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Stratigraphy and Paleontology of the Cretaceous in the Ishikari Province, Central Hokkaido
Part 1. Stratigraphy of the Cretaceous in the Southern Areas

By

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Abstract Litho- and bio-stratigraphy of the Middle to Upper Cretaceous in the central and southern parts of the Ishikari province are described for the following areas: the Ikushumbetsu, Oyubari, Manji and Hatonosu areas. These Cretaceous beds consist mainly of shale, siltstone, sandstone and alternating beds of sandstone and mudstone units often containing fossiliferous calcareous nodules. Successive and rich occurrence of ammonoids is ascertained. On the basis of detailed lithostratigraphy, occurrence of several important ammonoids, such as the Brancoceratidae, Acanthoceratidae and Collignoniceratidae, is described to show the more precise biostratigraphy of the Albian to Santonian beds. As one of the results, a revised scheme of zonation is suggested for the Turonian in the Japanese sequence.

Introduction

In central Hokkaido, the Cretaceous formations are distributed extensively, from which well-preserved marine invertebrates, such as ammonoids, bivalves including inoceramids, gastropods and echinoids, have been known to occur. Especially, the Middle and Upper Cretaceous beds contain these off-shore and near-shore invertebrate fossils which have been able to afford the biostratigraphic frameworks.

Historically, the studies on the geology and stratigraphy of these Cretaceous beds have been done for necessity of the coal mining to the Paleogene formations which unconformably overlies the Cretaceous (e.g., OTATSUME, 1950; TASHIRO, 1951; TAKAO, 1952). Apart from these studies, paleontological and biostratigraphic works have been made by various authors; YABE (1903–04, 1909), NAGAO and MATSUMOTO (1939), MATSUMOTO (1942–43, 1954, 1959, 1977, 1984). Among all, MATSUMOTO (1959), in summarizing the knowledge of the Japanese Cretaceous biostratigraphy which provided the basis of biostratigraphic zonations for subsequent works, noted the Cretaceous biostratigraphy in this district. In addition, the interregional correlation has been discussed on the basis of ammonoids and inoceramids (e.g., MATSUMOTO, 1977; MATSUMOTO *et al.*, 1985). Nevertheless, there are still numerous unresolved problems, for example, on the Turonian zonation.

In most cases of the studies of the Cretaceous biostratigraphy, the successive

ammonoid zones established at one region are defined by certain dominant or characteristic species which belong to the different evolutional lines. However, if the zonal division is possible on the basis of some successive species of a single phyletic stock, the result is the most useful for both the biostratigraphic and paleobiologic purposes (MATSUMOTO and OBATA, 1979). Central Hokkaido, where the Cretaceous rocks are well exposed successively, is one of the suitable field in Japan for such purposes.

In accordance with the above mentioned object, I selected seven areas in the Ishikari province, Hokkaido, where the Cretaceous strata contain numerous ammonoids. They are the Naie, Bibai, Ikushumbetsu, Manji, Hatonosu, Ashibetsu and Oyubari areas. In these areas, Turonian collignoniceratid ammonites of a single phyletic stock, such as *Subprionocyclus neptuni*, *S. normalis* and *Reesidites minimus* were anticipated to occur commonly and successively.

Geological field survey was made in each area mentioned above, on the basis of the mapping with scale 1 : 5000. On this ground I made the stratigraphical and paleontological study, with reference to the Turonian and Coniacian collignoniceratid ammonites, composition, mode of occurrence and global distribution of ammonoid fauna and interregional correlation (FUTAKAMI, 1985MS). As part of this study, I will describe the litho- and bio-stratigraphy of the southern part of the Ishikari province, namely, the Ikushumbetsu, Oyubari, Manji and Hatonosu areas, and will discuss the geologic age.

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General Geology

The Cretaceous sequence in the Ishikari province forms the basement of the Yubari range, and is situated in the western part of central Hokkaido. Its structure roughly shows a syncline with the axis of extending from the Ikushumbetsu to the Ashibetsu basin, and is complicated by the excelling faults of N-S and NW-SE trends. The geological structure in the Ashibetsu and Oyubari areas situated in the eastern part of the studied areas is more complicated by the overthrusts (OTATSUME, 1950) than that in the Naie, Bibai, Pombetsu, Ikushumbetsu, Manji and Hatonosu areas situated in the western part of them. There is an anticline, i.e. the Ikushumbetsu anticline by OTATSUME (1950), in the western margin with the axis passing, Mt. Bibai-yama and

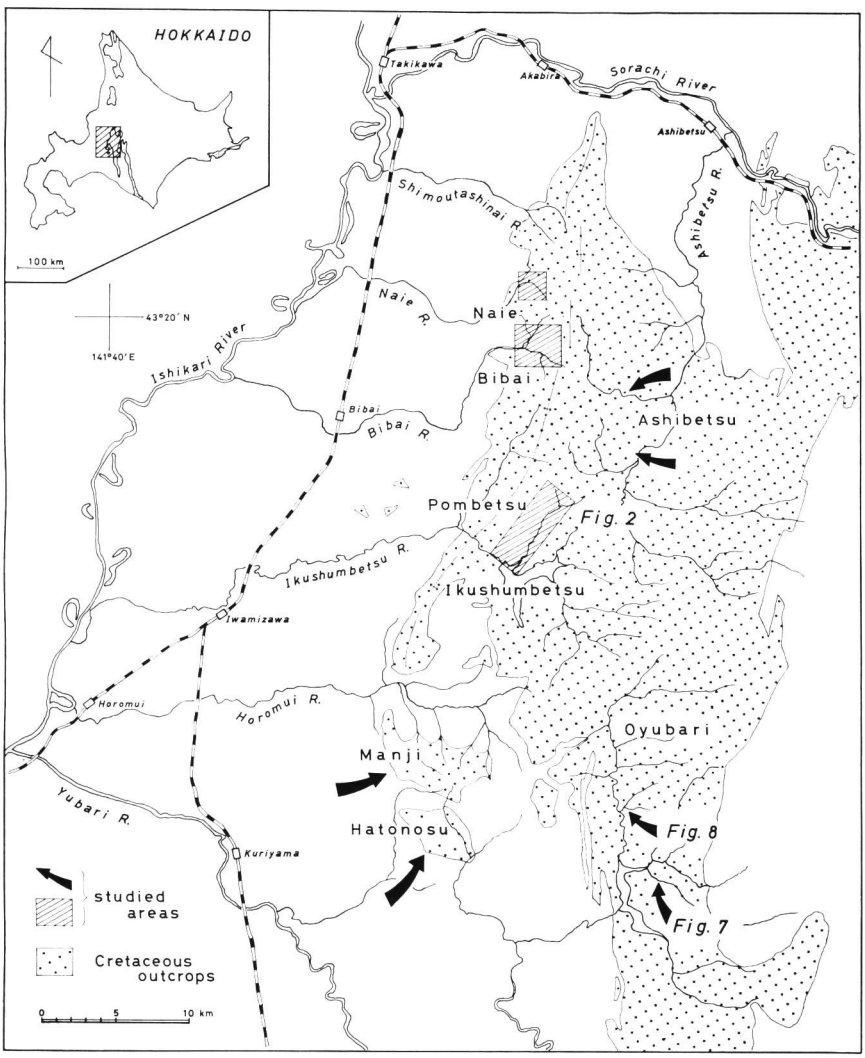

Fig. 1. Index map of the Ishikari province in central Hokkaido.

Mt. Pombetsu-dake. The southern extention of the anticline appears again in the Manji and Hatonosu areas respectively as a dome-like structure modified probably by later deformation. The dome-like structure of the former area is called the Manji dome by OTATSUME (1950) and that of the latter is called the Yubari dome by the same author or the Hatonosu dome by some others, e.g. TASHIRO (1951); TAKAO (1952).

The Cretaceous System of these areas is lithologically divided into four groups, the Lower, Middle and Upper Yezo Groups and the Hakobuchi Group, in ascending order. Among them the Middle (Upper Albian to Turonian) and Upper (Turonian

or Coniacian to Santonian or Campanian) Yezo Groups yield many molluscan fossils including the ammonoids, inoceramids and others.

Kamiichi-no-sawa in the Ikushumbetsu Area

The Cretaceous sequence of the Ikushumbetsu area, Hokkaido has been stratigraphically studied as a type area in Japan (e.g. MATSUMOTO, 1954, 1965). In this paper, I will describe the Cretaceous sequence in the northern part of the Kamiichi-no-sawa, a tributary of the Ikushumbetsu River. The studied area is situated on the eastern side of the type section in the Ikushumbetsu area. After 1957 the type section has been, for the most part, sunk under the Katsurazawa Lake because of the construction of Katsurazawa Dam. The detailed stratigraphic result of the present study must supplement the biostratigraphy of the type section, although some preliminary reports have been published on the Cretaceous of the Kamiichi-no-sawa area by several authors (FUKADA *et al.*, 1953; YOSHIDA and KAMBE, 1955; MATSUMOTO, 1965).

Stratigraphic Description

The main stream and branches of the Kamiichi-no-sawa River are situated in the eastern part of Ikushumbetsu anticline (OTATSUME, 1950), and the geological structure of this area is relatively simple. The Cretaceous strata are roughly divided into two parts by a relatively large fault of NW-SE trend in the area of the lower stream of the Kamiichi-no-sawa River. Generally, the relatively small faults of NW-SE trend are predominant in the studied area. The Cretaceous formations exposed in it are lithologically divided into two groups in ascending order, the Middle Yezo Group which is composed mainly of coarse-grained clastic sediments, and the Upper Yezo Group of mainly finer sediments. The geological map, generalized columnar section, columnar sections and geological route map of the Cretaceous in this area are shown in Figs. 2–5.

