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Cretaceous Stratigraphy of the Yubari Dome, Hokkaido

By

Tatsuro MATSUMOTO and Masato HARADA

Abstract

The stratigraphy of the Cretaceous sediments exposed in the Yubari dome is described in this paper. It may be summarized in a generalized section of Fig. 2. On fossil evidence the subdivided units are clearly correlated with the reference scales at home and abroad. Short palaeontologic remarks are given on some species in connection with the correlation.

The sedimentary accumulation in the site of the Yubari dome was generally less thick and much slower than that in other adjacent areas. This was especially remarkable in Cenomanian and Coniacian ages. The site of Yubari dome was fairly close to, if not on, the western margin of the Cretaceous sedimentary basin, while the geosynclinted sinking was more intense in the eastern area as represented by the Shuyubari valley.

Introduction

The purpose of this paper is to describe the up-to-date knowledge on the stratigraphy of the Cretaceous System exposed in the Yubari dome.

The Yubari dome is taken here to call a dome like structure immediately west of the streets of Yubari, in Ishikari coal-field, central Hokkaido. The mapped area is about 4 km (NS) × 5.5 km (EW), extending from 43°3′ to 43°5′30″ North Lat. and from 141°55′ to 141°59′ East Long. Topographically it corresponds approximately to the Hatonosu Hills, which are bounded on the southeast by the Shihorokabets (along which extend the streets of Yubari) and on the north and west by the creek of Ekimoanruru, upper reaches of the Anoro. All of these streams are tributaries of the Yubari which finally adjoins with the river Ishikari at Ebets near the city of Sapporo. Fig. 1 shows a general relief of the Hatonosu Hills and river systems, indicating the names of the creeks, along which rocks are better exposed than on the hills. As is seen in the map a watershed of N-S trend divides the mapped area into eastern and western parts.

Geologically the Hatonosu Hills form a dome like structure modified by probably later deformation. The dome is extremely asymmetric with gentle inclination on the north and east sides and overturned limb on the southwest. It is somewhat undulated, comprising at least two minor uplifts and a saddle within the core. It is, furthermore, cut by a number of thrusts of WNW-ESE

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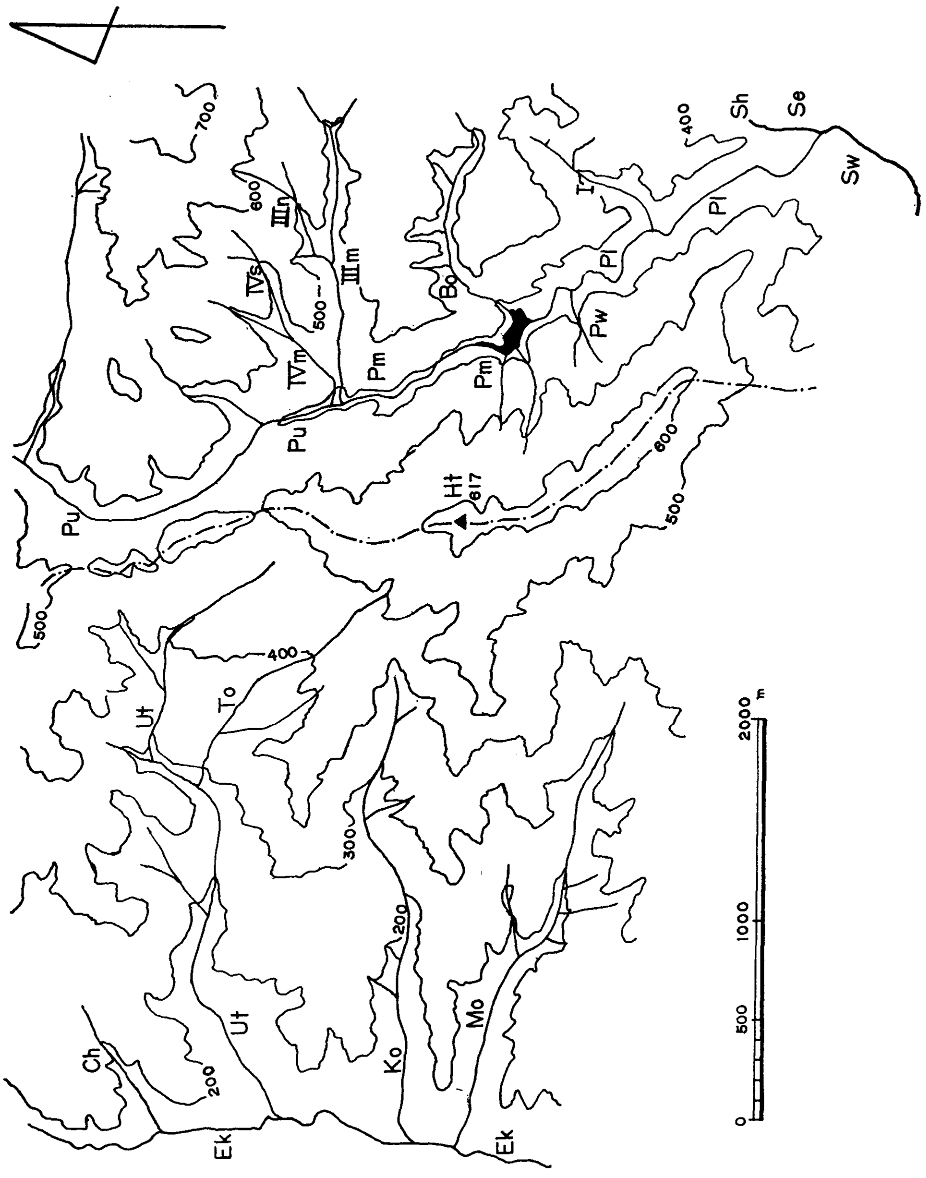

Fig. 1. Topographic relief of the Hatonosu Hills, showing the drainage systems. See Table 1 for the abbreviation of the names of streams.

trend (with southwestward "Vergenz") and by a few faults of NE-SW trend, and thus the structure is much complicated than a normal dome.

The Yubari dome, named by OTATUME (1950), is called the Hatonosu dome by some authors (e.g. TASHIRO, 1951; TAKAO, 1952; SAKAKURA, 1954). To the north of it, separated by a thrust of E-W trend, there is another dome of a similar shape, which is called the Manji dome (OTATUME, 1950; followed by

TASHIRO, 1951; TAKAO, 1952*). These two domes can be regarded as the southern extension of an anticline which crosses the celebrated Ikushumbets valley.

The main part of the Hatonosu dome is occupied by the Cretaceous rocks. The Cretaceous sequence exposed there is incomplete in that its upper part had been considerably eroded away before the deposition of the coal-bearing Tertiary and in that the underlying part cannot be observed from the surface outcrops. Yet the area is important, because it represents the relatively western part of the Cretaceous basin of Hokkaido and because fossils occur fairly abundantly.

There is a fault of N-S trend on the west side of the Hatonosu Hills. Beyond this fault there are no Cretaceous outcrops in the west, although there must be some Cretaceous rocks underneath the Tertiary sequence. Through the study of the Cretaceous sediments in the Yubari dome some important information about the palaeogeography is to be obtained.

The biostratigraphic sequence of the Cretaceous of Hokkaido has been established on the basis of the studies in the Ikushumbets valley, Shiyubari valley, both of which are situated close to the Yubari coal-field, and also other selected areas (MATSUMOTO, 1942-43, 1959). How far the proposed zones are extended to or how they are supplemented by the Cretaceous of the Yubari dome is another point to be worked out.

Aside from the pioneer works of LYMAN (1873-78) and JIMBO (1889-94), YABE (1909, 1926) and IMAI (1924) established fundamentals in the geology of the Yubari coal-field. The Cretaceous fossils from this area were described by JIMBO (1894), YABE (1903-4, 1910), ENDO (1925), YABE and NAGAO (1928), SHIMIZU (1931), NAGAO (1932, 1938, 1939), NAGAO and MATSUMOTO (1939-40) etc., together with those from other areas. Their results were so classic that one of us (T.M.) omitted to redescribe the Cretaceous stratigraphy of the Yubari coal-field in *"Fundamentals in the Cretaceous stratigraphy of Japan"* (see MATSUMOTO, 1942, p. 215).

Recently intensive studies have been carried on by coal geologists, of whom OTATUME (1950), TASHIRO (1951), TAKAO (1952), SAKAKURA (1954) and SHIMOGAWARA (1958, 1963) have made outstanding contributions. They are, however, primarily concerned with the Tertiary stratigraphy and geologic structure. As regards the Cretaceous stratigraphy of the Yubari dome there has been no remarkable addition to the works of YABE and IMAI. To meet the requirements for the up-to-date biostratigraphy and sedimentology of the Cretaceous of Hokkaido, we have done a renewed field work in the Yubari dome. This is a report of our stratigraphic study.

Stratigraphic Description

The stratigraphic sequence of the Yubari dome is summarized in ascending

* SAKAKURA (1954) described the Manji dome as the Yubari dome, which is a homonym of the Yubari dome of OTATUME, 1950.

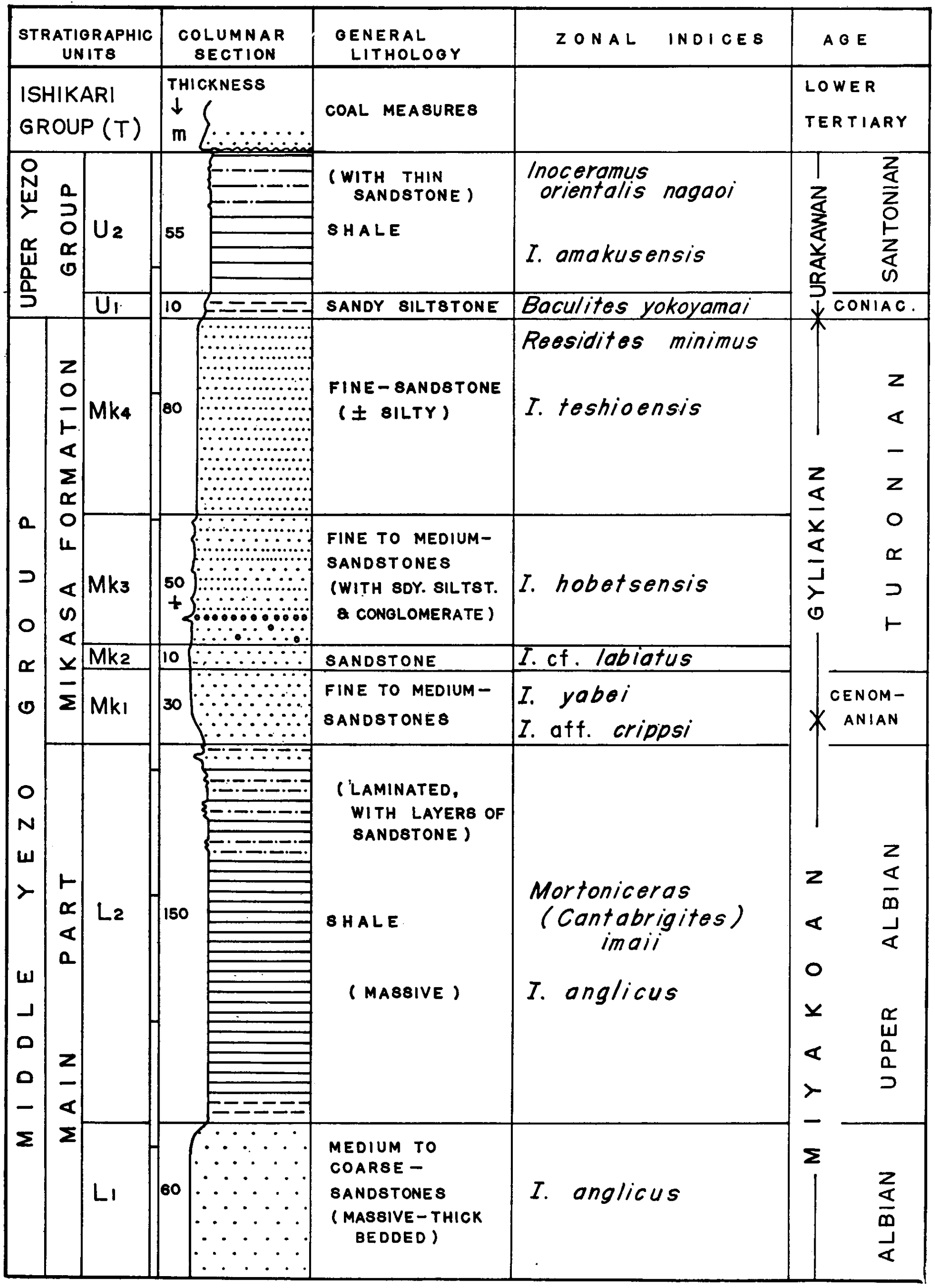

Fig. 2. Generalized stratigraphic section of the Yubari dome.

order as follows (see also Fig. 2):

——Lower limit unexposed——

Lower part of Middle Yezo Group

Medium- to coarse-grained sandstone in the lower part (Member L1), followed by indurated black mudstone or shale, with some intercalated sandstone, in the main part (Member L2), about 300 m thick altogether .... (Albian)

Upper part of Middle Yezo Group=Mikasa Formation

Sandstone of various grades of coarseness, in part subgraywacke and in part muddy graywacke, with intercalated pebbly, calcareous sandstone and conglomerate. About 170 m thick sequence is divisible into four members in the eastern part, Members Mk 1 to Mk 4 .... (Cenomanian and Turonian)

Upper Yezo Group

Glauconitic sandy silstone (U1) at the base, followed by a unit (U2) of black mudstone with thin sandy interbeds, 60 m in the maximum thickness of the exposed part .... (Coniacian and Santonian)

——Unconformity——

Overlying: Ishikari Group (Eocene) [abbr. T], which rests directly on Mk 3 in the western part

The Lower Yezo Group, which is well exposed in the upper reaches of the Shuyubari, and the Hakobuchi Group, the highest unit of the Cretaceous, which is exposed at the Hakobuchi gorge, the entrance of the Shuyubari valley in the east, are not exposed in the Yubari dome.

