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Cretaceous Stratigraphy in the Oyubari Area, Central Hokkaido, Japan

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Abstract The Cretaceous System along the Shuparo and Hakkin-zawa rivers in the Oyubari area, central Hokkaido, is characterized by deep-water muddy and turbiditic facies, and is divided into four groups, the Sorachi, Lower Yezo, Middle Yezo and Upper Yezo groups, in ascending order. The Sorachi Group is composed exclusively of siliceous rocks within this area. The Lower Yezo Group is subdivided into two formations, the Tomitoi and Shuparogawa formations. The former is dominantly sandstone with lesser alternating beds of mudstone, while the latter is dominantly mudstone, with alternating beds of sandstone, and including allochthonous limestone blocks. The Middle Yezo Group is subdivided into three formations, the Maruyama, Hikagenosawa and Saku formations. The Maruyama Formation is dominantly sandstone, alternating with beds of tuff and mudstone, the Hikagenosawa Formation is laminated mudstone, and the Saku Formation is also mudstone-dominated, with alternating beds of thickening-upward sandstone and mudstone. The Upper Yezo Group is composed of one formation, the Kashima Formation, characterized by monotonous mudstone. Ammonoids and inoceramid bivalves are abundant, and they suggest that the uppermost part of the Shuparogawa Formation to the Kashima Formation are correlated to the Upper Albian to Coniacian stages.
Key words: ammonoids, Cretaceous, inoceramids, Oyubari, stratigraphy, Yezo Supergroup.

Introduction

The Yezo Supergroup (Okada, 1983), deposited in the Cretaceous Yezo Forearc Basin, is widely distributed in north to south direction in central Hokkaido and western Sakhalin, and has been investigated stratigraphically and paleontologically by many authors since the last century (see summary in Kimura *et al.*, 1991).

The Yezo Supergroup in the central Hokkaido region is composed of shallow-water facies to the west, and deep-water facies to the east (see Hirano *et al.*, 1992). In the Oyubari area of the east, the offshore mudstone is widely exposed, and stratigraphic and faunal successions are readily observable. Matsumoto (1942, 1943), Hirano (1982), and Hirano *et al.* (1977, 1989a, b, c, 1990) researched details of the rich and diverse Cenomanian to Turonian ammonite faunas of this area. However, the stratigraphic distribution of all ammonoids and inoceramids from this area was never shown on a particular columnar section, because those workers emphasized age-diagnostic species. On the other side, the present author (Kawabe *et al.*, 1996) summarized on columnar sections the details of lithology and stratigraphic distribution of all ammonoid taxa of each section along the Shuparo River in the north part of the Oyubari area, in order to determine the true molluscan faunal ranges in the area. Many taxonomic revisions of ammonoids and inoceramids from Hokkaido have been undertaken during the last decade, and the Cretaceous stratigraphy in the Oyubari area has been re-evaluated by Motoyama *et al.* (1991) and Takashima *et al.* (1997). Therefore, re-examinations of the molluscan faunas hitherto listed are necessary in order to fully understand their diversity and stratigraphic distributions as reflected in the revised stratigraphic framework. This procedure also provides primary data of ammonoid assemblages in muddy facies in the east of the Yezo Supergroup outcrop belt, to be compared to those of sandy facies in the west in our future research.

In this paper, descriptions are given for lithostratigraphy and for stratigraphic distribution of ammonoids and inoceramids, which enable us to subdivide chronologically the Cretaceous succession. Two representative sections are examined, one along the upper stream of the Shuparo River in the north, and the other along the Hakkin-zawa River in the south (Fig. 1).

Geologic Outline and Previous Studies

The Yezo Supergroup belongs tectonically to the Sorachi-Yezo Belt (Kiminami *et al.*, 1986), together with the Sorachi Group (Sasa *et al.*, 1944), composed of green rocks below, and andesitic to basaltic volcanic and volcaniclastic rocks and tuffaceous mudstones above (Takashima & Yoshida, 1999). In the central part of the Sorachi-Yezo Belt, the Yezo Supergroup widely crops out in the eastern and western piedmonts of the Yubari Mountains, whose core is composed of the Sorachi Group and serpentinite melanges. The Oyubari area is located in the western piedmont of the Yubari Mountains. The Cretaceous deposits in the Oyubari area comprise the Sorachi, Lower Yezo, Middle Yezo, Upper Yezo and Hakobuchi groups, in ascending order. These groups trend in the N-S direction and are arranged from the east to the west, respectively.

The stratigraphic divisions of the Yezo Supergroup proposed by previous works are shown in Fig. 2. On the stratigraphic nomenclature of the supergroup, it is usual practice for convenience sake to use a letter nomination for members without local names, especially from the viewpoint of international correlation (e.g., Matsumoto, 1942; Hirano *et al.*, 1980; Tsuchida & Hirano 1995). The local formational names of Nagao *et al.* (1954) were not used subsequently, until Motoyama *et al.* (1991) revised the stratigraphic framework, establishing formational nomenclature that has been followed more recently (Kawabe *et al.*, 1996; Takashima *et al.*, 1997).

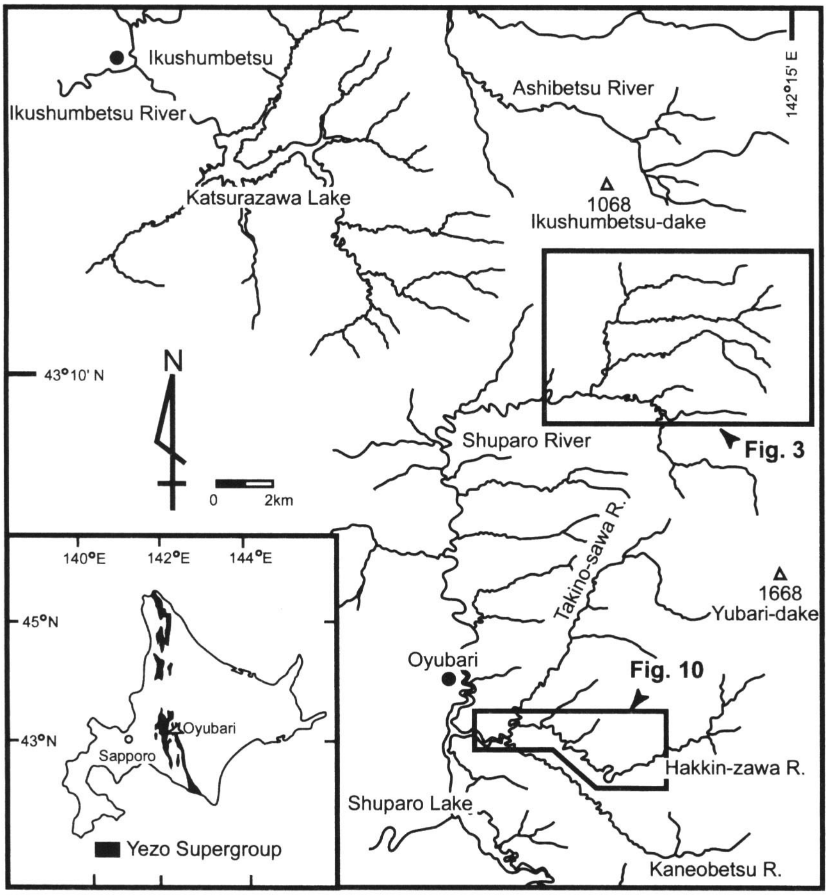

Fig. 1. Map showing the study area.

The relationship between the Lower and Middle Yezo groups had been regarded as an unconformity (Yoshida & Kambe, 1955; Nagao *et al.*, 1954) or a disconformity (Matsumoto, 1942); sedimentologic and biostratigraphic evidence, however, suggests this relationship is conformable (Motoyama *et al.*, 1991; Kawabe *et al.*, 1996; Takashima *et al.*, 1997; Matsumoto *et al.*, 1998). Takashima and Nishi (1999) shows that conglomerates previously considered as the basal conglomerates of the Middle Yezo Group were produced by debris-flows related to large-scale felsic volcanism during the late Albian. It is reasonable that Motoyama *et al.* (1991) united the Lower, Middle and Upper Yezo groups and replaced them by the Yezo Group, for the Upper Yezo Group also conformably overlies the Middle Yezo Group. We (Kawabe *et al.*, 1996) prefer to not integrate them at this time, because the relationships between the Sorachi and Lower Yezo groups, and between the Upper Yezo and Hakobuchi groups,

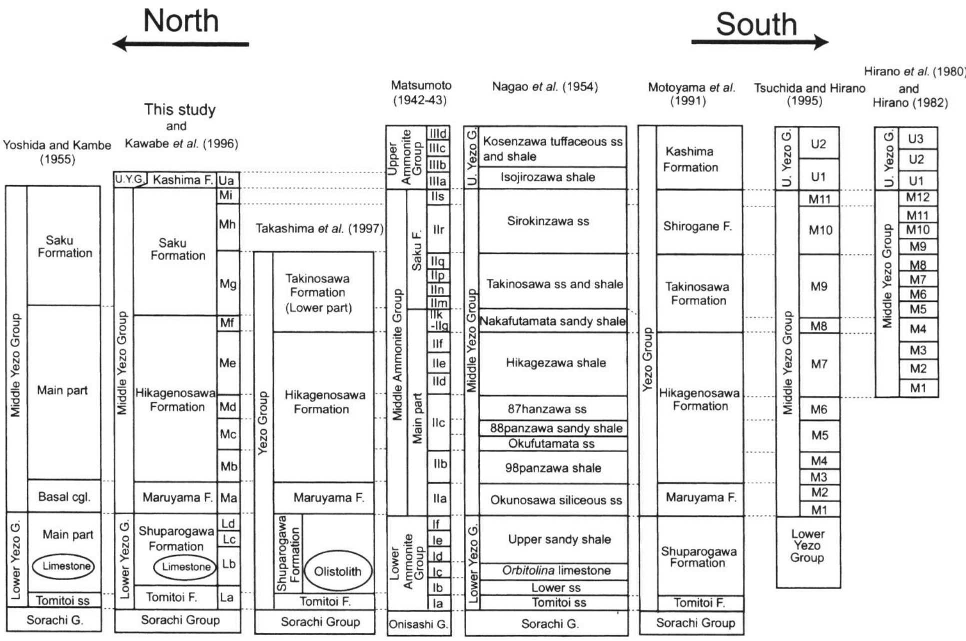

Fig. 2. Comparison of lithostratigraphic divisions proposed by previous workers in the Oyubari area.

are under investigation by other scientists, and our knowledge is not sufficient to revise completely the stratigraphic framework of the thick Cretaceous sequence running 1000 km in north-south direction.

Matsumoto (1939) named the Saku Formation for the rather sandy strata in the upper part of the Middle Yezo Group in the Saku area, north Hokkaido. Its equivalent formation in the Oyubari area is divided into six members (Matsumoto, 1942). Motoyama *et al.* (1991) named these equivalent strata in the Oyubari area as the Takinosawa and Shirogane formations. Not only the Takinosawa Formation but also the Shirogane Formation, however, is composed of alternating beds of sandstone and mudstone, and therefore we need not divide them into two formations. Matsumoto and Okada (1973) reported that the Saku Formation and its equivalents are distributed in the whole Cretaceous area of the central Hokkaido. Therefore, we (Kawabe *et al.*, 1996) adopt the Saku Formation in the Oyubari area, following Matsumoto (1942) and Yoshida and Kambe (1955).

The founder of the mega-biostratigraphy of the Oyubari area is Matsumoto (1942, 1943). Hirano *et al.* (1977) reported the stratigraphic distributions of ammonoids and inoceramids along the Hakkin-sawa and Takino-sawa rivers in southern part, with the result that the Oyubari area became the focus of worldwide attention as a Japanese reference section for the mid-Cretaceous faunas (Matsumoto *et al.*, 1978). Furthermore, Hirano *et al.* (1981, 1989a, b, c, 1990) summarized the molluscan fossil

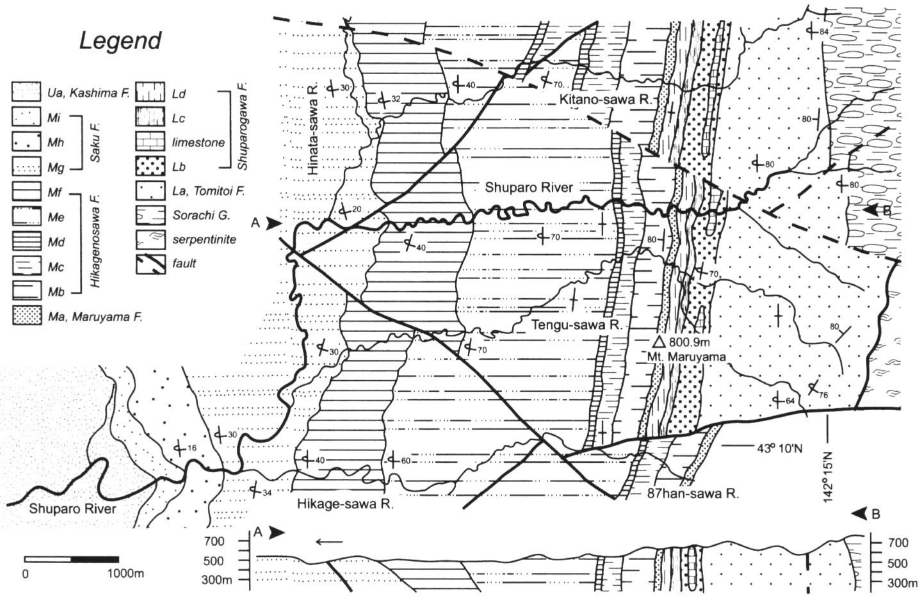

Fig. 3. Geologic map and cross section of the northern Oyubari area. Modified from Kawabe *et al.* (1996).

records from the entire Oyubari area and advanced the knowledge on biostratigraphy of the area. At the same time, the micro-biostratigraphy based on foraminifera has been discussed since Takayanagi (1960), and valuable information has accumulated (Motoyama *et al.*, 1991; Takashima *et al.*, 1997). Little is known, however, about the biostratigraphy of the transitional sequence from the Lower to Upper Cretaceous in Hokkaido because the strata below the lower part of the Middle Yezo Group are not exposed along the well-studied Hakkin-zawa River reference section. The transitional sequence in Hokkaido is best exposed along the upper stream of the Shuparo River in northern part (Kawabe *et al.*, 1996).

