The Type Himenoura Group : With Palaeontological Notes

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The Type Himenoura Group*

By

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With Palaeontological Notes

By

Tatsuro MATSUMOTO and Yoshiro UEDA

Abstract

The Senonian Himenoura group is restudied in the type section in Amakusa-Kamishima and adjacent islets. A zonal subdivision is established in the group on the grounds of *Inoceramus* and ammonite species. The zones run somewhat obliquely through the facies boundaries.

From the evidence in the type area and at other localities the general remarks are given on the Himenoura group in regards to the Urakawa transgression, the development of the basin of sedimentation, the changes of sedimentary environments in space and time and the post-Himenoura crustal movements.

Palaeontological notes are described on eight species of *Inoceramus* and ammonites, in which *Inoceramus orientalis nagaoi* nom. nov. is proposed.

Contents

I. Introduction

Geological province.—Kyushu is geotectonically subdivided by the Matsuyama-Imari and the Usuki-Yatsushiro tectonic lines into three parts, of which the central one is called the Nagasaki Triangle or simply Middle Kyushu. In the southern part of Middle Kyushu the Cretaceous deposits are distributed in several areas and have their own characteristic features in the respective areas. The Himenoura group in the area indicated in Fig. 1 is one of them.

* Received October 31, 1961.

Historical review.—The Cretaceous deposits in the islands of Amakusa and the adjoining areas in the southwestern part of Middle Kyushu have been known since the geological survey by YAMASHITA (1892) and the palaeontological work by YABE (1902). Owing to excellent exposures along the sea-coast and other routes, the Cretaceous sequence and its geological relations with other units can be clearly observable and the fossils are fairly commonly obtainable there. Accordingly the area has been visited by a large number of geologists and palaeontologists, of whom NAGAO (1922) made an epoch in separating the Upper Cretaceous from the Lower Tertiary group of beds, proposing the name of the Himenoura group for the former. In the same year YEHARA (1922) published a paper on the Cretaceous of Amakusa and subsequently another (YEHARA, 1925) on the trigonians. NAGAO (1924, 1925) furthermore studied the stratigraphic boundary between the Cretaceous and Tertiary strata. YABE and SHIMIZU (1924, 1925) described a nautiloid species from the Himenoura group in Amakusa and an ammonite species from the same group in the Uto peninsula. In a comprehensive summary of the Cretaceous stratigraphy of the Japanese Islands YABE (1927) gave remarks on the Cretaceous of Amakusa. A geological map of Amakusa (NOTOMI, 1930) was issued by the Geological Survey. In the same year NAGAO (1930) published a short paper on some molluscan species in which the older Goshonoura fauna was separated from the Senonian Himenoura fauna. MATSUMOTO (1938) did a precise work on the type Goshonoura group and NAGAO and MATSUMOTO (1939-40) described species of *Inoceramus* in a monograph. FUJIMOTO and MORI (1939) reported the occurrence of *Cycadeoidea* from the Himenoura group. From the standpoint of tectonic history KOBAYASHI and OTUKA (1938), OTUKA (1935, 1939), and KOBAYASHI (1941) mentioned the Cretaceous and Tertiary area of Amakusa.

During the succeeding decade the study of the Tertiary of the Amakusa area advanced as seen in the work of MATSUSHITA (1949, 1951, 1953), who depended, however, much on YABE and HANZAWA (1925) and NAGAO (1928a, b) for the palaeontology and TAKAYAMA (1944) for the field geology in the eastern part. Anyhow no significant result was brought to the Cretaceous side.

Having been stimulated by a compilation work by the Cretaceous Research Committee, lead by Chairman, Tatsuro MATSUMOTO (1954), the renewed studies of the Cretaceous and the overlying Lower Tertiary in the Amakusa and related areas have become again very active.

The results are now being published by a number of persons (AMANO, 1956, 1957, 1960a, b; AMANO and IMANISHI, 1958; HATAE, 1959, 1960; MATSUMOTO et al., 1960; MATSUSHITA et al., 1956, 1959; MURATA, MS.; NAKANO, 1957, 1960; OBATA MS.; OKADA, 1960, 1961; TAKAI and MATSUMOTO, 1961; TAKAI, 1962; UEDA and FURUKAWA, 1960). The present paper is one of the results.

Purpose of study.—Notwithstanding the active studies recently undertaken in the Amakusa and adjoining areas, the available data on the stratigraphy of the Himenoura group in its type area have depended primarily on NAGAO (1922, 1930). Therefore the restudy in the light of up-to-date stratigraphy and palaeontology has been utterly needed. At the suggestion of Professor MATSUMOTO I have been engaged in the restudy of the Himenoura group in its type area.

The purpose of the present paper is to describe precisely the stratigraphy of the type Himenoura group and to establish the zones in the group, with a result of correlation. The sequences in the areas outside the type area are briefly described and remarks are given for them from the knowledge established in the type area. Through the zonal correlation and facies analysis, a conclusion is lead regarding the geological environments in the successive stages of the deposition of the Himenoura group. Furthermore, comments are given for the post-Himenoura crustal movements. Finally in the palaeontological chapter the zonal indices are described, with a necessary revision. Microfossils are not included in this paper, since they are now being studied by MURATA.

Acknowledgements.—I wish to record here my sincere gratitude to Professor Tatsuro MATSUMOTO of Kyushu University who suggested and supervised this study and critically read the manuscript. Professor MATSUMOTO furthermore helped me in the identification of the fossils and joined me in the palaeontological descriptions.

I thank also to Professor Toru TOMITA, Professor Hisamichi MATSUSHITA, Professor Ryuzo TORIYAMA, Dr. Kametoshi KANMERA and Dr. Tsugio SHUTO of the same university for the encouragement in various ways. I am indebted to Professor Nobuhiro HATAE of Kagoshima University, Dr. Masahisa AMANO and Dr. Shigeru IMANISHI of Kumamoto University, Mr. Yasuaki TAKAI of the Geological Survey, and Mr. Ikuwo OBATA of Kyushu University for the kindness of providing me with valuable information and also some specimens.

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Finally my thanks are extended to friendly assistance offered by Messrs Isamu HASHIMOTO, Jonosuke OBARA, Toru IWAHASHI and Nobutsune FURUKAWA and Dr. Hakuyu OKADA during the course of this study and by Miss Mitsuye ISHIKAWA in drafting and Miss Chizuko OKAMURA in type-writing.

II. Stratigraphy of the Type Himenoura Group

The type area of the Himenoura group is in the eastern part of Amakusa-Kamishima and also in the satellite islets, Hinoshima, Kugu-shima and Yokoura-jima, as indicated in the index map (black area in Fig. 1). The group name Himenoura was introduced by NAGAO, 1922 from a place name on the east coast of Amakusa-Kamishima.

The Himenoura group is stratigraphically divided in three parts:—Lower, Middle and Upper formations. It begins with the basal conglomerate, is followed by sandstone, consists of mudstone in the main middle part and ends with sandstone with intercalated shale, representing altogether a cycle of marine sedimentation. The thickness of its whole sequence is about 1000–1100 m in the type area.

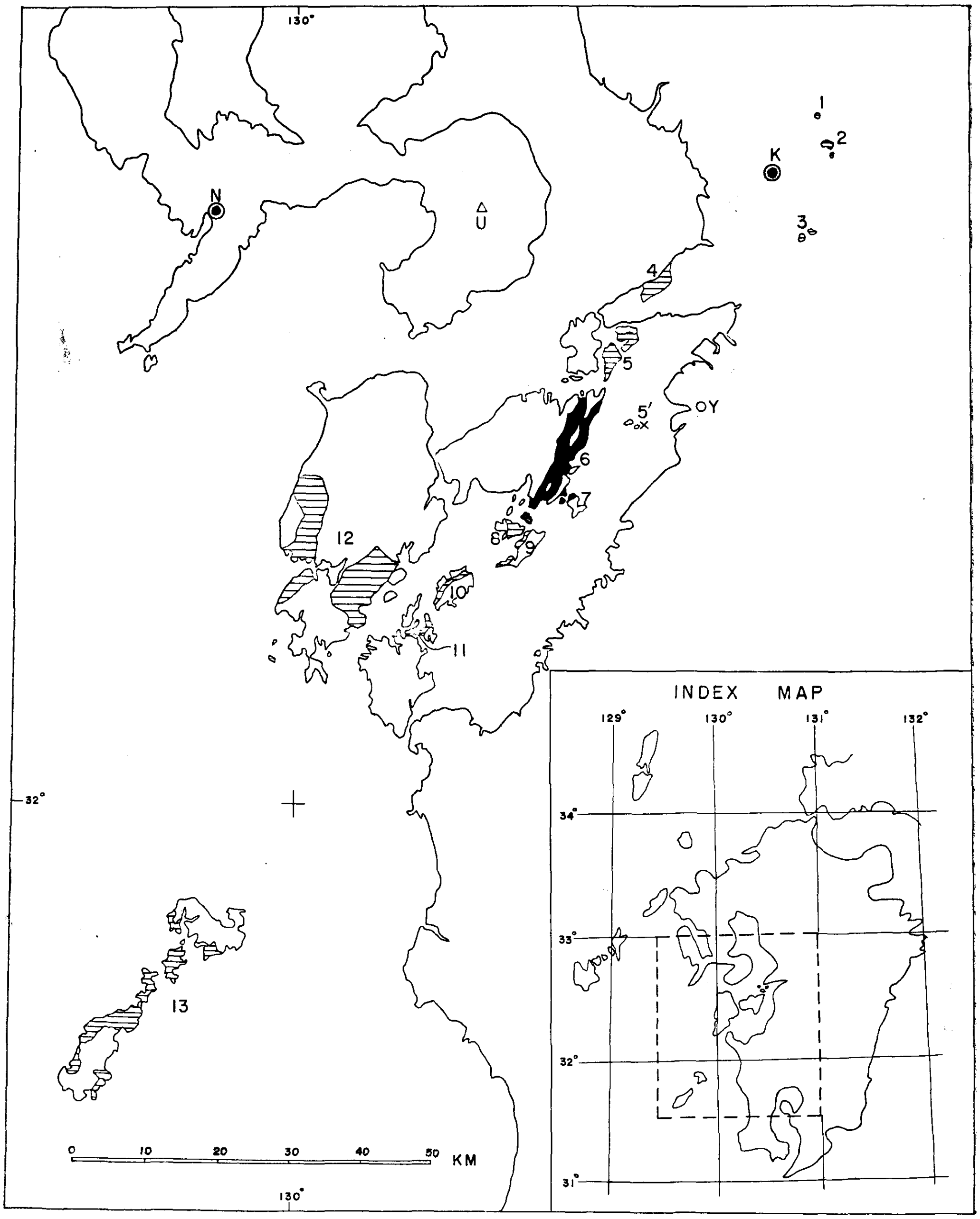


Fig. 1. Map showing the outcrop area of the Himenoura group, with an index of the area in Kyushu.