Middle Yezo Group

This group is lithologically divided into the Main part which is composed mainly of fine-grained clastic sediments and the Mikasa Formation of coarse-grained ones. Furthermore, the latter is lithologically subdivided into two members, Mk_1 and Mk_2 in ascending order. The stratigraphic relation between the Main part and the underlying strata is not clear in this area.

Main part: *Member M*

Distribution: Upper stream of the Ganseki-zawa, a tributary of the Kamiichi-no-sawa River.

Thickness: 200+meters.

Lithology: This member is composed mainly of dark bluish shale, and gradually becomes coarser from the lower upward in grain size in the upper part, resulting in

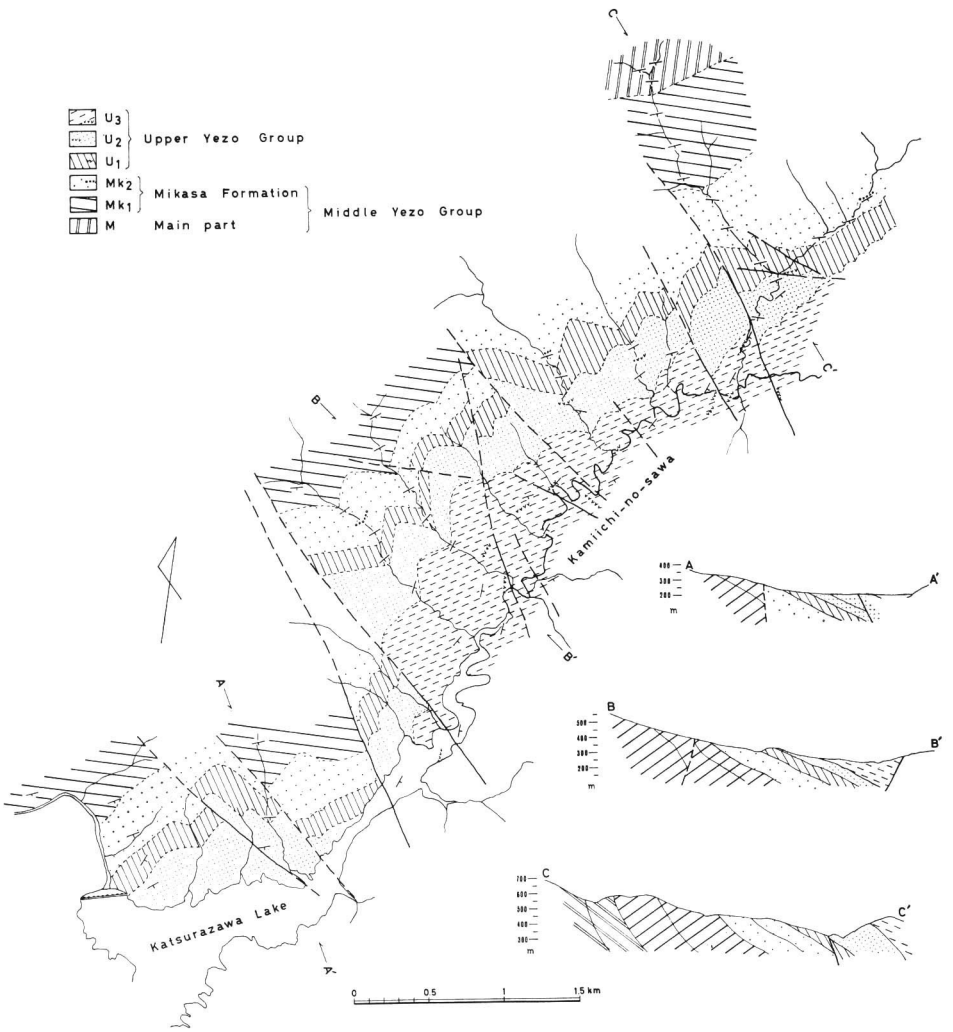

Fig. 2. The geologic map and sections of the Kamiichi-no-sawa area, Ikushumbetsu, central Hokkaido.

the bluish gray siltstone which contains a few plant fragments. Calcareous nodules are included rarely in the upper part. Fossils are found but not so numerous in this member.

Mikasa Formation

This formation consists mainly of thick, massive fine-grained sandstone, however, partly of thick bedded one. The lithology and the composition of fossils of the Mikasa Formation in this area differ from those of the Manji and Hatonosu areas

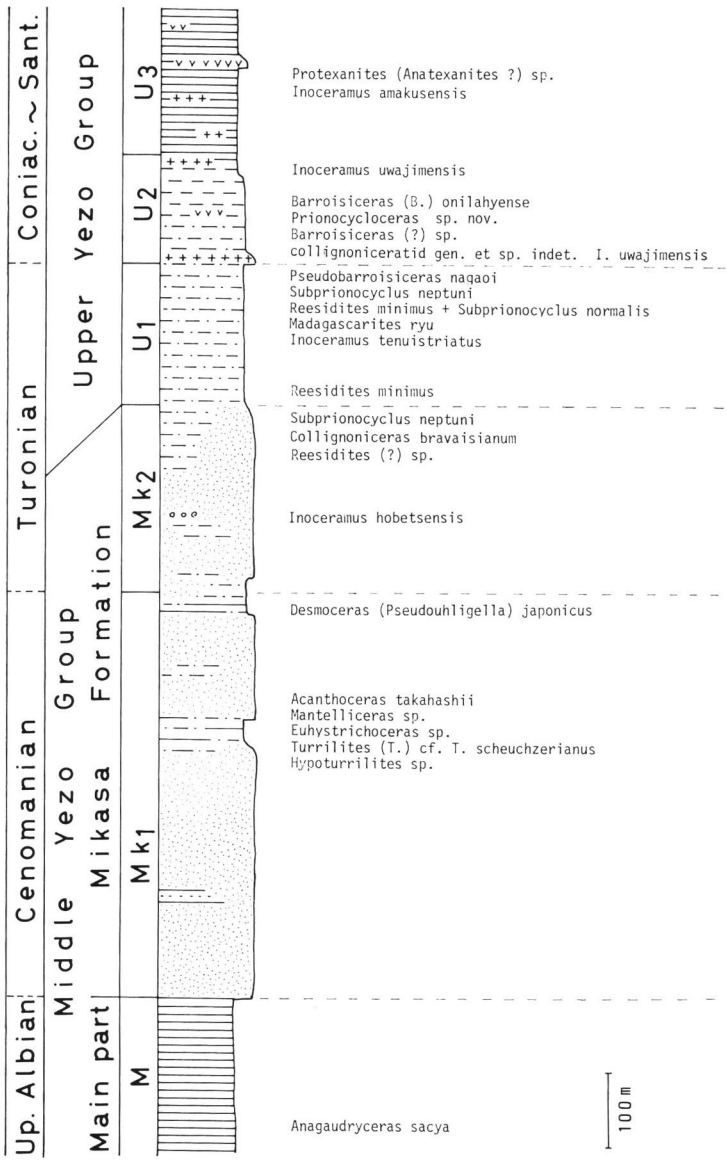

Fig. 3. The generalized columnar section of the Kamiichi-no-sawa area, Ikushumbetsu, central Hokkaido. Rock symbols are the same as in Fig. 4.

situated at the south of Ikushumbetsu, suggesting a difference of sedimentary environment from the latter areas.

Member Mk_1

Distribution: The industrial road along the Ikushumbetsu River, the upper

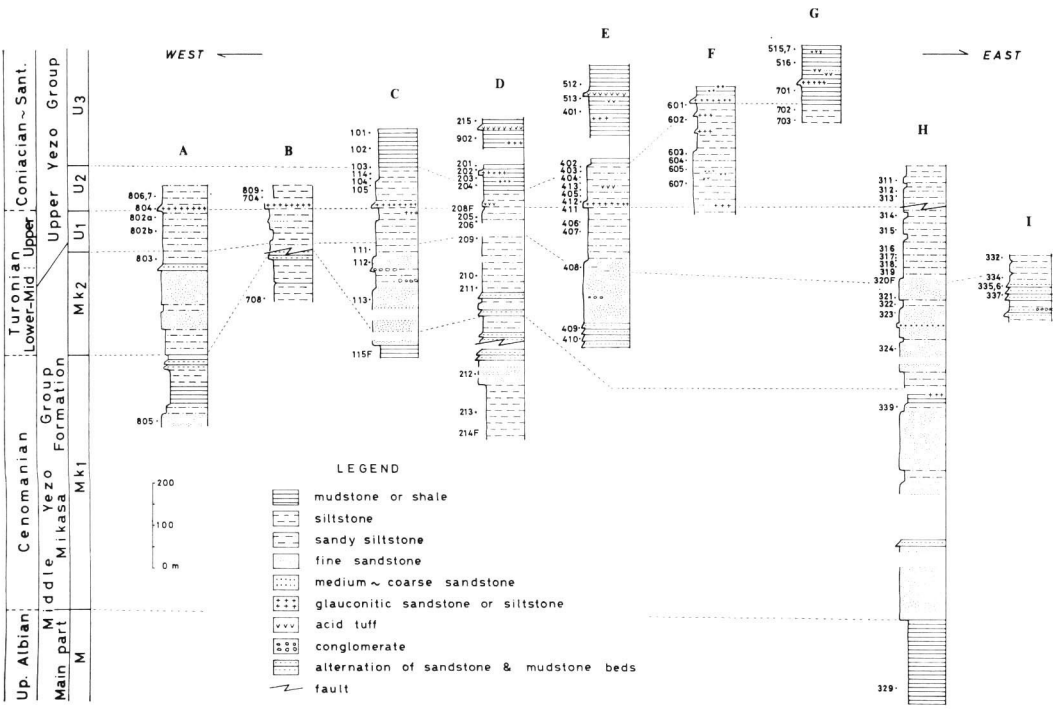

Fig. 4. The columnar sections in the Kamiichi-no-sawa area, Ikushumbetsu, central Hokkaido. A: the industrial road along the Ikushumbetsu River, B: the Ichi-no-sawa, C: the Tsuchisute-zawa, D: the Yon-no-sawa, E: the Fukuro-zawa, F: the Roku-no-sawa, G: the Kita-no-sawa, H: the Ganseki-zawa, I: the eastern branch of the Ganseki-zawa.