Stratigraphy along the Shuparo River in the Northern Oyubari

The area described by Kawabe *et al.* (1996) is enlarged westward for the present study (Figs. 3, 4). The Cretaceous deposits distributed in this area consist of the Sorachi, and the Lower, Middle and Upper Yezo groups. The strata, which are almost vertical in the eastern part, are overturned in the central to western part and exhibit a homoclinal structure dipping east acutely. There are only minimal structural differences among tectonic blocks of the strata divided by relatively larger faults with NE-SW and NW-SE trends. On the east, the Yubari-dake thrust (Nagao *et al.*, 1954) exposes serpentinite, which expands to the southern part of the studied area. Small-

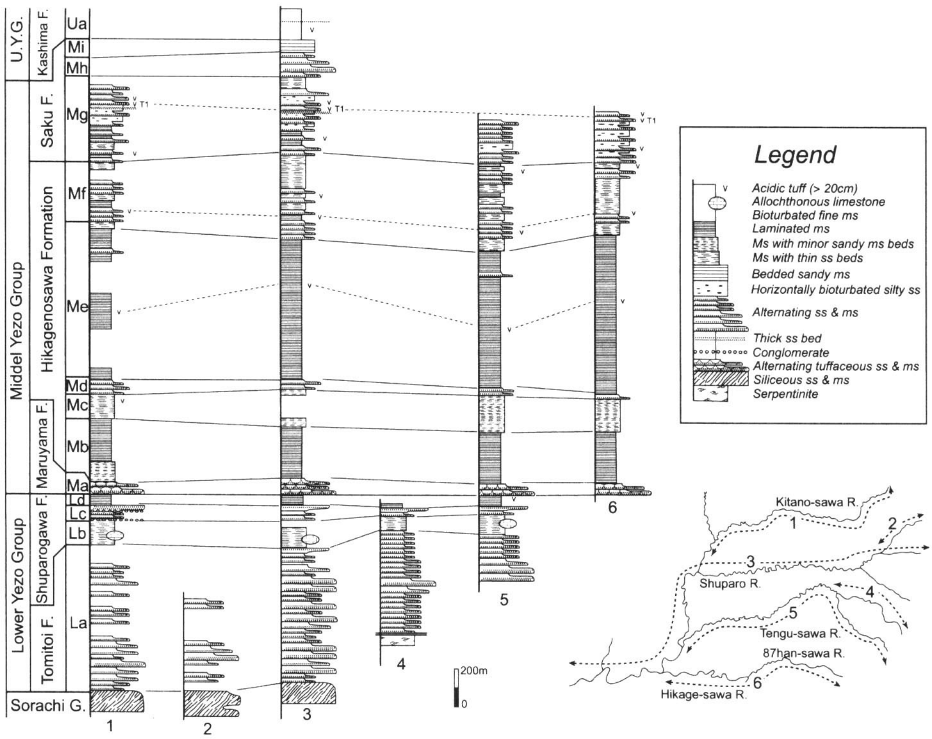

Fig. 4. Columnar sections of the Cretaceous deposits in the northern Oyubari area. Modified from Kawabe *et al.* (1996).

scale faults and folds associated with this major thrust are predominant in the upper stream of the Tengu-sawa River, where the Lower Yezo Group is distributed (Fig. 3).

The stratigraphic distributions of ammonoids and inoceramids are adapted from the collections of Kawabe *et al.* (1996) and Hirano *et al.* (1989a, b, c, 1990) with re-examination (Table 1). The locality numbers used in Table 1 are shown in Kawabe *et al.* (1996: fig. 4) and Hirano *et al.* (1989b: figs. 27, 28).

Sorachi Group

Designation: Matsumoto (1942) called this group the Onisashi Group, dividing it into six formations and one member, letter-nominated as Ot to Oz. The Sorachi Group was subsequently proposed by Sasa *et al.* (1944). The upper part of the group, the Shuyubari Formation of Hashimoto (1953), is exposed in the eastern margin of the northern Oyubari area (Yoshida & Kambe, 1955).

Lithology: The Shuyubari Formation cropping out along the Kitano-sawa and Shuparo rivers consists of green and dark gray siliceous mudstone with intercalations of sandstone and acidic tuff beds.

Table 1. List of ammonoids and inoceramids from the northern Oyubari area. Add the prefix Y on each locality. The prefix Y110: the Shuparo River, Y120: the Shuparo Forestry Road, Y410: the Hinata-sawa River, Y421: the Kitano-sawa Forestry Road, Y270 and Y271: the Tengu-sawa River, Y272: the Tengu-sawa Forestry Road, Y250: the Hikage-sawa River, Y260: the Hikage-sawa Forestry Road, Y251: the 87han-sawa River. For route maps in the northern Oyubari area see Kawabe *et al.* (1996, fig. 4) and Hirano *et al.* (1989b, figs. 27, 28).

Species	Shuparogawa F.	Hikagenosawa Formation					Saku Formation			Kashima F.
	Ld	Mb	Mc	Md	Me	Mf	Mg	Mh	Mi	Ua
Ammonoids										
Mortoniceras (*Mortoniceras*) cf. *stoliczkai*		421047								
Mortoniceras (*M.*) cf. *geometricum*	271001									
Mantelliceras cf. *saxbii*					110325					
Calycoceras asiaticum						110273, 250021, 250031, 421007 250025,				
Desmoceras (*Desmoceras*) *latidorsatum*		421047								
Desmoceras (*D.*) cf. *kossmati*					270097					
Desmoceras (*D.*) sp.		421047								
Desmoceras (*Pseudouhligella*) *dawsoni*		421047								
Desmoceras (*P.*) *japonicum*					110335, 421017, 110333, 251009, 110327, 250049, 110325, 270071, 110321, 270069, 110319, 270047, 251011, 270067, 270099, 270065 421019, 270043 421026,	110301, 421011, 270061, 270059, 270057, 270035, 250031, 421007, 260011	110269, 270017, 421001, 410046, 410045, 410044			
Desmoceras (*P.*) *poronaicum*				421039	251011, 421019 421035,					
Desmoceras (*P.*) *ezoanum*				421039	421019	270035				
Desmoceras (*P.*) spp.				421039	421019, 251026, 270091	270059, 270029, 110277, 272017 110273,	410041			
Desmoceras spp.		421047	421041							
Tragodesmoceroides subcostatus							250007, 110255, 260005, 110241, 270001, 110239, 410011, 110233 110219,			
Puzosia sp.							110269, 421003			
Mesopuzosia pacifica							110241, 110225, 110239, 110217	110151		
Mesopuzosia cf. *takahashii*							120119			
Pachydesmoceras sp.		272041								
Puzosiinae gen. indet.	270159					110273	270011			
Eopachydiscus sp.			421041							
Kossmaticeras sp.										110145

Table 1. Continued.

Species	Shuparogawa F.	Hikagenosawa Formation					Saku Formation			Kashima F.
	Ld	Mb	Mc	Md	Me	Mf	Mg	Mh	Mi	Ua
Ammonoids										
Marshallites cumshewaensis		421047								
Marshallites cf. *olcostephanoides*							110269			
Marshallites aff. *hendersoni*						270037				
Marshallites sp.					421019	270057				
Eogunnarites sp.				421039						
Sounnaites sp.		421047								
Tetragonites glabrus							270011, 110205 110255,			
Tetragonites aff. *kitchini*					110333, 110327					
Tetragonites sp.		272041 421047								
Tetragonitidae gen. indet.					270071, 270043					
Gaudryceras denseplicatum							250007, 110249, 110255, 110215	110151	110149	
Anagaudryceras sacya		272041			250049	270037, 250021, 270053, 421007 110277,	110269			
Anagaudryceras cf. *madraspatanum*					270045					
Anagaudryceras limatum										120021 110131
Anagaudryceras spp.	270159	421047								
Parajaubertella kawakitana					110331, 110327					
Parajaubertella cf. *zizoh*		421047	421041							
Parajaubertella aff. *zizoh*			421041							
Parajaubertella sp.				421039						
Gabbioceras yezoense				421039						
Zelandites spp.		421047				270029				
Partschiceras japonicum		421047	421041							
Hypophylloceras subramosum							421001, 110241	110153		
Hypophylloceras sp.				421039				110151		
Turrilites scheuchzerianus				421039						
Hamites sp.		421047								
Anisoceras sp.		421047								
Sciponoceras kossmati							250007, 110233, 410011, 110205 420007,			
Sciponoceras intermedium										110135
Muramotoceras yezoense							260005, 110225			
Muramotoceras laxum							110201			
Muramotoceras sp.							110255			
Eubostrychoceras japonicum							110241			
Scalarites scalaris							110239			
Ammonoidea gen. indet.	270159									
Inoceramids										
Actinoceramus concentrica		421047								
Actinoceramus nipponica						421007, 270021 272015,	110269, 421003, 110267, 410045			

Table 1. Continued.

Species	Shuparogawa F.	Hikagenosawa Formation					Saku Formation			Kashima F.
	Ld	Mb	Mc	Md	Me	Mf	Mg	Mh	Mi	Ua
Inoceramids										
Actinoceramus cf. *tamurai*						270037				
Mytiloides labiatus							272005, 110251, 110201, 120119			
Mytiloides incertus									120023	110145
Mytiloides spp.							420011, 250005, 250007, 110249			
Inoceramus virgatus					110335, 270083 421019,	421011				
Inoceramus aff. *reachensis*					270047					
Inoceramus pictus						110271	270017, 421003			
Inoceramus pennatulus							270017, 410049, 110267, 410044 421001,			
Inoceramus ginterensis						270059	110269, 421001, 110266, 410046 421003,			
Inoceramus gradilis							410045			
Inoceramus reduncus						110271				
Inoceramus ex gr. *pennatulus*						272015	421001, 420049 420044,			
Inoceramus nodai							110269, 110267			
Inoceramus kamuy							270011, 110217, 420007, 110203 110255,			
Inoceramus hobetsensis nonsulcatus							410011, 110223, 110229, 110219 110201			
Inoceramus hobetsensis hobetsensis								110153,	110151	
Inoceramus teshioensis									110147	
Inoceramus uwajimensis										110131 110129
Inoceramus n. sp.		421047								
Inoceramus sp.					270113					

Lower Yezo Group

It has been considered that the Lower Yezo Group, which is composed of terrestrial detritus, overlies conformably the Sorachi Group, composed exclusively of siliceous rocks within the study area. The group includes two formations, the Tomitoi Formation below, and the Shuparogawa Formation above. The former consists dominantly of sandstone, with alternating beds of sandstone and mudstone, and I also call the formation as the Unite La in this paper. The latter consists of mudstone with sandstone intercalations, and comprises three units, Lb, Lc and Ld. The Unit Ld involves allochthonous limestone blocks. The total thickness of this group is about 1000 m.

Tomitoi Formation (=Unit La)

Designation and synonyms: Hashimoto (1936) called the lowermost sandy strata of the Cretaceous in the Furano region the Tomitoi Sandstone. Subsequently, it was clarified that the same sandy strata were distributed also in the Oyubari area. They were named as the Member Ia (Matsumoto, 1942), the Tomitoi Sandstone (Yoshida & Kambe, 1955), or the Tomitoi Formation (Motoyama *et al.*, 1991).

Distribution: The Kitano-sawa, Shuparo and Tengu-sawa rivers.

Thickness: 700 m along the Kitano-sawa River and 760 m along the Shuparo River.

Lithology: The lower half of this formation is composed of sandstone-dominated, alternating beds of sandstone and mudstone whose thickness is 10 to 50 cm, and less than 10 cm, respectively, besides the mudstone dominated lowermost part. In the upper half, sandstone intercalations decrease upward. These sandstone beds exhibit sole marks (e.g., flute and groove casts), indicating that the axial sediment transport by turbidity currents is northward, if we consider such previous works as paleocurrents (e.g., Tanaka, 1963; Tanaka & Sumi, 1981) and the mode of distribution and the longitudinal change of the sedimentary facies in the Yezo Supergroup (e.g., Tanaka, 1963; Matsumoto & Okada, 1971).

Small-scale faults and slump folds are common in this formation, and stratal attitudes are disturbed along the upper stream of the Tengu-sawa River in the east of the area studied.

It can be seen at the Loc. Y411217 along the upper stream of the Kitano-sawa River that the boundary plane between the Tomitoi Formation and the Sorachi Group is sharp without any erosion and the attitudes of both units are same. On the other side, this formation meets serpentinite in the Tengu-sawa River, but the boundary is not exposed.

Fossils: Fossils are absent.

Shuparogawa Formation

Designation and synonyms: The base of this formation is defined by the mudstone-dominated horizon at which sandstone intercalations disappear suddenly. This formation was named by Motoyama *et al.* (1991) and is equivalent to the Main Part of Yoshida & Kambe (1955) and the Members Ib to If of Matsumoto (1942).

Takashima *et al.* (1997) mentioned extensive olistostromes, involving *Orbitolina* limestones, in the middle part of this formation. In this study, I divide the formation into three units, Lb, Lc and Ld, and interpret the *Orbitolina* limestones as allochthonous limestone blocks embedded in the Unit Lb.

Unit Lb

Synonyms: This unit is equivalent to the Members Ib to Id of Matsumoto (1942).

Distribution: The Kitano-sawa, Shuparo and Tengu-sawa rivers.

Thickness: 130 m along the Kitano-sawa River and 80 to 100 m along the Tengu-sawa River.

Lithology: This unit is composed of sandy mudstone intercalated with thin sandstone beds, and contains limestone blocks in the middle part. The limestone cropping out for about 150m along the Shuparo River (Loc. Y110387) is fairly arenaceous and contains *Orbitolina lenticularis* (Blumenbach). These strata strike in E-W direction, at right angle to the adjacent strata with their N-S orientation. Also in the Tengu-sawa River, the limestone is arenaceous and contains abundant *O. lenticularis*. The limestone is too massive to measure bedding, but the boundary plane with the adjacent sandy mudstone shows N-S strike at the Locs. Y421057 and Y411189 along the Kitano-sawa River, where the rudistid *Praecaprotina yaegashii* (Yehara) dominates, in association with *O. lenticularis*, corals and calcareous algae.

The upper part of the unit along the Kitano-sawa River is composed of sandy mudstone with pebble beds of mudstone and chert.

Fossils: Fossils are absent except the limestone blocks.

Unit Lc

Synonyms: This unit is equivalent to the Member Ie of Matsumoto (1942).

Distribution: The Kitano-sawa, Shuparo and Tengu-sawa rivers.

Thickness: 80 m along the Kitano-sawa River, 70 m along the Shuparo River and 35 m along the Tengu-sawa River.

Lithology: This unit is composed of alternating beds of thickening-upward sandstone and mudstone or well-bedded, fine sandstone. Sandstone beds often contain plant remains arranged parallel to the bedding plane and have various sedimentary structures such as grading, convolution and cross laminae which suggest southward paleocurrents.

The lower part of this unit along the Kitano-sawa and Shuparo rivers is composed predominantly of mudstone, with an equal proportion of alternating beds of sandstone and mudstone (about 50 m in thickness), while the upper part is composed of greenish sandstone (about 30 m in thickness). In contrast, along the Tengu-sawa River this unit is as thin as 35 m and composed solely of well-laminated sandstone. In the upper part of this unit, sandstones of the Kitano-sawa River (Loc. Y411183) are coarsened with a thin pebble layer at the base but sandstones of the Shuparo River (Loc. Y110381) are fine and contain rip-up mudstone clasts.

Fossils: Fossils are absent.

Unit Ld

Synonyms: This unit is equivalent to the Member If of Matsumoto (1942).

Distribution: The Kitano-sawa, Shuparo and Tengu-sawa rivers.

Thickness: 55 m along the Kitano-sawa River, 50 m along the Shuparo River and 60 m along the Tengu-sawa River.