1: Mure-yama, 2: Oyama-yama, Tojima-yama, 3: Toyoaki, 4: Uto peninsula, 5: Tobase-Senzokuzozo-jima, 5′: Neshima, 6: Amakusa-Kamishima, 7: Hinoshima, 8: Makishima, 9: Goshonoura-jima, 10: Shishi-jima, 11: Nagashima, 12: Amakusa-Shimojima, 13: Koshiki-jima.

Solid black: type area, shaded: other areas of the outcropping Himenoura group

K: Kumamoto, N: Nagasaki, Y: Yatsushiro, U: Volcano Unzen.

The outline of the stratigraphic sequence, with the basement and the overlying rocks, is indicated in a generalized column of Fig. 2 and also by a geological profile in Fig. 4. The outcropping area of each geological unit is shown in a geological map (Fig. 4). The measured successions are illustrated in Fig. 5, which are taken along the selected routes 1-17 in Fig. 3.

The following is the explanation of the units of the Himenoura group in ascending order.

I. Lower formation

This represents the transgressive phase of the cycle of sedimentation. It is

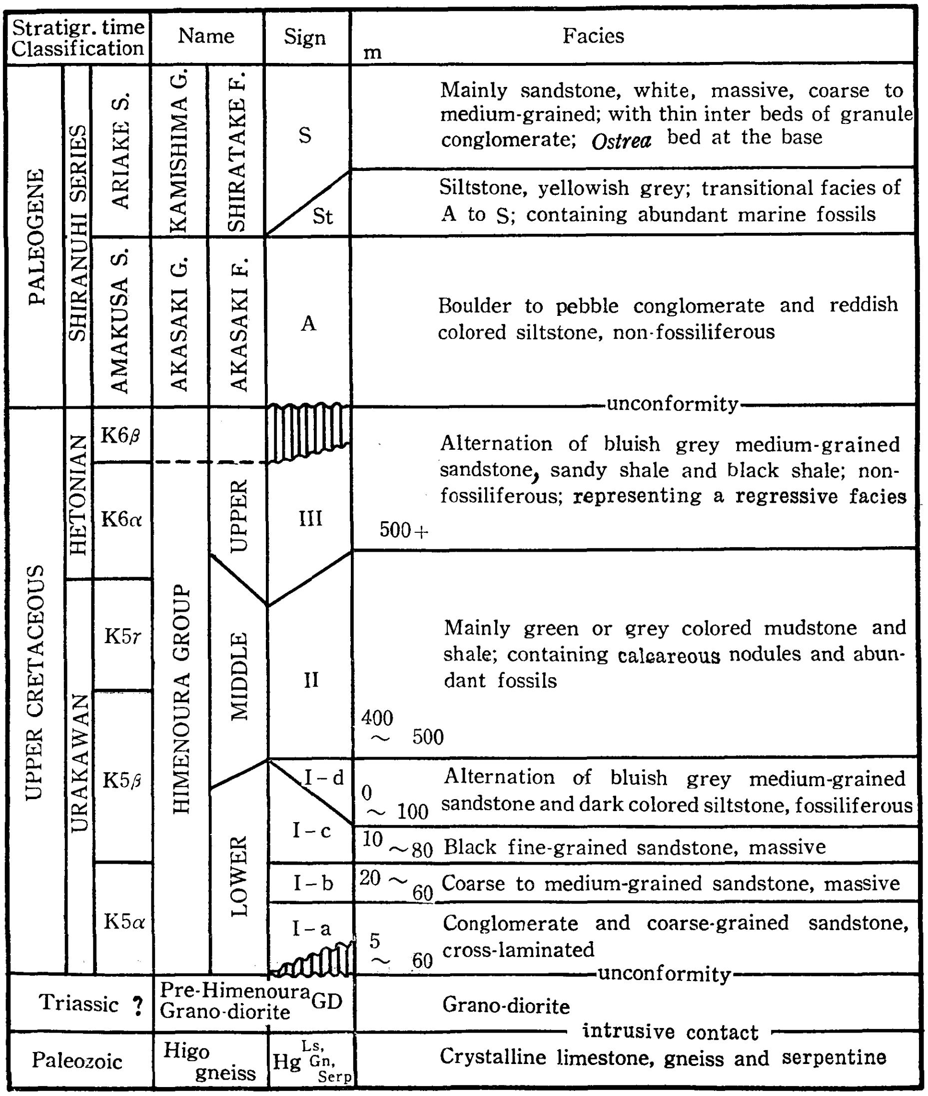


Fig. 2. Generalized geological column of the eastern part of Amakusa-Kamishima and Hinoshima.

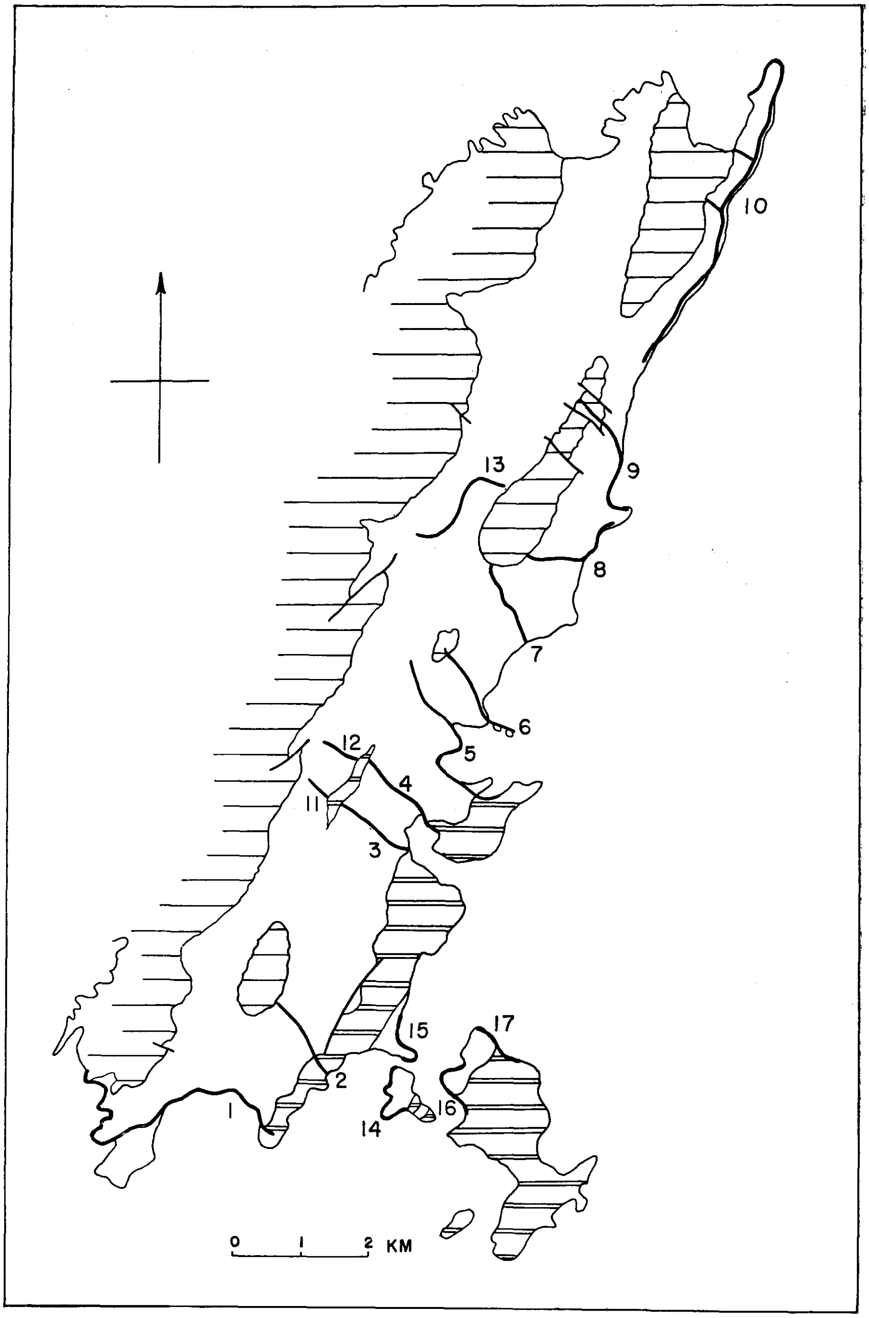


Fig. 3. Map of the eastern part of Amakusa-Kamishima and Hinoshima, showing the routes along which the stratigraphic sequences in Fig. 5 are measured.