streams of the Ichi-no-sawa, the Tsuchisute-zawa, the Yon-no-sawa and the Ganseki-zawa, the tributaries of the Kamiichi-no-sawa River.

Thickness: 540 meters.

Lithology: This member is typically exposed at the cliffs along the industrial road and Ikushumbetsu River and in the creek of the upper stream of the Ganseki-zawa. It is composed mainly of the massive fine-grained sandstone, however, sometimes intercalates well bedded sandstone. In the middle to upper part, the fossiliferous mudstone and dark bluish siltstone are intercalated at least more than 150 meters in thickness, and the alternating beds of fine-grained sandstone and siltstone are also intercalated. This member commonly contains sandy calcareous nodules which are about 30 centimeters to 2 meters in size and yield abundant fossils, especially of bivalves and gastropods. *Desmoceras* (*Pseudouhligella*) *japonicus*, a smooth ammonite, occurs commonly, associating with some acanthoceratids and turrilitids rarely.

Member Mk_2

Distribution: The industrial road along the Ikushumbetsu River, the middle

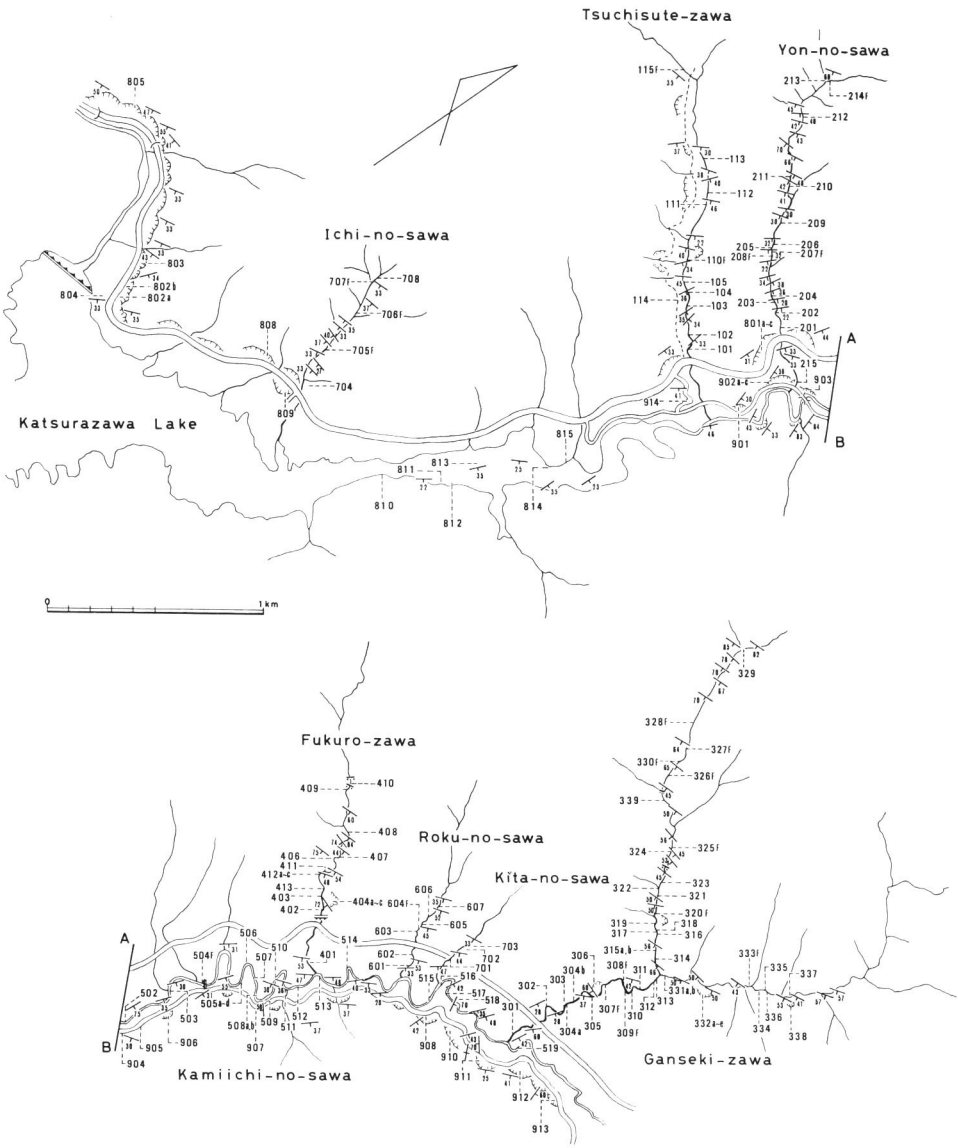

Fig. 5. The geologic route map of the Kamiichi-no-sawa area, Ikushumbetsu, central Hokkaido.

streams of the Ichi-no-sawa, the Tsuchisute-zawa, the Yon-no-sawa, the Roku-no-sawa, the Ganseki-zawa, the tributaries of the Kamiichi-no-sawa River.

Thickness: 250 meters.

Lithology: This member consists mainly of well bedded and fine-grained sandstone, and contains one or two intercalated conglomerate beds which are several

centimeters to 2 meters thick and are composed of well rounded pebbles of chart, older sandstone, etc. These beds sometimes become calcareous conglomerate which contains the bivalves and others. Partly, the upper part of the member intercalates sandy siltstone with plant fragments. The calcareous nodules often contain inoceramids, ammonoids and numerous plant fragments. Especially *Inoceramus hobetsensis* occurs commonly from nodules.

Upper Yezo Group

This group constitutes the uppermost part of the Cretaceous in the studied area. It is composed mainly of fine-grained clastic sediments, and contains abundantly calcareous nodules. It conformably overlies the Middle Yezo Group with a relatively abrupt change of lithology. 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: The industrial road along the Ikushumbetsu River, the middle streams of the Ichi-no-sawa, the Tsuchisute-zawa, the Yon-no-sawa, the Fukuro-zawa, the Roku-no-sawa, the Ganseki-zawa and the eastern branch of the Ganseki-zawa, the tributaries of the Kamiichi-no-sawa River.

Thickness: 190 meters.

Lithology: This member consists mainly of massive and bedded sandy siltstone and sometimes intercalates siltstone. Along the Ganseki-zawa and the Fukuro-zawa, massive fine-grained sandstone is recognized in the lower part. The calcareous nodules are obtained abundantly from this member, and they yield numerous molluscan fossils. Among them *Inoceramus tenuistriatus* and ornate ammonites such as *Reesidites minimus*, *Subprionocyclus neptuni* and *S. normalis* occur commonly.

Member U_2

Distribution: The industrial road along the Katsurazawa Lake, the lower stream of the Ichi-no-sawa, the middle streams of the Tsuchisute-zawa, the Yon-no-sawa, the Fukuro-zawa, the Roku-no-sawa, the Kita-no-sawa and the Ganseki-zawa, the tributaries of the Kamiichi-no-sawa River.

Thickness: 250 meters.

Lithology: This member is composed mainly of sandy siltstone and silstone, and becomes finer from the lower upward in grain size. In the basal part, a glauconitic medium-grained sandstone bed of about 2 meters in thickness lies (Pl. 1, Figs. 2, 3) and contains inoceramids and ammonoids. The member intercalates glauconitic sandstone and siltstone in the middle to upper part. It is also intercalated with a few acid tuffs of about 2–15 centimeters in thickness in the lower to upper part along the Yon-no-sawa, the Fukuro-zawa and the Roku-no-sawa of the eastern part of the studied area. Fossils are obtained abundantly from calcareous nodules and commonly from the host rock. Namely, *Inoceramus uwajimensis* and smooth or weakly ornate ammonites such as *Damesites damesi intermedius*, *Anagaudryceras limatum*, and others occur commonly.

Member U_3

Distribution: Main stream of the Kamiichi-no-sawa River and its forestry road, the lower streams of the Tsuchisute-zawa, the Yon-no-sawa, the Fukuro-zawa, the Roku-no-sawa, the Kita-no-sawa and the Ganseki-zawa, the tributaries of the Kamiichi-no-sawa River.