Lithology: This unit is composed of dark gray mudstone with thin acidic tuff beds. Mudstone is somewhat bioturbated along the Tengu-sawa River (Locs. Y270151–159, Y271001) and the Shuparo River (Locs. Y110375–379), while it is well-laminated and rather sandy along the Kitano-sawa River (Loc. Y411181). The 30 cm thick acidic tuff bed is embedded at the uppermost horizon in the Tengu-sawa River (Loc. Y270149). Calcareous concretions are rare in the unit.

Fossils: *Mortoniceras* (*Mortoniceras*) cf. *geometricum* Spath (Pl. 3, fig. 1), *Anagaudrycers* sp., Puzosiinae gen. et sp. indet., and undetermined ornate ammonoid were obtained at the uppermost horizon along the Tengu-sawa River, Locs. Y271001 and Y270159 (Fig. 7). They are compressed internal molds, embedded directly in the mudstone without forming calcareous concretions.

Middle Yezo Group

The Middle Yezo Group is composed mainly of muddy sediments except the basal tuffaceous sandstone beds, and turns into alternating beds of upward-coarsening sandstone and mudstone in the upper part. The group is divided into three formations, the Maruyama, Hikagenosawa and Saku formations, in ascending order. I also call the Maruyama Formation as the Unite Ma in this paper. The Hikagenosawa and Saku formations are subdivided into five units (Mb, Mc, Md, Me and Mf) and three units (Mg, Mh and Mi) respectively, based on the frequency of the sandstone intercalations.

Molluscan fossils occur throughout except in the basal Maruyama Formation. Fossils appear abundantly at restricted horizons in the lower part of the Hikagenosawa Formation (units Mb to Md). On the other hand, they occur sparsely through the upper part of the formation (units Me to Mf). The Saku Formation except the Unit Mi yields diversified ammonoids and inoceramids.

Total thickness of this group is about 2200 m.

Maruyama Formation (=Unit Ma)

Designation and synonyms: This formation was named by Motoyama *et al.* (1991) after the Mt. Maruyama, situated in the southeast part of the area. It is equivalent to the Member IIa of Matsumoto (1942), the Basal conglomerate and sandstone of Yoshida and Kambe (1955), and the Members M1 and M2 of Hirano *et al.* (1989a, b, c, 1990) and Tsuchida and Hirano (1995).

Distribution: The Kitano-sawa, Shuparo, Tengu-sawa and 87 han-sawa rivers.

Thickness: 60 m along the Kitano-sawa River, 75 m along the Shuparo River and 55 m along the Tengu-sawa River.

Lithology: This unit is composed of greenish, siliceous and hard sandstone with abundant biotite fragments and mudstone in alternation. The lowermost part is amalgamated midium-grained sandstone beds with mudstone rip-up clasts. Thick tuff and tuffaceous sandstone beds with large biotite fragments dominate in the lower part, but

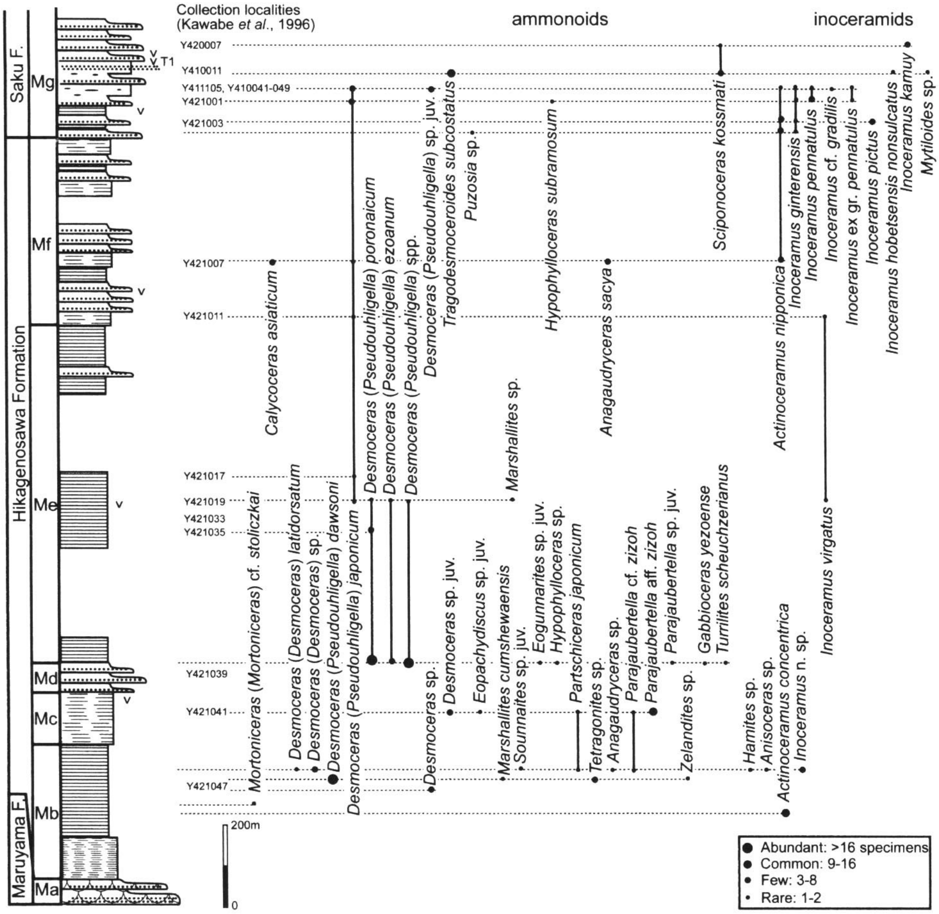

Fig. 5. Stratigraphic distribution of ammonoids and inoceramids in the Kitano-sawa River section. For legend see Fig. 4.

thin upward with increasing thickness of mudstone intercalations. Sedimentary structures such as parallel-, cross- and convolute-laminae are present in the sandstone beds. The southward paleocurrents are suggested by the cross-laminae.

As to the relationship between the Maruyama and Shuparogawa formations, the tuffaceous sandstone with mudstone rip-up clasts overlies the uppermost 30 cm thick tuff bed of the Ld (Shuparogawa Fm.) along the Tengu-sawa River route (Locs. Y270149–151). The contact is irregular along the other routes. The pebbles to boulders of mudstone, hard tuff, tuffaceous sandstone, chert and limestone of the Shuparogawa Formation underlying the basal tuffaceous sandstone of the Maruyama Formation in the Shuparo River (Loc. Y110375) are caused by local slumping. The irregular contact and large mudstone rip-up clasts of the Maruyama Formation in the

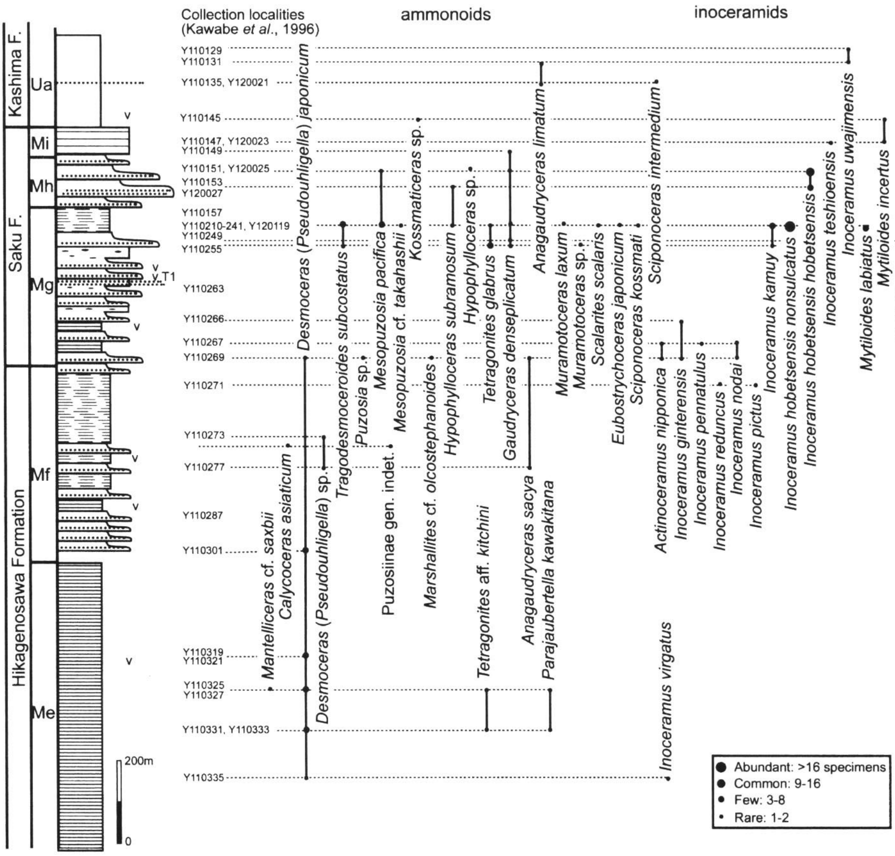

Fig. 6. Stratigraphic distribution of ammonoids and inoceramids in the Shuparo River section. For legend see Fig. 4.

Kitano-sawa River (Loc. Y411181) resulted from bed disruption and erosion by turbidity currents with higher energy levels in the north.

Fossils: Fossils are absent.

Hikagenosawa Formation

Designation and synonyms: The base is defined by the decease of the thinning-upward tuffaceous sandstone beds of the underlying Maruyama Formation (Motoyama *et al.*, 1991). The present formation is composed mainly of laminated-mudstone but intercalation of sandstone beds is common at various horizons; therefore I divide it into five units, Mb, Mc, Md, Me and Mf, based on the frequency of the sandstone intercalations.

The Hikagenosawa Formation used in the present study is equivalent to a part of the Member IIb to the Member IIf of Matsumoto (1942), the Main Part of Yoshida

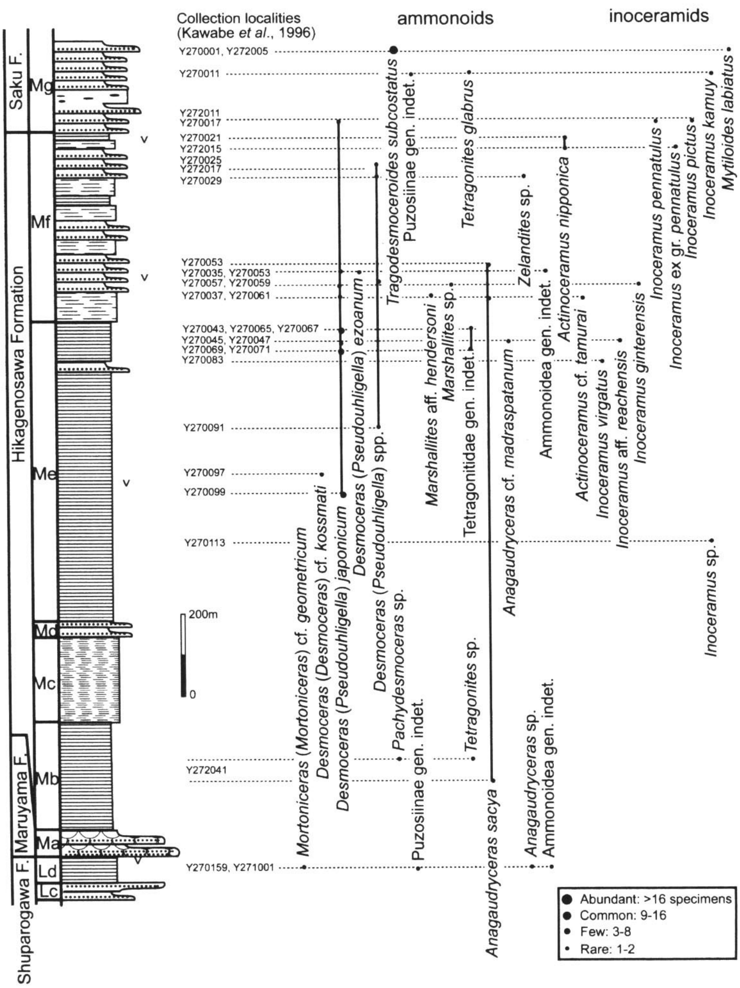

Fig. 7. Stratigraphic distribution of ammonoids and inoceramids in the Tengu-sawa River section. For legend see Fig. 4.

and Kambe (1955), and the succession from the Hikagenosawa Formation to the basal part of the Takinosawa Formation of Motoyama *et al.* (1991) and Takashima *et al.* (1997).

Unit Mb

Synonyms: This unit is equivalent to the IIb of Matsumoto (1942) and the Members M3 and M4 of Hirano *et al.* (1989a, b, c, 1990) and Tsuchida and Hirano (1995).

Distribution: The Kitano-sawa, Shuparo, Tengu-sawa and the 87 han-sawa

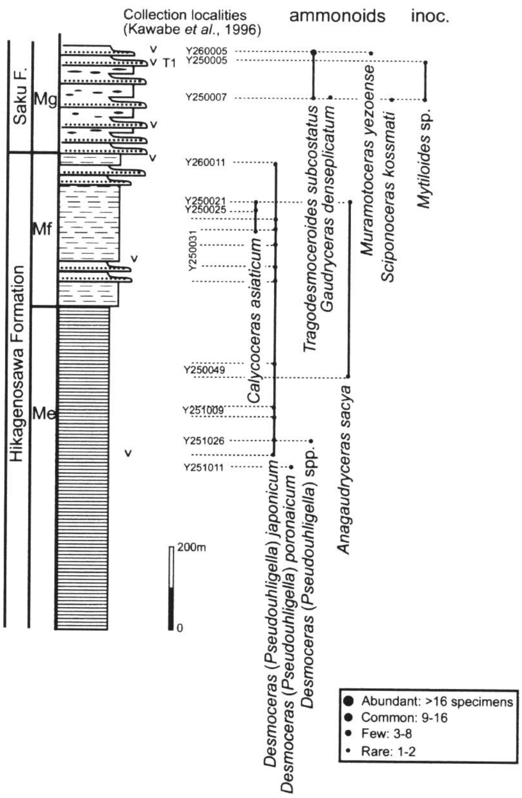

Fig. 8. Stratigraphic distribution of ammonoids and inoceramids in the Hikage-sawa River section. For legend see Fig. 4.

rivers.

Thickness: 335 m along the Kitano-sawa River, 275 m along the Shuparo River, 260 m along the Tengu-sawa River and 280 m along the 87 han-sawa River.

Lithology: This unit is composed of dark gray laminated mudstones (Pl. 1, fig. 1) with frequent intercalations of acidic tuff beds. Most of the tuff beds are a few centimeters in thickness, and some of them attain 5 cm. An exceptionally thick tuff bed (about 40 cm) is exposed at the Shuparo River (Loc. Y110371). Large lenticular calcareous concretions (more than 50 cm in diameter) are oriented parallel to bedding planes at some levels.

It is a major feature of this unit that plant remains are abundant, and fossil woods are often found at the Kitano-sawa Forestry Road (Loc. Y421047) and the Tengu-sawa Forestry Road (Loc. Y272041).

Fossils: The following fossils were obtained from the middle to upper succession which is composed of laminated mudstone along the Kitano-sawa Forestry Road

(Loc. Y421047).