1: From Takagushi, via Higashiura, Ikenoura, Kuzuzaki, to Akasaki
2: From Koyakawachi to Mt. Ryuga-dake
3: From Kojiro to Nishikawachi
4: Route passing Futamado
5: From Himenoura to Mt. Shishimi-dake
6: From Kojima to Mt. Shishimi-dake
7: From Nagame to Mt. Shira-take
8: From Muta to Mt. Shira-take
9: From Muta to Imaizumi
10: From the north of Muta, via Shirama, Pt. Otonomisaki, to Kakise
11: From Nishikawachi to Nenzu-dake
12: From Futamado to Nenju-dake
13: Uchinokochi
14: Kugu-shima
15: Wadanohana
16: Southwestern coast of Hinoshima
17: Northeastern coast of Hinoshima

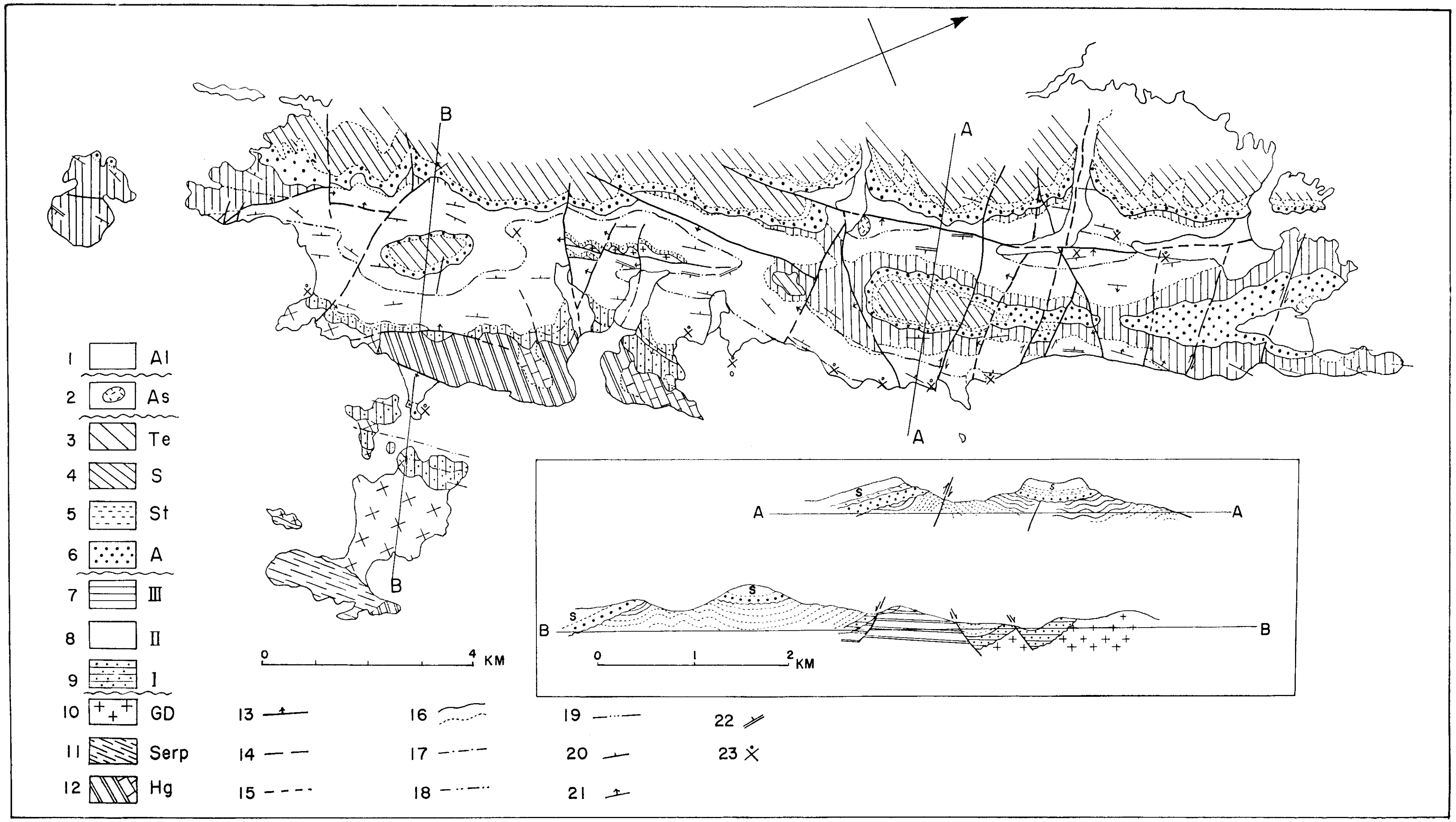


Fig. 4. Geological map and profile of the type area of the Himenoura group.

1 (Al): Alluvium, 2 (As): Aso welded tuff, 3–6: Lower Tertiary, 3 (Te): Tanasoko formation, 4 (S): Upper part of Shiratake formation, 5 (St): Lower part of Shiratake formation, 6 (A): Akasaki formation, 7–9: Upper Cretaceous Himenoura group, 7 (III): Upper formation, 8 (II): Middle formation, 9 (I): Lower formation of the Himenoura group, 10 (GD): Granodiorite, 11 (Serp): Serpentine, 12 (Hg): Higo gneiss group, with crystalline limestone, 13: fault, actually observed, 14: fault, presumed, 15: fault, concealed, 16: unconformable and conformable (dotted) boundary between the geological units, 17: boundary of the *Inoceramus amakusensis* zone and the *Inoceramus japonicus* zone, 18: boundary of the *I. japonicus* zone and the *I. orientalis nagaoi* zone, 19: boundary of the *I. orientalis nagaoi* zone and the *I. balticus toyajoanus* zone, 20–22: strike and dip, 20: dip 0–30°, 21: dip 31°–50°, 22: dip >50°, 23: important fossil locality.

variable in facies and stratigraphic succession. Its thickness ranges from 90 m to 220 m. It is exposed in the southern half of the present area (see Fig. 4).

The Lower formation can be stratigraphically subdivided in four members, I-a to I-d.

Member I-a. Basal conglomerate and sandstone

This member consists of conglomerate and coarse-grained sandstone. Its constituents are much affected by the lithology of the underlying basement rocks. Its thickness is 60 m in the eastern belt and decreases westward down to 2 m in the western belt of outcrop. This member consists typically of the very basal and the rhythmical parts. The details are as follows.

(1) The basal member in the eastern belt is best exposed on the northwestern coast of Hinoshima. It rests on the eroded plane of granodiorite with a distinct unconformity and is 60 m in thickness.

The basal part, 15 m, is made up mainly of boulder-bearing cobble- to pebble-conglomerate, becoming upwards finer and to have more matrix. The conglomerate is ill-sorted, containing subangular to subrounded blocks and pebbles of granodiorite and associated dike rocks (porphyrite, quartz-porphyry and diorite), without intermingling of meta-sediments. The matrix consists of sand grains of quartz, feldspar, hornblende, etc., the disintegrated products from the granodiorite. In the uppermost part of this submember there is a seam of coaly shale intercalated between beds of dark coloured, fine-grained sandstone.

The succeeding unit, 45 m in thickness, is here called the rhythmical part. Its lower part, about 25 m, begins with greenish granule-conglomerate, passing upwards to greenish, cross-laminated, coarse-grained sandstone and then to green, fine-grained sandstone, followed by alternating, platy beds, 1 m each, of granule-conglomerate and muddy fine-grained sandstone. The granule-conglomerate in the alternating portion is peculiar in that it is made up almost exclusively of angular grains of feldspar and contains occasionally rounded pebbles of granodiorite.

The remaining upper part, about 20 m, of the rhythmic unit shows twice repetition of a minor hemicycle from pebble-conglomerate to bluish grey, cross-laminated, coarse-grained sandstone.

(2) The basal member in the middle belt of outcrop is much thinner than that in the eastern and is characterized by the intercalation of the *Ostrea* bed. The composition of the coarse-grained sediments is remarkably different between the southernmost and the main areas, depending on the lithology of the basement rocks. In the southern quarter the basement is made up of granodiorite as in the eastern belt, but in the remaining three quarters it consists of paragneiss and crystalline limestone. At Kojiro quarry in the latter area the basal plane of unconformity is clearly exposed which shows the uneven surface of erosion on the gneiss group. The basal member at this locality is 6 m thick. Its very basal part, 1.5 m in thickness, consists of poorly sorted conglomerate, passing gradually upwards to massive, bluish, coarse-grained sandstone. The pebbles are those of gneiss and crystalline limestone. Many of them are angular and of pebble size, but some reach the boulder size.

The rhythmical part, 4.5 m thick, is composed of a sequence, 1.5 m, of massive, sometimes cross-laminated, bluish grey, coarse-grained sandstone and purple sandy siltstone, repeated in three times. Well rounded granules of gneiss may occur in the sandstone, forming a lenticular conglomeratic portion. The *Ostrea* bed is well traced throughout the sandstone of the first rhythm. In the southernmost area, where the basement is granodiorite, the upper fine-grained part of each rhythm is not purple.

(3) The basal member in the western belt is only 2 to 4 m thick, consisting only of basal conglomerate, without the rhythmical part. The conglomerate is made up of boulders and cobbles of granodiorite and also the matrix of coarse-grained granitic sand.

Member I-b. Lower medium-sandstone

This is typically exposed on the west coast of Hinoshima (eastern belt) and at Kojiro (middle belt). It rests on member I-a with a gradational change of lithology. Its thickness is about 50 to 60 m in the northern part of the middle belt, as seen in the columnar sections along the routes 3-5, but is almost constantly about 20 m in other areas.

Member I-b consists uniformly of massive, well sorted, bluish grey, medium-grained sandstone, without notable difference among the three belts of outcrop. The main constituents of the sandstone are quartz (with or without strain shadow) and feldspar. As accessory minerals hornblende, biotite and garnet are common. The intergranular space is almost wholly occupied by calcite. The sandstone is not very fossiliferous, but *Spondylus* sp. is found locally to the northwest of the point of Matsugahana, and *Ostrea* sp. occurs here and there.

Member I-c. Lower fine-sandstone

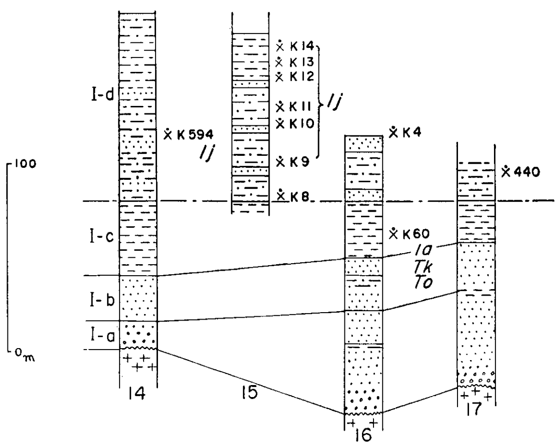
The type exposure of this member is at the neck of the head of Matsugahana on the coast east of Higashiura. This belongs to the middle belt. Other exposures are in the same belt and also in the eastern belt.