Thickness: 240 meters.

Lithology: This member is composed mainly of dark bluish or black shale and intercalates thin layers of several centimeters to one meter in thickness of acid tuff which sometimes includes numerous biotites. A glauconitic medium-grained sandstone of about 5–7 meters in thickness is recognized in the upper stream of the Kamiichi-no-sawa River, the entrance of the Roku-no-sawa and the lower stream of the Ganseki-zawa. Several beds of glauconitic sandstone of about 30–100 centimeters in thickness are also recognized. Fossils occur commonly from calcareous nodules: they are *I. uwajimensis*, *Tetragonites glabrum*, *Damesites damesi intermedius*, *Polyptychoceras pseudogaultinum* and others.

Biostratigraphy and Geological Age

From the Member M, *Anagaudryceras sacya* was found from the uppermost stream of the Ganseki-zawa. This species is a long-ranging ammonite and occurs commonly from the Upper Albian to the Cenomanian in Japan. *Mortoniceras* (*Cantabrigites*) *imaii*, an Upper Albian species, has been known to occur from the western extension of the Member M in addition to *A. sacya* in the main stream of the Ikushumbetsu River and the Yu-no-sawa, a branch of the Ikushumbetsu (MATSUMOTO, 1965). Thus, the Member M is probably assigned to the Upper Albian.

From the Member Mk_1, *Mantelliceras* sp. and *Acanthoceras takahashii* were obtained from the rolled nodules on the upper streams of the Ganseki-zawa and the Tsuchisute-zawa. The former genus has been reported from the basal to lower zone of the Cenomanian in the main stream of the Ikushumbetsu River. The latter has been reported from the middle zone in that river (MATSUMOTO, 1975). A specimen of *Euhystrichoceras* sp. was obtained from a rolled nodule on the middle stream of the Ganseki-zawa. This genus has been reported from the Cenomanian in Europe and Africa by KENNEDY and WRIGHT (1981). From the same nodule, a specimen similar to *Oxytropidoceras* or *Prohauericeras* was obtained, which is provisionally assigned to Mojsisovicziinae (?) gen. et sp. indet. The occurrence of these two specimens seems to be very interesting from a biostratigraphical point of view because these genera are not yet reported in Japan, though the shells of both specimens are immature, and it is necessary to search for the full-grown shells to determine the specific name through the future investigation. The smooth or weakly ornate ammonites, *Zelandites* sp., *Kossmatella* (*Murphyella*) *enigma* and *Desmoceras* (*P.*) *japonicus* were obtained. The genus *Zelandites* is a long-ranging ammonite which occurs from the Upper Albian to the Maestrichtian. *K.* (*M.*) *enigma* is obtained from the Lower Cenomanian in Hokkaido (MATSUMOTO *et al.*, 1972). A heteromorph ammonite of *Turrilites* (*T.*) cf. *T. sheuch-*

Table 1. List of mega-fossils from the Middle Yezo Group in the Kamiichi-no-sawa area, Ikushumbetsu, central Hokkaido.

	M	Mk_1	Mk_2
Neophylloceras ramosum (MEEK)			307F
N. sp.			113
Desmoceras (*Pseudouhligella*) *japonicum* YABE		207F, 326F, 328F, 330F, 707Fb	
D. sp.		339, 708, 805	210
Desmoceratid gen. et sp. indet.		326F	
Mesopuzosia sp.		212	209, 322, 330F, 332F, 705F
Jimboiceras sp.			111
Marshallites sp.		330F	
Yokoyamaoceras sp.			307F
Tetragonites glabrum (JIMBO)			334
T. sp.			335, 337
Gaudryceras sp.			211
Anagaudryceras cf. *A. sacya* FORBES	329		
Zelandites sp.		214F	
Kossmatella (*Murphyella*) *enigma* MATSUMOTO, MURAMOTO & TAKAHASHI		330F	
Reesidites (?) sp.			323
Subprionocylus neptuni (GEINITZ)			307F
Collignoniceras bravaisianum (d'ORBIGNY)			335
Mantelliceras sp.		326F	
Acanthoceras takahashii MATSUMOTO		115F	
Euhystrichoceras sp.		326F	
Mojsisovicziinae gen. et sp. indet.		326F	
Eubostrychoceras sp.			307F
Scalarites sp.			113, 307F
Otoscaphites (*O.*) *puerculus* (JIMBO)			210
Sciponoceras sp.		326F	
Turrilites cf. *T. scheuchzeranus* BOSC		214F, 326F	
Hypoturrilites sp.		214F	
Inoceramus hobetsensis NAGAO & MATSUMOTO			112, 211, 307F, 322, 323, 327F, 335, 409
I. cf. *I. hobetsensis* NAGAO & MATSUMOTO			113, 209, 324, 334, 337, 410
I. concentricus costatus NAGAO & MATSUMOTO		707Fb	
I. sp.		115F, 213, 327F, 706F	324, 336

Table 2. List of mega-fossils from the Upper Yezo Group in the Kamiichi-no-sawa area, Ikushumbetsu, central Hokkaido.

	U_1	U_2	U_3
Neophylloceras sp.			401
Damesites damesi (JIMBO)			907
D. cf. *D. damesi* (JIMBO)			913
D. semicostatus MATSUMOTO			901
D. damesi intermedius MATSUMOTO		110F, 404F, 607, 812, 813	501F, 512, 513
D. sp.	205, 308F, 332b	114, 208F, 306, 312, 404b, c, 601b, 702, 809	502, 508a, b, c, 509, 511, 514, 515, 517a, b, 518, 801a-c, 902a-d, 903, 907, 908, 910, 911b, 912
Anapachydiscus sp. aff. *A. deccanensis yezoensis* MATSUMOTO			505b
Mesopuzosia pacifica MATSUMOTO		413	
M. cf. *M. pacifica* MATSUMOTO	314		
M. yubarense (JIMBO)		404b	303, 517b
M. sp.	316, 332a	208F, 808, 811	
Kitchinites (*Neopuzosia*) sp.			401, 501F, 510a, b, 517a, 519, 904, 907, 908, 911, 912
Yokoyamaoceras jimboi MATSUMOTO			501F, 902a, 903
Y. kotoi (JIMBO)			510a
Y. sp.	331b		
Tetragonites glabrum (JIMBO)	332b	403, 412a	509, 517b, 902b, 903, 908
T. glabrum problematica MATSUMOTO			519
T. sp.	207F		215, 508a, 511, 516, 517a, 902a, b, 903, 911, 912
Gaudryceras denseplicatum (JIMBO)		808, 813	
G. cf. *G. denseplicatum* (JIMBO)		601b, 704	
G. tenuistriatum YABE		702	
G. sp.	308F, 332e, 338F	114, 208F, 404c, 601a, 603a, b, 605, 702, 809	508b, 513, 517a, b, 902c, 908, 910, 912
Anagaudryceras limatum (YABE)	205, 315a, 331, 332a, d	208F, 305, 313, 403, 404c, 606F, 607, 801c	103, 504F
A. sp.		404b, 405, 412	

Table 2. (Continued).

	U_1	U_2	U_3
Protexanites (*Anatexanites*?) sp.			902d
Reesidites minimus (HAYASAKA & FUKADA)	308F, 309F, 319, 320F, 338F, 406, 408, 802a, b		
Subprionocyclus normalis (ANDERSON)	406		
S. neptuni (GEINITZ)	317, 318, 604F		
Barroisiceras (*B.*) *onilayense* BASSE		208F	
Barroisiceras (?) sp.		808	
Pseudobarroisiceras nagaoi SHIMIZU	309F?		
Prionocycloceras sp. nov. A		607	
P. sp. nov. B		332b, 504F, 607	
P. sp.		313, 801b	
Polyptychoceras subundatum (YOKOYAMA)			902c, 907
P. pseudogaultinum (YOKOYAMA)			517b, 901, 902a
P. sp.			301, 505a, 509, 510a, 511, 513, 517c, 519, 902b, d, 903, 908, 910, 911a, b
Eubostrychoceras cf. *E. japonicum* (YABE)		105	
E. cf. *E. saxonicum* (SCHLÜTER)	331a, b	310F, 313, 404b, 504F	
E. sp.		306, 312, 404b, 809, 813	
Nipponites mirabilis YABE		306, 605	
Madagascarites ryu MATSUMOTO & MURAMOTO	338F		
Scalarites sp.	309F, 332e		
Scaphites pseudoequalis YABE		208F, 603b	302
S. cf. *S. pseudoequalis* YABE		813	
S. formosus YABE			503, 510a
S. sp. aff. *S. subdelicatulus* COBBAN & GRYC			304a
S. sp.		801c	
Otoscaphites (*O.*) *klamathensis* (ANDERSON)		801c	
O. (*O.*) *puerculus* (JIMBO)	332e	208F	

Table 2. (Continued).