Actinoceramus concentrica (Parkinson) appears within a shell bed in the greenish gray mudstone with intercalations of thin tuff beds 150 m above the base of this unit, and a body chamber of *Mortoniceras* (*Mortoniceras*) cf. *stoliczkai* (Spath) (Pl. 3, fig. 2), is found in the dark gray mudstone 50 m above the former (Fig. 5).

Huge calcareous concretions are abundant in the mudstone above the horizon yielding *Mortoniceras*. Some of them formed originally around giant ammonites and are accompanied by small ammonites in the mode of a sheltered preservation (Maeda, 1991). Three fossiliferous concretions were obtained from 190, 240 and 270 m above the base, respectively (Fig. 5). *Desmoceras* sp. occurred from the lower level. *Desmoceras* (*Pseudouhligella*) *dawsoni* (Whiteaves) (Pl. 3, fig. 3) is dominant, in association with *Zelandites* sp., *Tetragonites* sp., and *Marshallites cumshewaensis* (Whiteaves) (Pl. 4, fig. 2) from the middle level. *Partschiceras japonicum* Matsumoto (Pl. 4, fig. 8), *Parajaubertella* cf. *zizoh* Matsumoto (Pl. 4, fig. 4), *Anagaudryceras* sp. (Pl. 4, fig. 3), *Anisoceras* sp. (Pl. 4, fig. 10), *Hamites* sp. (Pl.4, fig.9), *Desmoceras* (*Desmoceras*) *latidorsatum* (Michelin) (Pl. 4, figs. 5–7), *Desmoceras* (*D.*) sp., *Sounnaites* sp. (Pl. 4, fig. 1), and *Inoceramus* n. sp. (not *I. tenuis* Mantell as identified by Kawabe *et al.*, 1996, pl. 1, fig. 1, but referable to the unnamed inoceramid figured in Nishida *et al.*, 1996, pl. 5) were obtained from the upper level.

On the other side, *Anagaudryceras sacya* (Forbes), *Tetragonites* sp., and *Pachydesmoceras* sp. were found at the Loc. Y271041 along the Tengu-sawa Forestry Road (Fig. 7).

Unit Mc

Synonyms: This unit is equivalent to the lower half of the Member IIc of Matsumoto (1942) and the Member M5 of Hirano *et al.* (1989a, b, c, 1990) and Tsuchida and Hirano (1995).

Distribution: The Kitano-sawa, Shuparo, Tengu-sawa and 87 han-sawa rivers.

Thickness: 135 m along the Kitano-sawa River, 200 m along the Tengu-sawa River and 155 m along the 87 han-sawa River, but unknown along the Shuparo River where exposures are poor.

Lithology: This unit is composed of mudstones with intercalations of coarsening-upward laminated sandy siltstones or very fine-grained sandstones of a few centimeters thickness. Thin beds of acidic tuff are common, but several tuff beds as thick as 30 cm are found along the Kitano-sawa Forestry Road.

Fossils: Most calcareous concretions in the succession are barren of fossils. If a concretion contains fossils, however, medium to small sized ammonites are densely concentrated (>10 individuals) and so well preserved that not only outer shell morphologies but also internal structures are seen. The following ammonoids are found along the Kitano-sawa Forestry Road but inoceramids are absent (Fig. 5).

Partschiceras japonicum, *Parajaubertella* cf. *zizoh*, *P.* aff. *zizoh*, *Desmoceras* sp., and *Eopachydiscus* sp. are found at the Loc. Y421041 in the middle part. *Parajaubertella*, composed of juvenile individuals less than 15 mm in diameter, is dominant among the assemblage.

Unit Md

Synonyms: This unit is equivalent to the upper half of the Member IIc of Matsumoto (1942) and the Member M6 of Hirano *et al.* (1989a, b, c, 1990) and Tsuchida and Hirano (1995).

Distribution: The Kitano-sawa, Shuparo, Tengu-sawa and 87 han-sawa rivers.

Thickness: 70 m along the Kitano-sawa River, 50 m along the Shuparo River, 40 m along the Tengu-sawa River and 30m along the 87 han-sawa River.

Lithology: This unit is composed of alternating beds of coarsening-upward light gray sandstones and dark gray mudstones. The thickness of sandstone beds ranges from 3 to 15 cm. The sandstone beds of this unit are somewhat tuffaceous, with parallel- and cross-laminations, and contain abundant carbonaceous matter (e.g., Loc. Y270121–122: Tengu-sawa River).

Fossils: A few calcareous concretions, containing abundant fossils, are found in the mudstones. Numerous individuals of *Desmoceras*, mainly composed of *Desmoceras* (*Pseudouhligella*) *poronaicum* Yabe (Pl. 4, fig. 11; Pl. 5, figs. 1, 2), are found in calcareous concretions at the Loc. Y421039 of the Kitano-sawa Forestry Road (Fig. 5). A few individuals of other ammonoids such as *Eogunnarites* sp., *Gabbioceras yezoense* Shigeta (Pl. 4, fig. 12), *Parajaubertella* sp., *Hypophylloceras* sp., and *Turrilites scheuchzerianus* Bosc (Pl. 4, fig.13) are also found from the locality.

Unit Me

Synonyms: This unit is equivalent to the Members IId and IIf of Matsumoto (1942) and the Member M7 of Hirano *et al.* (1989a, b, c, 1990) and Tsuchida and Hirano (1995).

Distribution: The Kitano-sawa, Shuparo, Tengu-sawa, 87 han-sawa and Hikage-sawa rivers.

Thickness: 790 m along the Kitano-sawa River, 730 m along the Shuparo River, 720 m along the Tengu-sawa River and 820 m along the 87 han-sawa River and the Hikage-sawa River.

Lithology: This unit is composed of dark gray well-laminated mudstones with intercalations of 1 to 2 cm thick acidic tuff beds. The biotite-rich 40 cm thick coarse-grained tuff bed of the middle part is useful as a key marker bed (Fig. 4).

Fossils: Molluscan fossils occur from in the matrix of the mudstones rather than in calcareous concretions. Ammonoid assemblages are monotonous, and *Desmoceras* (*Pseudouhligella*) *japonicum* Yabe occurs sparsely in association with other types of ammonites throughout the succession. As to reference ammonite species of this member, *Mantelliceras* cf. *saxbii* (Sharpe) (Pl. 7, fig. 1), *Parajaubertella kawakitana*

Matsumoto, and *Tetragonites* aff. *kitchini* (Krenkel) were obtained from the middle part along the Shuparo River (Fig. 6). *Desmoceras* (*D.*) cf. *kossmati* was also found in the Tengu-sawa River (Fig. 7).

Inoceramids are rare in this unit. *Inoceramus virgatus* Schlüter occurs sparsely, and only one individual of *Inoceramus ginterensis* Pergament was obtained from the upper part.

Unit Mf

Synonyms: This unit is equivalent to the Members IIg to IIk of Matsumoto (1942), the Member M8 of Hirano *et al.* (1989a, b, c, 1990) and Tsuchida and Hirano (1995) and the basal part of the Takinosawa Formation of Motoyama *et al.* (1991) and Takashima *et al.* (1997).

Distribution: The Kitano-sawa, Shuparo, Tengu-sawa and Hikage-sawa rivers.

Thickness: 450 m along the Kitano-sawa River, 480 m along the Shuparo River, 450 m along the Tengu-sawa River and 375 m along the Hikage-sawa River.

Lithology: This unit is composed of mudstone with very fine- or fine-grained sandstone intercalations. The thickness of the sandstone beds is less than 5 cm. This unit is transitional in lithology between the Unit Me of the typical mudstone facies of the Hikagenosawa Formation and the Saku Formation, which is composed of alternating beds of sandstone and mudstone. Acidic tuff beds are frequently intercalated, and a biotite-rich, coarse-grained tuff >30 cm in thickness is useful as a key marker bed in the lower part (Fig. 4). Greenish minerals at some horizons are coarser and more abundant to the north (e.g., Loc. Y421007, Y411121: Kitano-sawa River).

Fossils: Ammonoids and inoceramids often occur from both host rocks and calcareous concretions. *Desmoceras* (*Pseudouhligella*) *japonicum* (Pl. 5, figs. 3, 4) is the dominant taxon of eight ammonites identified from this unit (Figs. 5–8). As to reference ammonite species of this unit, *Calycoceras asiaticum* (Jimbo) (Pl. 6, fig. 1) occurs at a restricted level of the middle part. *Anagaudryceras sacya* is found from here and there, and sometimes in association with *Calycoceras asiaticum*.

Inoceramids are common in this unit, including *Inoceramus ginterensis* from the lower part, *Inoceramus reduncus* Pergament, *Inoceramus* ex gr. *pennatulus* Pergament, *Inoceramus pictus* Sowerby, and *Actinoceramus nipponica* (Nagao & Matsumoto) from the upper part. They are sometimes concentrated.

Saku Formation

Designation and synonyms: This formation is characterized by alternating beds of sandstone and mudstone and equivalent to the Members M9 to M11 of Hirano *et al.* (1989a, b, c, 1990) and Tsuchida and Hirano (1995), and the Takinosawa Formation of Motoyama *et al.* (1991) and Takashima *et al.* (1997). Total thickness is about 560 m. I divided it into three units, Mg, Mh and Mi, on the basis of the frequency of the sandstone intercalations.

Unit Mg

Synonyms: This unit is equivalent to the Members IIm to IIp of Matsumoto (1942) and the Member M9 of Hirano *et al.* (1989a, b, c, 1990) and Tsuchida and Hirano (1995).

Distribution: The Hinata-sawa, Kitano-sawa, Shuparo, Tengu-sawa and Hikage-sawa rivers.

Thickness: 300 m along the Kitano-sawa River, 360 m along the Shuparo River, 200 m along the Tengu-sawa River and 270 m along the 87 han-sawa River and the Hikage-sawa River.

Lithology: The base of this unit is defined by the appearance of rather thick (>10 cm) sandstone beds. This unit is composed of rhythmic alternating beds of thickening-upward sandstone and mudstone. Most sandstone beds are 5 to 10 cm thick, but some are thicker than 20 cm. Mudstone changes upward from somewhat arenaceous siltstone to hard muddy fine sandstone.

Acidic tuff beds several tens of cm in thickness are often intercalated. The thickest one, named as a key marker T1 (Tsuchida & Hirano, 1995; Fig. 4), attains 2 m thickness with some intercalating sandstone beds less than 5 cm thickness at the Shuparo River (Loc. Y110205, 225, 259), the Hinata-sawa River (Loc. Y410007) and the Hikage-sawa River (Loc. Y250005, Y260003–005).

Fossils: Sixteen species of ammonoids and eleven species of inoceramids occur frequently from both calcareous concretions and host rocks through this unit (Figs. 5–8).

Seven species of inoceramids, including *Inoceramus ginterensis*, *Inoceramus pennatulus* Pergament, and *Actinoceramus nipponica* were found from the lower part. *Desmoceras* is dominant among ammonoids.

Tragodesmoceroides subcostatus Matsumoto, *Muramotoceras yezoense* Matsumoto (Pl. 7, fig. 2), *Sciponoceras kossmati* (Nowak), and *Inoceramus kamuy* Matsumoto & Asai are contained within calcareous concretions in the mudstone above the key maker bed of 2 m thick tuff. *Tetragonites glabrus* (Jimbo), *Gaudryceras denseplicatum* (Jimbo), *Eubostrychoceras japonicum* (Yabe), *Scalarites scalaris* Yabe, and *Mesopuzosia pacifica* Matsumoto occur abundantly from the horizon about 100 m above the key marker bed T1 along the Shuparo River section (Fig. 6).

Unit Mh

Synonyms: This unit is equivalent to the Member IIr of Matsumoto (1942) and the Member M10 of Hirano *et al.* (1989a, b, c, 1990) and Tsuchida and Hirano (1995).

Distribution: The Shuparo River.

Thickness: 100 m.

Lithology: This unit is composed mainly of sandstone-rich, alternating beds of sandstone and mudstone. The sandstone beds thicken rapidly upward in the lower part, and a 1 m thick amalgamated bed appears at Loc. Y120027.

The sandstones grade into mudstone rich with alternating beds of sandstone and mudstone in the upper part.

Fossils: A giant inoceramid, Inoceramus hobetsensis hobetsensis Nagao & Matsumoto, characterizes the unit. Ammonoids seldom appear (Fig. 6).

Unit Mi

Synonyms: This unit is equivalent to the Member IIs of Matsumoto (1942) and the Member M11 of Hirano *et al.* (1989a, b, c, 1990) and Tsuchida and Hirano (1995).

Distribution: The Shuparo River.

Thickness: 70 m.

Lithology: This unit is composed of dark gray sandy mudstone with bedding. This lithology is resultant from the sudden disappearance of the sandstone beds of the Unit Mh.

Fossils: Fossils are scarce in this unit. A few specimens of *Inoceramus teshioensis* Nagao & Matsumoto, *Mytiloides incertus* (Jimbo), and *Gaudryceras denseplicatum* were found (Fig. 6).

Upper Yezo Group

This group overlies conformably the Middle Yezo Group. As the boundary between them is gradational, the base of the Upper Yezo Group is defined by the appearance of homogenous mudstone without any sandy elements. Motoyama *et al.* (1991) treated the Member IIIa of Matsumoto (1942) exposed along the Shuparo River as the lower part of their Shirogane Formation, but it is more reasonable to regard the Member IIIa as a part of the Kashima Formation because its lithology is homogenous mudstone.

I examined only the lower part of the group and therefore provisionally call the succession the Unit Ua.

Kashima Formation (=Unit Ua)

Synonyms: This unit is equivalent to the Member IIIa of Matsumoto (1942), and the Member U1 of Hirano *et al.* (1989a, b, c, 1990) and Tsuchida and Hirano (1995).

Distribution: The Shuparo River.

Thickness: More than 200 m.

Lithology: It is composed of homogenous bioturbated mudstone. A greenish, poorly-sorted, coarse-grained sandstone bed is found 100m above the base of this formation (Loc. Y110137), and its basal part contains mud-clasts indicating some erosion.