Member I-c ranges from 80 to 10 m in thickness, thinning to the north. It is not developed in the western belt. It rests on member I-b with a gradual change of lithology and partly merges laterally to the upper part of I-b. It consists of massive, dark grey or greenish grey, fine-grained sandstone. The sandstone contains a considerable amount of muddy matrix. This member is fossiliferous, with scattering marine molluscan shells. The assemblage is characterized by *Nanonavis sachalinensis*, *Glycymeris amakusensis*, *Inoceramus amakusensis*, texanitine and hamitoid (*Polyptychoceras*) ammonites.

Member I-d. Lower alternating sandstone and shale

This member is typically exposed at Point Wadanohana in the eastern belt and is distributed also in the northern part of the middle belt. It is 100 m thick in the northern part but thins away to the south, probably merging laterally to the mudstone of the lower part of the Middle formation.

Member I-d consists primarily of alternating beds of sandstone and shale. In the lower part the sandstone is coarse- to medium-grained, often thick-bedded, extremely ill-sorted, bearing drifts of wood and penecontemporaneous pebbles of sandy shale, with sedimentary features of slumping; isolated pebbles of granodiorite are some-



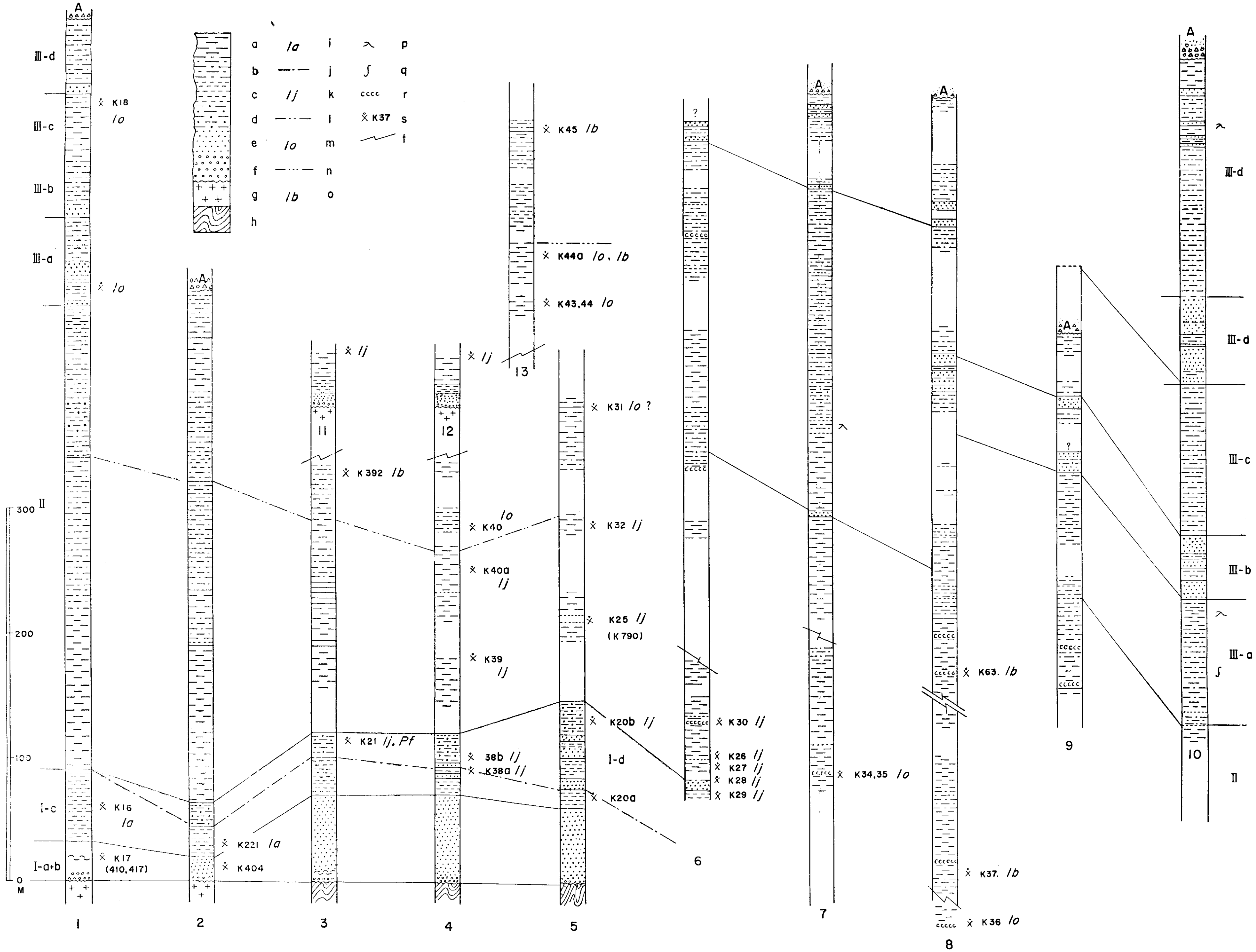


Fig. 5. Stratigraphic sections of the Himenoura group along the selected seventeen routes, 1–17, as indicated in Fig. 3.
a: mudstone or shale, b: shale and fine-grained sandstone in frequent alternation, c: fine-grained sandstone, d: shale and medium-grained sandstone in alternation, e: medium- to coarse-grained sandstone, f: conglomerate, g: granodiorite, h: paragneiss and crystalline limestone, i(Ia): *Inoceramus amakusensis*, j: boundary of the zones of *I. amakusensis* and *I. japonicus*, k (Ij): *Inoceramus japonicus*, l: boundary of the zones of *I. japonicus* and *I. orientalis nagaoi*, m (Io): *Inoceramus orientalis nagaoi*, n: boundary of the zones of *I. orientalis nagaoi*, and *I. balticus toyajoanus*, o (Ib): *Inoceramus balticus toyajoanus*, p: cross-bedding, q: sand pipe, r: calcareous nodules, s: stratigraphic position of a fossil-locality, A: Akasaki formation, *Pf*: *Protexanites fukazawai*, *Tk*: *Texanites kawasakii*, *To*: *Texanites oliveti*.

times contained and lenticular bodies of granule-conglomerate is intercalated; the shale is greenish dark grey and sandy, containing redeposited sand. In the upper part the sandstone is medium-grained, better sorted and occurs as thin and less frequent intercalates in the laminated, bluish dark grey to black shale. Fossils of marine molluscan shells and a simple coral occur fairly abundantly from the shale. The representative elements of the assemblage are *Nucula formosa, Acila (Truncacila) hokkaidoensis, Glycymeris amakusensis, Nanonavis sachalinensis, Apiotrigonia minor, Inoceramus japonicus, Lucina* sp., *Solemya angusticaudata, Gaudryceras denseplicatum, G. tenuiliratum, Polyptychoceras haradanum, P. obstrictum, Eupachydiscus haradai* and *Platycyathus* cf. *kawakamiensis*.

II. Middle formation

This formation constitutes the main, middle part of the Himenoura group. It is about 400-500 m thick, occupying approximately a half of the entire thickness of the group. It consists primarily of dark coloured muddy sediments of relatively uniform facies and thickness, representing the inundation phase of the marine cycle of sedimentation. This contrasts to the variable facies of the Lower formation which was formed under unstable environments. The lithological change from the Lower formation to the Middle is, however, quite gradual and the absence of the sandstone of considerable thickness may be a criterion which makes us to discriminate the latter from the former.

The exposures along the coast from Matsugahana through Higashiura to Ikenoura (route 1 in Fig. 3) and those along the coast from Himenoura through Nagame to Muta (combining parts of routes 5-9 in Fig. 3) show the type sections of this formation. The relatively upper part is also well exposed near Uchinokochi (route 13 in Fig. 3), Imaizumi, Aizu (northern area) and Nishikawachi (route 3 in Fig. 3).

Because of the monotonous muddy facies the Middle formation is hardly subdivided on lithologic grounds only. *Inoceramus*, ammonites and echinoids (mostly squashed) are commonly contained. The succession of *Inoceramus* species as explained in the next article enables us to discriminate the lower, middle and upper parts, which may have respectively certain detailed lithological features. They are as follows:

IIa. Lower part (zone of Inoceramus japonicus).—The lower one third, 50-60 m, of this part consists mainly of black laminated shale, with intercalated thin layers (10-15 cm) of brownish, fine-grained, sandstone. The upper two thirds, 100-200 m, are primarily massive, bluish dark grey mudstone containing calcareous nodules of 20-30 cm diameters. In its lower part there are thin layers of white, soft, sandy tuff.

IIb. Middle part (zone of Inoceramus orientalis nagaoi).—This is about 150-160 m in thickness. Its lower half is made up of thin layers (3-5 cm each) of shale and sandy shale (sometimes fine-grained sandstone) in alternation, with interbeds (5-10 cm each) of calcareous mudstone (i.e. indurated marl) and also layers rich in limy concretions of smaller diameters (10 cm or less). The upper half consists of bluish dark grey mudstone.

IIc. Upper part (*zone of Inoceramus balticus toyajoanus*).—This ranges from 100 m to 150 m in thickness. It is composed of shale and sandy shale in frequent alternation, with many intercalates of brownish, fine- to medium-grained sandstone.

III. Upper formation

This consists of beds, 1-2 m thick each, of bluish grey, medium-grained sandstone and thin-bedded shale and sandy shale (or fine-grained sandstone) in composite alternation. The sandstone interbed tends to be thicker and more frequent in the upper part. The formation represents the regressive phase of the marine cycle of sedimentation.

The upper formation conformably succeeds the Middle formation with a gradual change of lithology. The former can be discriminated by the intercalation of the medium-grained sandstone beds of considerable thickness (more than 20 cm each). The Tertiary Akasaki formation (conglomerate and red beds) rests on the Himenoura group with a distinct unconformity. The original thickness of the Upper formation cannot, therefore, be precisely estimated. The preserved part in the Kamishima area is 500 m thick.

The typical outcrop is on the eastern coast of Matsushima in the northern part of the present area. Other exposures are on the flanks of the ridge of Kompira-yama, Shira-take, etc. and also on the coast between Ikenoura and Akasaki in the southern part.

The sequence in detail may be given as follows:

(a) A unit, about 90 m thick, of 20-30 cm beds of bluish grey medium-grained sandstone and alternating thin layers of shale and sandy shale in composite repetition. The intercalation of the sandstone bed becomes relatively more frequent as we ascend the sequence. The sandstone is not well sorted, containing rock fragments of shale, porphyrite, etc. in addition to quartz, feldspar and matrix of clay and a smaller amount of calcite.