	U_1	U_2	U_3
O. (*O.*) sp. aff. *O. puerculus* (JIMBO)			701
O. (*Hyposcaphites*) cf. *H. matsumotoi* TANABE			701
O. (*H.*) sp.		605	506
O. sp.		801a, c	701
Baculites yokoyamai TOKUNAGA & SHIMIZU		114	
B. sp.		313, 404c, 405b, 504F, 801a, b, 808, 812	
Sciponoceras intermedium MATSUMOTO & OBATA	308F, 314, 319		
S. sp.	408, 317		
Inoceramus amakusensis NAGAO & MATSUMOTO			902
I. naumanni YOKOYAMA			517a
I. sp. aff. *I. orientalis nagaoi* MATSUMOTO & UEDA			914
I. uwajimensis (YEHARA)		114, 404a,b, 702, 703, 813, 814, 815	101, 203, 305, 901, 907
I. cf. *I. uwajimensis* (YEHARA)		105, 208F, 310F, 312, 405b, 411, 601a, b, 602, 605, 702, 801c, 809	505b, 507, 907
I. teshioensis NAGAO & MATSUMOTO	206, 317, 332a		
I. cf. *I. teshioensis* NAGAO & MATSUMOTO	318, 332c		
I. tenuistriatus NAGAO & MATSUMOTO	206, 331a, b, 604F		
I. cf. *I. tenuistriatus* NAGAO & MATSUMOTO	205, 308F, 319, 604F		
I. sp.	316, 318, 332a, b, 407, 408	405, 412b, 601a,b, 606a, c, 804	102, 201, 302, 304a, b, 505a, 506, 508a, 510b, 514, 515, 518, 910, 905, 906, 907F, 908
Didymotis akamatsui (YEHARA)		801b, c	
aptychi		114, 208F, 801c	304b, 902d
Linuparus japonicus NAGAO		311	
Notopocorytes (*Eucoryates*) *japonicus* (JIMBO)			511
shark teeth	314		

zerianus were also obtained, which is a cosmopolitan species and occurs from the Lower to Upper Cenomanian (KLINGER and KENNEDY, 1978). The calcareous nodules which include the above mentioned ammonites contain also numerous bivalves and gastropods. For example, *I. concentricus costatus* was obtained from the upper stream of the Ichi-no-sawa. This species occurs from the Cenomanian to Turonian in Hokkaido. From the composition of species mentioned above, the Member Mk_1 is assigned to the Cenomanian.

From the Member Mk_2, although any zonal index was not found in the lower part of this member, *I. hobetsensis* occurs commonly from the middle to upper part. *Subprionocyclus neptuni* was obtained from a rolled nodule on the middle stream of the Ganseki-zawa. This is a cosmopolitan species and is an important index-fossil of the Upper Turonian (e.g. MATSUMOTO, 1965). *Collignoniceras bravaisianum* was obtained from the eastern branch of the Ganseki-zawa. This species has been reported by d'ORBIGNY (1840–41) from *Romaniceras deverianum* Zone in Uchaux, France, which is probably referred to the Middle to Upper Turonian. From the evidence of above fossils and the stratigraphic position lying above the Member Mk_1 (Cenomanian), the main part of the Member Mk_2 is assigned to the Middle to Upper Turonian, and the lower limit is probably referred to the Lower Turonian.

From the Member U_1, *Reesidites minimus*, the ornate ammonite, was obtained abundantly from the lower to upper part of this member, and *Subprionocyclus normalis* occurred from the same nodule which contained *R. minimus* at loc. Ki406 in the middle stream of the Fukuro-zawa. In the middle stream of the Ganseki-zawa, *S. neptuni* occurred from a nodule, about 1 meter stratigraphically above the bed of *R. minimus*, and *Pseudobarroisiceras nagaoi* was obtained from a rolled nodule. *Madagascarites ryu*, a heteromorph ammonite, was found with association of *R. minimus* from a rolled nodule on the eastern branch of the Ganseki-zawa. In addition to these ammonoids, *Inoceramus teshioensis* and *I. tenuistriatus* occur commonly from the lower to upper part. Accordingly the Member U_1 is safely referred to the Upper Turonian from the composition of species mentioned above. Thus, the biostratigraphical occurrence of *I. teshioensis-S. neptuni-R. minimus* is well correlated with the Upper Turonian *S. neptuni* Zone in Europe (KENNEDY, 1984).

From the Member U_2, three specimens of *Barroisiceras* (*B.*) *onilahyense*, the ornate ammonites, were obtained from a rolled nodule on the Yon-no-sawa. One of those specimens closely resembles the specimen reported from Madagascar (BASSE, 1947, pl. 6, fig. 2) in having the weak ornamentation. Concerning Hokkaido, the species has been reported to occur from the Obira area by MATSUMOTO *et al.* (1981). Both the Madagascar and Hokkaido specimens are from the Coniacian in age. Two new species of *Prionocycloceras* were obtained from this member. A few heteromorph ammonites, i.e. *Scaphites pseudoequalis*, *Otoscaphites* (*O.*) *klamathensis*, *Eubostrychoceras* cf. *E. saxonicum* were also obtained. It has been recognized by TANABE (1977) that *S. pseudoequalis* occurs from *I. uwajimensis* Zone to the lower part of *I. mihoensis* Zone in Hokkaido. *E. saxonicum* has been reported by WRIGHT (1979)

to occur in the Upper Turonian in England. Apart from the above ammonoids, *I. uwajimensis* occurs commonly from this member. As an interesting fact, collignoniceratid gen. et sp. indet. was found associated with *I. uwajimensis* from loc. Ki804 in a glauconitic medium-grained sandstone bed of the basal part. This specimen is several millimeters in shell diameter, and closely resembles the immature shell of *Reesidites* and *Subprionocyclus* in the morphological feature, suggesting its systematic position in either of these genera. Accordingly, the Member U_2 is equivalent to the zone of *I. uwajimensis* and is assigned to the Coniacian. The Turonian-Coniacian boundary is just below a glauconitic sandstone bed (Pl. 1, Fig. 2).

From the Member U_3, *Protexanites* (*Anatexanites*) sp., an ornate ammonite, was obtained from the forestry road along the Kamiichi-no-sawa River. The subgenus *Anatexanites* has been shown to occur from the Santonian in Japan (MATSUMOTO, 1970). *Scaphites formosus* and *Otoscaphites* (*Hyposcaphites*) cf. *O. matsumotoi*, the heteromorph ammonites, were found from the main stream of the Kamiichi-no-sawa River. The former species has been known from the Upper Coniacian, and the latter one from the Lower to Upper Coniacian in Hokkaido (TANABE, 1977). In addition to the common occurrence of *Inoceramus uwajimensis*, *I. naumanni*, *I.* sp. aff. *I. orientalis nagaoi* and *I. amakusensis* were rarely found. *I. naumanni* occurs from the Upper Coniacian to the Santonian, *I. orientalis nagaoi* from the Upper Santonian to the Lower Campanian and *I. amakusensis* from the Santonian in Japan. From the composition of species mentioned above, the Member U_3 is referred to the Coniacian, except for the uppermost part which is assigned to the Santonian.

The Oyubari (Shuyubari) Area

The Cretaceous in this area has been frequently studied from a biostratigraphical point of view since MATSUMOTO, 1942 (e.g. MATSUMOTO and OKADA, 1973; HIRANO *et al.*, 1977, 1980, 1981). The investigated area of this study is the lower streams of the Kaneobetsu and the Isojiro-zawa, the tributaries of the Syuparo River. Figs. 6–8 show the geologic route maps and the columnar sections, and Table 3 shows the list of mega-fossils from the Yezo Group in two routes.

a) The Lower Stream of the Kaneobetsu River

The Cretaceous strata exposed on this route shows more complicated geologic structure than that in the western marginal areas: the beds generally showing vertical dipping are often overturned, and are sometimes folded. Lithostratigraphically the Cretaceous consists of the Saku Formation of the Middle Yezo Group. The Saku Formation is composed mainly of alternating beds of fine- to medium-grained sandstone and mudstone and dark bluish shale, and sometimes intercalates acid tuff beds of 5–40 centimeters thick and fine-grained and glauconitic medium-grained sandstone beds of 40–100 centimeters thick. The trace fossils and flute casts are observed respectively at the bottom of sandstone in the alternating beds. In the bottom of flute

