1) adapted from FUTAKAMI, 1982; 2) adapted from OBATA and FUTAKAMI, 1975; 3) MATSUMOTO, 1965; 4) adapted form MATSUMOTO, 1965; *: MATSUMOTO, 1971; **: MATSUMOTO, 1975.

because the habitat of these collignoniceratids was influenced by the environmental factors and the apparent occurrence may be variable according to sedimentary conditions, and the true duration of a species is longer than the formerly accepted one. Thus the result seems to support the opinion of MATSUMOTO and OBATA (1979) as to the evaluation of ammonites for interregional correlation.

Based on the above result on the Turonian zonation of the Ishikari province, I try to make the interregional correlation with the other regions of the world.

In Touraine, France where is the type area of the Turonian, the stratigraphic succession has been characterized by the following six ammonite assemblage zones grouped into three portions: (Lower) *Mammites nodosoides*; (Middle) *Kamerunoceras turoniense*, *Romaniceras kallesi*, *R. ornatissimum*; (Upper) *R. deverianum* and *Subprionocyclus neptuni*, in ascending order (AMÉDRO *et al.*, 1982). From its uppermost

part, however, index-fossils are not found. It may have been caused by environmental factors during sedimentation.

The Turonian in England has been divided into five ammonite subzones, which are grouped into three portions: (Lower) *Watinoceras coloradoense*, *Mammites nodosoides*; (Middle) *Collignoniceras woollgari*; (Upper) *Romaniceras deverianum* and *Subprionocyclus neptuni—S. normalis* in ascending order (HANCOCK and KENNEDY, 1981). The occurrence of ammonites from the uppermost beds of the areas in England is not recognized as in the type area of France. It should be noticed that *S. neptuni* and *S. normalis* are known to occur together from the uppermost subzone at Hitch Wood and Kensworth in southeastern England (HANCOCK *et al.*, 1977). As above mentioned, our knowledge on the upper Turonian zonation in Europe is incomplete because of the absence of ammonites in the uppermost part of the successions. Inhabitable environments of ammonoid might have been restricted there because of a strong regression by eustatic movement in the Late Turonian (HANCOCK and KAUFFMAN, 1979; HANCOCK and KENNEDY, 1981).

In the Western Interior of North America, ten zones of Turonian ammonites have been established: (Lower) *Pseudaspidoceras flexuosum*, *Vascoceras birchbyi*, *Mammites nodosoides*; (Middle) *Collignoniceras woollgari*, *Prionocyclus percarinatus* (?), *P. hyatti*; (Upper) *P. macombi*, *P. wyomingensis*, *Scaphites whitfieldi* and *P. quadratus* in ascending order (COBBAN, 1984).

As mentioned above, the Turonian zonation in Europe including that of the type area has lacked the ammonite zone of its uppermost part. Thence, the biostratigraphical data of the Upper Turonian of the Ishikari province in Japan, a standard area in the Pacific region, serve an important role for completion of the zonation.

Conclusions

1. The Cretaceous sequences in the Naie and Bibai areas are lithologically divided into three, i.e. the Main part and the Mikasa Formation of the Middle Yezo Group, and the Upper Yezo Group in ascending order, and these are of late Albian to Santonian age.

2. The Cretaceous rocks in the studied routes in Ashibetsu are represented by the Saku Formation of Middle Yezo Group and the Upper Yezo Group, which show a more off-shore facies for sedimentary environment in the Ishikari province than those of the western areas, i.e. Naie, Bibai, Ikushumbetsu, Manji and Hatonosu. From the beds at Ashibetsu Turonian collignoniceratids such as *Reesidites minimus*, *Subprionocyclus normalis* and *Lymaniceras planulatum* were newly found.

3. From the Upper Albian in the studied area, a few fossil-molluscs including ammonites are found. Its rocks are parallel-laminated mudstone, and differ from those of the southern areas, e.g. Ikushumbetsu, Manji and Hatonosu, where the Upper Albian strata yield common such indices as *Mortoniceras* (*Cantabrigites*) *imaii*, *M.* (*Deiradoceras*) sp., *Ammonoceratites ezoensis* etc. Therefore, the sedimentary environ-

ment seems to have been deeper to the north.

4. The deposits of the Upper Yezo Group assigned to the late Turonian to Santonian age in Naie and Bibai areas grades upward into finer sediments. Accompanied with the change of sedimentary facies, occurrence of fossil-molluscs is decreasing.

5. Common occurrence of *Reesidites minimus* and *Lymaniceras planulatum* and rare occurrence of *Subprionocyclus neptuni*, *S. normalis* and *Prionocyclus cobbani* are recognized in the lower part of the Upper Yezo Group in the studied areas. Such occurrences of ammonites closely resemble those of the Upper Turonian sequence of the Pombetsu area (FUTAKAMI *et al.*, 1980; MATSUMOTO *et al.*, 1981).

6. *Lymaniceras planulatum* and *Prionocyclus cobbani* are not found in the southern areas such as Ikushumbetsu, Manji, Hatonosu and Oyubari. Thus, this fact seems to show somewhat different conditions of inhabitat and the environment of ammonites between the northern and the southern areas, which are not always reflected by the lithofacies.

7. The Turonian zonation in the Ishikari province by collignoniceratid ammonites such as *Collignoniceras*, *Subprionocyclus*, *Lymaniceras*, *Prionocyclus* and *Reesidites* species is established on the sound basis of the lithostratigraphy and the inoceramid biostratigraphy: the *Mammites costatus*, *Collignoniceras bravaisianum* and *Subprionocyclus neptuni* Zones in ascending order. The proposed zones will be expected to be very useful for the global correlation of the Japanese Turonian.

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