Fossils: Fossils are scarce at the basal part, from which only one specimen each of *Mytiloides incertus* and *Kossmaticeras* sp. were obtained. *Inoceramus uwajimensis*

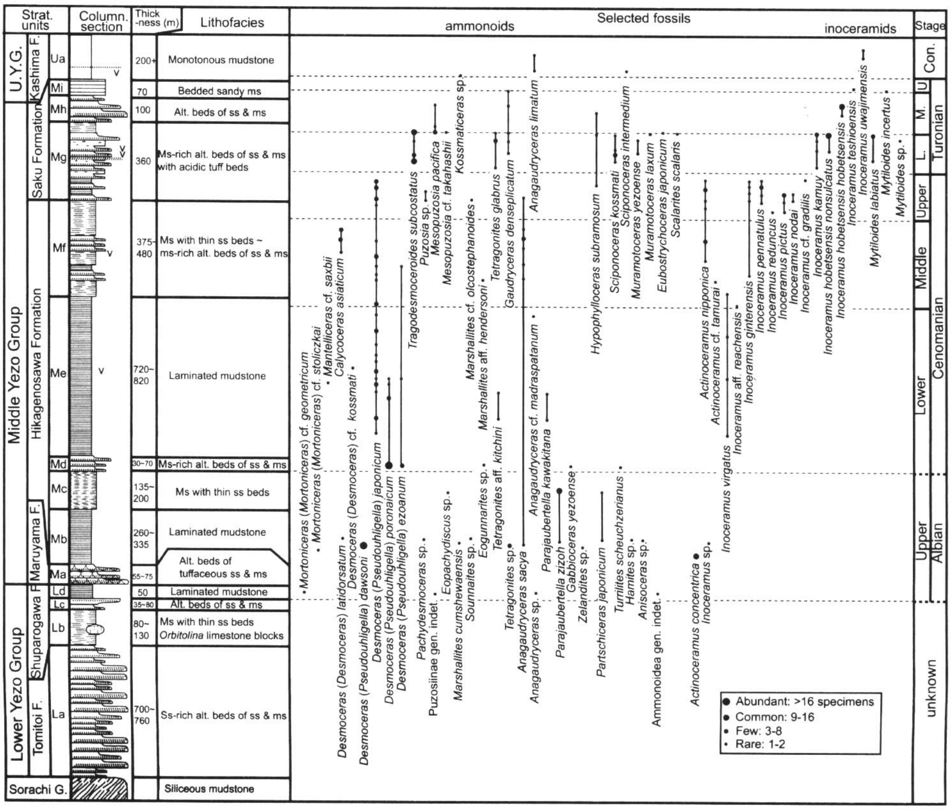

Fig. 9. Composite geologic columnar section and biostratigraphic succession in the northern Oyubari area.

Yehara, *Anagaudryceras limatum* (Yabe), and *Sciponoceras intermedium* Matsumoto & Obata appear in the matrix of strata above the coarse-grained sandstone bed (Fig. 6).

Stratigraphy along the Hakkin-zawa River in the Southern Oyubari

The Cretaceous deposits with the N-S trend across the Hakkin-zawa River preserve only the Middle Yezo Group of the Hikagenosawa and Saku formations (Fig. 10); the Yubari-dake thrust, running along the eastern margin, results in the absence of the Sorachi and Lower Yezo groups.

The distribution of the Saku Formation along the Hakkin-zawa River and adjacent areas is most extensive throughout the Oyubari area. Tsuchida and Hirano (1995) demonstrated, based on their lineament analysis, that there is frequent repetition of strata by faults and folds. Motoyama *et al.* (1991), who divided the succession

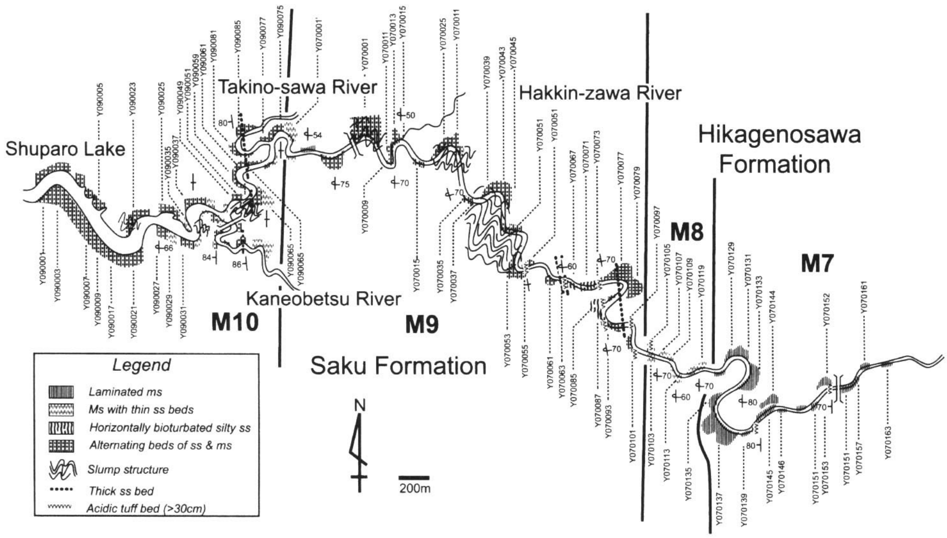

Fig. 10. Geologic route map along the Hakkin-zawa River in the southern Oyubari area.

into the Takinosawa and Shirogane formations, suggested that frequent submarine slumps enhanced the appearance of structural complexity. Slumping probably produced part of the complicated geological structure seen in the formation, but stratigraphic repetition by faults and folds cannot be ignored. Therefore, the thickness of the columnar section shown in (Fig. 11) is approximate. The stratigraphic nomenclature of units for this area follows that of Tsuchida and Hirano (1995).

Ammonoids and inoceramids are found continuously along the Hakkin-zawa and the Takino-sawa routes. Fossil data (Table 2) are based on the collection of the Waseda University (Hirano *et al.*, 1990) and specimens collected by the author during 1997 to 1998. The collection of the Waseda University has been reexamined from the taxonomic point of view for this study. The locality numbers used are shown in Hirano *et al.* (1989a: figs. 4, 8–10).

Hikagenosawa Formation

Hikagenosawa formation distributed along the Hakkin-zawa River is characterized by laminated mudstone and divided into two units, M7 and M8, based on thin sandstone intercalations.

Unit M7

Synonyms: This unit is equivalent to the Hikagenosawa shale of Nagao *et al.* (1954) and the Members M1 to M3 of Hirano *et al.* (1980).

Thickness: More than 900 m (basal part is lacking).

Lithology: This unit is composed of laminated mudstone with acidic tuff interca-

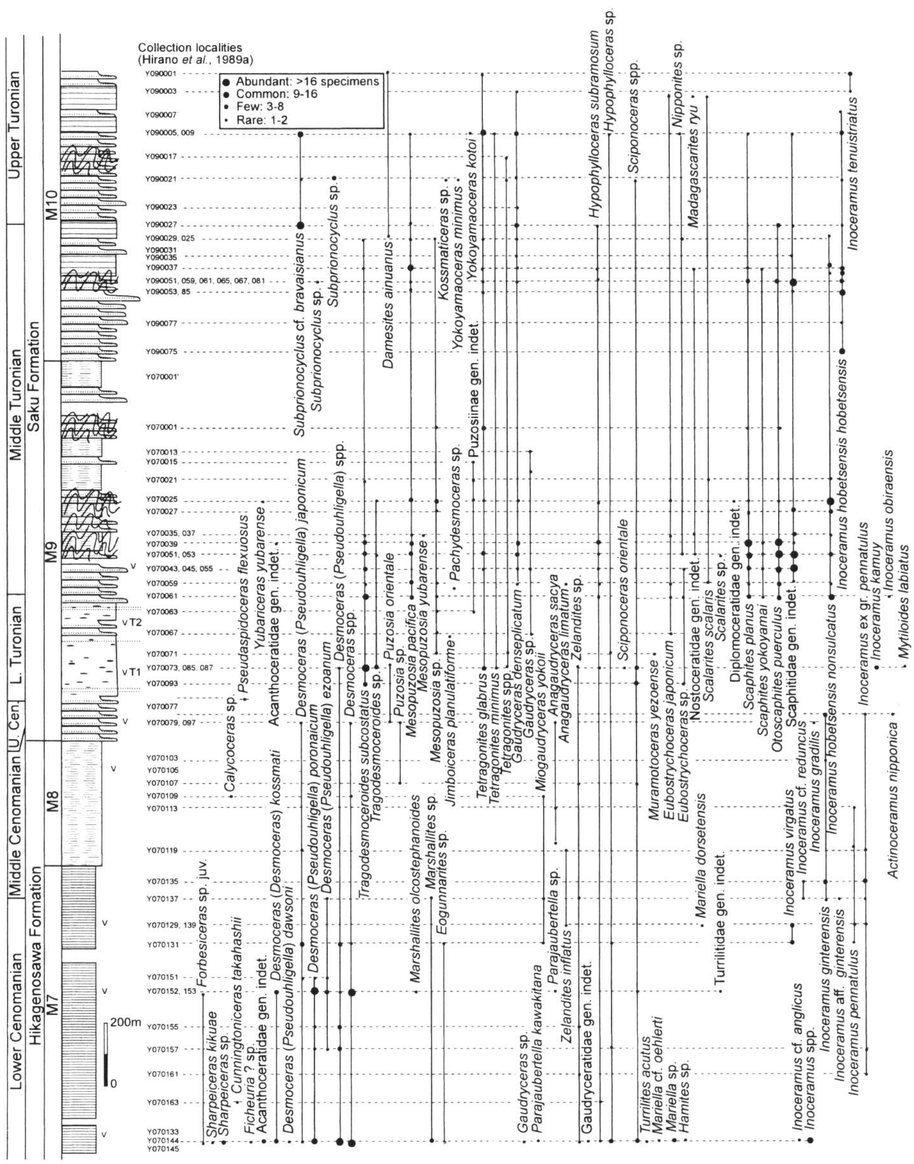

Fig. 11. Columnar section and stratigraphic distribution of ammonoids and inoceramids along the Hakkin-zawa River route. For legend see Figs. 4, 8.

lations. A thick tuff bed (50 cm) is observable at Locs. Y070153 and Y070143. The succession with frequent thin tuff beds along the middle part of the river (Locs. Y070133, Y070144 and Y070145) is older than the adjacent strata (Locs. Y070151–163), based on the biostratigraphic data (see Hirano *et al.*, 1977; Nishida *et al.*,

Table 2. List of ammonoids and inoceramids from in the southern Oyubari area. Add the prefix Y on each locality.

Species	Hikagenosawa Formation		Saku Formation	
	M7	M8	M9	M10
Ammonoids				
Forbesiceras sp.	070144, 070153			
Sharpeiceras kikuae	070144			
Sharpeiceras sp.	070145, 070144			
Cunningtoniceras takahashii	070163			
Calycoceras sp.		070109		
Pseudaspidoceras flexuosus			070077	
Yubariceras yubarense			070025	
Acanthoceratidae gen. indet.	070144		070039	
Subprionocyclus cf. *bravaisianus*				090027, 090021, 090009
Subprionocyclus spp.				090067, 090051, 090021
Ficheuria ? sp.	070145			
Desmoceras (*Desmoceras*) *kossmati*	070145, 070144, 070153			
Desmoceras (*Pseudouhligella*) *dawsoni*	070145, 070144			
Desmoceras (*P.*) *japonicum*	070145, 070150, 070144, 070131	070119	070097	
Desmoceras (*P.*) *poronaicum*	070145, 070155, 070151 070144, 070153, 070157, 070152,			
Desmoceras (*P.*) *ezoanum*	070157, 070151, 070153, 070137			
Desmoceras (*P.*) spp.	070145, 070157, 070153, 070144, 070155, 070131		070087	
Desmoceras spp.	070145, 070153, 070131 070144, 070152,	070109	070097	
Tragodesmoceroides subcostatus			070093, 070061, 070053, 070087, 070059, 070039, 070085, 070055, 070035, 070073, 070045, 070021	090037, 090027
Tragodesmoceroides sp.			070085, 070051, 070025	
Damesites ainuanus				090029, 090001
Puzosia orientale			070097, 070087	
Puzosia sp.		070107	070097	
Mesopuzosia pacifica			070061, 070053, 070037, 070059, 070039, 070025	090085, 090037, 090025, 090049, 090027, 090009
Mesopuzosia yubarense			070035	
Mesopuzosia sp.			070071, 070061, 070025, 070067, 070059, 070001, 070063, 070027,	090025,
Jimboiceras planulatiforme			070067	
Pachydesmoceras sp.			070060	

Table 2. Continued.

Species	Hikagenosawa Formation		Saku Formation	
	M7	M8	M9	M10
Ammonoids				
Puzosiinae gen. indet.			070063, 070021, 070025, 070015	
Kossmaticeras sp.				090021
Marshallites olcostephanoides	070152			
Marshallites sp.	070144, 070133, 070137			
Eogunnarites sp.	070145, 070133, 070131			
Yokoyamaoceras minimus				090021
Yokoyamaoceras kotoi				090009
Tetragonites glabrus			070085, 070043, 070025, 070073, 070053, 070001	090085, 090037, 090009, 090049, 090029, 090001
Tetragonites minimus			070085	090009
Tetragonites spp.			070085, 070071	090021, 090017
Gaudryceras denseplicatum			070059, 070039, 070045, 070025 070053, 070051,	090067, 090027, 090009, 090065, 090025, 090005, 090037, 090023, 090003 090031, 090021,
Gaudryceras spp.	070145		070067, 070019, 070043, 070013	
Anagaudryceras sacya		070118, 070113	070097	
Anagaudryceras limatum			070059	
Miogaudryceras yokoii	070137, 070131	070109		
Parajaubertella kawakitana	070144			
Parajaubertella sp.	070153			
Zelandites inflatus	070129	070119		
Zelandites sp.	070133, 070155, 070161, 070137	070107	070087	
Gaudryceratidae gen. indet.	070144			
Hypophylloceras subramosum	070144		070085, 070045, 070025 070061, 070053, 070059, 070039,	090081, 090037, 090027
Hypophylloceras sp.	070144, 070157	070131	070071	090009
Turrilites acutus	070133			
Mariella dorsetensis	070129			
Mariella cf. *oehlerti*	070144			
Mariella sp.	070145, 070144			
Turrilitidae gen. indet.	070153			
Hamites sp.	070144			
Sciponoceras orientale			070087, 070073	
Sciponoceras sp.	070144, 070153		070097, 070087, 070073 070093, 070085,	090021
Muramotoceras yezoense			070071	
Eubostrychoceras japonicum			070067, 070035, 070059, 070025	090003
Eubostrychoceras sp.			070093, 070061, 070055	
Nipponites sp.			070053	090025, 090009
Madagascarites ryu				090003

Table 2. Continued.

Species	Hikagenosawa F.		Saku Formation	
	M7	M8	M9	M10
Ammonoids				
Nostoceratidae			070053	090037
gen. indet.				
Scalarites scalaris			070059, 070021	090003
Scalarites sp.			070051	
Diplomoceratidae			070025	
gen. indet.				
Scaphites planus			070061, 070053, 070027,	090049,
			070059, 070051, 070025,	090037,
			070045, 070039, 070001	090009
Scaphites yokoyamai			070061, 070053,	090037
			070045, 070039	
Otoscaphites puerculus			070061, 070053, 070025,	090051,
			070059, 070051, 070001	090049,
			070045, 070039,	090027,
Scaphitidae gen. indet.			070059, 070053, 070027	090085, 090027,
			070055, 070039,	090049, 090009
			070045, 070035,	090035,
Inoceramids				
Actinoceramus			070077	
nipponica				
Mytiloides labiatus			070073	
Inoceramus cf. *anglicus*	070145			
Inoceramus virgatus	070131, 070139			
Inoceramus pennatulus	070131, 070139	070119, 070113		
Inoceramus ginterensis	070137, 070135	070103	070077	
Inoceramus aff.	070137			
ginterensis				
Inoceramus gradilis			070079	
Inoceramus cf. *reduncus*	070137, 070135			
Inoceramus ex gr.	070161, 070139, 070135	070119	070077	
pennatulus	070157, 070137,			
Inoceramus kamuy			070081	
Inoceramus obiraensis			070061	
Inoceramus hobetsensis			070061, 070049, 070025,	090037
nonsulcatus			070059, 070035, 070021	090025
			070043, 070027,	
Inoceramus hobetsensis				090075, 090059, 090021,
hobetsensis				090077, 090047, 090009,
				090053, 090049, 090007
				090085, 090037,
				090051, 090027,
Inoceramus cf.				090003, 090001
tenuistriatus				
Inoceramus spp.	070144, 070145, 070133			

1993). This succession has probably been tectonically imbricated with younger strata but geological structure is simple in appearance.