Lower part of Middle Yezo Group

This is exposed at the core of the Yubari dome. It was at one time called the Lower Ammonite bed (YABE, 1909, 1926), but MATSUMOTO (1942-43) has made clear that the so-called Lower Ammonite Bed in the Ishikari coal-field is correlated with the lower part of the Middle Ammonite Group in the Yubari range (or the Shuyubari valley) in the east where the type Lower Ammonite Group is unconformably overlain by the Middle Ammonite Group. The Lower, Middle and Upper Ammonite Groups or Beds were later altered to be called the Lower, Middle and Upper Yezo Groups (MATSUMOTO, 1951) to avoid the confusion with ammonite beds of various geological ages in various regions in the world.

The exposed part of the lower part of the Middle Yezo Group is about 200 m to 300 m in thickness and is divided into two members, provisionally called L1 and L2.

Member L1 Whether this represents the basal part of the Middle Yezo Group or is merely a tongue intercalated in the middle of the group cannot be decided from the evidence of surface outcrops. Rock-stratigraphically it seems to correspond to the Yunosawa Sandstone in the lower part of the Middle Yezo Group of the Ikushumbets valley. The shale which is exposed in a narrow area along the upper reaches of the Kosen-no-sawa might be interpreted to lie below the sandstone of L1, but we are inclined to regard it as L2 which is separated by a thrust plane from L1 in the south.

Member L1 consists of medium- to coarse-grained sandstone. The predominant sandstone is rather massive, without distinct bedding planes and virtual lamination, coarse-grained, and sometimes bearing granules and fragments of shale. It is of subgrawacke type, very poor in fossils, devoid of drifted wood or fragmental vegetable matter and has few calcareous nodules. Partly the sandstone is bedded, with intercalated thin layers of sandy shale.

The sandstone at locs. Yb 16 and Yb 110, top of L1 exposed along the Ponhorokabets, is calcareous (calcite about 35 percent under the microscope) and contains a little amount of glauconite.

Thickness of Member L1 is 60 m in the eastern part and 150 m in the western part (measured along the section of Kosen-no-sawa), but this is concerned only with the exposed part.

Representative exposures of L1 are at locs. Yb 16, Yb 103, Yb 110, Yb 410 and Yb 412 along the Ponhorokabets; Yb 245 along the Utagoe-zawa; several localities along the middle course of the Kosen-no-sawa.

Inoceramus anglicus WOODS was obtained from loc. Yb 245.

Member L2 This conformably overlies Member L1. It consists primarily of black shale or indurated mudstone and about 150 m in thickness.

The base of Member L2 is marked by a 10-20 cm thick bed of dark grey, muddy, medium-grained sandstone containing rounded pebbles of porphyrite and chert, as is clearly shown by the exposure at loc. Yb 110b. In addition to the basal one a similar pebble bearing muddy sandstone sometimes occurs in the overlying shale at a horizon not far from the base.

Massive indurated mudstone predominates in the lower part and laminated shale, more or less sandy or silty, predominates in the upper part of Member L2. The laminated sandy siltstone often contains scattered grains of glauconite. In higher portion of the upper part very thin layers, at first 2 cm or so thick, of sandstone are intercalated and as we ascend the sequence the intercalation becomes more frequent and the intercalated sandstone beds become somewhat thicker (about 20 cm), forming thus a thin bedded alternation of sandstone and shale, and finally appears a sandstone of 2-3 m thick, with very thin seams, 1-2 cm, of shale. We include this rigid sandstone and also another set of alternating sandstone and shale resting on this sandstone, about 2 m, in the upper most part of L2. They are overlain conformably by the massive sandstone of Mk1. This succession is well exposed at loc. Yb 109, upper reaches of the Ponhorokabets .

Member L2 is typically exposed along the creek of the Ponhorokabets and its tributaries. This represents the eastern inlier. The exposures of the western inlier are along the creeks of the Kosen-no-sawa and the Utagoezawa. L2 crops out in the central inliers, forming smaller exposures along the upper reaches of the Utagoe-zawa and its tributary, Tokei-no-sawa (see geologic map).

Ammonoids, Inocerami and other fossils are found at many places in the main part of Member L2. They are more common in the eastern area. The fossil localities are Yb 26, Yb 27, Yb 28, Yb 34r, Yb 39, Yb 48, Yb 53r, Yb 105, Yb 107p, Yb 109, Yb 110, Yb 111, Yb 112, Yb 112r, Yb 113, Yb 113p, Yb 115p, Yb 116p, Yb 117r, Yb 224, Yb 231, Yb 247, Yb 297, Yb 410, Yb 416, Yb 417, Yb 418, Yb 419, etc. Among the ammonoids small specimens of *Mortoniceras* (*Cantabrigites*) *imaii* are most predominant. Larger shells of other *Mortoniceras* are occasionally found. Less strongly ornate coiled ammonoids, such as *Hypophylloceras, Anagaudryceras, Desmoceras* and *Puzosia,* and such heteromorpha as *Pseudhelicoceras,* with delicately preserved spines, *Proscaphites* and *Hamites,* are associated with the Mortoniceratids. Thin shelled bivalves are not uncommon, often with two valves unseparated. As rare occurrence a small belemnite and a crab (*Protunites*) were found.

Upper part of Middle Yezo Group: Mikasa Formation

The upper part of the Middle Yezo Group consists primarily of sandstone. This was at one time called the *Trigonia* Sandstone (YABE, 1909, 1926) but later altered to be called the Mikasa Formation (MATSUMOTO, 1951, 1954) to avoid the confusion with *Trigonia* sandstones of other areas which may be of different ages and of different sedimentary basins from that of the Ishikari coal-field. The type area of the Mikasa Formation is in the Ikushumbets valley, which belongs administratively to Mikasa city. The Mikasa Formation in the Hatonosu Hills is somewhat different from the type Mikasa in the Ikushumbets area in the details of stratigraphic succession, facies and thickness. In the Hatonosu Hills it is about 160 m thick and is stratigraphically divisible into four units, provisionally called Members Mkl to Mk4. It occupies the main part of the Hatonosu Hills and its succession is typically exposed along the creek of the Ponhorokabets and its fourth tributary, "Yon-no-sawa", although exposures are sometimes interrupted by dense vegetation (see Fig. 3).

Member Mkl The lower limit of this member has already been defined in the description of Member L2.

The sandstone of Member Mkl is massive, not well bedded, nor well laminated, without intercalation of shale, mostly medium-grained, moderately sorted and graywacke type, showing little change of facies.

Member Mkl is not rich in fossils. A few species of *Inoceramus, I. yabei* and others, often with both valves preserved, have been so far obtained from locs. Yb 18, Yb 36p2, Yb 38, Yb 50p, Yb 96p and Yb 352. Drifted wood, other plant remains and nodules are occasionally found.

Member Mkl is exposed on the coast of an artificial lake at the middle of the Ponhorokabets, along the Yon-no-sawa, and in the upper reaches of the Ponhorokabets beyond the area of L2. It is furthermore extensively exposed in the western part of the Hotonosu Hills, as seen along the Tokei-no-sawa and the middle course of the Utagoe-zawa. Its thickness is estimated at about 25-30 m along the Yon-no-sawa. The variation of the thickness in other parts is not exactly measured.

Member Mk2 This is represented by the rocks exposed at locs. Yb 19 and Yb 20 along the creek of Yon-no-sawa, being estimated at about 10 m thick

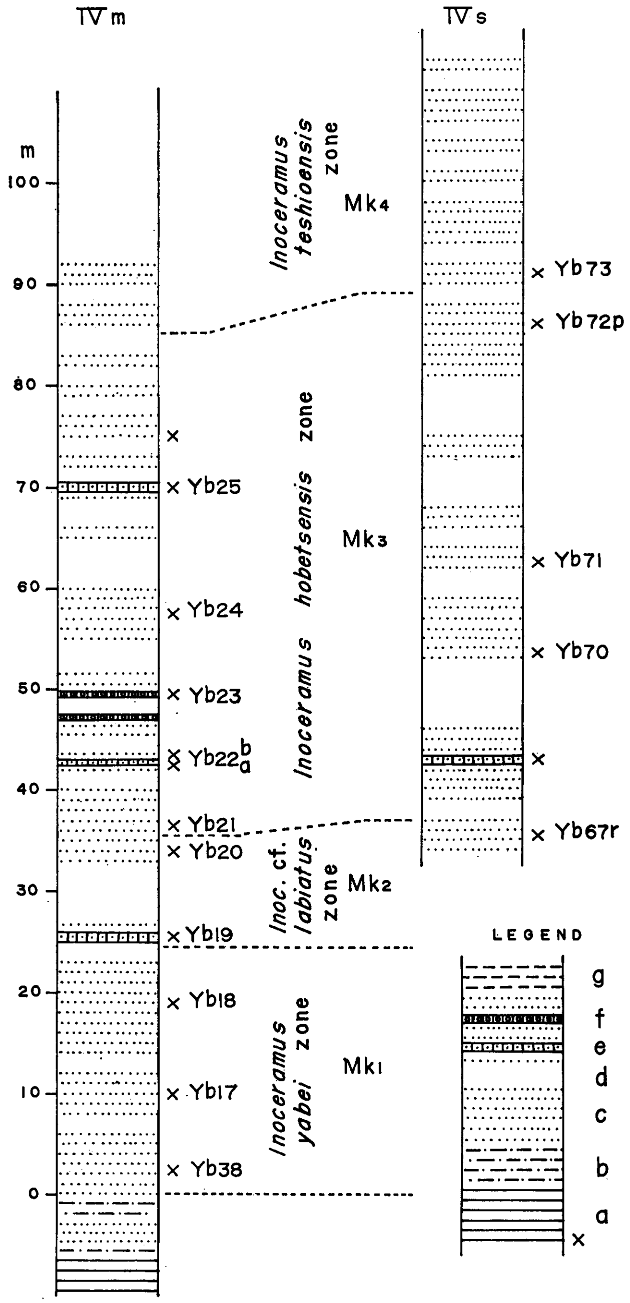

Fig. 3. Stratigraphic sections of the Mikasa Formation along the Yon-no-sawa, the fourth tributary of the Ponhorokabets, northeastern part of the Yubari dome. IVm: main stream, IVs: southern branch. Legend—×: Locality (or stratigraphic position) where fossils or rock samples were obtained, a: shale, b: shale and sandstone in frequent alternation, c: sandstone, d (blank): no exposure, e: calcareous sandstone, f: calcareous conglomerate, g: fine-sandy siltstone or silty very fine-sandstone.

there. The rocks exposed at locs. Yb 423 and Yb 424 on the hill side of the road above the southwestern coast of the artificial lake of the Ponhorokabets are probably to be referred to the same member.

Member Mk2 consists of thick-bedded sandstone, with occasionally intercalated laminae of sandy silt rich in plant drifts and also interbeds and nodulous layers of arenaceous limestone or calcareous sandstone. Its lower limit is defined at the base by 20 cm layer of calcareous sandstone with accumulated shells of *"Callista" pseudoplana, Apiotrigonia minor, Meekia* sp., etc.

The sandstone, as seen in a representative sample, is of graywacke type. Isolated pebbles may occur in a certain lamina, but the conglomerate is very rare. Fossils occur rather sparsely but laminae with abundant shells of *Apiotrigonia minor* or *Steinmannella (Yeharella) ainuana* are occasionally found. Ammonoids are rare but do occur. Certain sorts of problematic trace fossils are sometimes found in the sandstone.

Fossil localities are Yb 19, Yb 20, Yb 67r and Yb 423. *Inoceramus* spp. cf. *I. labiatus* and *I. capulus* are found among other mollusca.

Member Mk3 This consists primarily of fine- to medium-grained sandstones, with more or less lenticular bodies and nodules of arenaceous limestone or calcareous sandstone and variable amount of conglomerate. It is fairly variable in facies both vertically and horizontally.

Thick beds of medium-grained sandstone occupy the lower part (about 12-13 m) in the eastern area. This sandstone is rather of subgraywacke type. The lithological change from Mk2 to Mk3 is gradual, but the sandstones of Mk3 more commonly contain fossils, calcareous parts and also scattered pebbles. The species of *Inoceramus* would be a good key to distinguish the two units. More accumulated pebble-conglomerate, with some cobbles, occurs above the thick bed of sandstone, forming a layer of 20-50 cm, but other, thinner pebbly layers may be contained in the sandstone below the conglomerate. The pebbles and cobbles are well rounded chert and hard sandstone.

The rest main part of Member Mk3 in the eastern area of the Hatonosu Hills consists of the fine-grained graywacke or silty fine-sandstone with intercalated medium-grained sandstone of subgraywacke type. The repetition of the two kinds of rock may be found at each 40 to 70 cm thickness, but the bedding is not always well manifested. Calcareous nodules are sometimes contained in the fine-grained sandstone.

Small lenticular bodies of pebble-bearing calcareous sandstone or pebbly arenaceous limestone characteristically occurs in the lower part of Mk3 in the eastern area but may be found also in other parts. Some of them form a continuous bed and others occur as nodulous layers in the thick sandstone. They usually contain in abundance well preserved shells of *"Callista" pseudoplana, Apiotrigonia minor, Steinmannella (Yeharella) ainuana, Glycymeris hokkaidoensis, Pinna saitoi, Ostrea* sp., etc. The contained pebbles are well rounded and almost exclusively those of chert. Fossils and pebbles are sparsely distributed in the surrounding sandstone, too.

Fig. 4. Calcareous conglomerate in the lower part of Member Mk3. White matters are fossil shells in section. The specimen is in the upper course of the Ponhorokabets, northern part of the Yubari dome. The hammer is 35cm long.

In the upper part of Member Mk3 occur a few calcareous beds, each 50 cm or so thick, in which shells of *Glycymeris hokkaidoensis* and *Apiotrigonia minor* are accumulated but pebbles are rare.