The uppermost portion, 2-5 m thick, consist of alternating shale and sandy shale, is cross-bedded with other parts of the alternation.

(b) A unit, 50-60 m thick, of composite repetition in which a thick platy bed (10-15 m) of the medium-grained sandstone occurs twice.

(c) Another unit, about 120 m, of composite repetition like (a). The shale contains sand pipes.

(d) A unit, about 70 m, of massive, thick beds (25-30 m) of medium-grained sandstone and thin bedded shale and sandstone in composite alternation. The sandstone in the lower part contains irregular fragments of shale and that in the upper granules of quartzose rocks. A seam of coaly shale is intercalated in the upper, cross-laminated sandstone.

(e) Another unit, about 170 m, of composite repetition, in the upper part of which medium-grained sandstone occur as beds of moderate thickness (10 m). The sandstone in the middle part shows cross-lamination.

III. Zonation of the Type Himenoura Group

In the type area of the Himenoura group more than sixty fossil localities are found, which can be arranged in six groups on account of their stratigraphic position and assemblage of species. The representative localities of the six groups are as follows.

(1) K17 (Matsugahana), K65 (Kojiro quarry), K404 (Furukojiro), K417 (Takagushi)
(2) K16 (north of Takagushi), K60 (Hinoshima), K61 (east of Higashiura)
(3) K9-14 (Wadanohana), K21 (Nishikawachi), K29 (east coast of Kojima), K38a, b (Maruyama), K594 (Kugu-shima)
(4) K25 [=K790] (Himenoura), K26-K27 (small islet west of Kojima), K28 (south coast of Kojima), K39 (Futamado)
(5) K34-K35 (Nagamé), K36 (1500 m northeast of Nagamé), K40 (Futamado), K43-K44-K44a (Uchinokochi), K48 (Aizu)
(6) K37 (Imamura), K45 (Uchinokochi), K63 (north of Muta)

The location and stratigraphic position of these and other selected* fossil localities are shown in the geological map (Fig. 4) and the stratigraphic columns (Fig. 5) respectively. The important species, among others, of the six groups of localities are given below.

(1) The localities of the first group belongs to Member I-a or I-b. Only *Spondylus* sp. and *Ostrea* sp. occur in this part. They may suggest the littoral or near shore environments but are not good indicators of geological age.

(2) The localities of the second group are assigned to Member I-c. Good age indicators from them are

Inoceramus amakusensis NAGAO and MATSUMOTO
Texanites oliveti (BLANCKENHORN)
Texanites kawasakii (KAWADA)
Polyptychoceras obstrictum (JIMBO)
Polyptychoceras haradanum (YOKOYAMA)

In addition *Glycymeris amakusensis* NAGAO and *Nanonavis sachalinensis* (SCHMIDT) occur abundantly.

(3) The localities of the third group are referred to Member I-d. The following species are useful for the age determination and occur abundantly or commonly at many localities.

Inoceramus japonicus NAGAO and MATSUMOTO
Apiotrigonia minor (YABE and NAGAO)
Eupachydiscus haradai (JIMBO)
Protexanites cf. *fukazawai* (YABE and SHIMIZU)
Gaudryceras denseplicatum (JIMBO)
Gaudryceras tenuiliratum YABE
Polyptychoceras obstrictum (JIMBO)
Polyptychoceras haradanum (YOKOYAMA)

* In this paper all the localities are not indicated for simplification. In the Japanese paper (UEDA and FURUKAWA, 1960) they are fully indicated and listed.

In addition *Nucula formosa* (NAGAO), *Acila* (*Truncacila*) *hokkaidoensis* (NAGAO), *Glycymeris amakusensis* NAGAO, *Nanonavis sachalinensis* (SCHMIDT) and *Solemya angusticaudata* NAGAO are the common associates.

(4) The localities of the fourth group stratigraphically belong to the lower part of the Middle formation, from which the following important species occur.

Inoceramus japonicus NAGAO and MATSUMOTO
Neophylloceras cf. *ramosum* (MEEK)
Hauericeras (*Gardeniceras*) *angustum* YABE
Eupachydiscus haradai (JIMBO)
Gaudryceras denseplicatum denseplicatum (JIMBO)
Gaudryceras denseplicatum intermedium YABE
Polyptychoceras obstrictum (JIMBO)
Polyptychoceras haradanum (YOKOYAMA)

Nucula formosa (NAGAO) is a common associate, but *Acila* (*Truncacila*) *hokkaidoensis* (NAGAO), *Glycymeris amakusensis* NAGAO and *Opis amakusaensis* UEDA occur at a limited number of localities.

(5) The localities of the fifth group are in the middle part of the Middle formation. The diagnostic species from them are

Inoceramus orientalis nagaoi MATSUMOTO and UEDA, nom. nov.
Hauericeras (*Gardeniceras*) *angustum* YABE
Eupachydiscus haradai (JIMBO)

From the localities (e. g. K44a) in the relatively higher part *Inoceramus balticus toyajoanus* NAGAO and MATSUMOTO sometimes occur along with *I. orientalis nagaoi*. *Leionucula* sp. may associate with these inocerami.

A locality belonging to Member III-a on the southern coast (route 1 in Figs. 3, 5) probably represents the same level, because *I. orientalis nagaoi* is still obtainable there.

(6) The localities of the sixth group are mostly referred to the upper part of the Middle formation. The diagnostic age indicator is

Inoceramus balticus toyajoanus NAGAO and MATSUMOTO

As far as the available evidence is concerned, this is not associated with *I. orientalis nagaoi* in this part. Although *I. orientalis orientalis* SOKOLOW could occur here, it has not been confirmed yet.

(7) The Upper formation is very poor in megafossils. Locality K18 on the southern coast is stratigraphically assigned to the upper part of Member III-c, where *Lucina* cf. *occidentalis* MORTON occurs abundantly. *Inoceramus* sp. of the *balticus* group was obtained here, but it is too poorly preserved for precise identification. Although *Inoceramus schmidti* could be expected to occur in this part of the Himenoura group, I have not yet obtained it. Aside from the specimens misidentified with *I. japonicus*, MATSUMOTO (1954) found specimens of *I.* cf. *schmidti* from the Upper formation of the Himenoura group in the northern part of Shimokoshiki-jima.

From the above described facts the zonal distribution of the species in the Himenoura group is evident. Although good zonal indices are lacking in the basal and upper parts of the Himenoura group in the type area, they are supplemented by the equivalent parts in other areas, as will be explained in detail in the next chapter. Thus the zones are called in ascending order as follows:

zone of *Inoceramus uwajimensis* (represented in the Nagashima area) (Judging from the stratigraphic position the localities of the first group in the present area are most probably regarded as correlatable with this zone.)

zone of *Inoceramus amakusensis* (represented by the localities of the second group)

zone of *Inoceramus japonicus* (represented by the localities of the third and fourth groups.)

zone of *Inoceramus orientalis nagaoi* (represented by the localities of the fifth group)

zone of *Inoceramus balticus toyajoanus* (represented by the localities of the sixth group) (From the evidence in other areas the poorly fossiliferous main part of the Upper formation in the present area is presumed to be still within the time-range of the same zone.)

This zonal sequence conforms fairly well with that in Hokkaido which was defined by MATSUMOTO (1942-43, 1954, 1959) as a standard for the Japanese Upper Cretaceous. In Hokkaido (and also in Sakhalin) the zone of *Inoceramus orientalis orientalis* and then that of *Inoceramus schmidti* come above the zone of *Inoceramus orientalis nagaoi,* while *Inoceramus balticus toyajoanus* is occasionally found along with *I. orientalis orientalis* and *I. schmidti.* In Southwest Japan *I. balticus* occurs more commonly, but at Toyajo, the type locality of *I. balticus toyajoanus, I. schmidti* is associated with it in the middle part of the Toyajo formation and in the island of Awaji. *I. orientalis orientalis* was reported to occur along with *I. balticus toyajoanus* from the basal fossiliferous unit. Therefore the zone of *I. balticus toyajoanus* in Amakusa is certainly the correlative of the zone of *I. orientalis orientalis* plus that of *I. schmidti* in Hokkaido.

In Hokkaido *Inoceramus orientalis nagaoi* seems to appear earlier than in Kyushu, occurring in some places together with *Inoceramus japonicus.* Similarly *I. balticus toyajoanus* may appear somewhat earlier in Kyushu than in Hokkaido. The superposition of the *I. japonicus* zone above *I. amakusensis* zone is commonly held in both Hokkaido and Kyushu, as far as the available evidence is concerned, but the overlapping of the ranges of the two species might happen in some unsurveyed regions. In fact *Protexanites fukazawai* is found in the upper part of the *amakusensis* zone and also in the lower part of the *japonicus* zone.

From these and other reasons the zones that are recognized in the Himenoura group may be better called the subzones, if the whole region of the Japanese Islands are considered. For brevity and for the convenience of describing the Himenoura group they are called the zones in this paper.

On the basis of the above explained zonal correlation between Amakusa and Hokkaido, the geological age of the Himenoura group is determined as follows:

zone of *I. uwajimensis*: K5 α (Lower Urakawan): Coniacian

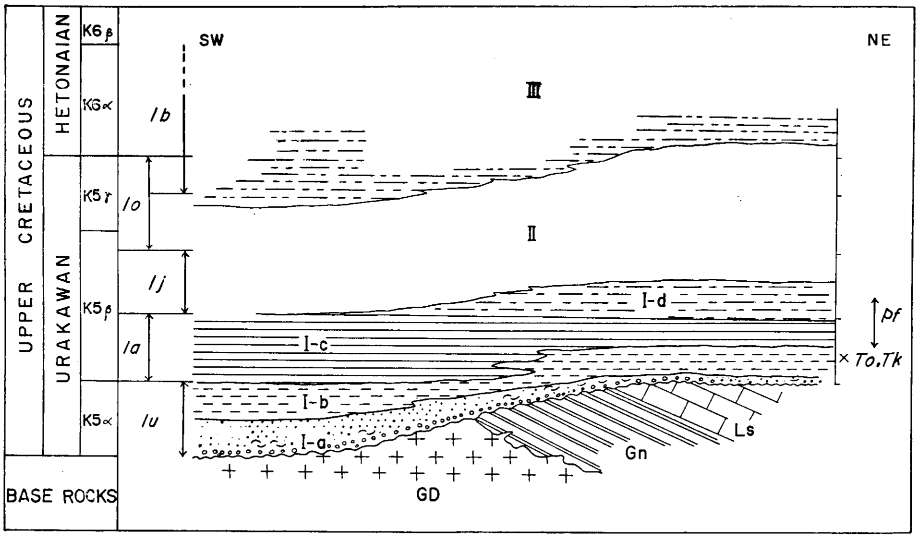


Fig. 6A.