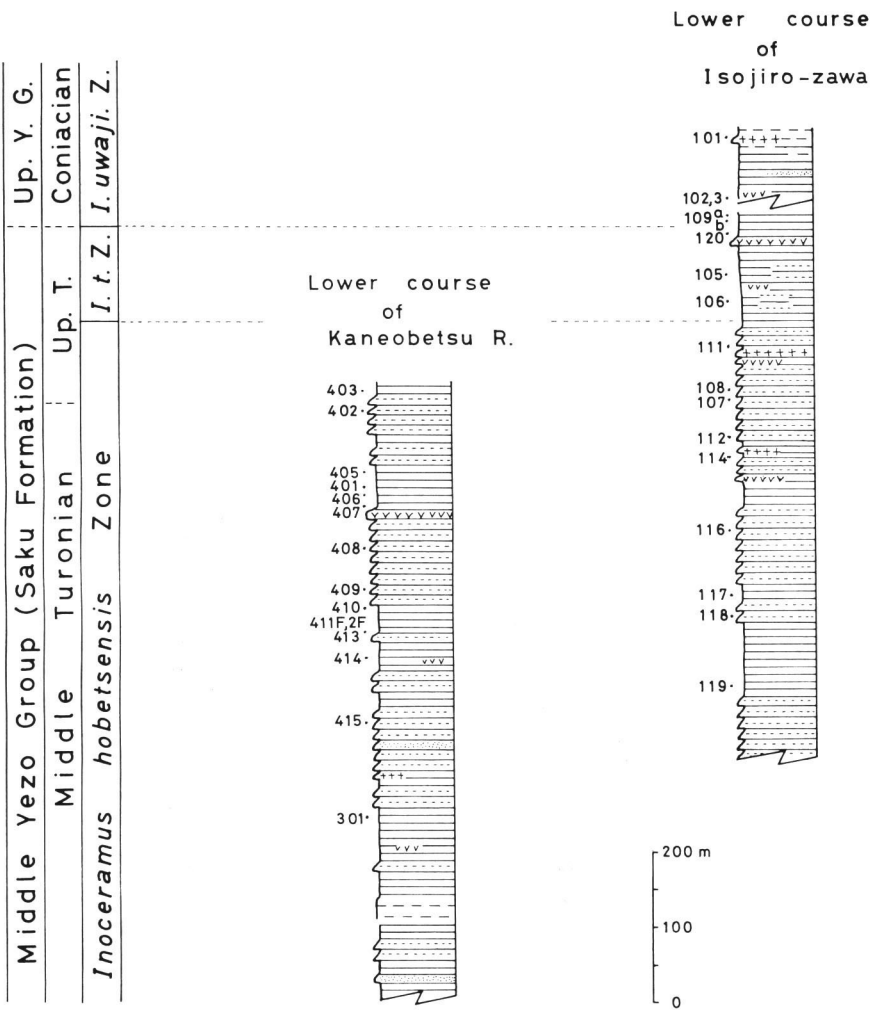

Fig. 6. The columnar sections of the Isojiro-zawa and the Kaneobetsu River in the Oyubari area, central Hokkaido. Rock symbols are the same as in Fig. 4.

casts, the fragments of shell which may be referable to gigantic *Inoceramus hobetsensis* are found richly (Pl. 2, Fig. 4). Such concentration of the fragments is considered to be due to the deposition of sediment in the neritic sea.

Inoceramus hobetsensis occurs commonly in this route, which indicates the *I. hobetsensis* Zone (mainly the Middle Turonian) biostratigraphically. *Collignoniceras bravaisianum* was obtained from the calcareous nodules at successive localities, Y407, 409, 410, 411F, 413 and 416, which span about 150 meters in thickness. Furthermore, it is also obtained from the western creek of the Kaneobetsu River, the lower stream

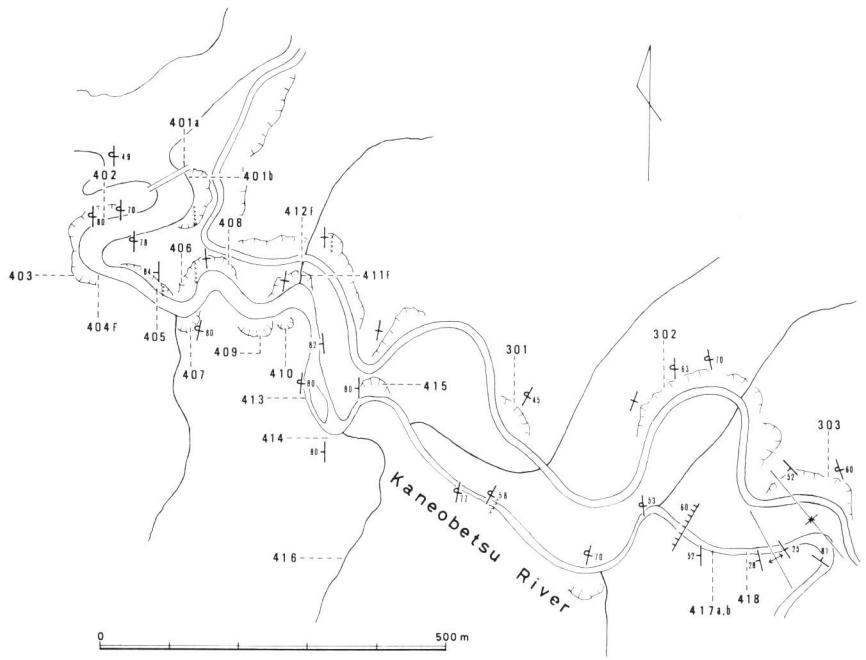

Fig. 7. The geologic route map of the lower stream of the Kaneobetsu River in the Oyubari area, central Hokkaido.

of the Hakkin-zawa River and the main stream of the Syuparo River. The fact verifies a wide distribution of this species in the *I. hobetsensis* Zone of the Oyubari area. From the relatively lower part of the stratigraphic range of *C. bravaisianum*, *Reesidites* (?) sp. occurs abundantly from a calcareous nodule without *C. bravaisianum*. *Yubariceras* sp. occurs commonly from loc. Y417. Common occurrence of this genus was reported from loc. Y5206 (HIRANO *et al.*, 1977) of the Hakkin-zawa River which is situated on the east of this route. Thus, it is biostratigraphically noticed that some species of *Yubariceras* occur commonly from a narrow, limited part in the columnar section.

b) The Lower Stream of the Isojiro-zawa River

The Cretaceous in this route is lithologically divided into the Saku Formation of the Middle Yezo Group and the Upper Yezo Group in ascending order.

The lower part of the Saku Formation in the investigated route is composed mainly of alternating beds of fine- to medium-grained sandstone and siltstone, and is rarely intercalated with acid tuff beds of 10–30 centimeters thick. Whole thickness is more than 290 meters along the investigated route. I call the alternating beds the Member Sk_1 for the sake of convenience. As *Inoceramus hobetsensis* and *Scaphites planus* occur commonly from the member, Sk_1 is assigned to the Middle to Upper (?) Turonian. Above the Member Sk_1, the strata consist mainly of shale and are some-

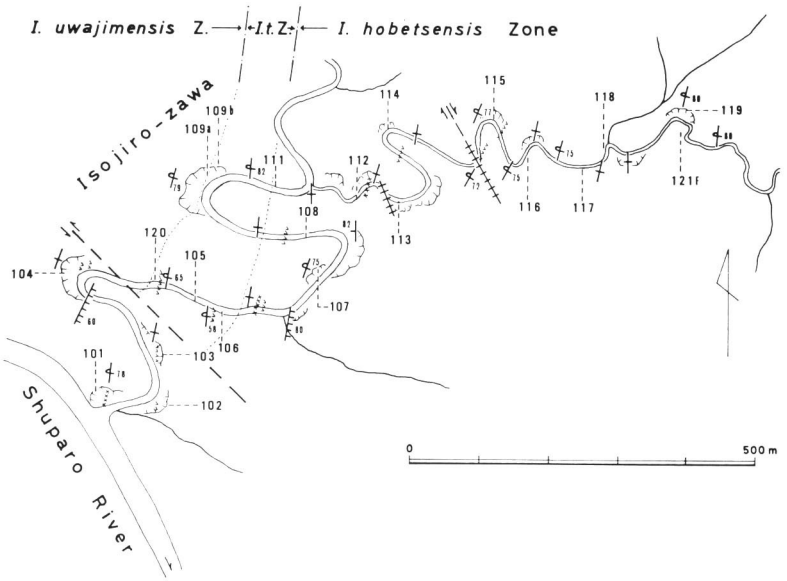

Fig. 8. The geologic route map of the lower stream of the Isojiro-zawa River in the Oyubari area, central Hokkaido.

times intercalated with beds of medium-grained sandstone and mudstone, and acid tuff beds of about 20 centimeters thick containing rich biotite. I correlated this part with the Member Sk_2, considering the transitive feature in its lithology between the Saku Formation of the Middle Yezo Group and the Upper Yezo Group. Its thickness is about 100 meters. As *Inoceramus teshioensis* and *I. tenuistriatus* occur from Sk_2, the member is assigned to the Upper Turonian.

The Upper Yezo Group is exposed near the entrance of the Isojiro-zawa River. It is composed mainly of siltstone and shale, and intercalates thin (about 5 centimeters in thickness) acid tuff and fine-grained sandstone beds. Siltstone sometimes contains numerous glauconites. *Reesidites* sp., an ornate ammonite, occurs abundantly from loc. Y109b with association of *Inoceramus* sp. aff. *I. uwajimensis*. Above it, *I. uwajimensis* occurs commonly. Accordingly, the Upper Yezo Group is mainly assigned to the Coniacian. However, the basal part seems to be the uppermost of Upper Turonian.

The Manji Area

This area is important to clarify the bio- and litho-facies of the Cretaceous of the central zone of Hokkaido. Especially concerning the problems of Turonian collignoniceratid ammonites, it gives us biostratigraphically useful data. The Cretaceous se-

Table 3. List of mega-fossils from the Middle and Upper Yezo Groups in the Isojiro-zawa and the Kaneobetsu River in the Oyubari area, central Hokkaido.