Member Mk3 is generally more fossiliferous than Members Mk1 and Mk2. Fossils occur in the calcareous layers and nodulous bodies mentioned above and also in the sandstone itself. The calcareous nodules in the fine-grained sandstone contain amber and other drifted vegetable matters as well as shells. *Scaphites* may be found in this kind of nodule.

Numerous fossil localities, including those where rolled or fallen blocks (with suffix p or r) were obtained, are referred to Member Mk3 in the eastern area: Yb 1p, Yb 4r, Yb 11-Yb 15, Yb 21-Yb 25, Yb 23p, Yb 24p, Yb 28p, Yb 35p, Yb 38p2, Yb 49p, Yb 51p, Yb 53p, Yb 54p, Yb 62p, Yb 69-Yb 71, Yb 94p, Yb 95p, Yb 97p, Yb 99p, Yb 101p, Yb 108p, Yb 109p, Yb 120p, Yb 121p, Yb 122, Yb 122p, Yb 324, Yb 327, Yb 350, Yb 351, Yb 421c,d, Yb 422, Yb 426, Yb 427a-e and Yb 427r.

In addition to the species mentioned above, *Inoceramus hobetsensis* and *Pterotrigonia hokkaidoana* are common. Ammonoids are rather rare but have been found in some calcareous nodules in the silty fine-grained sandstone. Certain kinds of trace fossils are fairly common in sandstones.

Member Mk3 in the eastern part is about 50 m in thickness as measured along the section of the Yon-no-sawa.

In the western part of the Hatonosu Hills Member Mk3 is overlain unconformably by the Noborikawa Formation of the Ishikari Group (Lower

Tertiary coal measures), but its thickness attains 60 m along the creek of the Mosekidomé. Member Mk3 in this area is made up of calcareous, medium-grained sandstone and conglomerate in alternation. The pebbles of the conglomerate are well-rounded chert. *Steinmannella (Yeharella) ainuana* and other shells are sometimes found in the calcareous sandstone (locs. Yb 208, Yb 220p, Yb 250p, Yb 252p, Yb 263p, etc.) but Mk3 in the western area is not so fossiliferous as that in the eastern area.

Member Mk4 This is developed only in the eastern part of the Yubari dome. In other part it had been eroded away before the Ishikari Group unconformably overlay the Cretaceous rocks. It is exposed along the lowest course of the Ponhorokabets, on the Shihorokabets above the confluence with the Ponhorokabets, and upper reaches of the first and the fourth tributaries [Ichi-no-sawa and Yon-no-sawa] of the Ponhorokabets. Its thickness is 70-80 m, as estimated near the confluence of the Ponhorokabets with the Shihorokabets.

Member Mk4 consists almost exclusively of muddy, fine-grained sandstone, containing calcareous nodules. Bedding or lamination is not so well developed as in Member Mk3 and only thin layers of medium- to coarse-grained sandstone are intercalated in some parts.

In the upper part of Member Mk4 minute patches of glauconite are contained in the calcareous nodules and in its uppermost part fine grains of glauconite occur more commonly in the sandstone itself but are not so densely accumulated as to make the rock perfectly green. The sandstone is somewhat calcareous at the top of Member Mk4. Fragments of light coloured pumice of probably acid volcanics are sometimes contained in the calcareous nodules.

Fossils are fairly common in Member Mk4, occurring in the calcareous nodules and also in the country rocks. Ammonoids, both the coiled ones and heteromorpha, occur more commonly in Member Mk4 than in Members Mk1-3. *Inoceramus teshioensis* and other pelecypods are also common. Drifted wood and other small plant remains are frequently intermingled with the marine mollusca in the calcareous nodules. A gigantic *Mesopuzosia* (now preserved at the National Science Museum, previously collection of the Geological Survey of the Hokkaido Steamship and Colliery Co., Ltd.) once occurred from this member (about the middle of the beds exposed at loc. Yb 29).

The fossil localities which are referred to Member Mk4 are Yb 29, Yb 41, Yb 42, Yb 43, Yb 57p, Yb 58p, Yb 62p, Yb 86p, Yb 87, Yb 92p (?), Yb 320-Yb 323, etc.

Upper Yezo Group

The Upper Yezo Group is developed on the northeastern and southeastern marginal part of the Yubari dome forming a narrow belt. This narrowness is due partly to the slow deposition and partly to the great erosion before the Ishikari Group unconformably covered the Cretaceous. The Upper Yezo Group in this area is stratigraphically divided into two parts, the basal and the main, which are called here Member U1 and Member U2 respectively.

Member U1 This is best exposed on the hanging wall at the confluence of the Pomporokabets with the Shihorokabets (loc. Yb 33). Other exposures are in a creek southwest of the Hospital of Yubari Coal-mine and in the upper reaches of the third tributary [San-no-sawa] of the Pomporokabets. The thickness of the unit is about 10 m.

Member U1 consists of dark green sandy mudstone and muddy fine-grained sandstone. The sediments contain glauconite in abundance. The lithological change from Mk4 to U1 is rather abrupt and there may be a stratigraphic gap at the base, although there is no structural angularity.

Member U1 contains fossiliferous calcareous nodules. Ammonoids of both coiled, less ornate group and heteromorpha, *Inoceramus mihoensis, Propeamussium* and *Dentalium* are often intermingled with drifted plant remains. The fossil localities are Yb 33p1, p2, p3 and Yb 64p1, p2.

Member U2 This forms the main part of the Upper Yezo Group in the Yubari dome. It consists primarily of black shale with some intercalation of thin sandstone. At the basal part of U2, as in Member U1, the rock is greenish

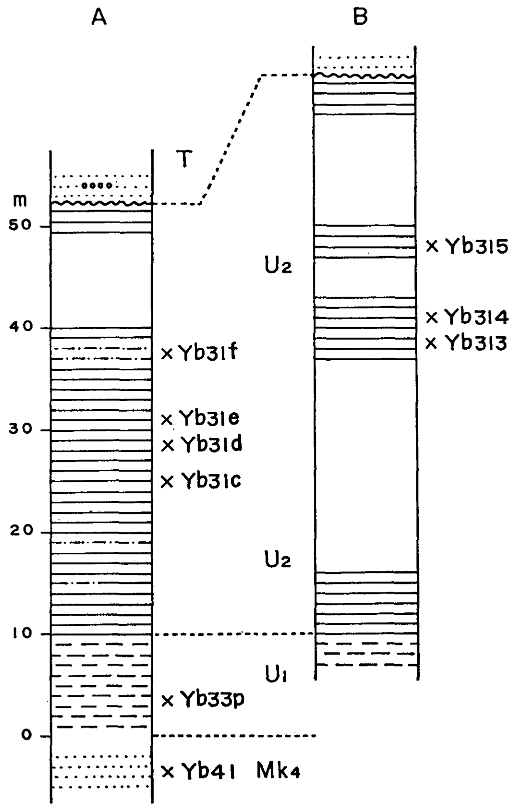

Fig. 5. Stratigraphic sections of the Upper Yezo Group.
A: along the road southwest of the Asahi-machi Street,
B: on the left bank of the Shihorokabets, on the southeastern margin of the Yubari dome.
See Fig. 3 for legend.

on account of its glauconite contents, but unlike that in Member U1, it is devoid of sand grains. The main part of Member U2 is free from sandstone intercalation, but the upper part and a portion of the lower part occasionally have thin interbeds and lenses of compact, fine-grained, calcareous sandstone and those of bentonitic tuffite. The shale is well stratified and contains calcareous nodules of various size. Some amount of glauconite is found also in the upper part.

The thickness of Member U2 is estimated at about 55 m along the stream of the Shihorokabets, about 45 m along the road west of the stream and still somewhat thinner at an exposure south of the Hospital of the Yubari Coal-mine. This variation is probably due to the unconformity at the base of the Noborikawa Formation.

Member U2 is fairly fossiliferous. Fossils occur abundantly in some nodules, as in the Upper Yezo Group in other areas. Ammonoids of both coiled, less ornate group and heteromorpha, *Inoceramus* and *Propeamussium* are common. The specific names and localities are indicated in Table 4.

Explanation for Table 1 (p. 92-93)

Every locality number has a prefix Yb.

Abbreviations for the names of streams and hills are as follows:

- I: Ichinosawa (First tributary of the Ponhorokabets) [一の沢]
- IIIm: San-no-sawa, Honryu (Main stream of the third tributary of the Ponhorokabets) [三の沢]
- IIIn: San-no-sawa, Kitazawa (North branch of the third tributary of the Ponhorokabets) [三の沢北支流]
- IVm: Yon-no-sawa, Honryu (Main stream of the fourth tributary of the Ponhorokabets) [四の沢]
- IVs: Yon-no-sawa, Minamisawa (South branch of the fourth tributary of the Ponhorokabets) [四の沢南支流]
- Bo: Boat-noriba-no-sawa [ボート乗場の沢]
- Ch: Chogoe-zawa [蝶越沢]
- Ek: Ekimoanruru [エキモアンルル川]
- Ht: Top of the Hatonosu Hills [鳩巣山頂上]
- Ko: Kosen-no-sawa [鉱泉の沢]
- Mo: Mosekidome-zawa [モセキドメ沢]
- Pl: Lower course of the Ponhorokabets [ポンホロカベツ川下流]
- Pm: Middle course of the Ponhorokabets [ポンホロカベツ川中流]
- Pu: Upper course of the Ponhorokabets [ポンホロカベツ川上流]
- Pw: Western small branch of the lower Ponhorokabets [ポンホロカベツ川下流西側小沢]
- Se: East side of the Shihorokabets [志幌加別川の東側]
- Sh: Shihorokabets [志幌加別川]
- Sw: West side of the Shihorokabets [志幌加別川の西側]
- To: Tokei-no-sawa, a tributary of the Utagoe-zawa [歌越沢支流時計の沢(仮称)]
- Ut: Utagoe-zawa [歌越沢]

For locations see Fig. 1 and Route Map (Plate 11).

Table 1. List of collecting localities

Loc. Yb	Stream	Member	Loc. Yb	Stream	Member
1p_1, p_2	Pl	Mk3	51	Pm	L2
4r	Pl	Mk3	51p	Pm	Mk3 (?)
8	Pl	Mk3	52a	Pm	Mk1 (?)
11	Pl	Mk3	52b	Pm	Mk1 (?)
12	Pl	Mk3	53r	IIIm	L2
13	Pl	Mk3	53p	IIIm	Mk3
14	Pl	Mk3	54	IIIm	L2
15	Pl	Mk3	54p	IIIm	Mk
16	Pm	L1	55	IIIm	L2
17	IVm	Mk1	56p	IIIm	Mk
18	IVm	Mk1	57p	IIIn	Mk4
19	IVm	Mk2	58p	IIIn	Mk4
20	IVm	Mk2	59p	IIIn	Mk4
21	IVm	Mk3	60p	IIIn	Mk4
22	IVm	Mk3	61p	IIIn	Mk4
23	IVm	Mk3	62p	IIIn	Mk3
24	IVm	Mk3	63	IIIn	?
24p, r	IVm	Mk3	64p	IIIn	U1
25	IVm	Mk3	65p	IIIn	U2
26	Pm	L2	66	IIIn	T
27	Pm	L2	67r	IVs	Mk2
28	IVm	Mk1/L2	69	IVs	Mk3
29	Sw	Mk4	70	IVs	Mk3
30p	Sw	U2	71	IVs	Mk3
31	Sw	U2	72p	IVs	Mk4
32p	Sw	U2	73	IVs	Mk
33p	Pl	U1	74	IVs	Mk4 (?)
34r	IVm	L2	75	IVs	Mk4 (?)
35p	IVm	Mk	76p	IVs	Mk4 (?)
36p	IVm	Mk4	77	IVs	T
38	IVm	Mk4	80, 80p	Pw	Mk3
38p	IVm	Mk3	81, 81p	Pw	Mk3
39a	IVm	Mk1	82	Pl	Mk3
39b	IVm	Mk1	83	Pl	Mk3
39p	IVm	L2	84p	I	Mk4
40p	IVm	Mk	85p	I	Mk
41	Pl	Mk4	86p	I	Mk4
42	Pl	Mk4	87p	I	Mk4
43	Pl	Mk4	91p	Bo	Mk3
44	Pl	Mk3	92p	Bo	Mk4 (?)
45	Pl	Mk3	93p	Bo	Mk4
48	Pm	L2	94p	Bo	Mk3
49p	Pm	Mk3	95p	Bo	Mk3
50p	Pm	Mk1	96p	Bo	Mk4 (?)

Loc. Yb	Stream	Member	Loc. Yb	Stream	Member
97p, r	Bo	Mk4 (?)	265	To	Mk
98	Bo	T	296	Ut	L2
99p	Pm	Mk	297	Ut	L2
100	Pm	L2	300p	Sh	U2
100p	Pm	Mk	305	Sw	U2
101p	Pm	Mk	311	Sw	U2
103	Pu	L1	312	Sw	U2
104	Pu	L2	313	Sh	U2
105	Pu	L2	314	Sh	U2
106	Pu	L2	315	Sh	U2
107p	Pu	L2	320	Se	Mk4
108p	Pu	Mk3	321	Pl	Mk4
109	Pu	L2	322	Pl	Mk4
109p	Pu	Mk	323	Pl	Mk4
110	Pu	L2	324	Pl	Mk3
111	Pu	L2	325	Pl	Mk3
112r	Pu	L2	326	Pl	Mk3
113	Pu	L2	327	Pl	Mk3
113p	Pu	L2	328	Pl	Mk3
114	Pu	L2	329	Pl	Mk3
115p	Pu	L2	330	Pl	Mk3
116p	Pu	L2	331	Pl	Mk3
117r	Pu	L2	332	Pl	Mk3
118	Pu	Mk (?)	333	Pl	Mk3
119	Pu	Mk3	350	Pl	Mk3
120p	Pu	Mk3	351	Pl	Mk3
121p	Pu	Mk3	352	Pl	Mk3
122	Pu	Mk3	410	Pu	L2
201	Ek	Poronai	411	Pm	L1
208	Ch	Mk3	412	Pm	L1
211	Mo	Mk3	413	Pm	L1
212	Mo	Mk3	416	Pm	L2
213	Mo	Mk3	417	Pm	L2
220p	Ut	Mk3 (?)	418	Pm	L2
224	Ut	L2	421a	Pm	Mk
236	Ut	L2	421b	Pm	Mk
237	Ut	L2	421c	Pm	Mk3 (?)
242	Ut	L1	421d	Pm	Mk3
245	Ut	L1	422	Pm	Mk2
250p	Ut	Mk3	426	Pm	Mk3
252p	Ut	Mk3	427	Pm	Mk3
253	Ut	Mk3	427a	Pm	Mk3
256p	Ut	Mk3	427b	Pm	Mk3
257p	Ut	Mk	427c	Pm	Mk3
263p	Ut	Mk3	427d	Pm	Mk3
			427e	Pm	Mk3

Biostratigraphic Sequence and Geologic Age

The fossils from the stratigraphic units described in the preceding chapter are listed in Tables 2-4. They are mostly identified by us, although some are preliminarily. The Baculitidae have been identified and already monographed by MATSUMOTO and OBATA (1963). Many of others may likewise need full palaeontologic descriptions. The fossils described by previous authors cannot be listed in the same tables, because it is difficult to refer them exactly to the subdivisions in this paper.