Fossils: Fossils are found from both host rocks and calcareous concretions. The following ammonoids and inoceramids were obtained at the Locs. Y070133 and

Y070144–145; *Forbesiceras* sp., *Sharpeiceras kikuae* Matsumoto & Kawashita, *Ficheuria*? sp., *Desmoceras* (*Desmoceras*) *kossmati*, *Desmoceras* (*Pseudouhligella*) *dawsoni*, *D.* (*P.*) *japonicum*, *D.* (*P.*) *poronaicum*, *Marshallites* sp., *Eogunnarites* sp., *Gaudryceras* sp., *Parajaubertella kawakitana*, *Hypophylloceras subramosum*, *Sciponoceras* sp., *Turrilites acutus*, *Mariella* cf. *oehlerti* (Pervinquière), *Hamites* sp., and *Inoceramus* cf. *anglicus* Woods. *Desmoceras* is dominant among them, but its identification at the species level is very hard due to their poor-preservation and juvenile individuals.

Cunningtoniceras takahashii (Matsumoto) was obtained from about 100 m above the horizon mentioned above in the columnar section. Many specimens of *Desmoceras* appear abundantly at the Locs. Y070152–153 of the middle part of this unit, and most of them are those of *Desmoceras* (*Pseudouhligella*) *poronaicum*. Ammonoids occur sparsely in the upper part. For example, *Miogaudryceras yokoii* Matsumoto, *Zelandites inflatus*, and *Mariella dorsetensis* (Spath) occur. On the other hand, inoceramids including *Inoceramus virgatus*, *Inoceramus pennatulus*, *Inoceramus ginterensis*, and *Inoceramus* cf. *reduncus* often appear.

Unit M8

Synonyms: This unit is equivalent to the Nakafutamata sandy shale of Nagao *et al.* (1954), the Member M4 of Hirano *et al.* (1980), and the basal part of the Takinosawa Formation of Motoyama *et al.* (1991).

Thickness: 400 m.

Lithology: This unit is composed of mudstone, with coarsening-upward sandstone intercalations. The mudstone is generally well laminated but somewhat bioturbated at some horizons. The sandstone beds are 1 to 5cm thick. A thick coarse-grained tuff bed (30 cm) is embedded in the upper part (Loc. Y070105).

Fossils: Most ammonites are found in the matrix of mudstones lacking calcareous concretions. *Desmoceras* (*Pseudouhligella*) *japonicum*, *Puzosia* sp., and *Anagaudryceras sacya* occur sparsely, and the age diagnostic ammonite *Calycoceras* sp. appears at the Loc. Y070109. Inoceramids, including *Inoceramus pennatulus* and *Inoceramus ginterensis*, also occur.

Saku Formation

Saku formation along the Hakkin-zawa and Takino-sawa rivers is characterized by alternating beds of sandstone and mudstone, and divided into two units, M9 and M10, based on the frequency of the sandstone intercalations.

Unit M9

Synonyms: This unit is equivalent to the Takinosawa sandstone and shale of Nagao *et al.* (1954), the Members M5 to M8 of Hirano *et al.* (1980), and the Takinosawa Formation of Motoyama *et al.* (1991).

Thickness: 1200 m in appearance.

Lithology: This unit is composed of mudstone-rich, alternating beds of sandstone and mudstone. Acidic tuff beds are intercalated frequently and two thick tuff beds (>1 m thick) in the lower part are named T1 and T2 as key markers, respectively (Tsuchida & Hirano, 1995). The K-Ar dating of T1 is 87.7±1.9 Ma (Hirano *et al.*, 1997). Horizontal burrows are very obvious on the sole of sandstone beds. The lower part is characterized by greenish sandy mudstone or muddy sandstone with horizontal burrows whose size increases from a few mm to some cm upward. This lithology is very similar to a *Planolites* mudstone (Maeda, 1987) distributed in the Lower Turonian sequence in the Tappu region, north Hokkaido.

The upper part of this unit (Locs. Y070057–Y070001) is composed of bedded, sandy mudstone with sandstone intercalations, and is characterized by slump structures and sandstone dykes. Slumps vary in scale, from several tens of meters to full-exposure scale, and the upper part of this unit is therefore considered as an extensive zone of slumping.

Sandstones grade into mudstones at the uppermost part (Loc. Y070001′).

Fossils: *Desmoceras* (*Pseudouhligella*) *japonicum*, *Anagaudryceras sacya*, *Inoceramus ginterensis*, *Inoceramus gradilis*, and *Actinoceramus nipponica* occur within calcareous concretions from the lowermost part. The age diagnostic ammonoid *Pseudaspidoceras flexuosus* (Powell) appears at the Loc. Y070077.

A succession of strata 250 m thick, and starting 150m above the base of this unit, is composed of bioturbated muddy sandstones or sandy mudstones and is fossiliferous. Both ammonoids, such as *Tragodesmoceroides subcostatus*, *Mesopuzosia* sp., *Jimboiceras planulatiforme* (Jimbo), *Tetragonites glabrus*, *Tetragonites minimus* Shigeta, *Hypophylloceras subramosum*, *Sciponoceras orientale*, and *Muramotoceras yezoense*, as well as inoceramids, such as *Inoceramus kamuy* and *Mytiloides labiatus*, occur from calcareous concretions.

Inoceramus hobetsensis nonsulcatus and diversified ammonites appear continuously in the upper part of this unit (above the Loc. Y070061 in columnar section: Fig. 11), which is composed of alternating beds of sandstone and mudstone and often shows slump structures. Especially in the slump zone (Locs. Y070025–053), not only planispiral ammonoids but also heteromorph ammonoids including *Eubostrychoceras japonicum*, *Scalarites scalaris*, and the scaphitids *Scaphites planus*, *Scaphites yokoyamai*, and *Otoscaphites puerculus*, occur frequently within calcareous concretions. Body-chamber remains of *Neomphaloceras* are found commonly as float along the route where the succession is exposed, although they are not found in situ. Giant puzosiinaes about 1m in diameter also characterize the upper part of this unit.

Unit M10

Synonyms: This unit is equivalent to the Sirokinzawa sandstone of Nagao *et al.* (1954), the Members M9 to M11 of Hirano *et al.* (1980), and the Shirogane Formation of Motoyama *et al.* (1991).

Thickness: More than 950 m in appearance.

Lithology: This unit is composed mainly of sandstone-rich, alternating beds of sandstone and mudstone. The sandstone beds thicken rapidly upward in the lower part. There are two cycles (1 m thick each) of sandstone-rich alternations of 5 to 10 cm thick sandstone beds and thin mudstone beds, at the horizon of 300 m apparently above the base of this unit (Locs. Y090085, Y090081, Y090065, Y090055, Y090053, Y060001 and Y050011), and they are useful as key marker beds.

The upper part (Locs. Y090001–Y090051) is composed of alternating beds of sandstone and mudstone of which thickness and proportion fluctuate rhythmically. Slumping is also frequent.

Fossils: *Inoceramus hobetsensis hobetsensis* characterizes the lower succession but ammonoids are rare. The unit becomes more fossiliferous near the Loc. Y090051 etc., i.e. about 250 m above the base, and all ammonoids found continue their range from underlying the Unit M9 (Pl. 7, figs. 3–7). *Subprionocyclus* cf. *bravaisianus* (d'Orbigny) (Pl. 7, fig. 5), as a recruit, appears frequently in association with other ammonoids above the Loc. Y090027, i.e. about 400 m above the base.

Biostratigraphic Correlation

Shuparo River Section in the Northern Oyubari

The occurrence of *Mortoniceras* from two stratigraphic levels, *Mortoniceras* (*Mortoniceras*) cf. *geometricum* from the Unit Ld and *Mortoniceras* (*M.*) cf. *stoliczkai* from Unit Mb, suggests the Upper Albian. *Mortoniceras* (*M.*) *geometricum* is an element of the *Hysteroceras varicosum* Subzone in the middle part of the Upper Albian in England (Kennedy & Hancock, 1978) and has been reported to occur from the correlatives of the same subzone in Venezuela and Angola (see Matsumoto *et al.*, 1998). *Mortoniceras* (*M.*) *stoliczkai* is considered an intermediate form between *Mortoniceras* (*M.*) *inflatum* (Sowerby), of the middle part of the Upper Albian, and *Mortoniceras* (*M.*) *rostratum* of the upper part of the Upper Albian (see Matsumoto *et al*, 1998). The *Mortoniceras* (*M.*) *rostratum* Subzone [=*Arrhaphoceras substuderi* Subzone of some authors] is established in the lower part of the tripartite upper part of the Upper Albian in Europe (Gale *et al.*, 1996). Matsumoto *et al.* (1998) reported *Mortoniceras* (*M.*) *rostratum* from the Unit Mb along the Tengu-sawa Forestry Road (Loc. Y272041), whose horizon is somewhat above that of *Mortoniceras* (*M.*) cf. *stoliczkai* from the Kitano-sawa River.

Desmoceras (*Pseudouhligella*) *dawsoni* and *Desmoceras* (*Desmoceras*) *latidorsatum*, from the upper part of the Unit Mb along the Kitano-sawa Forestry Road (Loc. Y421047), are useful as the Upper Albian indicators (Matsumoto, 1959b; Toshimitsu *et al.*, 1995). The horizon is placed in the uppermost part of the Upper Albian because they are accompanied by *Marshallites cumshewaensis*, *Hamites* sp., *Anisoceras* sp., *Parajaubertella zizoh*, *Anagaudryceras* sp., *Zelandites* sp., *Tetragonites* sp., *Partshiceras japonicum*, and *Inoceramus* n. sp. (figured in Nishida *et al*., 1996, pl. 5). The faunal composition is quite similar to that of the Albian-Cenomanian transitional sequence of other circum-Pacific regions; e.g., northwestern Kamchatka (Alabushev, 1995; Pergament, 1977), south Alaska (Jones, 1967; Matsumoto, 1959a), and northern California (Murphy & Rodda, 1996).

The Shumarinai-Soeushinai area, northwestern Hokkaido, has recently been investigated for settling a biostratigraphy of the Albian-Cenomanian transitional sequence in Hokkaido. The Member My2 (Hashimoto *et al*., 1965) of the area is assigned to the uppermost Albian by the assemblage of dominant *Desmoceras* (*Pseudouhligella*) *dawsoni*, *Mortoniceras* (*Durnovarites*) cf. *subquadratum* Spath, *Cantabrigites* spp., *Anisoceras* sp., *Hamites* sp., *Mariella bergeri* Brongniart, and *Inoceramus* n. sp., while the Member My3 (Hashimoto *et al*., 1965) is assigned to the *Desmoceras* (*D.*) *kossmati-Graysonites adkinsi* Zone of the basal Cenomanian by the assemblage of dominant *Desmoceras* (*D.*) *kossmati*, *Graysonites adkinsi* Young, *Graysonites wooldridgei* Young, *Sounaites alaskaensis* (Matsumoto), *Marshallites cumshewaensis*, and heteromorph ammonites such as *Mariella*, *Stomohamites*, and *Anisoceras* (Matsumoto & Inoma, 1975, 1991; Nishida *et al*., 1996, 1997).

Desmoceras (*Pseudouhligella*) *poronaicum*, which is quite dominant in association with *Eogunnarites* sp., *Gabbioceras yezoense*, *Parajaubertella* sp., and *Turrilites scheuchzerianus* in the Uhit Md along the Kitano-sawa Forestry Road (Loc. 421039), is closely allied to *Desmoceras* (*D.*) *kossmati* in morphological aspects (Matsumoto, 1954) and now considered to be a likely synonym of the latter species (T. Matsumoto, personal communication, 1998). The stratigraphic distribution of *Desmoceras* (*D.*) *kossmati* extends to the Upper Albian (Matsumoto & Inoma, 1991) but is abundant in the Lower Cenomanian (see Toshimitsu *et al*., 1995). Matsumoto (1942) reported *Mariella oehlerti*, the Lower Cenomanian indicator, from the Unit Md (=IIc by Matsumoto, 1942) along the Tengu-sawa route. Therefore, we can consider that the Unit Md already represents the Cenomanian. Most of ammonoids obtained in this study range through both stages, and ammonoids such as *Graysonites adkinsi* and *Mantelliceras mantelli*, useful to recognize the basal Cenomanian, have not yet been obtained in the Oyubari area.

The continuous stratigraphic distribution of *Desmoceras* (*Pseudouhligella*) *japonicum* through the Units Me to Mg in the northern Oyubari indicates assignment of these strata to the Cenomanian. *Mantelliceras* cf. *saxbii* and *Inoceramus virgatus*, which occur from the middle part of the Unit Me, indicate the Lower Cenomanian. *Calycoceras asiaticum* occurs from the middle part of the Unit Mf, and the *Calycoceras asiaticum* Zone is established for the upper part of the Middle Cenomanian in Japan (Toshimitsu *et al*., 1995). The succession from the uppermost part of the Unit Mf to the lower part of the Unit Mg is correlated to the Upper Cenomanian by the occurrences of *Inoceramus pennatulus*, *Inoceramus ginterensis*, *Inoceramus reduncus*, *Inoceramus gradilis*, *Inoceramus nodai*, *I. pictus*, and *Actinoceramus nipponica*.

A distinctive black shale serves as a key marker for the Cenomanian/Turonian boundary at the basal horizon of the Saku Formation, Loc. Y260009 along the Hikage-sawa Forestry Road (e.g., Hirano *et al.*, 1992). The ammonoid and inoceramid zonation of the Turonian applies well in the Oyubari area is based on Toshimitsu *et al.* (1995). The middle part of the Unit Mg is correlated to the Lower Turonian by the occurrence of *Inoceramus kamuy* and *Mytiloides labiatus*. The Unit Mh is considered as the upper part of the Middle Turonian by the occurrence of *Inoceramus hobetsensis hobetsensis*. The Unit Mi along the Shuparo River is correlated to the Upper Turonian by *Inoceramus teshioensis* and *Mytiloides incertus*.

The Kashima Formation distributed along the Shuparo River is correlated with the Coniacian by the occurrence of *Inoceramus uwajimensis*.

Hakkin-zawa River Section in the Southern Oyubari

In the Hakkin-zawa route of the southern Oyubari, the Albian-Cenomanian transition is suggested by the occurrence of *Desmoceras* (*Pseudouhligella*) *dawsoni*, *Desmoceras* (*D.*) *kossmati*, *Sharpeiceras kikuae*, *Turrilites actus*, *Mariella* cf. *oehlerti*, *Hamites* sp., etc. from Locs. Y070133 and Y070144–145.