	Sk_1	Sk_2	U_3
Neophylloceras sp.	111, 301, 412F, 418		109b
Damesites sp.		105	103
Phyllopachyceras ezoense (YOKOYAMA)	408		
Mesopuzosia pacifica MATSUMOTO	301, 404F		
M. cf. *M. yubarense* (JIMBO)	405		
M. sp.	112, 401a, 302		109b
Tetragonites glabrum (JIMBO)	118, 119, 303, 407, 410		
T. sp.	104, 402, 404F, 406, 414, 418		
Gaudryceras denseplicatum (JIMBO)	114, 409, 418		
G. sp.	410, 421F		
Anagaudryceras limatum (YABE)		105, 120	103
Yubariceras sp.	121F, 404F, 417a, b		
Y. (?) sp.	401a		
Collignoniceras bravaisianum (d'ORBIGNY)	407, 409, 410, 411F, 413, 416		
Reesidites (?) sp.	412F		109b
Eubostrychoceras cf. *E. japanicum* (YABE)	301, 406		
E. sp.	118		
Scalarites sp. aff. *S. densicostatus* MATSUMOTO	415		
S. (?) sp.	113, 114, 404F		
Scaphites planus (YABE)	404F, 410, 412F		
S. sp.	119		
Otoscaphites (*O.*) *puerculus* (JIMBO)	107, 114, 118, 301, 418		
aptychi	107, 409		
Inoceramus uwajimensis (YEHARA)			109b
I. cf. *I. uwajimensis* (YEHARA)			102, 109a, b
I. sp. aff. *I. uwajimensis* (YEHARA)			101, 104
I. teshioensis NAGAO & MATSUMOTO		106	
I. cf. *I. tenuistriatus* NAGAO & MATSUMOTO		105, 120	
I. hobetsensis NAGAO & MATSUMOTO	114, 117, 404F, 408, 410, 413, 414, 418		
I. cf. *I. hobetsensis* NAGAO & MATSUMOTO	107, 108, 111, 115, 116, 119, 403		
I. sp.	302, 303		
shark teeth			109b

quence in this area has been already studied in detail biostratigraphically by OBATA and FUTAKAMI (1975, 1977) and paleoecologically by TANABE *et al.* (1978). Accordingly, only a brief note on the Cretaceous biostratigraphy of this area is given in this paper as is shown below.

The Cretaceous sequence in this area is exposed on the southerly extended part of the Ikushumbetsu anticline which was called the Manji dome by OTATSUME (1950). It has been indicated by OBATA and FUTAKAMI (1975) that this Cretaceous sequence shows the western marginal lithofacies in the central zone, Hokkaido. It is lithologically divided into three, the Main part and Mikasa Formation of the Middle Yezo Group, and the Upper Yezo Group in ascending order.

Main part

The Main part consists of silty sandstone (the Member M_1), mudstone (the Member M_2) and alternating beds of sandstone and mudstone (the Member M_3) in ascending order, and whole thickness is more than 480 meters. From the Member M_1 and M_2, well-preserved specimens of the genera *Mortoniceras*, *Diplasioceras*, *Hysteroceras*, *Neophlycticeras* and others which indicate the Upper Albian are obtained commonly from large nodules of about 30–100 centimeters in size. Thus, it is assigned to the Upper Albian, although the mega-fossil is not found from the Member M_3.

Mikasa Formation

This formation is lithologically and biostratigraphically divided into three members, Mk_1, Mk_2 and Mk_3 in ascending order, and its thickness is more than 385 meters. The Member Mk_1 is composed mainly of massive fine-grained sandstone, and contains *Inoceramus yabei*. Thus, it is assigned to the Cenomanian. The Member Mk_2 consists mainly of massive fine- to coarse-grained sandstone, which shows a distinct cross lamination. Some conglomerate beds of several meters thick are intercalated in the middle part, and they decrease in thickness and number in the eastern part of this area. Two ostreid banks of 1 meter thick are intercalated in the western part of this area, suggesting the littoral sedimentary environment. *I. hobetsensis* occurs commonly from the member, and is assigned to the Lower (?) to Middle Turonian. The Member Mk_3 is composed mainly of massive fine-grained sandstone. In addition to common occurrence of *I. teshioensis* from this member, *Reesidites minimus* and *Subprionocyclus neptuni* occur abundantly from the calcareous nodules in different horizons of the upper part. *S. normalis* occurs rarely from the same nodule which contained *R. minimus*, Thus Mk_3 is safely assigned to the Upper Turonian.

Upper Yezo Group

This group consists mainly of siltstone and shale, and contains some intercalated glauconitic sandstone and acid tuff beds. The upper part is unconformably overlain by the Ishikari Group of the Paleogene. The thickness of the group is about 180 meters. *Inoceramus mihoensis*, *I. amakusensis*, *I. naumanni* and others were obtained from this group ranging from the Upper Coniacian to the Santonian. However, *I. uwajimensis*, an index of the Lower Coniacian in Japan, has not been found in this area. Considering an abrupt change of lithology between the Mikasa Formation of the Middle Yezo Group and the Upper Yezo Group, a certain break in sedimentation or a delicate erosion is presumed. Thus, the zone of *I. uwajimensis* seems to be lacking in the Manji area. The Upper Yezo Group is assigned to the Upper

Coniacian to Santonian. Besides, HAMAMOTO *et al.* (1980) reported that isotopic ages of three tuffs intercalated in the lower, middle and upper parts of the Upper Yezo Group (Santonian) are 81.1±1.6 m.y.~84.4±8.3 m.y.

The Hatonosu Area

The Cretaceous outcrops in this area are situated on the southerly extended part of the Ikushumbetsu anticline (see Fig. 1), and form a dome-like structure, which is called the Hatonosu dome by OTATSUME (1950) as in the northern Manji area. The Cretaceous of this area has been frequently studied from the geological and palaeontological point of views since JIMBO (1894) and YABE (1903–4, 1909). Recent re-examination by MATSUMOTO and HARADA (1964) and FUTAKAMI (1982) clarified that the Cretaceous sequence of this area closely resembles that of the Manji area both in lithology and bio-facies. Stratigraphy of this area is simply given below, as has been described by FUTAKAMI (1982).

The Cretaceous in the Hatonosu area is lithologically divided into three, the Main part of the Middle Yezo Group, the Mikasa Formation of the Middle Yezo Group and the Upper Yezo Group in ascending order. The middle and upper parts of the Mikasa Formation and the Upper Yezo Group are unconformably overlain by the Ishikari Group of the Paleogene. From the mega-fossil evidence the Main part of the Middle Yezo Group, the Mikasa Formation, and the Upper Yezo Group are assigned to the Upper Albian, the Cenomanian to Turonian, and the Upper Coniacian (?) to Santonian, respectively. As in the case of the Manji area, *Inoceramus uwajimensis*, an index of the Coniacian, has not been found from the lower part of the Upper Yezo Group. Thus, it is also presumed that there is a certain local diastem or nondeposition.

The following facts are particularly important in biostratigraphy: (1) the occurrence of some species of *Mortoniceras*, *Diplasioceras* and *Dipoloceras*, the important indices of the Upper Albian, is confirmed in its continuous section along the middle stream of the Pomporokabetsu River and its forestry road; (2) collignoniceratid ammonites such as *Reesidites minimus*, *Subprionocyclus neptuni* and *S. normalis*, the important indices of the Upper Turonian, occur abundantly from calcareous nodules, along the Shihorokabetsu River and the eastern branches of the Pomporokabetsu River in Yubari City. It is worthy of notice that the most of specimens of *S. normalis* are found from the same nodules with *Reesidites minimus*. *S. neptuni* occurs from the *Inoceramus teshioensis* Zone and the upper part of *I. hobetsensis* Zone. These ammonite assemblages have been already reported (FUTAKAMI, 1982; FUTAKAMI and MIYATA, 1983).

Conclusions

1. The Cretaceous beds in the central and southern parts of the Ishikari province

are lithologically divided into the Middle and Upper Yezo Groups in ascending order. Furthermore, the Middle Yezo Group is subdivided into two units named the Main part and the Mikasa Formation in the Ikushumbetsu, Manji and Hatonosu areas, and the Main part and the Saku Formation in the Oyubari area. Details of lithology and stratigraphic occurrence of ammonoids are given in each area.

2. The biostratigraphically important ammonoids, such as the Brancoceratidae, Acanthoceratidae and Collignoniceratidae occur commonly from the Middle and Upper Yezo Groups. These ammonoids indicate that the Main part of the Middle Yezo Group is correlated with the Upper Albian, that the Mikasa and Saku Formations of the Middle Yezo Group with the Cenomanian to the Turonian, and that the Upper Yezo Group with the Upper Turonian or the Coniacian to the Santonian.

3. Common occurrence of collignoniceratids such as *Collignoniceras bravaisianum*, *Subprionocyclus neptuni*, *S. normalis*, *Reesidites minimus*, *Pseudobarroisiceras nagaoi*, *Barroisiceras* (*B.*) *onilahyense*, *Prionocycloceras* sp. nov. is recognized in the Kamiichi-no-sawa of Ikushumbetsu area. Thus, the biostratigraphy in this route provides the important supplement to that of the Ikushumbetsu route, a type section in Japan, which has been sunk under the lake.

4. There is considerable variation in the mode of occurrence of the Upper Turonian ammonite and inoceramid species from place to place. For example, *Subprionocyclus neptuni* occurs abundantly from the uppermost part of *Inoceramus teshioensis* Zone in the Manji area, commonly from the *I. teshioensis* Zone and the upper part of *I. hobetsensis* Zone in the Ikushumbetsu and Hatonosu areas, and rarely from the upper part of *I. hobetsensis* Zone in the Oyubari area.

5. The Upper Turonian in the studied areas is defined by the Zone of *Subprionocyclus neptuni*, in which *Subprionocyclus normalis*, *Reesidites minimus* etc. also occur. The above zone is well correlated with the Upper Turonian *S. neptuni* Zone in Europe. Thus the further subdivision is unnatural.