Some of the listed species, such as *Glycymeris hokkaidoensis, Apiotrigonia minor* and *"Callista" pseudoplana,* are long-ranging and restricted to a particular sedimentary facies, although they occur in abundance. If we furthermore take into consideration the occurrence in other areas, we can distinguish the species which are relatively valuable for the age determination from those which are not.

The explanation and discussion are given below with regard to the biostratigraphic sequence and the geologic age of the Cretaceous rocks in the Yubari dome. In connection with the correlation palaeontologic remarks may be concisely given for certain species (see also Plate 9).

Member L1.—This is very poor in fossils, except for an occurrence of *Inoceramus anglicus* WOODS (See Pl. 9, Fig. 2). On this evidence and from the stratigraphic position lying below L2, Member L1 is referable to the Albian, but what part of the Albian is not exactly determined.

Member L2.—The most common species in this member is *Mortoniceras (Cantabrigites) imaii* (YABE and SHIMIZU) (See Pl. 9, Fig. 4). It occurs throughout the whole thickness of L2, although it is most common in the main, middle part of L2. Other species of *Mortoniceras,* of which *M. (Deiradoceras)* sp. is found at loc. Yb 53r in the middle part of L2, *Pseudhelicoceras* n. sp. (Pl. 9, Figs. 6, 7), *Hamitoides* sp. and *Inoceramus concentricus subsulcatus* Wiltshire (Pl. 9, Fig. 3) are the good associates. The assemblage indicates the Upper Albian and the strata characterized by this assemblage can be called the zone of *Mortoniceras (Cantabrigites) imaii,* or simply the *imaii* zone.

Among other less ornate, possibly long-ranging ammonoids, *Hypophylloceras* n. sp. (Pl. 9, Fig. 8) resembles *Hypophylloceras* n. sp. of PACKARD (1960, p. 425, pl. 56, fig. 2 only) from California but differs from *Hypophylloceras californicum* ANDERSON (1938, p. 143, pl. 12, fig. 7; IMLAY, 1960, p. 98, pl. 11, fig. 29) from the Lower to Middle Albian of California and Alaska. PACKARD's *Hypophyllocares* n. sp. is of uncertain stratigraphic position, but one of the specimen from Alaska described by MATSUMOTO (1959a, p. 55, pl. 12, fig. 4 only) as *Neophylloceras seresitense* (PERVINQUIÈRE) is better referable to it rather than the true *N. seresitense.* While the true example of *N. seresitense,* i.e. the other specimen of MATSUMOTO (1959a, p. 55, pl. 12, fig. 5; text-fig. 3), came from USGS. Mes. loc. 25445, a probably Cenomanian part of the sequence in the Upper Chitina valley, Alaska, that specimen of *Hypophylloceras* cf. *H.* n. sp.

Table 2. List of fossils from the lower part of the Middle Yezo Group in the Yubari dome (Hatonosu Hills)

Species	L1	L2
Ammonoidea		
Hypophylloceras n. sp. of PACKARD, 1960		Yb 53r, 34r, 296
Desmoceras sp. cf. *D.* (*Pseudouhligella*) *dawsoni* WHITEAVES		Yb 34r, 53r, 418
D. sp. cf. *D.* (*P.*) *vetus* MURPHY and RODDA		Yb 53r, 410
Puzosia subcorbarica (YABE MS.) MATSUMOTO		Yb 27, 53r, 224, 410(?)
Hulenites n. sp. aff. *Puzosia alaskana* IMLAY		Yb 34r, 53r
Marshallites sp.		Yb 27, 53r
Mortoniceras (*Cantabrigites*) *imaii* (YABE and SHIMIZU)		Yb 27, 28, 34r, 39, 48, 53r, 107p(?) 109, 110, 111, 112, 112r, 410, 416
Mortoniceras (*s. l.*) sp.		Yb 34r, 53r, 48(?), 109(?)
M. (*Deiradoceras*) sp.		Yb 53r
Stoliczkaia (?) sp.		Yb 297
Tetragonites sp.		Yb 53r
Anagaudryceras sacya (FORBES)		Yb 53r, 224, 231
Pseudhelicoceras n. sp.		Yb 34r, 53r, 297
Hamites (*s. s.*) sp.		Yb 236
Hamitoides sp.		Yb 34r, 112r, 117r
Lechites (?) sp.		Yb 34r
Bivalvia		
Cucullaea sp.		Yb 26
Propeamussium cowperi yubarensis YABE and NAGAO		Yb 26, 27, 34r, 53r, 39p, 117r
Inoceramus anglicus WOODS	Yb 245	Yb 34r, 247
I. sp. of I. *anglicus-crippsi* group		Yb 48, 53r
I. concentricus subsulcatus WILTSHIRE		Yb 34r, 53r
I. sp.		Yb 236
Lucina (*Myrtea*) *ezoensis* NAGAO		Yb 27, 34r, 53r, 116p, 224(?)
Solemya sp. cf. *S. angusticaudata* NAGAO		Yb 34r
Others		
Belemnites (*s. l.*) sp.		Yb 34r
Annelid, indet		Yb 34r, 105
Makiyama sp.		Yb 53r
Protunites sp.		Yb 34r
Cladophlebis sp.		Yb 26, 34r

of PACKARD was derived from USGS. Mes. loc. 25442, a probably Albian part of the same sequence.

The specimens of *Desmoceras* spp. from L2 are secondarily deformed but are comparable to *Desmoceras* (*Pseudouhligella*) *dawsoni* WHITEAVES, from the Haida formation of British Columbia and the Albian of California and Alaska, and to *Desmoceras* (*Pseudouhligella*) *vetus* MURPHY and RODDA, 1959, from the Upper Albian *hulenana* zone of northern California.

Examples of *Puzosia subcorbarica* (YABE MS.) MATSUMOTO, 1954 from L2 (Pl. 9, Fig. 9) closely resembles the holotype from the main part (shale) of the Middle Yezo Group above the Ikushumbets gorge. *Hulenites* n. sp. (Pl. 9, Fig. 5) from L2 is apparently similar to but not quite identical with "*Puzosia*" *alaskana* IMLAY (1960, p. 104, pl. 16, figs. 1-13) from the bed with *Brewericeras breweri* of Alaska.

The specimens of *Marshallites* sp. from L2 are too fragmentary to be accurately identified, but they are similar to *Marshallites cumshewaensis* (WHITEAVES) from Queen Charlotte Island, British Columbia and Alaska (see MATSUMOTO, 1959a, p. 63, 64).

These and other associated species make no objection against the conclusion that Member L2 represents the zone of *Mortoniceras* (*Cantabrigites*) *imaii* and that it is assigned to Upper Albian.

Member Mk1.—This is referred to the Lower Gyliakian [K4α], i.e. approximately Cenomanian in terms of the international scale, because *Inoceramus yabei* NAGAO and MATSUMOTO and *Inoceramus concentricus nipponicus* NAGAO and MATSUMOTO occur in the sandstone. The principal part of Mk1, as represented by loc. Yb 38 and Yb 18 in the section of the Yon-no-sawa, is regarded as belonging to the zone of *Inoceramus yabei*—*I. concentricus nipponicus* in MATSUMOTO's (1959b, chart in pl. 8) scheme.

Unfortunately no ammonoids have been obtained from Mk1, and accordingly finer subzonal correlation is impossible. Whether or not the Infragyliakian [K3γ], i.e. the zone of *Desmoceras kossmati,* is included in the lower part of Mk1 cannot either be decided with certainty. The occurrence of *Inoceramus* aff. *I. crippsi* MANTELL as a rolled block at loc. Yb 50p suggests the existence of K3γ in the sandstone of Mk1.

A short remark must be given on this occasion about *Inoceramus yabei* NAGAO and MATSUMOTO, 1940. This species was established on a number of syntypes, although the two authors indicated typical examples. Since there is a homoeomorphic similarity, a confusion may arise from this situation. In fact one of the illustrated specimen in NAGAO and MATSUMOTO (1940, pl. 2, fig. 8a, b) has proved to belong to another species, *Inoceramus mihoensis* MATSUMOTO, 1957, of Lower Senonian age. Misidentification of *Inoceramus teshioensis* NAGAO and MATSUMOTO with *I. yabei* would likewise occur especially when the preservation is unfavourable. The specimen illustrated by NAGAO and MATSUMOTO, 1939, as Fig. 6a, b on their plate 34 [12], from the lower part of the Mikasa Formation [="*Trigonia* Sandstone] of the Ikushumbets area, is here designated as the lectotype. The specimens in our collection from Member Mk1 are well identified with this lectotype. *Inoceramus yabei,* thus defined, is allied to *Inoceramus crippsi* MANTELL, but its valves are more inflated than those of the latter and it is somewhat inequivalve, with a more prominent and more incurved, left umbo than the right.

Member Mk2.—This member is not prolific in fossil, but the occurrence of *Inoceramus* cf. *I. labiatus* (SCHLOTHEIM) and *I.* cf. *I. capulus* SHUMARD enables us to correlate it with the zone of *Inoceramus labiatus* in the Ikushumbets area and to refer it to the Lower Turonian. The associated ammonoids, *Mesopuzosia indopacifica* (KOSSMAT) and *Hyphantoceras* sp., are common in the Turonian, although they are not short-lived zonal indices. Among other mollusca *Apitotrigonia minor* (YABE and NAGAO) and *"Callista" pseudoplana* YABE and NAGAO range throughout the Upper Cretaceous in Hokkaido.

Member Mk3.—This is characterized by the common occurrence of *Inoceramus hobetsensis* NAGAO and MATSUMOTO from bottom to top and undoubtedly assigned to the zone of *Inoceramus hobetsensis* in the middle part of Upper Gyliakian [K4β] in Japan, approximately Middle Turonian in terms of the international scale (see MATSUMOTO, 1959b). In spite of our efforts a good zonal index of ammonite, such as *Collignoniceras woollgari* (MANTELL) or *Collignoniceras bakeri* (ANDERSON), has not been found. The associated ammonoids are *Mesopuzosia pacifica* MATSUMOTO, a Turonian species, and other long-ranging species, *Gaudryceras denseplicatum* (JIMBO), *Hyphantoceras* sp., *Scaphites* cf. *S. planus* (YABE), *Otoscaphites puerculus* (JIMBO) and *Neophylloceras* cf. *N. ramosum* (MEEK). Other mollusca, such as *Apiotrigonia minor* (YABE and NAGAO), *Pterotrigonia hokkaidoana* (YEHARA), *Steinmannella* (*Yeharella*) *ainuana* (YABE and NAGAO), *Glycymeris hokkaidoensis* YABE and NAGAO, *"Callista" pseudoplana* YABE and NAGAO, *Pinna saitoi* NAGAO, occur in abundance in Member Mk2, but they are so long-ranging that are not necessarily useful for the zonal correlation here attempted. The occurrence of *Pterotrigonia hokkaidoana* in Mk3, i.e. the zone of *Inoceramus hobetsensis*, probably indicates the upper limit of the stratigraphic range of this species.

We should like to give here a few remarks on the three specimens described by JIMBO (1894). An illustrated specimen of *Trigonia longiloba* JIMBO (1894, p. 42, pl. 8, fig. 2), i.e. lectotype of *Acanthotrigonia longiloba* (JIMBO) (KOBAYASHI and NAKAO, 1957, p. 235, pl. 17, fig. 6; MATSUMOTO, 1963, p. 45, pl. 67, fig. 2), and that of *Inoceramus angulosus* JIMBO (1894, p. 43, pl. 8, fig. 6) are recorded to have come from the sandstone on the right side of the Ponhorokabets. From this record and from the lithology of the specimens the source can be presumed to be a cliff of Member Mk3. We have failed, however, to find the specimens which can be precisely identified with them. Even Dr. NAKANO, a specialist in the Cretaceous trigonians in Japan, has not ascertained any example of *Acanthotrigonia longiloba* in our collection from the sandstone of the Ponhorokabets.