The appearance of *Inoceramus ginterensis* in the uppermost part of the Unit M7 shows the Middle Cenomanian. *Calycoceras* sp. from the middle part of the Unit M8 indicates the upper part of the Middle Cenomanian. The succession from the uppermost part of the Unit M8 to the lowermost part of the Unit M9 is correlated to the Upper Cenomanian by the occurrences of *Inoceramus ginterensis*, *Inoceramus gradilis* and *Actinoceramus nipponica*.

Pseudaspidoceras flexuosus, an index of the second ammonoid zone from the basal Turonian in the Pueblo section, U.S. Western Interior (Kennedy & Cobban, 1991), appears above the black shale at the basal horizon of the Saku Formation (see Hirano, 1995). The lower part of the Unit M9 is correlated to the Lower Turonian by the occurrence of *Inoceramus kamuy* and *Mytiloides labiatus*. The appearance of *Inoceramus hobetsensis nonsulcatus*, *Scaphites planus*, *Otoscaphites puerculus*, and associated ammonoids suggests that the slump zone and adjacent strata in the middle part of the Unit M9 are the Middle Turonian. The succession from lower to middle part of the Unit M10 is considered as the upper part of the Middle Turonian by the occurrence of *Inoceramus hobetsensis hobetsensis*. The upper part of the Unit M10 is assigned to the Upper Turonian by the occurrence of *Subprionocyclus* cf. *bravaisianus*.

Remarks on the Sedimentary Facies and Ammonoid Distributions

It is possible to chronologically subdivide the Cenomanian-Turonian succession in the Oyubari area in more detail. The sedimentary environments of the succession

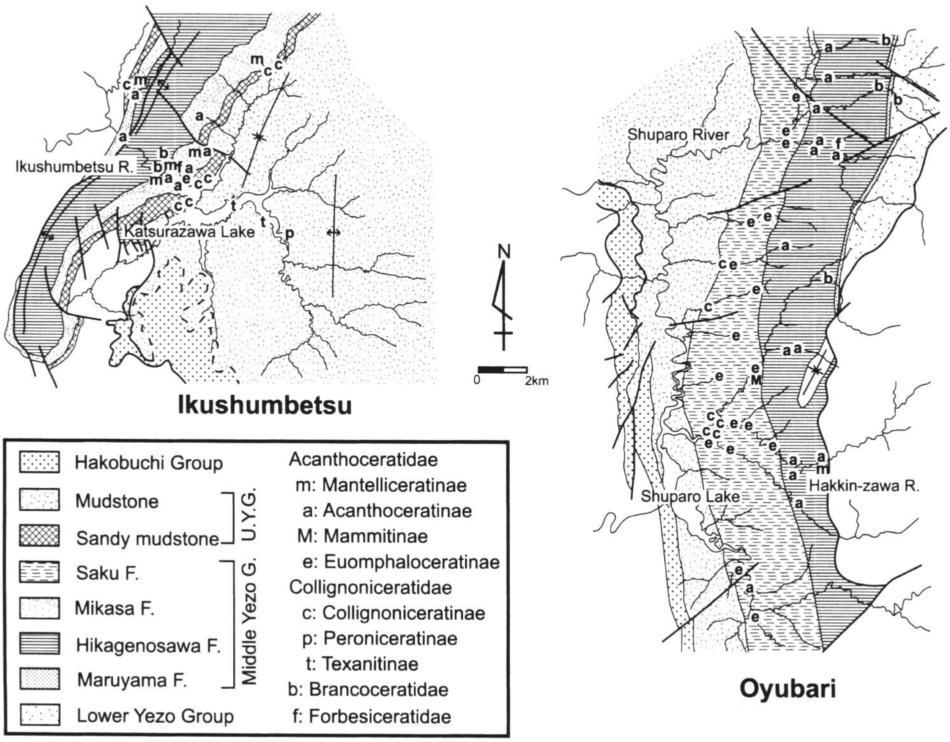

Fig. 12. Geographic distribution of acanthocerataceans. Data from previous studies as follows; Ikushumbetsu area: Matsumoto (1965a, b, 1969, 1970a, b, 1971, 1975, 1987, 1988), Matsumoto and Kawano (1975), Matsumoto and Obata (1982), Matsumoto and Takahashi (1992), Matsumoto and Toshimitsu (1991), Matsumoto *et al.* (1957, 1969, 1981, 1989), Futakami (1986), and Asai (1997); Oyubari area: Matsumoto (1965a, 1970a, 1971, 1975, 1991), Matsumoto and Haraguchi (1978), Matsumoto and Kawashita (1998), Matsumoto and Muramoto (1978), Matsumoto and Suekane (1987), Matsumoto *et al.* (1957, 1978, 1981, 1985, 1989, 1998), Hirano *et al.* (1981, 1990), Futakami (1986), and Kawabe *et al.* (1996).

are reconstructed as transitional from a shelf apron to a submarine fan, based on the benthic foraminifera (Motoyama *et al.*, 1991) and the sedimentary facies (Kawabe *et al.*, 1996; Takashima *et al.*, 1997).

The contemporaneous western succession in the Ikushumbetsu area comprises the Mikasa Formation (Matsumoto, 1951) and the lower part of the Upper Yezo Group. Depositional environments of the Mikasa Formation, ranging from the Lower Cenomanian to the Middle Turonian, are mainly above the storm wave base. Those of the lower part of the Upper Yezo Group, ranging from the Middle to Upper Turonian, are below the storm wave base but they are rather shallower in the outer shelf (Ando 1990). Numerous species of acanthoceratacean ammonites useful for international correlation have been collected from sandy strata from the Ikushumbetsu (e.g., Matsumoto, 1965a, 1975; Matsumoto *et al.*, 1957, 1969). The Ikushumbetsu area is a reference section of Japanese biostratigraphy for the Cenomanian to Turonian (e.g., Matsumoto, 1959b; Matsumoto *et al.*, 1978, 1991; Toshimitsu *et al.*, 1995).

On the basis of the records of previous papers, Fig. 12 shows the occurrences of acanthoceratacean at a family or a subfamily level as plotted on the simplified geological map. The reason why the acanthoceratacean were obtained from a limited number of localities in the Ikushumbetsu area is that the sandy Mikasa Formation is exposed narrowly and we can study it along only a few routes. In contrast, the acanthoceratacean show a widespread and random distribution in the Oyubari area, where the muddy Hikagenosawa and Saku formations crop out continuously. Consequently, the ornate acanthoceratacean ammonoids lived not only in the shallower Ikushumbetsu area but also in the deeper Oyubari area. This evidence supports the point that the ammonite species of Acanthocerataceae are useful for interregional correlation irrespective of the lithofacies difference, and they advance the biostratigraphic correlation of the Yezo Supergroup composed mainly of offshore mudstones in the whole of Hokkaido.

Conclusions

1. Two sections of the Oyubari area, along the Shuparo River in the north and along the Hakkin-zawa and Takino-sawa rivers in the south, were investigated. The Lower Yezo Group overlies conformably the Sorachi Group, which is composed exclusively of siliceous rocks. The Lower Yezo Group includes two formations, the Tomitoi Formation (sandstone-dominated, alternating beds of sandstone and mudstone with slumping) below, and the Shuparogawa Formation (mudstone-dominated, alternating beds of sandstone and mudstone with allochthonous limestone blocks) above. The Middle Yezo Group is divided into three formations, the Maruyama Formation (tuffaceous sandstone-dominated, alternating beds of sandstone and mudstone), the Hikagenosawa Formation (laminated mudstone), and the Saku Formation (mudstone-dominated, alternating beds of sandstone and mudstone with slumping), in ascending order. The Upper Yezo Group involves only the Kashima Formation (mudstone). A geological map of the northern Oyubari area is presented.

2. No significant time gap exists between the Lower and Middle Yezo groups because the Upper Albian index *Mortoniceras* occurs from both the Units Ld and Mb.

3. The ammonoid assemblage of the Albian-Cenomanian transitional interval is found in the succession of the Hikagenosawa Formation (Units Mb to Md) in the northern Oyubari area.

4. Biostratigraphically-useful ammonoids and inoceramids occur commonly from the Hikagenosawa and Saku formations in the Oyubari area. These fossils indicate that the lower part of the Hikagenosawa Formation is correlated to the Lower Cenomanian and the upper part of the formation with the Middle Cenomanian. The

succession from the uppermost part of the Hikagenosawa Formation to the basal part of the overlying Saku Formation is correlated to the Upper Cenomanian. The lower part of the Saku Formation is correlated to the Lower Turonian, the middle part of the formation to the Middle Turonian, and the upper part to the Upper Turonian. The Kashima Formation in the area studied is correlated to the Coniacian.

5. Acanthoceratacean ammonoids of Hokkaido are widely distributed in both shallow- and deep-water facies, allowing refined biostratigraphic correlation of Cenomanian strata.

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Explanation of Plates

The repositories of the illustrated specimens are abbreviated as follows:
NSM: National Science Museum, Tokyo 169–0073, Japan
WE: Institute of Earth Sciences, School of Education, Waseda University, Tokyo 169–8050, Japan

Plate 1.

Fig. 1. Laminated mudstone of the Unit Mb [Upper Albian] along the Tengu- sawa River in the northern Oyubari.

Fig. 2. Alternating beds of sandstone and mudstone of the lower part of the Unit Mg [Upper Cenomanian] along the Kitano-sawa River in the northern Oyubari.

Plate 2.

Fig. 1. Horizontally bioturbated muddy sandstone, which is similar to *Planolites* mudstone (Maeda, 1987), of the lower part of the Unit M9 [Lower Turonian] along the Hakkin-zawa River in the southern Oyubari.

Fig. 2. Slump structure of the middle part of the Unit M9 [Middle Turonian] along the Hakkin-zawa River in the southern Oyubari.

Plate 3.

Fig. 1. *Mortoniceras* (*Mortoniceras*) cf. *geometricum* Spath. WE A211Y, left lateral view, from Loc. Y271001 of Kawabe *et al.* (1996), along the Tengu-sawa River. ×0.75.

Fig. 2. *Mortoniceras* (*Mortoniceras*) cf. *stoliczkai* (Spath). WE A395Y, left lateral view, from Loc. Y421047 of Kawabe *et al.* (1996), along the Kitano-sawa River. ×1.0.

Fig. 3. Cluster occurrence of *Desmoceras* (*Pseudouhligella*) *dawsoni* (Whiteaves) in a calcareous concretion. WE A404Y, from Loc. Y421047 of Kawabe *et al.* (1996), along the Kitano-sawa River. ×1.0.

Plate 4.

Fig. 1. *Sounnaites* sp. WE A405Y, right lateral view, from Loc. Y421047 of Kawabe *et al.* (1996), along the Kitano-sawa River. ×1.0.

Fig. 2. *Marshallites cumshewaensis* (Whiteaves). WE A400Y, right lateral view, from Loc. Y421047 of Kawabe *et al.* (1996), along the Kitano-sawa River. ×1.0.

Fig. 3. *Anagaudryceras* sp. WE A396Y, right lateral view, from Loc. Y421047 of Kawabe *et al.* (1996), along the Kitano-sawa River. ×1.0.

Fig. 4. *Parajaubertella* cf. *zizoh* Matsumoto. WE A401Y, right lateral view, from Loc. Y421047 of Kawabe *et al.* (1996), along the Kitano-sawa River. ×1.0.

Figs. 5-7. *Desmoceras* (*Desmoceras*) *latidorsatum* (Michelin). WE A398Y, ventral, left lateral and apertural views, from Loc. Y421047 of Kawabe *et al.* (1996), along the Kitano-sawa River. ×1.0.

Fig. 8. *Partschiceras japonicum* Matsumoto. WE A403Y, right lateral view, from Loc. Y421047 of Kawabe *et al.* (1996), along the Kitano-sawa River. ×1.0.

Fig. 9. *Hamites* sp. WE A399Y, lateral view, from Loc. Y421047 of Kawabe *et al.* (1996), along the Kitano-sawa River. ×1.0.

Fig. 10. *Anisoceras* sp. WE A397Y, lateral view, from Loc. Y421047 of Kawabe *et al.* (1996), along the Kitano-sawa River. ×1.0

Fig. 11. *Desmoceras* (*Pseudouhligella*) *poronaicum* Yabe. NSM PM16124, left lateral view, from Loc. Y421039 of Kawabe *et al.* (1996), along the Kitano-sawa River. ×1.0.

Fig. 12. *Gabbioceras yezoense* Shigeta. WE A382Y, right lateral view, from Loc. Y421039 of Kawabe *et al.* (1996), along the Kitano-sawa River. ×2.0.

Fig. 13. *Turrilites scheuchzerianus* Bosc. WE A385Y, right lateral view, from Loc. Y421039 of Kawabe *et al.* (1996), along the Kitano-sawa River. ×2.0.

Plate 5.

Figs. 1, 2. *Desmoceras* (*Pseudouhligella*) *poronaicum* Yabe. NSM PM16125, left lateral and apertural views, from Loc. Y421039 of Kawabe *et al.* (1996), along the Kitano-sawa River. ×1.0.

Figs. 3, 4. *Desmoceras* (*Pseudouhligella*) *japonicum* Yabe. NSM PM16126, right lateral view, from Loc. Y110301 of Kawabe *et al.* (1996), along the Shuparo River. ×1.0.

Plate 6.

Fig. 1. *Calycoceras asiaticum* (Jimbo). WE A275Y, left lateral view, from Loc. Y250021 of Kawabe *et al.* (1996), along the Hikage-sawa River. ×0.5.

Plate 7.

Fig. 1. *Mantelliceras* cf. *saxbii* (Sharpe). WE A256Y, left lateral view, from Loc. Y110325 of Kawabe *et al.* (1996), along the Shuparo River. ×1.0.

Fig. 2. *Muramotoceras yezoense* Matsumoto. WE A410Y, apical view, from Loc. Y260005 of Kawabe *et al.* (1996), along the Hikage-sawa River. ×1.0.

Fig. 3. *Tragodesmoceroides subcostatus* Matsumoto. NSM PM16127, left lateral view, from Loc. Y090037 of Hirano *et al.* (1989a), along the Takino-sawa River. ×1.0.

Fig. 4. *Hypophylloceras subramosum* (Shimizu). NSM PM16128, right lateral view, from Loc. Y090037 of Hirano *et al.* (1989a), along the Takino-sawa River. ×1.0.

Fig. 5. Cluster occurrence of *Collignoniceras* cf. *bravaisianus* (d'Orbigny) in a calcareous concretion. NSM PM16129, from Y090027 of Hirano *et al.* (1989a), along the Takino-sawa River. ×2.0.

Fig. 6. *Mesopuzosia pacifica* Matsumoto. NSM PM16130, right lateral view, from Loc. Y090037 of Hirano *et al.* (1989a), along the Takino-sawa River. ×1.0.

Fig. 7. *Gaudryceras denseplicatum* (Jimbo). NSM PM16131, right lateral view, from Loc. Y090025 of Hirano *et al.* (1989a), along the Takino-sawa River. ×1.0.