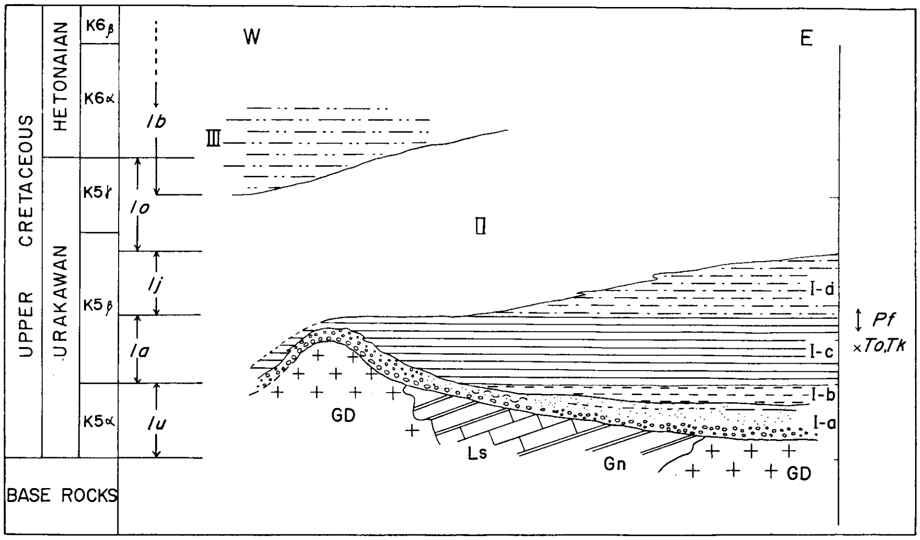


Fig. 6B.

Fig. 6. Schematic illustration of the stratigraphic classification of the Himenoura group in the type area, showing the relation of the rock-stratigraphic and biostratigraphic classifications. Fig. 6A shows the change of facies from northeast to southwest and Fig. 6B that from northwest to southeast. The thickness is not considered in this figure, so as to indicate a given stratigraphic horizon by a horizontal line.

Iu: zone of *Inoceramus uwajimensis*
Ia: zone of *Inoceramus amakusensis*
Ij: zone of *Inoceramus japonicus*
Io: zone of *Inoceramus orientalis nagaoi*
Ib: zone of *Inoceramus balticus toyajoanus*
Pf: stratigraphic position of *Protexanites fukazawai*
Tk: stratigraphic position of *Texanites kawasakii*
To: stratigraphic position of *Texanites oliveti*

Basement rocks GD: granodiorite, Gn: paragneiss, Ls: crystalline limestone

Himenoura group I: Lower formation, comprising Members I-a, I-b, I-c and I-d, II: Middle formation, III: Upper formation.

zone of *I. amakusensis*: lower part of K5 β (lower Upper Urakawan): approximately Lower Santonian

zone of *I. japonicus*: upper part of K5 β (upper Upper Urakawan): approximately Upper Santonian

zone of *I. orientalis nagaoi*: mainly K5 γ (Uppermost Urakawan="Infrahetonaian"): approximately Lower Campanian

zone of *I. balticus toyajoanus*: mainly K6 α (Lower Hetonaian): approximately Middle to Upper Campanian

Regarding the international correlation, I depend on MATSUMOTO's recent conclusion (1959). The occurrence of *Texanites oliveti* (BLANCKENHORN) from the second zone confirms a part of the conclusion.

The Himenoura group, thus, ranges in geological age from the Lower Urakawan to the Lower Hetonaian, i.e. from the Coniacian to the Campanian in terms of the international scale. Only in the area of Amakusa-Shimojima the Upper Hetonaian (Maestrichtian) is possibly recognized (see chapter IV).

Another interesting result of the zonation is that the zones are traced obliquely through the different rock-stratigraphic units in the Himenoura group. For example, the zone of *Inoceramus orientalis nagaoi* is represented by the middle part of the Middle formation (II-b) in the northern area, but it is traced to the lower part of the Upper formation (III-a) in the southern area. The zone of *Inoceramus japonicus* runs from the lower part (II-a mudstone) of the Middle formation to Member I-d (alternating sandstone and shale) of the Lower formation. These and other relations are schematically shown in Fig. 6A, B. The geological meaning of this fact is to be discussed in chapter V.

IV. Notes on the Himenoura Group Outside the Type Area

The strata which are referable to the Himenoura group outcrop in a belt of NE-SW trend from the scattered areas northeast of Kumamoto to the islands of Koshiki as indicated in Fig. 1. Owing to the covering by the Cenozoic formations and the sea waters the outcrops are separated in thirteen areas as numbered in the same figure. In this chapter brief description is given for the outcropping strata of these areas and the correlation is attempted on the basis of the above established stratigraphy and zonal sequence of the type Himenoura group. The heading number of each article corresponds to the index number in Fig. 1. For the local geology of each area the writer depends much on the previous works which are to be indicated in each article.

1. *Mure-yama area*

There are several small hills around the city of Kumamoto which are made up of the Upper Cretaceous strata. They are described in the articles 1-3. The first of them is the area of Mure-yama and Hanko-yama about 10 km northeast of Kumamoto. According to AMANO and IMANISHI (1958), the following sequence of strata in ascending order is observed there.

1-a 20 m. Medium-grained sandstone

1-b 10 m. Conglomerate
1-c 20 m. Sandstone and shale in alternation
1-d 35 m. Medium-grained sandstone
1-e 10 m. Conglomerate
1-f 30 m. Sandstone

The exposed part, 125 m in thickness, is probably a fraction of the Himenoura group, because of its general lithologic similarity to that in the second area. As no fossil has been obtained the zonal correlation is impossible.

2. *Oyamayama area*

This area comprises small hills called Oyama-yama, Shinsono-yama, Mifunezuka and Toshima-yama, which are situated about 10 km ENE from the center of the city of Kumamoto. The outcropping strata, 165 m thick, show the following succession in ascending order, as reported by AMANO and IMANISHI (1958).

2-a 55 m. Medium- to coarse-grained sandstone, partly with conglomerate
2-b 30 m. Siltstone predominant, with thin interbeds of sandstone, fossiliferous
2-c 20 m. Well bedded medium- to fine-grained sandstone, with occasionally interbedded siltstone
2-d 25 m. Conglomerate, containing boulders and cobbles of schists, quartzite and granite
2-e 25 m. Greenish grey, medium-grained sandstone
2-f 10 m. Pebble- to granule-conglomerate

Inoceramus amakusensis, *Pseudomelania* sp. and an echinoid have been obtained from 2-b, which certainly indicate the zone of *I. amakusensis*. Conglomerate and sandstone are more predominant than in the type area.

3. *Toyoaki area*

Toyoaki is located about 10 km SSE of Kumamoto and is close to the area of the Mifuné group (Upper Albian-Turonian). A 50 m-sequence of fine-grained sandstone with thin interbeds of conglomerate is exposed there. Although no good age indicators have been found, this is from its lithology more probably referable to a part of the Himenoura group than to the Mifuné group.

The thick conglomerate of the Gankaisan Hills to the southwest of the Toyoaki area is said to rest on the red beds similar to that of the Upper Mifuné (AMANO and IMANISHI, 1958). Therefore it might be equivalent to the basal conglomerate of the Himenoura group but is so questionable that it is excluded from the present paper.

4. *Uto peninsula*

The Uto peninsula is mainly occupied by the Cenozoic volcanic rocks. Underneath them crop out the Upper Cretaceous strata which were studied by NAGAO (1922) and OBATA (M.S.). The relatively continuous succession is observable along the coast of Ôda below the unconformable plane at the base of the Lower Tertiary Akasaki formation, although the very base of the Himenoura group is not exposed in the area.

The exposed part of the Himenoura group in this area ranges from 300 m to

400 m in thickness and consists mainly of black mudstone and dark colored fine-grained sandstone in thin bedded alternation, with fairly frequent intercalation of medium-grained sandstone and conglomerate. The conglomerate often shows a peculiar form, with a concave or uneven lower surface and the plane upper one, and sometimes contains boulders in addition to pebbles and cobbles. Isolated pebbles sometimes occur in the mudstone. The alternating sandstone and mudstone take unusual attitudes which probably indicate the cross-bedding or submarine sliding. The strata are fossiliferous and the type locality of *Protexanites fukazawai* (YABE and SHIMIZU) is in the Ôda area. According to OBATA this species has a certain extent of stratigraphic distribution along the section of the Ôda coast and is accompanied with *Glycymeris amakusensis* and *Apiotrigonia minor.* OBATA discovered *Inoceramus japonicus* in an inland locality which is stratigraphically slightly higher than the localities of *P. fukazawai.* Here occur *Propeamusium cowperi* var. and *Gaudryceras denseplicatum.* From this evidence the exposed part of the Himenoura group in the Uto peninsula is assigned to the zone of *Inoceramus japonicus* plus the subjacent part. In facies it is similar to, but not quite identical with, Member I-d in the type area.

5. *Tobase-Senzokuzozo-jima area*

AMANO (1960) has recently described the geology of Tobase-jima and Senzokuzozo-jima. According to his work the Himenoura group in this area ranges in thickness from 325 m to 570 m and has the following stratigraphic sequence. Its lower limit is concealed by the sea water and its upper limit is cut by the Lower Tertiary with a distinct unconformity.