The holotype, by monotypy, of *Inoceramus angulosus* JIMBO is preserved in the University of Tokyo (with reg. no. I-150). On examining it we have noticed its similarity to an anterodorsal part of a large specimen of *Inoceramus hobetsensis* NAGAO and MATSUMOTO, but the former is more globose than the latter. It might be a broken fragment of *Inoceramus iburiensis* NAGAO and MATSUMOTO, but we have collected no example of *I. iburiensis* from the Mikasa formation of the Yubari dome. Anyhow JIMBO's specimen is so incompletely preserved that identity with the better known species cannot be definitely

Table 3. List of fossils from the Mikasa Formation of the Yubari dome (Hatonosu Hills)

Species	Mk1	Mk1	Mk3	Mk4
Ammonoidea				
Neophylloceras sp. cf. *N. ramosum* (MEEK)			Yb 15	Yb 42
Damesites sp.				Yb 29c
Mesopuzosia pacifica MATSUMOTO			Yb 15, 23p, 25, 427	Yb 58p
M. indopacifica (KOSSMAT)		Yb 67r, 423		
M. yubarensis (JIMBO)				Yb 41a,d, Yb 295
Snbprionocyclus neptuni (GEINITZ)				Yb 36p
S. normalis (ANDERSON)				Yb 87p
Reesidites sp. cf. *R. minimus* (HAYASAKA and FUKADA)				Yb 41a
Tetragonites glabrus (JIMBO)			Yb 24p, 427 dp2	Yb 29c
Gaudryceras denseplicatum (JIMBO)			Yb 427 d3	Yb 42
"*Bostrychoceras*" n. sp. aff. "*B.*" *indicum* (STOLICZKA)				Yb 42
Scalarites mihoensis WRIGHT and MATSUMOTO				Yb 29, 57p, 58p, 60p, 72p
Scalarites sp.			Yb 24p, 25	
Hyphantoceras sp.		Yb 423	Yb 421c	
Gen. et sp. nov. (Nostoceratinae)				Yb 36p, 42
Pseudoxybeloceras n. sp.				Yb 62p
Sciponoceras sp.				Yb 29, 43
Baculites undulatus ROMAN and MAZERAN				Yb 87p, 84p (?)
Scaphites yokoyamai JIMBO			Yb 427a	Yb 36p
Otoscaphites puerculus (JIMBO)			Yb 49p, 427dp	Yb 36p
Gastropoda				
Pugnellus (*Gymnarus*) *yabei* NAGAO			Yb 108p (?)	
Turritella cf. *soratiense* NAGAO			Yb 108p (?)	
Piestochilus laevigatus NAGAO			Yb 256p (?)	
Avellana problematica NAGAO			Yb 108, 252p, 263p	Yb 29c
Ataphrus teshioensis NAGAO			Yb 108p (?)	
Scaphopoda				
Dentalium sp.				Yb 29, 57p, 58p, 59p
Bivalvia				
Yoldia (?) sp.			Yb 263p	
Acila sp.			Yb 69	
Cucullaea ezoensis YABE and NAGAO			Yb 256p	
Glycymeris hokkaidoensis (YABE and NAGAO)		Yb 19	Yb 22, 23, 25, 53p, 69, 108p, 120p, 250p, 263p, 327, 351, 422, 426, 427a	
Jupiteria (*Ezonuculana*) *mactraeformis* (NAGAO)			Yb 11, 13, 53p, 108, 109, 120p, 122p, 250p	

Species	Mk1	Mk2	Mk3	Mk4
Propeamussium cowperi yubarensis YABE and NAGAO				Yb 29, 57p
Ostrea sp.			Yb 422, 427a	
Pinna saitoi NAGAO			Yb 427a	
Inoceramus yabei NAGAO and MATSUMOTO	Yb 36p2, 38			
I. sp. aff. *I. crippsi* MANTELL	Yb 50p			
I. concentricus nipponicus NAGAO and MATSUMOTO	Yb 18, 36p, 52p, 352			
I. concentricus costatus NAGAO and MATSUMOTO			Yb 1p1	Yb 43, 58p, 60p, 96p, 97r
I. capulus SHUMARD		Yb67 r		
I. sp. cf. *I. labiatus* (SCHLOTHEIM)		Yb67 r		
I. hobetsensis NAGAO and MATSUMOTO			Yb 1p2, 4r, 21, 24, 24p, 25, 49p, 51p, 62p, 70, 71, 80p, 81p, 94p, 95p, 108p, 120p, 247, 324, 350, 421d, 427, 427b-e	
I. teshioensis NAGAO and MATSUMOTO				Yb 29, 41, 42, 57p, 58p, 59p, 60p, 61p, 72p, 84p, 86p, 92p, 93p, 97p, 322b
I. tenuistriatus NAGAO and MATSUMOTO				Yb 29, 41, 87p
Apiotrigonia minor (YABE and NAGAO)		Yb 19, 67r, 423	Yb 1p1, 11, 13, 14, 21, 22, 24, 25, 38p2, 53, 422, 426, 427a	Yb 43
Pterotrigonia hokkaidoana (YEHARA)		Yb 423	Yb 25, 54p, 101p, 121p, 421, 422, 427	
Steinmannella (*Yeharella*) *ainuana* (YABE and NAGAO)		Yb 423	Yb 108p, 121p, 220p, 250p, 422, 426, 427	
Lucina (*Myrtea*) *ezoensis* NAGAO				Yb 29d, 57p, 59p
"*Callista*" *pseudoplana* YABE and NAGAO	Yb 17	Yb 19, 20, 67r, 423	Yb 13, 21, 22, 23, 69, 97p, 99p, 108p, 109p, 120p, 121p, 220p, 250p, 263, 422, 426, 427a	
"*Meekia*" spp.		Yb 19, 20, 423	Yb 13, 23, 91p, 108p, 120p, 122, 208, 252p, 327, 422, 426	Yb 29h, 41b, e
Dreissenia sp.			Yb 422, 426	
Tellina (?) sp.			Yb 252p	
Spisula tellinoides NAGAO and OTATUME			Yb 108p, 211, 252p, 263p	Yb 76p
Periplomya (?) sp.			Yb 256p	Yb 58p
Panopea sp.		Yb 423	Yb 28p, 35p, 38p2, 53p2, 427a	

Species	Mkl	Mk2	Mk3	Mk4
Teredo sp.			Yb 427	
Others				
Crinoids			Yb 70	Yb 97p
Broad leaves		Yb 423	Yb 24, 427	

concluded.

The third specimen to be mentioned is the holotype of *Lytoceras denseplicatum* JIMBO (1894, p. 36, pl. 7, fig. 1). According to JIMBO it came from a sandstone near the source of the Ekimonaanoro, now called the Ekimoanruru. This part is probably referred to Member Mk3 of the western area, but we have sought there in vain another adult shell as large as JIMBO's original specimen. We have obtained an immature shell of the same species from a calcareous nodule in Mk3 of the eastern area. *Gaudryceras denseplicatum* occurs more commonly in the muddy facies in Hokkaido and has a long stratigraphic range from K4β to K5γ.

Member Mk4.—This is characterized by the common occurrence of *Inoceramus teshioensis* NAGAO and MATSUMOTO, sometimes accompanied with *Inoceramus tenuistriatus* NAGAO and MATSUMOTO and also with such species of ammonites as mentioned below. Thus it evidently represents the zone of *Inoceramus teshioensis* in the upper part of Upper Gyliakian and is certainly correlated with the Upper Turonian in terms of the international scale (see MATSUMOTO, 1959b).

Subprionocyclus neptuni (GEINITZ), a world-wide index of the Upper Turonian, is found in Mk4, although it is rather rare. *Reesidites* sp. (immature) cf. *R. minimus* (HAYASAKA and FUKADA) is found near the top of Mk4, i.e. in the uppermost part of the zone of *Inoceramus teshioensis*. This is in harmony with the stratigraphic occurrence of that species in the Ikushumbets valley (see pl. 7 in MATSUMOTO, 1959b) and probably represents the subzone of *Reesidites minimus* in the Yubari dome. In rolled blocks washed out from the relatively upper part of Mk4 *Baculites undulatus* ROMAN and MAZERAN is found together with *Subprionocyclus normalis* (ANDERSON). This assemblage is again the same as that in the *normalis* zone just below the *minimus* zone in the Ikushumbets valley. *"Bostrychoceras"* sp. aff. *"B." indicum* (STOLICZKA), which probably needs a revised generic assignment, and another diagnostic, entirely new, aberrant ammonoid (Nostoceratid) are also found in the upper part of the zone of *Inoceramus teshioensis* as in the Ikushumbets area.

It is interesting to find examples of *"Pseudoxybeloceras* (?)*"* sp. aff. *Hyphantoceras venustum* (YABE) from Yb 62p, because one of us (T.M.) once collected the same species, together with *Subprionocyclus* sp. cf. *S. neptuni*, at loc. TM. 7001 [=C1T. 79] in the transitional part from the Baker Canyon Conglomerate to the Holz Shale of the Santa Ana Mountains, southern California (see MATSUMOTO and POPENOE *in* MATSUMOTO, 1960, p. 65).

Many other species from Mk4 are long-ranging, of which *Mesopuzosia yubarensis* (JIMBO), *Scalarites mihoensis* WRIGHT and MATSUMOTO, *Scaphites yokoyamai* JIMBO and *Otoscaphites puerculus* (JIMBO) are not uncommon. These species range from K4β [Upper Gyliakian] to K5α [Lower Urakawan, i.e. Coniacian].

Member U1.—In the fossils derived from Member U1 there are *Baculites yokoyamai* TOKUNAGA and SHIMIZU and *Baculites schencki* MATSUMOTO, which have recently been described by MATSUMOTO and OBATA (1963). These species indicate the Lower Urakawan, i.e. Coniacian in terms of the international scale. In the normal sequence in Hokkaido the zone of *Inoceramus uwajimensis* lies above the zone of *Inoceramus teshioensis*. *I. uwajimensis* is really widespread in various parts of the Japanese Islands and adjacent areas, occurring in abundance regardless of a certain extent of variation in sedimentary facies. In the Ikushumbets area, for instance, numerous specimens of this species are contained in a bed of green sandstone and also calcareous nodules in the adjacent fine-sandy siltstones. Despite the resemblance in lithology, unmistakable examples of *I. uwajimensis* have not been found from the glauconitic fine-grained sandstone and sandy mudstone of Member U1 of the Yubari area, while *Inoceramus mihoensis* MATSUMOTO has been obtained from a nodule. The latter species is most common in the transitional part between the zone of *I. uwajimensis* and that of *I. amakusensis*, although it is sometimes found in the same bed as *I. uwajimensis*. Taking this and other facts into consideration, we are inclined to consider a high possibility that the main part of the zone of *Inoceramus uwaimensis* is lacking in the Yubari dome. In other words there may be a certain kind of break in sedimentation—at least a local diastem, if not a regional disconformity—at the base of the Upper Yezo Group in the Yubari dome.

Member U2.—This is characterized by the common occurrence of *Inoceramus naumanni* YOKOYAMA. From its comparatively lower part *Inoceramus* cf. *I. amakusensis* NAGAO and MATSUMOTO and from the upper part *Inoceramus orientalis nagaoi* MATSUMOTO and UEDA have been obtained. Member U2 is, thus, reasonably referred to the Upper Urakawan [K5β], approximately Santonian.

The associated ammonoids are mostly long-ranging species of the Urakawan [Coniacian—Lower Campanian]. *Baculites princeps* MATSUMOTO and OBATA, among others, indicates in our present knowledge the Upper Urakawan (see MATSUMOTO and OBATA, p. 55, 71, 80). No examples of distinctly ornate and short-lived ammonites, such as species of *Texanites* and *Pseudoschloenbachia*, have been found from U2.

For the reason of stratigraphic and palaeontologic break, the Campanian and Maestrichtian are completely lacking in the Yubari dome. The time gap represented by the unconformity at the base of the Noborikawa Coal Measures (Eocene Ishikari Group) is great in the area of the Yubari dome.

Table 4. List of fossils from the Upper Yezo Group of the Yubari dome (Hatonosu Hills)

Species	U1	U2
Ammonoidea		
Neophylloceras ramosum (MEEK)	Yb 64p2	Yb 32p1, 313 (?)
Phyllopachyceras sp.	Yb 64p2	
Damesites sp.	Yb 64p2	Yb 31c3, 313, 314
Neopuzosia ishikawai (JIMBO)		Yb 31e
Anapachydiscus sp.	Yb 33p1	Yb 31c3, 300p
Tetragonites glabrus (JIMBO)	Yb 64p2	
Gaudryceras tenuiliratum YABE	Yb 33p3, 64p1, p2	
Polyptychoceras obstrictum (JIMBO)	Yb 64p1	Yb 30p, 31e, 32p, 314
P. sp. cf. *P. haradanum* (YOKOYAMA)		Yb 65p
P. pseudogaultinum (YOKOYAMA)		Yb 32p1
P. (*Subptychoceras*) sp.	Yb 64p2	
Baculites yokoyamai TOKUNAGA and SHIMIZU	Yb 33p2, 64p1, p2	
B. schencki MATSUMOTO	Yb 33p2, 64p2	
B. sp. cf. *B. boulei* COLLIGNON		Yb 32p2
B. princeps MATUMOTO and OBATA		Yb 30p, 65p
Aptychi	Yb 33p3	Yb 313
Others		
Propeamussium cowperi yubarensis YABE and NAGAO	Yb 64p2	Yb 31c5
Inoceramus naumanni YOKOYAMA		Yb 30p, 31c2, c3, c4, 65p, 311p, 314
I. orientalis nagaoi MATSUMOTO and UEDA		Yb 315
I. mihoensis MATSUMOTO	Yb 33p2	
I. sp. cf. *I. amakusensis* NAGAO and MATUMOTO		Yb 31c1, 305
I. sp.	Yb 64p2	
Lucina (*Myrtea*) *ezoensis* NAGAO	Yb 64p1	
Dentalium sp.	Yb 33p2	
Echinoid indet.		Yb 313
Crinoid ident.		Yb 311p

Comparison with the Cretaceous Sediments of Other Areas

To understand the geologic setting of the Cretaceous deposits of the Yubari dome we attempt here to compare them with those of the Ikushumbets valley, which is situated about 25 km northeast-north of Yubari along the general trend of structure, and also with those of the Shuyubari valley, which is located at present about 10-20 km east of Yubari across the folds and thrusts of various grades of magnitude and, accordingly, presumed to have been originally much more apart eastward from the site of the Yubari dome than the present distance (Fig. 6).