Plate 1

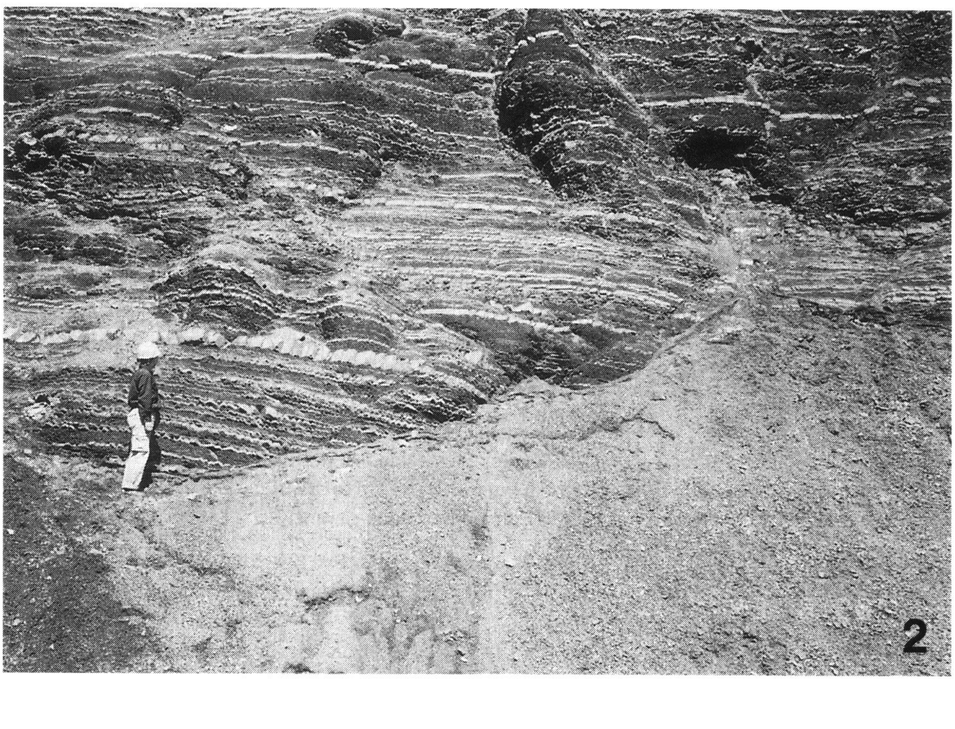
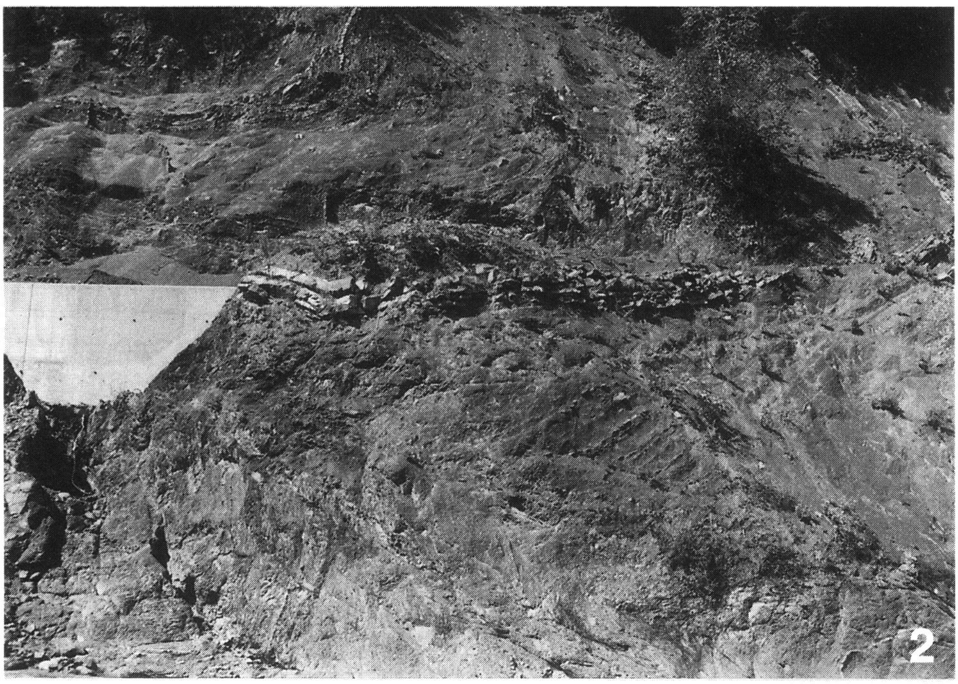


Plate 2



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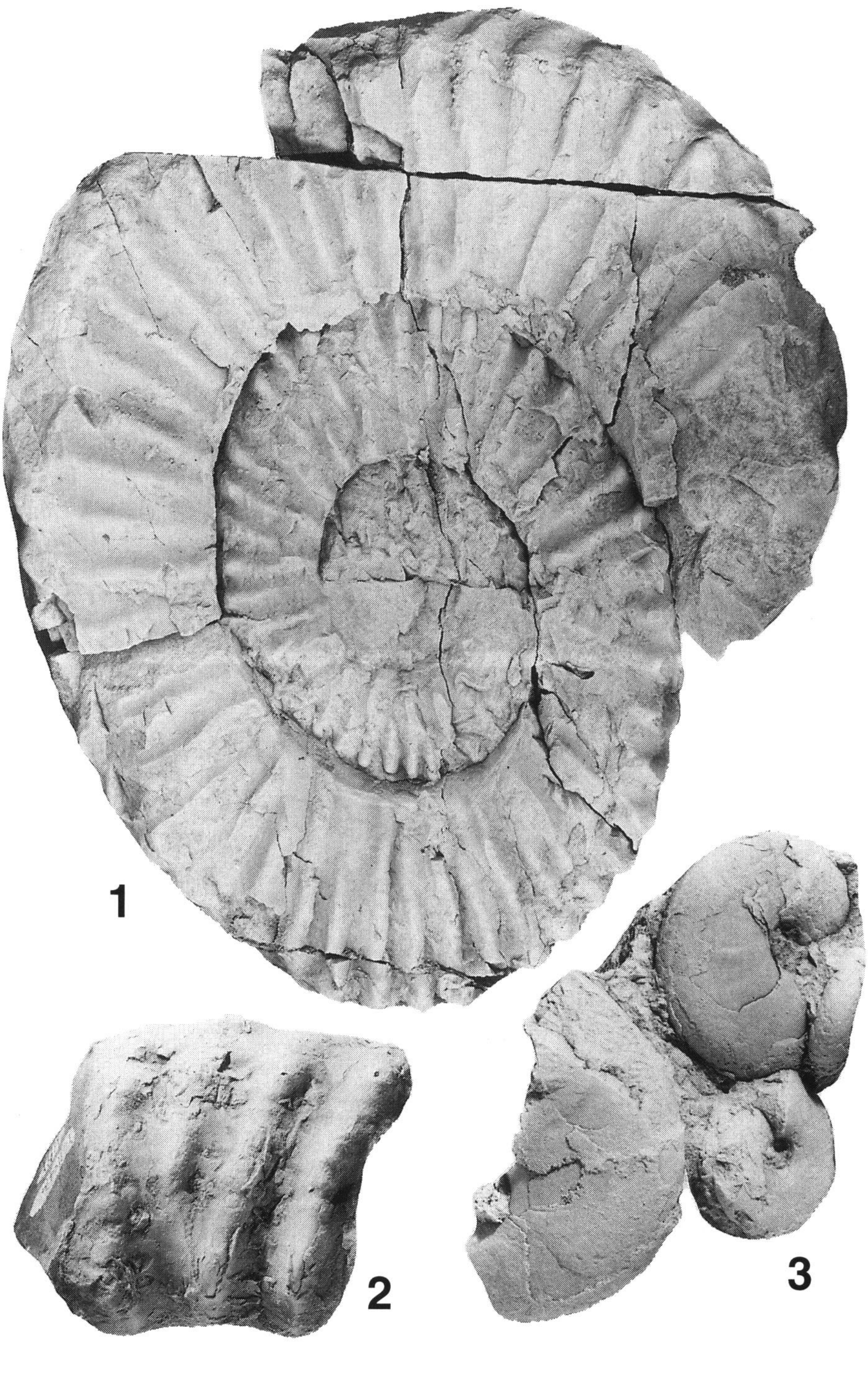

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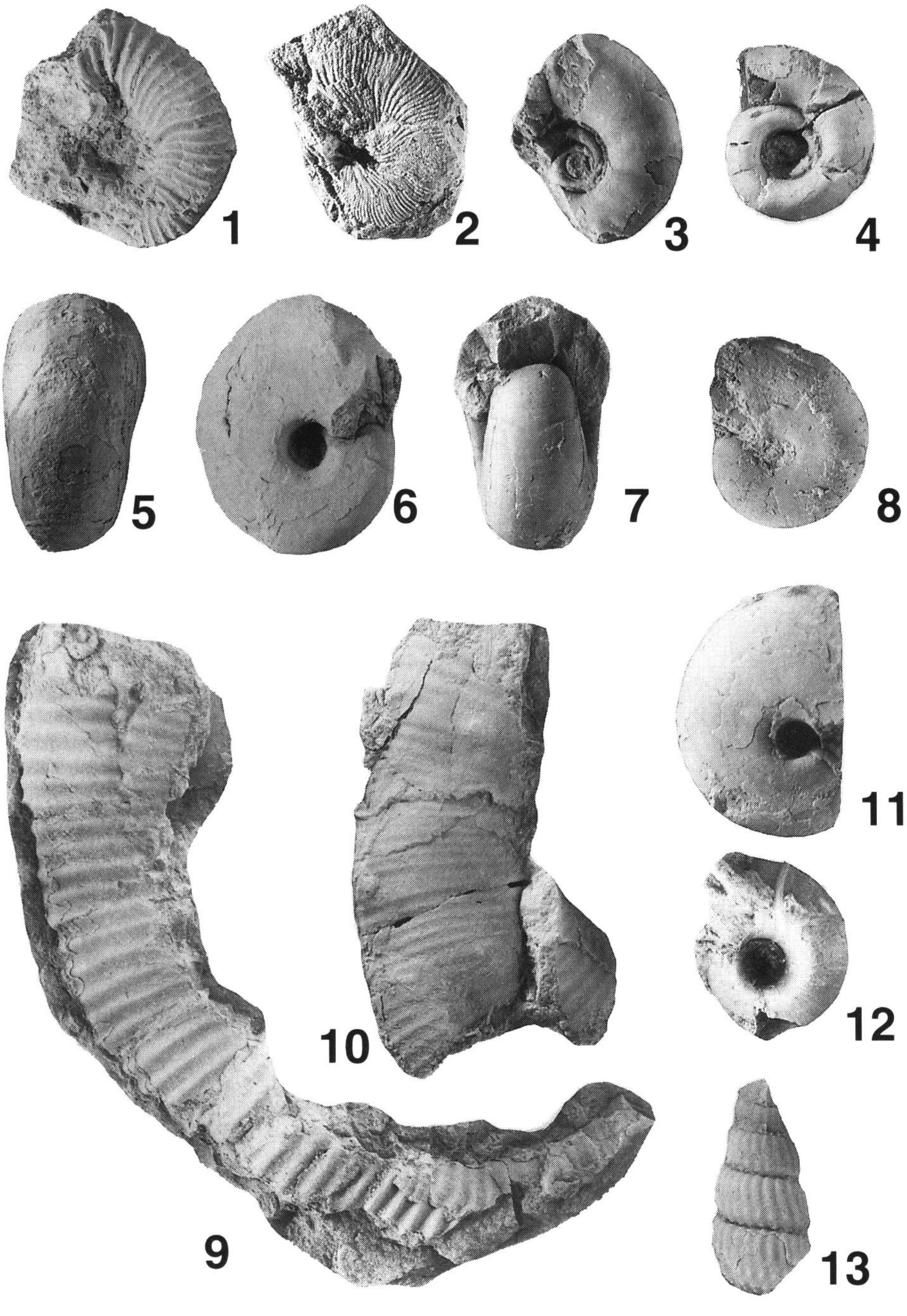

Plate 5

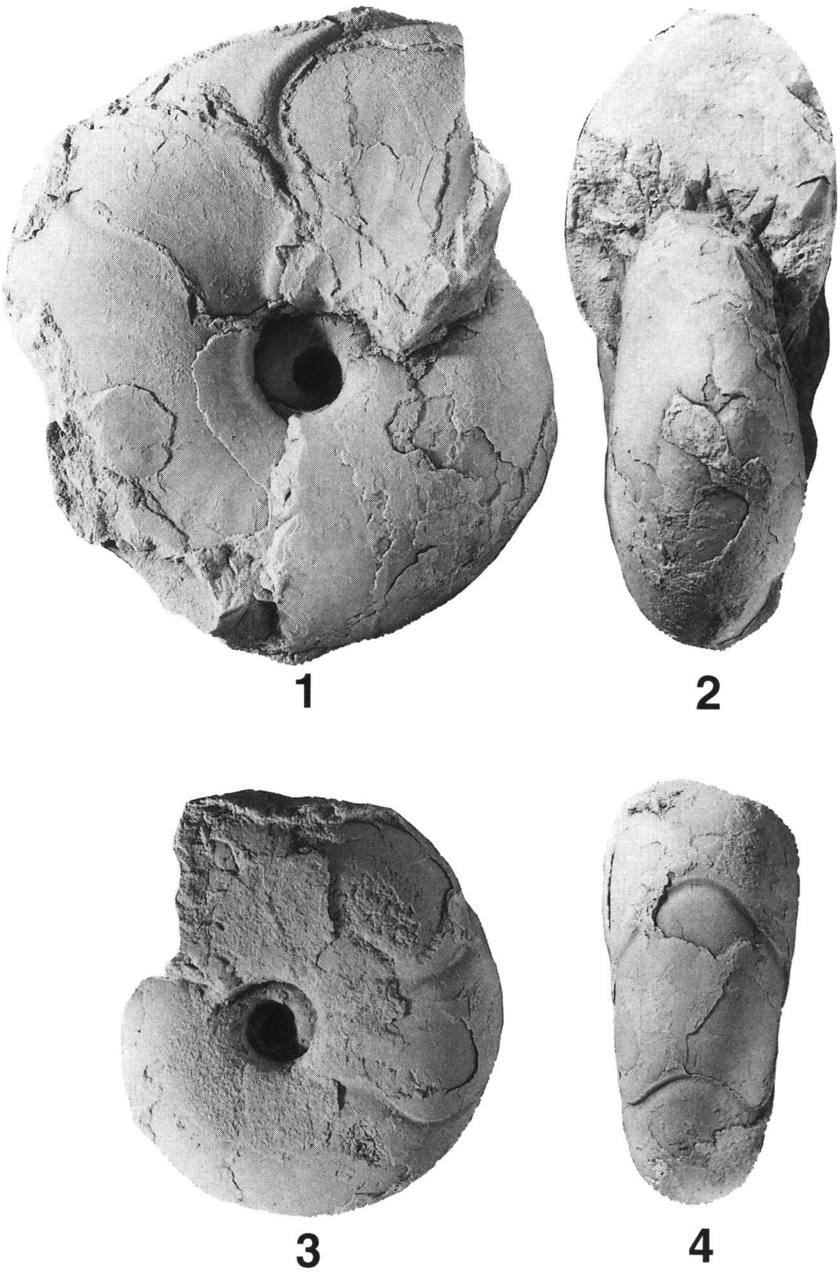

Plate 6

1

Plate 7