5-a	115 m.	Bluish dark grey siltstone
5-b	25-40 m.	Grey medium-grained sandstone, sometimes containing pebbles, with thin interbeds of siltstone in the upper part; fossiliferous
5-c	50-140 m.	Massive fine-grained sandstone in the lower part; alternating sandstone and shale in the upper part
5-d	40-100 m.	Massive sandstone in the lower part; laminated, fine-grained sandstone in the upper part
5-e	75 m.	Dark grey siltstone, occasionally with thin layers of fine-grained sandstone
5-f	150 m.	Coarse- to medium-grained sandstone, occasionally with shale and sandy shale

Inoceramus orientalis nagaoi MATSUMOTO and UEDA (see the description in p. 167) occurs abundantly in member 5-b and *Inoceramus* sp. cf. *I. balticus* (s. l.) was obtained from member 5-e. Member 5-a may be assigned in facies to the Middle formation and the overlying strata from 5-b to 5-f to the Upper formation of the Himenoura group. From the standpoint of zonal correlation the zone of *I. orientalis nagaoi* and probably that of *I. balticus toyajoanus* are represented here by members 5-a plus 5-b and 5-c to 5-f respectively. The two zones are both more sandy in this area than in the type area.

5′. *Neshima*

There is a small islet called Neshima southeast of Otsuki-jima off the coast of

Yatsushiro, or, in other words, to the southeast of the preceding area. While Otsuki-jima is composed of crystalline limestone of the Higo gneiss group, Neshima is made up of siltstone with fine-grained sandstone of the Himenoura group. KANMERA (*in* MATSUMOTO and KANMERA, 1962) discovered there *Inoceramus amakusensis.*

6. *Amakusa-Kamishima* } type area of the Himenoura group, as described in
7. *Hinoshima* } chapters II and III

8. *Makishima area*

The geology of Maki-shima and adjacent islets was described in Japanese by AMANO (1960). The Himenoura group exposed in this area is subdivided into two parts, lower and upper. Its lower limit is concealed by the sea water, but the probably subjacent part reappear on the island of Goshonoura (described in the next article). The outline of the stratigraphic sequence revealed by AMANO is as follows.

8-a Lower part 190 m, consisting of siltstone and silty shale in frequent alternation. A bed (0.7 m thick) of sandstone is intercalated in the upper part. No fossils have been obtained.

8-b Upper part, composed of the following four members

b1 140 m, consisting of the lower sandy and upper shaly parts. The sandstone is light grey to bluish grey, medium-grained, contains fragments of shale and forms beds of 0.8-1.2 m in thickness. The upper part is silty and clayey shales in frequent alternation, with occasional interbeds (0.6 m) of medium-grained sandstone. The abnormal, disturbed sedimentation is common in this unit. *Inoceramus* sp. cf. *I. balticus* was obtained.

b2 160 m, composed of again the lower sandy and upper shaly parts. The sandstone in this member is less predominant than in the preceding member and is well bedded. The shaly part shows the disturbed sedimentation of submarine slump.

b3 160 m, alternating sandstone and siltstone. The sandstone is predominant in the lower part, while the shale is so in the upper. Graded bedding is common, with an uneven lower surface of the sandstone bed. *Inoceramus balticus* (s. l.) was obtained.

b4 100 m, another sequence of alternating sandstone and siltstone similar to b3. *Inoceramus* sp. and *Eupachydiscus* (?) sp. were obtained.

The lower part (8-a) of the sequence in this area belongs facies-stratigraphically to the Middle formation and the upper part (8-b) to the Upper formation of the Himenoura group. The latter is to be referred to the zone of *Inoceramus balticus toyajoanus.*

9. *Goshonoura-jima*

The Cretaceous of Goshonoura island, with its satellite islets, Mae-shima and Mayu-shima, was studied accurately by MATSUMOTO (1938). This island is mainly occupied by the Goshonoura group, but a part of the Himenoura group, which comes below the sequence in Maki-shima, is exposed in Mae-shima, Mayu-shima and northern coast of Goshonoura-jima itself. In the western part of the island the Himenoura group rests on the Goshonoura group (Upper Albian-Cenomanian and also ? Turonian), but in the northeastern part it covers the granitic basement with a distinct unconformity. According to MATSUMOTO (1938), the following ascending sequence is established in this area.

9-a Basal conglomerate and arkose, 12-20 m in the northeastern part and 10-35 m in the southwestern part where silty layer may be intercalated.

9-b Bluish or greenish grey sandstone, rather massive, partly bedded, mainly fine-grained and in part medium-grained, 60-75 m. Fossils occur frequently in which *Glycymeris amakusensis* is very common. *Inoceramus amakusensis* and *Gaudryceras tenuiliratum* occur at a locality (G 235) in the southwestern part.

9-c Dark grey siltstone and mudstone, rather massive, containing *Inoceramus*, ammonites, other fossils and limy concretions, about 170 m in the northwestern part. The identified species are *Nucula formosa, Acila* (*Truncacila*) *hokkaidoensis, Portlandia* (?) sp., *Nanonavis sachalinensis, Solemya angusticaudata, Inoceramus amakusensis, Inoceramus japonicus, Anomia* sp., *Cardita* (?) sp., *Brunonia cassidaria, Gaudryceras tenuiliratum, Gaudryceras denseplicatum, Polyptychoceras obstrictum, Polyptychoceras haradanum, Protexanites fukazawai, Glyptoxoceras* sp. and *Hauericeras angustum*. Many of the species are long-ranging, but *Inoceramus amakusensis* occur below *I. japonicus* in every section, occupying about the lower five sixths of this member. Thus the zone of *Inoceramus amakusensis* is distinguished from that of *I. japonicus*. *Protexanites fukazawai* occurs fairly commonly in the upper part of the *I. amakusensis* zone. Loc. G 240 in the southwestern part, from which *Eupachydiscus* cf. *haradai* was obtained, may belong to the *I. japonicus* zone.

9-d Silty shale and fine-grained sandstone in frequent alternation, incompletely exposed in the Goshonoura area.

As rock stratigraphic units members 9-a and 9-b in the above sequence are to be referred to the Lower formation and member 9-c to the Middle formation of the Himenoura group. Member 9-d is probably still a portion of the Middle formation, since the sequence in Maki-shima (described in 8) is higher than it. Biostratigraphically the zone of *Inoceramus amakusensis* is represented by the main part of member 9-c in in the northern part of this area, which is more fine-grained and of more offshore facies than the same zone in the type area.

10. *Shishi-jima*

Shishi-jima is geologically very similar to Goshonoura-jima as shown by the geological map of NOTOMI (1930). AMANO has been engaged in the Cretaceous stratigraphy and palaeontology of the area, but his results have not yet been fully published. There is unfortunately no available data precise enough for the present problem of the Himenoura group.

11. *Nagashima area*

TAKAI and MATSUMOMO (1961) have recently clarified the stratigraphic sequence of the Upper Cretaceous and Lower Tertiary in the northern part of Nagashima and neighbouring islets. The equivalent of the Himenoura group rests on the Goshonoura group and is overlain with a remarkable unconformity by the Akasaki formation. The Himenoura group in this area has more mudstone and shale than in other areas. Its ascending sequence is, according to the authors, as follows.

11-a Medium-grained sandstone with some shale. The very contact with the Goshonoura group is unexposed.

11-b Massive, dark grey siltstone, somewhat fine-sandy, 150 m, containing calcareous nodules and fossils in the lower part. *Inoceramus* cf. *uwajimensis*, *Gaudryceras denseplicatum* and *Kingena* (?) sp. have been identified.

11-c Unexposed part, presumably about 130 m of relatively softer rock like mudstone

11-d Black shale, with occasional sandy laminae, about 250 m. Fossils are sporadically found. The identified species in the upper part are *Inoceramus* cf. *orientalis*, *I. elegans pseudosulcatus* and *I. balticus toyajoanus*.

11-e Still more sequence of shale with thin layers and laminae of fine-grained sandstone. Thickness not exactly known.

As rock-stratigraphic units all the above members except 11-a are to be referred to the Middle formation of the Himenoura group in the type area. Biostratigraphically unit 11-b represents the zone of *Inoceramus uwajimensis* (K5 α, Coniacian) and unit 11-d the zone of *Inoceramus orientalis* (K5 γ, Lower Campanian). The zones of *I. amakusensis* and *I. japonicus* are presumably in the intervening unexposed part (unit 11-c).

12. *Amakusa-Shimojima*

There was a debate about the Cretaceous—Tertiary boundary in the Amakusa-Shimojima area (HATAE, 1959 and MATSUSHITA *et al.*, 1959), so the described sequence is not necessarily reliable. TAKAI (1962 in press) is doing a revision. Owing to his kind information, the outline of the revised sequence of the Upper Cretaceous in this area may be written as follows in ascending order.

12-a The lower limit is unknown because of faulting. The exposed lowest part, which actually belongs to the Upper formation of the Himenoura group, is composed of medium-grained sandstone with interbeds of sandy shale or siltstone. This may correspond at least partly to HATAE's Member H_1, 120 m, which contains *Apiotrigonia postonodosa*. Along the section of Shirakikochi it is 150 m (+).

12-b Dark grey fine-sandy siltstone and shale predominant, with fine-grained sandstone, 220 m along the Shirakikochi section. *Inoceramus balticus* (including *I. balticus toyajoanus*), *Apiotrigonia postonodosa*, *Glycymeris* cf. *amakusensis* and *Plesiaster* sp. occur in this member.

12-c Coarse-grained sandstone predominant, with subordinate granule-conglomerate and shale or sandy siltstone. This member is variable in thickness

(400-500 m or more ?) and in facies. *Ostrea* sp. occurs at certain horizons and in the silty part along the section of Oe-Sakitsu-Kamenoura *Eucrassatella* (s. l.) sp., *Astarte* (?) cf. *trigonalis*, *Brachidontes* aff. *nankoi*, *Corbula* sp. etc are found.

12-d Arkose, conglomeratic sandstone, and subordinate shale, with coal or coaly shale at several horizons and tuff at a few levels, 300 to 360 m. *Platanus guillelmae* GOEPERT came from the section of Nakanoura-Onoura.

12-e Thick sequence, 1500-1700 m, of conglomerate, coarse-grained sandstone, sandy shale, alternating shale and sandstone, and shale with isolated pebbles. Abnormal sedimentary features, which probably indicate the submarine slumps, are observed here and there. The sandstone is bluish greenish grey with chlorite like clayey matrix. This formation is poor in fossils, but TAKAI discovered *Pleurogrammatodon splendens* and *Nanonavis sachalinensis* (identified by K. ICHIKAWA) at a few localities and an asteroid (?) at another which are stratigraphically 500 and 400 m below the observable top of the sequence. This formation is overlain unconformably by the conglomerate with *Nummulites*. In the section of Shimoda-Fukuregi its sequence is incomplete, being 490 m in thickness, and is covered unconformably by the Eocene conglomerate and sandstone (Fukuregi formation) with *Colpospira* (*Acutospira*) *okadai*.