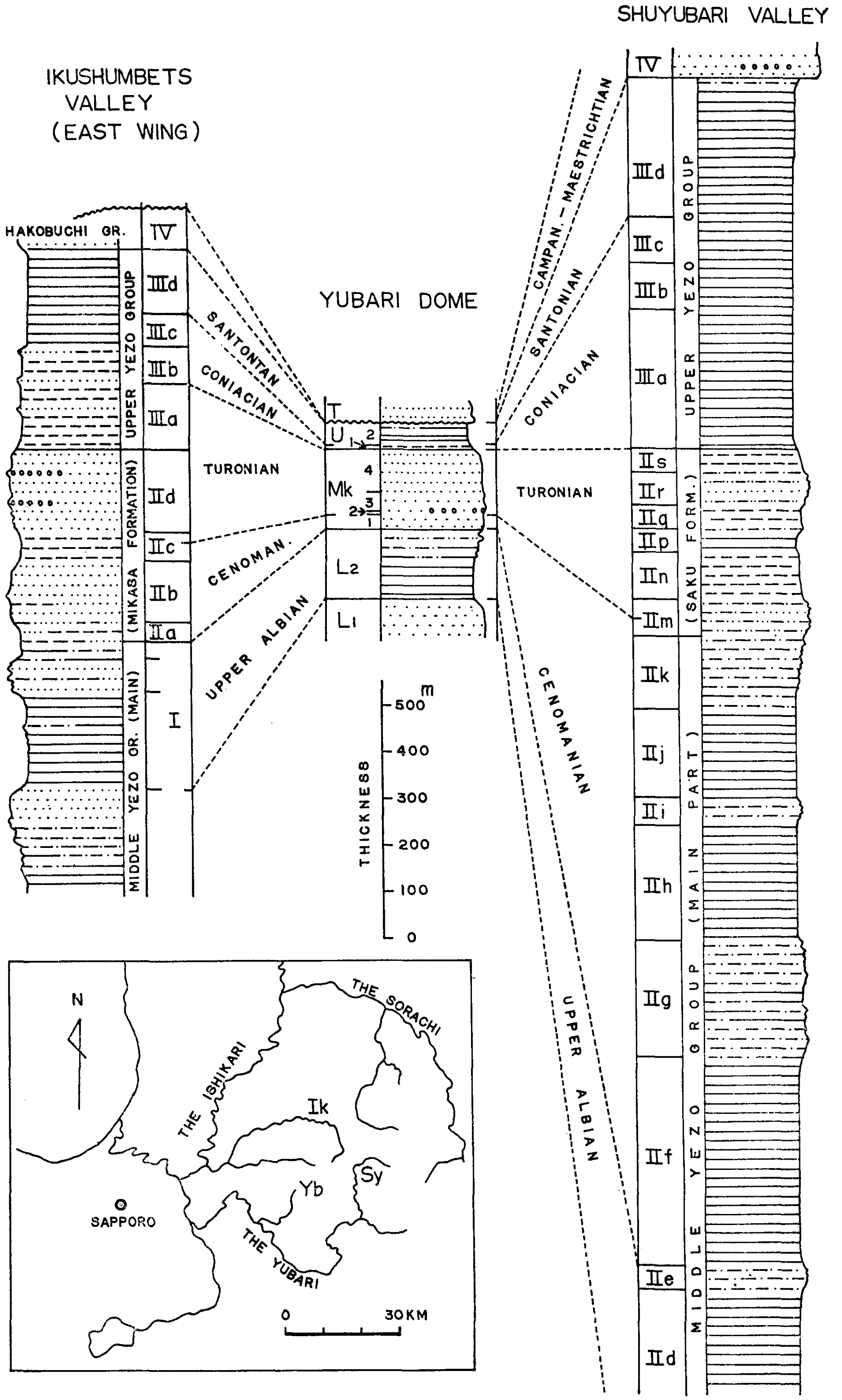

Fig. 6. Comparison of the Cretaceous sequence of the Yubari dome with those on the eastern wing of the Ikushumbets anticline and in the Shuyubari valley. See Fig. 3 for legend. The uppermost part and the lower half of the Shuyubari section is ommitted for brevity. Inset is an index map at the lower left corner, showing the location of the Ikushumbets valley (eastern wing), Yubari dome and Shuyubari valley with Ik, Yb and Sy respectively.

Concerning the Cretaceous stratigraphy of the Ikushumbets valley, one of us (T.M.) have been doing a detailed field work for several years assited by some coworkers. The final result has not yet been published, but a concise summary was shown in a columnar section (MATSUMOTO, 1959b, pl. 7), which is one of the reference scales. As has already been known at the date of YABE (1926), the Cretaceous strata form there an anticline of NEN-SWS trend, which is called the Ikushumbets or Sorachi anticline. The Manji and the Yubari domes are so to speak an extension of this anticline. Even in this anticlinal belt there are changes from place to place in the details of the stratigraphic sequence, facies and thickness of the Cretaceous deposits.

If we compare the Cretaceous sediments of the Yubari dome with those of the typical exposure on the eastern wing of the anticline in the Ikushumbets area, the following salient points may be noticed.

(1) Member L1 may be approximately correlated with the Yunosawa Sandstone of the Ikushumbets area. Nearly 130 m sequence of alternating sandstone and shale lies below the 70 m thick, massive Yunosawa Sandstone. The corresponding alternation is not exposed in the Yubari dome.

(2) Member L2 is correlated with the unit of laminated shale with thin sandy layers above the Yunosawa Sandstone in the Ikushumbets area, as judged from the common occurrence of *Mortoniceras* (*Cantabrigites*) *imaii* and the resemblance in lithology. This Upper Albian part is 150 m in the Yubari dome, being much thinner (about a half) as compared with 315 m sequence in the Ikushumbets area.

(3) The thick sandstone and the alternating shale and sandstone which we have placed at the uppermost part of Member L2 seem to correspond to similar rocks which one of us (T.M., 1959b, pl. 7) put in the uppermost part of the main, lower part of the Middle Yezo Group in the section of Ikushumbets. Again there is a great difference in the thickness of the sediments:—only about 4-5 m in the section of the Yubari dome as compared with 110 m in that of the Ikushumbets area.

(4) The Mikasa formation is 160 m thick in the Yubari dome and about 400 m in the section of the eastern wing of the Ikushumbets anticline. It is divided in the latter section into four units, IIa, IIb, IIc and IId, by MATSUMOTO (1959b, pl. 7), but they do not precisely correspond to Mk1, Mk2, Mk3 and Mk4 of the Yubari area in age and in facies, as is discussed below in more detail.

(5) The Cenomanian is represented by the massive sandstone, 25 m or so, of Member Mk1 in the Yubari dome but by units IIa (fine-sandy siltstone, 40 m), IIb (muddy sandstone, 130 m) plus the main part of IIc (siltstone, 50 m) in the eastern Ikushumbets section. The sediments are extremely thinner, less muddy and less fossiliferous in the former than in the latter area. Ammonoids, trigonians and other fossils occur commonly in the Cenomanian on the eastern wing of the Ikushumbets anticline.

(6) A tongue of mudstone, as represented by unit IIc, is intercalated in the sandstones of the Mikasa Formation in the Ikushumbets area. On the

evidence of fossils the uppermost part of IIc, about 13 m, is referred to the Lower Turonian. The same substage is represented by the thick-bedded sandstone, about 10 m, of Member Mk2 in the Yubari dome, where no tongue of mudstone is intercalated in the Mikasa Formation.

(7) The lithologic constituents of the Middle Turonian are not much different between the two areas, as shown by the sandstone with some conglomerate and silty matter of Member Mk3 and unit IId. The thickness of Mk3, however, is one third of that of IId, being about 50-60 m as compared with 175 m of IId. Their fossil contents are generally similar, although the mode of occurrence may change from place to place.

(8) In Member Mk3 conglomerate and calcareous sandstone occur more frequently in the western part than in the eastern part of the Yubari dome. Similarly the upper part of the Mikasa Formation contains more conglomerate on the western and southwestern wings of the Ikushumbets anticline than on the eastern wing.

(9) The Upper Turonian is represented by the silty fine-grained sandstone of Mk4, 70-80 m thick, in the Yubari dome. In the Ikushumbets area the fine-sandy siltstone with a few interbeds of green sanstone represents the same substage. For the reasons of the litho- and biofacies and the stratigraphic relationship this part is better referred to the lower part (unit IIIa), 130 m, of the Upper Yezo Group rather than the upper part of the Mikasa Formation (see MATSUMOTO, 1959b, pl. 7). Unit IIIa of Ikushumbets is somewhat thicker than Member Mk4 of Yubari. Their fossil contents are essentially similar, but the former has more ammonites than the latter.

(10) The Coniacian is extremely thin and probably incompletely developed in the Yubari area, as represented by only 10 m glauconitic sediments of Member U1, in which the zone of *Inoceramus uwajimensis* is not well recognized. The *uwajimensis* zone is well developed in eastern Ikushumbets, as represented by fine-sandy siltstone, about 80 m, with some interbeds of green sandstone, of unit IIIb. The overlying unit IIIc, another 80 m sequence of mudstone with some intercalary sandy tuff, of the Ikushumbets area may also be included in the upper part of the Coniacian, because it contains *Inoceramus mihoensis*. A stratigraphic break very possibly exists at the base of the Upper Yezo Group in the Yubari dome, while in the Ikushumbets area the sequence is conformable with a gradual change of lithology from the Mikasa Formation to the Upper Yezo Group and a complete succession from Turonian to Coniacian can be seen.

The Cretaceous stratigraphy of the Shuyubari [=Siyubari or Shiyubari] valley was described by one of us (MATSUMOTO, 1942, p. 215-243, pls. 13-15) and was summarized in a columnar section (MATSUMOTO, 1954a, pl. 5). The difference in the succession, facies and thickness of the Cretaceous sediments is still greater between the Yubari dome and the Shuyubari valley than that between the Yubari and the Ikushumbets areas described above. The important points may be enumerated as follows.

(11) In the Shuyubari valley the exposed sequence is nearly complete

from the Sorachi Group, through the Lower, Middle and Upper Yezo Groups, to the Hakobuchi Group. Whereas, in the Yubari dome the incomplete sequence of the Middle Yezo and Upper Yezo Groups are exposed.

(12) The Middle Yezo Group, from the Upper Albian to the top of Turonian, is about 2600 m thick in the Shuyubari sequence but only 460 m in the Yubari sequence.

(13) The thick-bedded or massive sandstone, with some intercalated conglomerate, as seen in the Yubari dome is not developed in the Middle Yezo Group of the Shuyubari valley, where the group consist of predominant mudstone or shale with occasional intertongues of thin-bedded sandstone and shale in alternation. Trigonians and glycymerids which are very common in the Mikasa Sandstone are not found in the Middle Yezo Group of the Shuyubari valley, where ammonites occur commonly in calcareous nodules contained in the shale.

(14) The main part of the Middle Yezo Group in the Shuyubari valley, ranging from unit IIe to unit IIk of MATSUMOTO (1942) (see also columnar section in MATSUMOTO, 1954a, pl. 5), is Cenomanian. This is about 1300 m in thickness. In the Yubari dome the Cenomanian is extremely thin, since it is represented by the sandstone, about 25 m, of Member Mk1. In this case the difference in thickness and lithology of the sediments is surprisingly great.

(15) The Turonian is represented in the Shuyubari valley by the uppermost part, about 300 m, of the Middle Yezo Group. This part consists of shale and sandy siltstone frequently interbedded with sandstone and is called the Saku Formation. It is of the same age as the sandstones of Members Mk2, Mk3 and Mk4, about 130-150 m thick altogether, of the Yubari dome.

(16) The Coniacian in the Shuyubari section is the lower part, about 500 m mudstone, of the Upper Yezo Group. The zones of *Inoceramus uwajimensis* and *Inoceramus mihoensis* are well distributed there. The Coniacian in the Yubari dome is very thin, as represented by only 10 m glauconitic, muddy, fine-grained sandstone or fine-sandy mudstone of Member U1. Again the difference is extremely great.

(17) The upper part of the Upper Yezo Group, primarily of Santonian age, in the Shuyubari valley is estimated as being several times as thick as that in the eastern area of the Yubari dome.

(18) The Hakobuchi Group, consisting of predominant sandstones of about 400 m (for details see FUJII, 1958, p. 137-138), of Campanian-Maestrichtian age, rests on the Upper Yezo Group as seen on the good exposure at the Hakobuchi gorge, the entrance of the Shuyubari valley about 11 km ESE of the streets of Yubari. This group is overlain there with parallel unconformity by the Eocene Ishikari Group. In the Yubari dome the same group is not developed but the Ishikari Group unconformably covers the incompletely developed Upper Yezo Group on the eastern margin and furthermore overlies Mk4 and still more deeply Mk 3 in the remaining parts around the Yubari dome. The stratigraphic gap is, thus, very great in the west. A similar situation is observed also on

the western wing of the Ikushumbets anticline.

Summarizing the above it can be concluded at first that the site of the belt of the Ikushumbets anticline and the Yubari dome represents a relatively marginal part of the Cretaceous basin of sedimentation, situated near the land or mountains in the west. The shore-line, however, may have shifted from time to time during the Cretaceous Period. In the Middle Turonian the site of the Ikushumbets anticline-Yubari dome was under a shallow sea water, with bottoms of sands and some gravels. Whether this was a coastal belt or a bank off the coast may still remain unsettled, but on the evidence of bio- and litho-facies and also sedimentology (see Appendix), the latter interpretation may be rather preferable. Anyhow the area does not seem to have been much apart from a hinterland.

The second conclusion is that the site of the Yubari dome was already in the Cretaceous Period an area of slow sedimentation where the amount of subsidence was comparatively less than that in other areas. The extremely slow subsidence, with accumulation of comparatively thin sediments, took place there in the Cenomanian and also in the Coniacian. Even upheaval and erosion may have taken place in early Coniacian and at the close of the Cretaceous or the beginning of the Tertiary Period.