6. Abundant occurrence of *Collignoniceras bravaisianum* from the successive strata in the relatively upper part of *Inoceramus hobetsensis* Zone (mainly the Middle Turonian) is newly confirmed in the Oyubari area. This is an important fact for the Turonian zonation in Japan.

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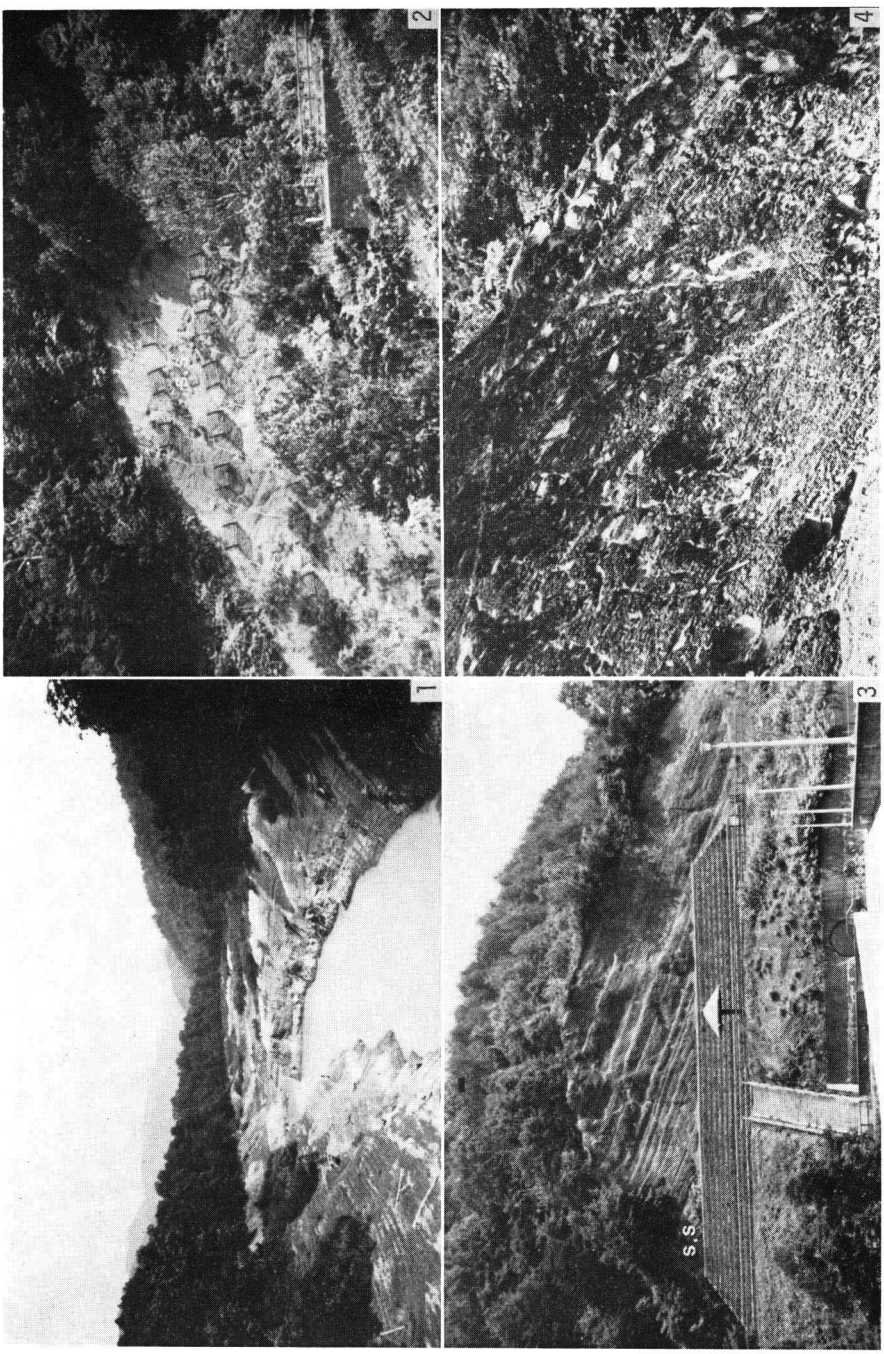
Explanation of Plates 1–2

Plate 1

Fig. 1. A studied area along the Kamiichi-no-sawa River in Ikushumbetsu.
Fig. 2. A boundary of the Turonian and the Coniacian observed on the cliff (loc. Ki802) along the Ikushumbetsu industrial road in Ikushumbetsu. A glauconitic sandstone (s.s) showing the base of the Coniacian.
Fig. 3. The lower part of the Coniacian containing a glauconitic sandstone (s.s) exposed on a cliff (loc. Ki804) on the east of the Katsurazawa Dam-site.
Fig. 4. The Upper Yezo Group (the Santonian) with many calcareous nodules exposed on a cliff (loc. Ki902) along the Kamiichi-no-sawa forestry road in Ikushumbetsu.

Plate 2

Fig. 1. The Middle Turonian strata with *Collignoniceras bravaisianum* exposed along the lower stream of the Kaneobetsu River in Oyubari.
Fig. 2. A relatively small syncline observed on the cliff (loc. Y303) along the Kaneobetsu forestry road in Oyubari.
Fig. 3. The Middle Turonian alternated beds of the Saku Formation exposed along the lower stream of the Kaneobetsu River in Oyubari.
Fig. 4. The flute casts and the fragments of shell (probably huge *Inoceramus hobetsensis*) of 1–2 centimeters in size observed on the bottom of sandstone in the alternating beds at loc. Y412 on the Kaneobetsu River in Oyubari.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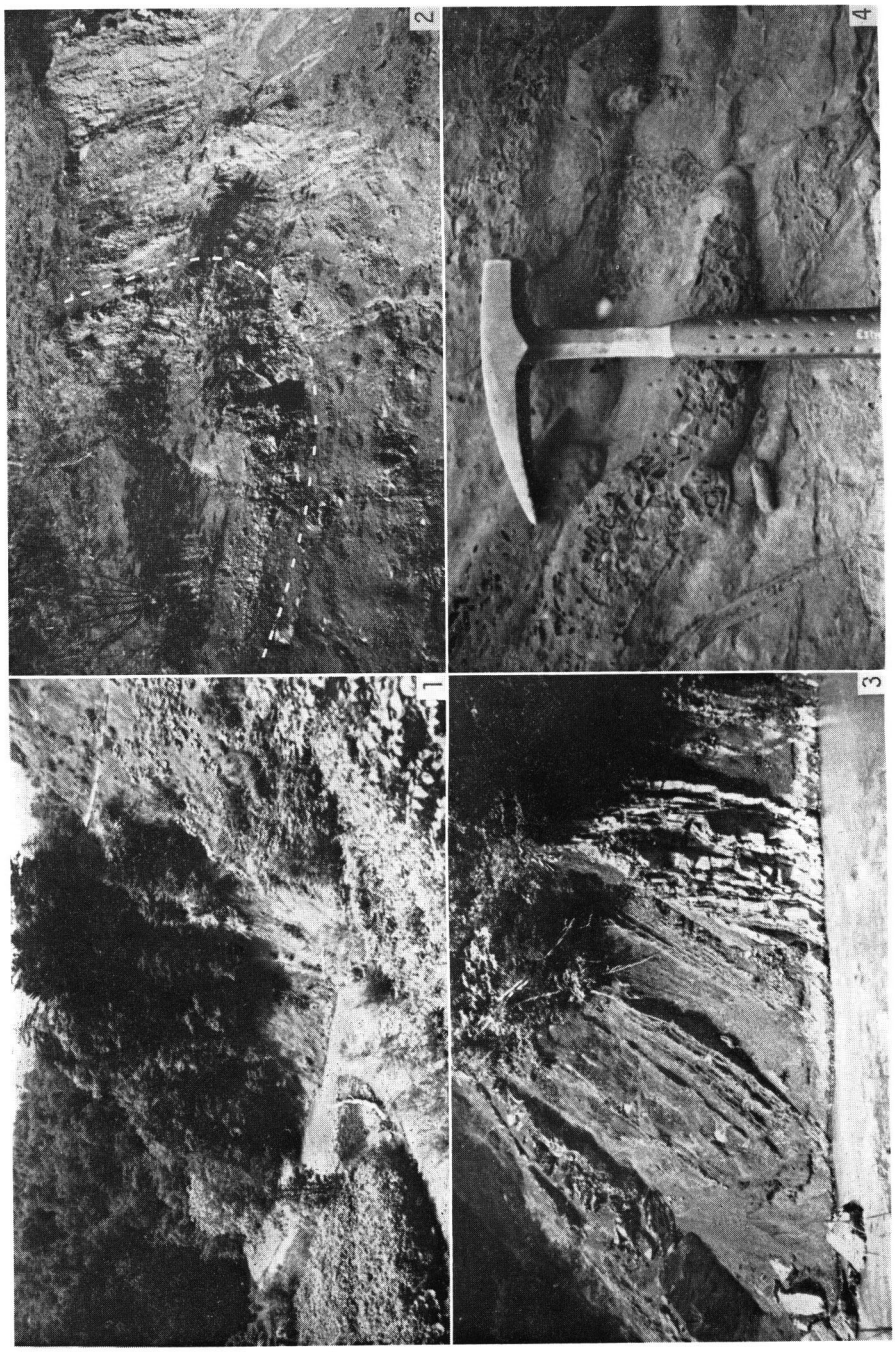
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