The third conclusion which can be led from the present study is that the belt which is exemplified by the section of the Shuyubari valley in the east represents a part of the Cretaceous geosyncline in which the amount of subsidence and that of the accumulation of fine-grained clastics were much greater than that in the site of Yubari. It is interesting to note that the former is closer than the latter to the backbone of Hokkaido where metamorphic and plutonic rocks are now extensively exposed. Where was the axis of the geosyncline, how it was shifted from time to time, whether the sources of sedimentary material came from one side (i.e. from the west) or from two or more areas, how they changed in the course of the evolution of geosyncline, when and how the metamorphic belts in the backbone and also the tectonics were formed, how they affected the sedimentary history are the problems which should be solved on various kinds of evidence. The petrologic study of the clastic sediments would furnish some information. In connection with this FUJII (1958) did an interesting work, but he did not treat the Cretaceous of the Yubari dome. In this paper Dr. OKADA joins us in undertaking the petrographic study (see Appendix).

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Appendix

Petrographic Notes on the Cretaceous Sandstones of the Yubari Dome

By

Hakuyu OKADA, Masato HARADA and Tatsuro MATSUMOTO

We have examined representative samples of the sandstones from the Middle Yezo Group which occupies the main part of the Yubari dome. The sandstone is so poorly developed in the Upper Yezo Group that it is omitted from the present notes.

A. Mineralogic composition

(1) Framework constituents

Eighteen thin-sections of sandstones have been examined to elucidate the chief framework constituents and the result is presented in Table 5.

The clay matrix contents are variable, making up from 2 to 28 percent of the total volume of the sandstones examined. Sandstones with clay matrix of less than 15 percent can be called the subgraywacke of PETTIJOHN's classification (PETTIJOHN, 1957, p. 284, Table 48) and the others are in the graywacke clan. Some of the sandstones are more or less calcareous due generally to secondary replacement of matrices by calcite. In such a case the present volume of their mud or clay is no doubt less than the volume of the one in the original sediment. The clay matrix is on the whole a microcrystalline aggregate composed chiefly of chlorite, sericite and quartz. The amount of the clay matrix is large in the examined specimens of Members Mk1, Mk2 and Mk4, while it is rather variable in those of Members L1, L2 and Mk3. This may imply the

Table 5. Framework constituents of the Cretaceous sandstones of the Yubari dome

Stratigraphic Position	Specimen Number	Quartz	Chert	Feldspar	Rock Fragments	Clay Matrix	Calcite Cement	Md (in mm)	So coefficient	Roundness
Mk 4	Yb 29a	21	13	17	20	22	7	·0.44	1.35	B
	Yb 321	24	7	14	29	23	3	0.46	1.35	A
Mk 3	Yb 24	23	9	9	38	2	19	0.35	1.67	B
	Yb 119	35	12	11	25	17		0.43	1.45	A
	Yb 253	16	21	19	35	9	+	0.54	1.70	C
	Yb 326	28	9	12	26	25	+	0.41	1.43	A
	Yb 328	17	24	17	24	18	1	0.42	1.66	A
	Yb 330	27	25	6	25	13	4	0.56	1.65	A
	Yb 427a	34	5	6	33	17	5	0.46	1.67	A
Mk 2	Yb 423	29	7	14	25	25	+	0.43	1.53	A
Mk 1	Yb 17	31	8	9	28	24		0.37	1.68	A
	Yb 18	27	6	10	29	28		0.37	1.31	A
	Yb 39b	22	16	17	18	28		0.35	1.33	C
L 2	Yb 109	44	17	5	16	14	4	0.44	1.39	A
	Yb 265	12	36	15	16	2	19	0.60	2.25	A
L 1	Yb 242	26	22	10	22	19	1	0.42	1.81	B
	Yb 411	25	13	10	29	5	18	0.55	1.69	B
	Yb 412	23	23	10	30	4	10	0.67	1.77	B

interbeds of subgraywackes.

Quartz constitutes 17 to 35 percent of the graywackes, and 12 to 44 percent of the subgraywackes. There seems to be no significant regularity in the stratigraphic variation of the quartz content. Quartz grains are in general angular or subangular. They are occasionally sutured and show undulatory extinction. Fluid inclusions in individual grains are common. In a specimen from loc. Yb 423, there is a detrital quartz grain showing secondary enlargement. This outgrowth is considered to have been produced in older sandstones from which the quartz grain was brought into the present sandstone, because the hexagonal outgrowth enlarged on the completely rounded quartz is somewhat abraded.

Feldspar grains are angular to subangular, being more or less cloudy due to kaolinitization or partial replacement with calcite. The feldspar content ranges from 5 to 19 percent. No regularity is recognized in the feldspar distribution through the whole Cretaceous succession. Plagioclases (An 28-35) and potash feldspars are of almost equal amount. The former is for the most part albite-twinned or albite-Carlsbad-twinned. Perthite and microcline are not uncommon. In addition, myrmekite is also met with, although rarely.

Rock fragments are the important constituent of the sandstones next to quartz, as is shown by their large amount (Table 5). The fragments are andesite, altered diabasic rocks, spherulitic volcanic rocks, shale, graywacke, porphyrite, tuffaceous rocks, granitic rocks and chert, of which chert is presented in Table 5 to be distinguished from the other fragments. As a rule, these rock fragments are somewhat better rounded than the grains of quartz and feldspar. Aside from chert, andesitic rocks, diabasic rocks and sedimentary rocks occur commonly. The fragments other than chert amount to 20 percent or more in most of the examined specimens of the Mikasa Formation, while in those of Member L2 they are less than that. In the specimens of Member L1 they are more than 22 percent, being evidently of larger amount than those in Member L2.

Chert varies from 6 to 36 percent of the rocks. Some grains show originally fractured texture. Indeterminable radiolarian remains are often detected. Reddish variety of chert is also common.

(2) *Heavy minerals*

The heavy minerals make up, on the average, about 2.89 percent of the sandstones of the Mikasa Formation and about 1.33 percent of those of Member L1 and L2. The identified minerals (Table 6) are divided into five major groups: opaques, garnet, zircon, augite and minor minerals.

Opaques.—Magnetite-ilmenite, pyrite, hematite, marcasite and leucoxene are recognized. Although relative abundance of them was not decided, they occur in variable amount. Of these minerals, magnetite or ilmenite and leucoxene are the common opaques. Pyrite is also common and in some specimens especially prominent as an authigenic mineral. It sometimes replaces radiolarian remains.

Garnet.—The percentage of garnet is in general high throughout the Cretaceous succession. In particular, garnet occurs in much larger amount in the specimens of Member L1 and L2 than in most of the Mikasa Formation; namely more than 50 percent in those of L1 and L2, whereas in those of the latter it varies from 16 to 59 percent. The garnet group is subdivided into colourless, pale pink and orange pink varieties, of which the pale pink variety is predominant. The grains occur as irregularly fractured pieces. Sometimes euhedrals of dodecahedron or trapezohedron are met with.

Zircon.—Angular euhedral zircon is represented by colourless and pale pink varieties. That of purple variety is also very rarely traced. On the other hand, almost all the rounded grains of zircon have a pale pink or purple colour. The angular euhedral zircon and the rounded one share the content in nearly equal proportions with each other.

Table 6. Heavy mineral compositions of the Cretaceous sandstones of the Yubari dome

Stratigraphic position	Specimen number	Zircon Euhedral colourless	Zircon Euhedral pale pink	Zircon Euhedral purple	Zircon Rounded colourless	Zircon Rounded pale pink	Zircon Rounded purple	Monazite	Garnet	Tourmaline blue	Tourmaline brown	Tourmaline green	Rutile	Anatase	Hornblende brownish green	Hornblende green	Augite	Hypersthene	Epidote	Chromite	Biotite	Chlorite	Non-opaque Minerals	Iron Minerals	Weight Percentage of Heavy Minerals
Mk 4	Yb 29a	10	17		1	9	4	1	23		1		1				26	+	2	+	6		64	36	2.45
Mk 3	Yb 21	2	3		+	4	2		22		+	+	+				63		2	+	1	+	65	35	2.54
	Yb 24	8	13		+	6	2	+	20		2	+	+	+			44		+	1	3		65	35	2.36
	Yb 119	7	22			10	4	1	20		1	+	+				28	1	2	2	2		35	65	1.88
	Yb 253	3	18		+	15	7	+	54		+		+				2		+	+	+		53	47	1.33
	Yb 330	1	5	+		5	1		37	+	3	+	+		+	16	29		+	2	+		52	48	1.53
	Yb 427a		7			6	3	+	16		+		1	1			62		4		+		77	23	2.35
Mk 2	Yb 423	5	19			9	3		18		+						38		3	+	4		69	31	2.51
Mk 1	Yb 17	2	11			4	3	+	37	+	3		1			+	36		1	+	+		39	61	2.41
	Yb 18	1	11	+		5	4		17		+		+				54		3	+	3	+	67	33	4.83
	Yb 39a	1	19			9	6	+	59		1	+	2				+				2		24	76	1.89
L 2	Yb 109	4	21			9	6	+	52	+	2	+	2		1	1				+	+		70	30	1.00
L 1	Yb 16	+	19			9	5		64		2					+				+	+		69	31	1.12
	Yb 242	2	23	+		11	3	+	56	+	1		+		+	+				+	2	+	64	36	0.57
	Yb 411	1	17	+		16	9	+	56		+					+					1		48	52	2.00
	Yb 412	2	19			12	9	+	54							+				1	2		51	49	1.98
*	Yb 427b	+	7		+	7	8		46		+					+	28			+	+	+	66	34	2.04

* Sandstone occurring as a pebble of the conglomerate in the lower part of Member Mk3.

It should be noted that the well-rounded purple variety of zircon shows significantly high frequency distribution in the Cretaceous sandstones of the Yubari dome as compared with those of other areas which are under examination by one of us (H.O.).

Augite.—Augite is characteristically contained in the sandstones of the Mikasa Formation in appreciable amount, but is absent or negligible in those of Members L1 and L2. It occurs mostly as roughly equidimensional grains and infrequently as prismatic ones, presenting faint greenish colour.

Minor group.—Monazite, tourmaline, rutile, anatase, hornblende, hypersthene, epidote, chromite, biotite and chlorite are detected in minor quantity.

Of these epidote is confined to the Mikasa Formation as augite is so. Chromite has been identified by its translucent part at the corner of the grains. As it resembles the one which was examined by the X-ray method (OKADA, 1964), the present one may also belong to magnesiochromite. Monazite occurs as euhedral, light yellowish brown grains with microstructures of zoning and fissures. As to tourmaline, three varieties are recognized; blue, brown and green, of which the brown variety is common. Tourmaline usually occurs as broken prismatic grains and rounded ones are rarely found. Rutile is as a rule somewhat rounded. A rounded grain of geniculate twinning has been detected in a specimen from loc. Yb 109 near the top of Member L2. Anatase occurs in a compound pyramidal form, which seems to be authigenic. Hornblende is divided into two varieties of green and brownish colours, of which green hornblende is prevalent and in particular persistently present in Members L1 and L2.

B. Texture

Grain size analysis and estimation of roundness of sand grains have been made through thin-sections of all the sandstone samples on which mineral compositions have been analysed. Median diametre (Md) of each specimen, its sorting index (So) and its roundness are shown in Table 5.

Many examined sandstones are medium-grained and several others are coarse-grained, as shown by their Md value. Of the observed sandstones, graywackes tend to have increased amount of clay matrix with decreasing Md value and they exhibit a bimodal grain size distribution, as generally does the graywacke. No linear relation seems to exist between grain size and mineral composition, except for clay matrix in the graywackes.

Sorting in most of the measured sandstones is moderate, ranging from 1.31 to 1.81. In a specimen from loc. Yb 265, the So value is measured as large as 2.52, assuming that the clay matrix in this calcareous sandstone was replaced almost wholly by calcite.

Roundness is classified into the following five grades according to PETTIJOHN (1957, pp. 58-59): A-angular, B-subangular, C-subrounded, D-rounded and E-well-rounded. Many of the examined sandstones of the Mikasa Formation, which have been obtained from the eastern part of the Yubari dome, are as a whole characterized by angular grains. It is, however, interesting to note that the two specimens distinguished by the roundness C are both from the beds exposed on the western wing of the Yubari dome. In the specimens of Member L1 roundness seems to be somewhat better than in those of Member L2.

C. Remarks

The Cretaceous sandstones of the Yubari dome consist mainly of graywackes, accompanied with somewhat calcareous subgraywackes. So far as the examined specimens are concerned, those of Members Mk1, Mk2 and Mk4 are all graywackes, while those of Members L1, L2 and Mk3 are classified into graywackes and subgraywackes.

With regards to the major framework constituents of sandstones any significant criterion to distinguish one member from another is hardly extracted. On the other hand, the heavy mineral suite is very useful for that purpose. Members Mk1 to Mk4 are clearly discriminated from the underlying Members L1 and L2 by the augite-epidote suite of a considerable amount. Whereas, garnet is more concentrated in Members L1 and L2 than in Members Mk1 to 4. Such a fact is also recognized in the sandstones of the corresponding stratigraphic positions of the Cretaceous sequence exposed along the Ikushumbets.

It is interesting to note that the purple zircon is significantly higher in frequency in the Cretaceous sandstones of the Yubari dome than in those of other areas in Hokkaido. The existence of chromite in the sandstones throughout the whole succession is likewise noteworthy, as it suggests the provenance from ultrabasic or basic rocks.

Pebbles in the conglomerate in the Mikasa Formation are mostly those of chert but those of compact sandstones are not uncommon. This fact agrees very well with the character of the heavy minerals which indicates that a group of older sedimentary rocks was one of the main sources of the Cretaceous sediments.

Integrating all the facts obtained, source rocks were mainly older sedimentary rocks and intermediate to basic volcanics (andesite, porphyrite, diabase, etc.) and subordinately acid igneous rocks (granite, rhyolitic rocks, etc.). The second group of rocks is confined to the age of the Mikasa Formation.

For further discussion on the palaeogeographic and tectonic significance of these sediments, more comparative study is needed.

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Cretaceous Stratigraphy of the Yubari Dome

Plates 9–11

Plate 9

Explanation of Plate 9

(Figures of natural size unless otherwise stated)

Fig. 1. *Inoceramus anglicus* WOODS. ....Page 94
A specimen, GK. H 5533, from loc. Yb 34r, Member L2, Yon-no-sawa, the fourth tributary of the Ponhorokabets, northeastern part of the Yubari dome (Coll. T. MATSUMOTO & M. HARADA).

Fig. 2. *Inoceramus anglicus* WOODS......................................Page 94
Another specimen, GK. H5534, from loc. Yb. 245, Member L1, Utagoe-zawa, western part of the Yubari dome, × 3/2 (Coll. M. HARADA).

Fig. 3. *Inoceramus concentricus subsulcatus* WILTSHIRE. ....Page 94
A specimen, GK. H5535, from loc. Yb 34r, Member L2, Yon-no-sawa, the fourth tributary of the Ponhorokabets, northeastern part of the Yubari dome (Coll. T. MATSUMOTO & M. HARADA).

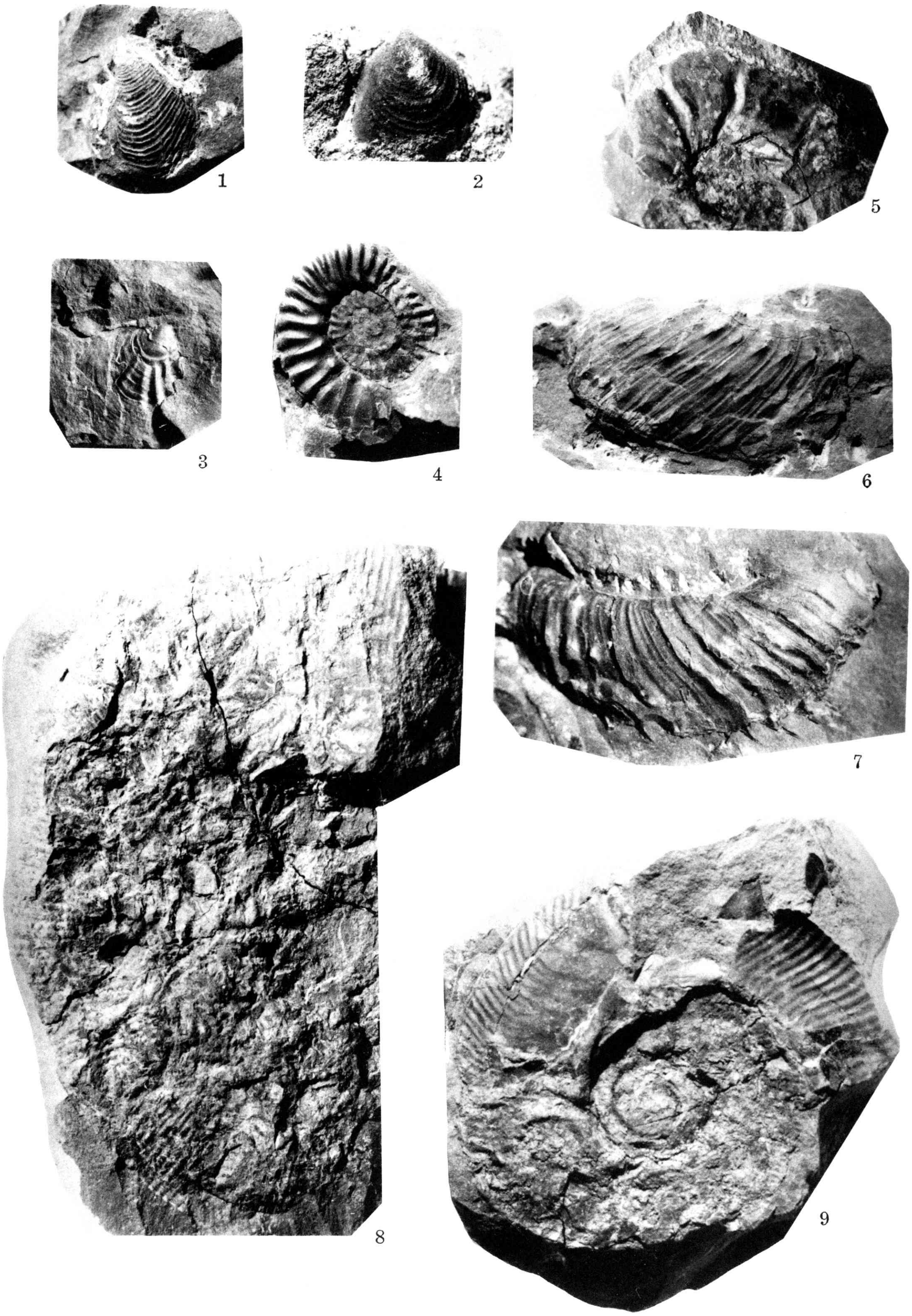
Fig. 4. *Mortoniceras (Cantabrigites) imaii* (YABE and SHIMIZU). ....Page 94
A specimen, GK. H5536, from loc. Yb 34r, Member L2, Yon-no-sawa, the fourth tributary of the Ponhorokabets, northeastern part of the Yubari dome (Coll. T. MATSUMOTO and M. HARADA).

Fig. 5. *Hulenites* n. sp. aff. *Puzosia alaskana* IMLAY. ....Page 96
A specimen, GK. H5537, from loc. Yb 35r, Member L2, San-no-sawa, the third tributary of the Ponhorokabets, northeastern part of the Yubari dome (Coll. M. HARADA).

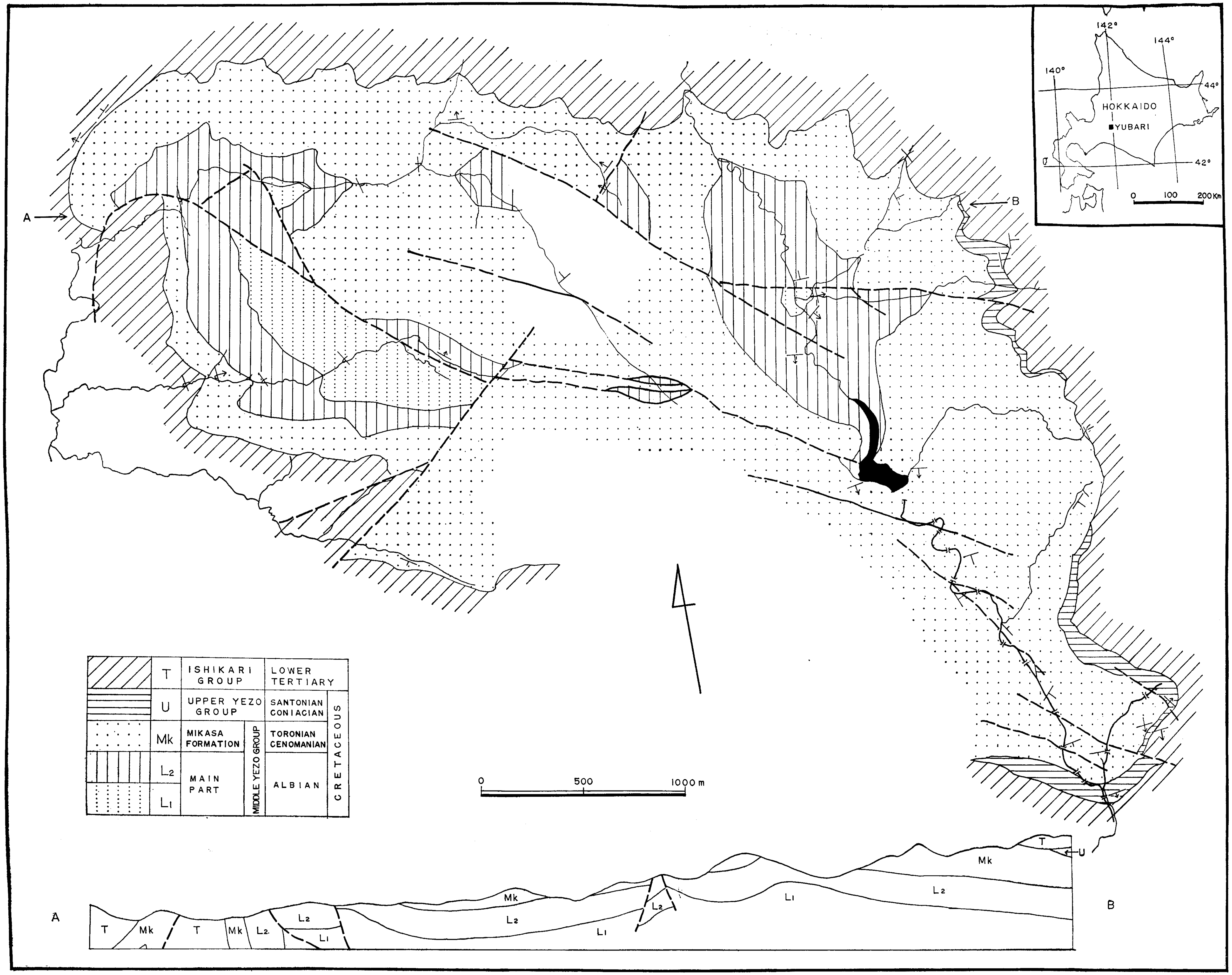
Figs. 6, 7. *Pseudhelicoceras* n. sp. ....Page 94
Two specimens, GK. H5538-39, from loc. Yb 34r, shale of Member L2, Yon-no-sawa, the fourth tributary of the Ponhorokabets, northeastern part of the Yubari dome (Coll. T. MATSUMOTO & M. HARADA).

Fig. 8. *Hypophylloceras* n. sp. ....Page 94
A secondarily deformed specimen, GK. H5540, from loc. Yb 53r, Member L2, San-no-sawa, the third third tributary of the Ponhorokabets, northeastern part of the Yubari dome (Coll. M. HARADA)

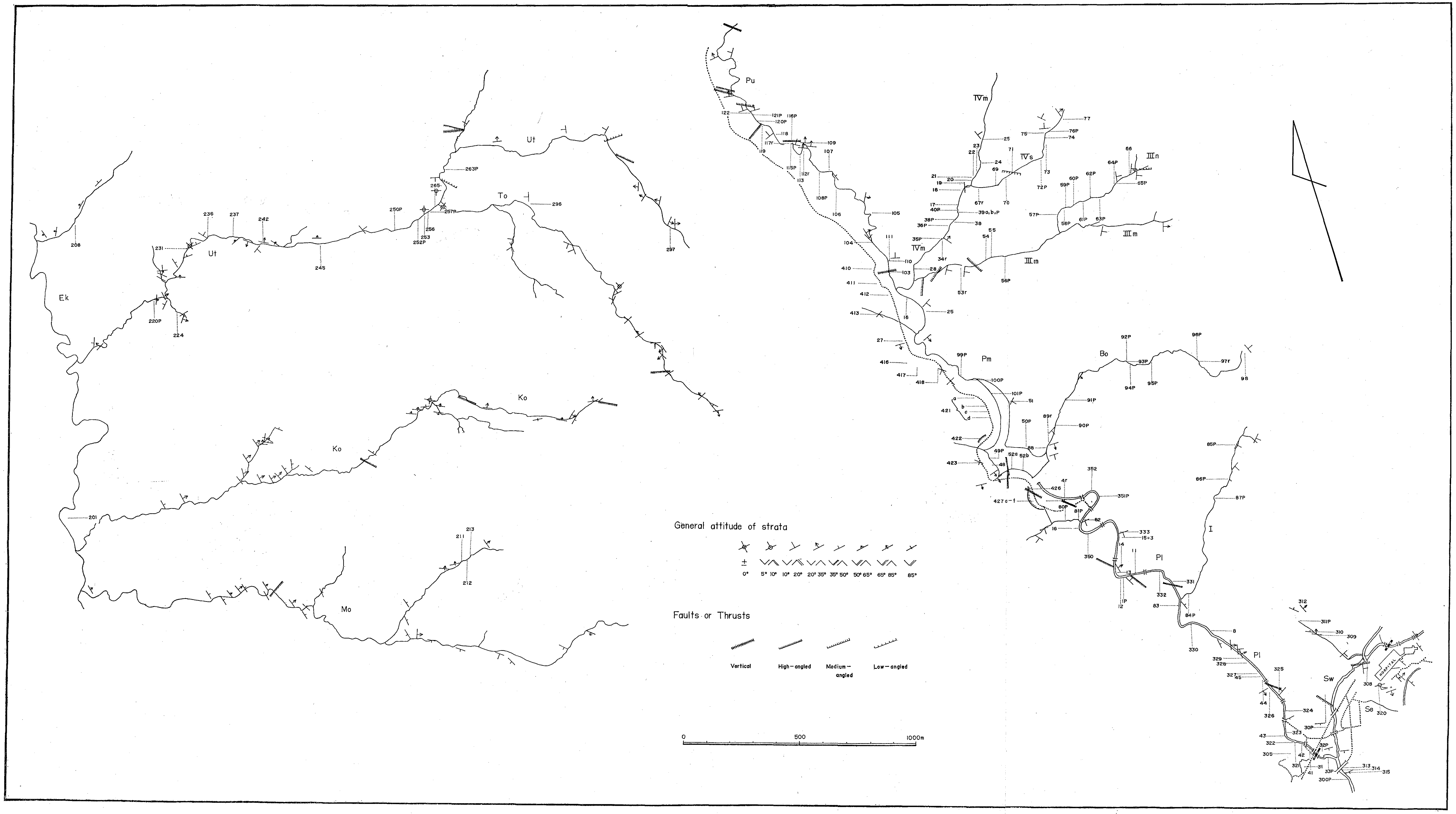
Fig. 9. *Puzosis subcorbarica* (YABE MS.) MATSUMOTO ....Page 96
A specimen, GK. H5541, from loc. Yb 53r, Member L2, San-no-sawa, the third tributary of the Ponhorokabets, northeastern part of the Yubari dome (Coll. M. HARADA).



T. MATSUMOTO and M. HARADA: Cretaceous of the Yubari Dome



Geological map of the Yubari dome, Hokkaido



Geologial route map of the Yubari dome, Hokkaido
See table 1 for the abbreviation of the names of streams.