Although the fossils are not sufficient, the available evidence suggests that the units from 11-b to 11-d is probably referable to K6 α (stage of *Inoceramus balticus*) and that the last one, 12-e, to K6 β (Upper Hetonaian) which is not developed in the type area.

In Oshima islet off Ushibuka, southern end of Amakusa-Shimojima, a fraction (146 m) of the Himenoura group is exposed (HATAE, 1960). It consists of alternating sandstone and siltstone, containing at horizons *Inoceramus balticus toyajoanus*, *Glycymeris amakusensis*, *Steinmanella* (*Yeharella*) *japonica*, *Callista* (*Larma*) *japonica*, etc. This is to be referred to the zone of *I. balticus toyajoanus*.

13. *Koshiki-jima*

AMANO is carrying on the stratigraphy and palaeontology of the Cretaceous of the islands of Koshiki. The best exposure of the Cretaceous sequence is in the northern part of Shimokoshiki-jima. It is, according to AMANO (1957), as follows in ascending order.

13-a 140 m. Black silty shale, fairly fossiliferous in the upper part.

13-b 500 m. Medium- to fine-grained sandstone, with thin interbeds of black silty shale, fossils not rare.

13-c 150 m. Black silty shale, with fine-grained sandstone, containing abundantly *Inoceramus* and other molluscan fossils.

13-d 400 m. Fine- to medium-grained sandstone and black silty shale in alternation. Fossils occur here and there but are poorly preserved.

13-e 70 m (+). Coarse- to medium-grained sandstone, rather massive. In the lower part cross-lamination and ripple marks are often observable and

Ostrea banks are intercalated.

AMANO rejected to apply the name Himenoura group for the above sequence and proposed to call the first five members (a-d) Imuta formation and the last (e) the Taira formation. The last one seems to develop more extensively in Taira-jima which is situated to the north of Shimokoshiki-jima.

Although there are some new species, such as *Neilonella obliquistriata, Callistina* (*Larma*) *japonica* and *Protocardium koshikijimense*, which were first introduced to our Cretaceous Palaeontology by AMANO, the fauna as a whole is not so particular as to warrant the separation of the Shimokoshiki sequence from the Himenoura group. *Inoceramus balticus* (with varieties) occurs commonly in Member 13-c and even *Inoceramus* cf. *orientalis* (s. l.) [=*Inoceramus* sp. of *naumanni* group, AMANO, 1957, p. 58, pl. 2, fig. 8] is associated with it. *Nanonavis sachalinensis* and *Apiotrigonia tuberculata, Microtrigonia amanoi* occur in the same member. A variety of *Steinmanella* (*Yeharella*) *japonica* was described by KOBAYASHI and AMANO (1955) from Member 13-e, which may correspond to unit 12-c in the Amakusa-Shimojima sequence. The sequence in Shimokoshiki-jima is nothing but a fraction of the upper part of the Himenoura group and its age is probably Campanian. MATSUMOTO once obtain *Inoceramus* cf. *schmidti* from the part which is to be assigned to unit 13-e. Kamikoshiki-jima, northern island of the Koshiki archipelago, is mostly occupied by the Lower Tertiary formation containing red beds, but on its southwestern sea cliff the underlying Cretaceous beds are exposed, which consists of conglomerate, sandstone and shale. This member may be the equivalent of 12-e in the Amakusa-Shimojima sequence.

V. Geological Setting of the Himenoura Group

In this character the geological setting of the Himenoura group is attempted on the grounds of the stratigraphically analysed facts described in the preceding pages. Other related facts may be brought into consideration for a comparative study. The results obtained are summarized under the following four minor headings:

(1) Urakawa transgression
(2) Himenoura basin of sedimentation
(3) Changes of sedimentary environments in space and time
(4) Post-Himenoura crustal movements

The results and the necessary discussion are given below.

1. *Urakawa transgression*

The evidence of the Senonian marine transgression is recorded in various areas in Japan. Summarizing the Cretaceous stratigraphy of the Japanese Islands, YABE (1927) concluded the extensive epeirogenic movements in the Cretaceous period, of which the Senonian invasion of the sea water is a remarkable one. This has been called the Urakawa transgression. MATSUMOTO (1941, 1954) confirmed the same idea with more concrete and up-to-date evidence.

The Himenoura group is a very good record of the Urakawa transgression in western Kyushu in the following points. (a) It is essentially made up of the marine sediments ranging in age from Lower Urakawan [K5 α] (Coniacian) to Lower Hetonaian [K6 α] (Campanian). (b) It covers not only the Goshonoura group (Upper Albian-Turonian) but also various basement rocks. (c) The overstepping of the Himenoura group with age on different parts of the basement is proved from the zonation and the facies analysis of the group. (d) The sequence of the Himenoura group represents a cycle of sedimentation, with an inundation phase in the Upper Urakawan [K5 β] (Santonian). (e) The fauna of the Himenoura group consists primarily of the elements which are common between Kyushu and Hokkaido. Certain species are internationally widespread. (f) The maximum of the succeeding regression is marked by the unconformity between the Upper Cretaceous and Lower Tertiary groups of beds.

2. *Himenoura basin of sedimentation*

As a result of the crustal movement about the middle of the Cretaceous period a new basin of sedimentation was brought forth and continued to develop from late Albian to Turonian in the western part of middle Kyushu, where the Goshonoura and Mifuné groups (MATSUMOTO, 1938, 1939) were deposited on the older basement rocks. In a sense they represent a post-orogenic basin formed in the eroded metamorphic and plutonic terrain. While red beds and brackish water deposits predominate in the Mifuné group in the northeast, open-sea sandstones with trigonians and some ornate ammonites occur in the middle of the Goshonoura group in the southwest. Even the provenances of the sandstones are dissimilar between the two groups, as has recently been analysed in detail by OKADA (1960, 1961). The trend of the outcropping strata of the Goshonoura group is NE-SW, while that of the Mifuné is rather NEE-SWW, both forming a synclinorium.

Now the Himenoura group is distributed in a belt of the N30°~N40°E trend from the northeast of Kumamoto, through the Uto peninsula, Amakusa islands, Shishi-jima, Nagashima, to the islands of Koshiki. Although it rests on the Goshonoura group disconformably in some parts of the belt, it directly overlies the crystalline basement rocks with a remarkable unconformity in other parts. It does not come directly on the Mifuné group, but seems to rest on the basement of crystalline schists which is situated on the northern side of the Mifuné basin. Thus the site of the Senonian basin of the Himenoura group partly overlaps but as a whole shifts from that of the Upper Albian-Turonian basin of the Goshonoura-Mifuné group.

Examining in more detail, one may lead to the conclusion that the topographic relief was variably remarkable when the Himenoura basin commenced to develop. This is exemplified by the facts that the basal part of the Himenoura group shows a considerable change in thickness and facies from place to place and that the conglomerate has dissimilar kinds of pebbles and variable grades of sorting by places, and that the burried hills (islands) made up of the granitic basement are found in the western belt of the type Himenoura area. The relief may be a result of the crustal mobility still having been continued from the Gyliakian (Cenomanian-Turonian) epoch.

3. *Changes of sedimentary environments in space and time*

From the zonal correlation and the facies analysis the changes of the environments during the period of the sedimentation of the Himenoura group can be inferred as follows.

(a) *Coniacian* [K5 α].—This is the stage of *Inoceramus uwajimensis* and is best represented by the dark colored sandy siltstone in the Nagashima area, where the Himenoura group rests on the Goshonoura group. In the type area Members I-a and I-b probably represent this stage. They are exposed in three belts, eastern, middle and western, as described in chapter II. In the eastern belt the basal conglomerate is thicker than in other belts, consisting of poorly sorted boulders and cobbles of the granodiorite from the basement; the succeeding coarse-grained sandstone is arkosic and cross-laminated, with intercalated coaly shale. Thus the sedimentary facies is rather terrestrial in the eastern belt. In the middle belt the basal conglomerate is thinner and is followed by the well traceable *Ostrea* beds, which probably indicate the littoral environment. In the western belt the basal member is still thinner and is followed directly by the ammonite bearing muddy sediments of the Middle formation (see Fig. 5). The sedimentation on the burried hills of this western belt possibly began slightly later than the eastern, because *Inoceramus japonicus* is found in that muddy part. Anyhow the land was on the eastern side and the western belt represents the off-shore part, although there may have been rocky islands in the western belt in a short period.

In the area to the northeast of the type area the sediments of this stage are not confirmed, while in the Nagashima area, which is located to the southwest of the type area, *Inoceramus* bearing fine-sandy siltstone predominates. In the intervening part, as in the Goshonoura island, the basal conglomerate and coarse-grained sandstone is very thin and is succeeded by the *Glycymeris* bearing calcareous sandstone, which probably indicates the shallow sea near the coast.

Summarizing the above, the Himenoura basin began to develop in the Coniacian age with a more open-sea condition in the southwest. The sea water in this embayment does not seem to have invaded into the main island of Kyushu to the northeast.

The strata referable to the zone of *Inoceramus uwajimensis* is widespread in various areas of the Japanese Islands. In fact a part of the Onogawa group in Oita Prefecture, eastern Kyushu, represents this zone, but there is no evidence to conclude that the Ônogawa and Himenoura basins were directly connected.

(b) *Lower Santonian* [K5 β_1].—This is the stage of *Inoceramus amakusensis*. Fig. 7 is a diagram which shows the change in thickness and proportion of conglomerate, sandstone and shale (mudstone) from place to place. Fig. 11 (lines a and b) is another representation of the facies change.

This stage is represented by the predominant sandstone and conglomerate in the Oyama-yama area (2 in Fig. 1) in the northeast, alternating mudstone and sandstone with intercalated conglomerate in the Uto peninsula (4), fine-grained sandstone in the Hinoshima area (7) in the middle, siltstone and sandy shale in the Goshonoura area (9) and presumably mudstone in the Nagashima area (11) in the southwest. Thus the change in facies from northeast to southwest is evident, with the southwestward

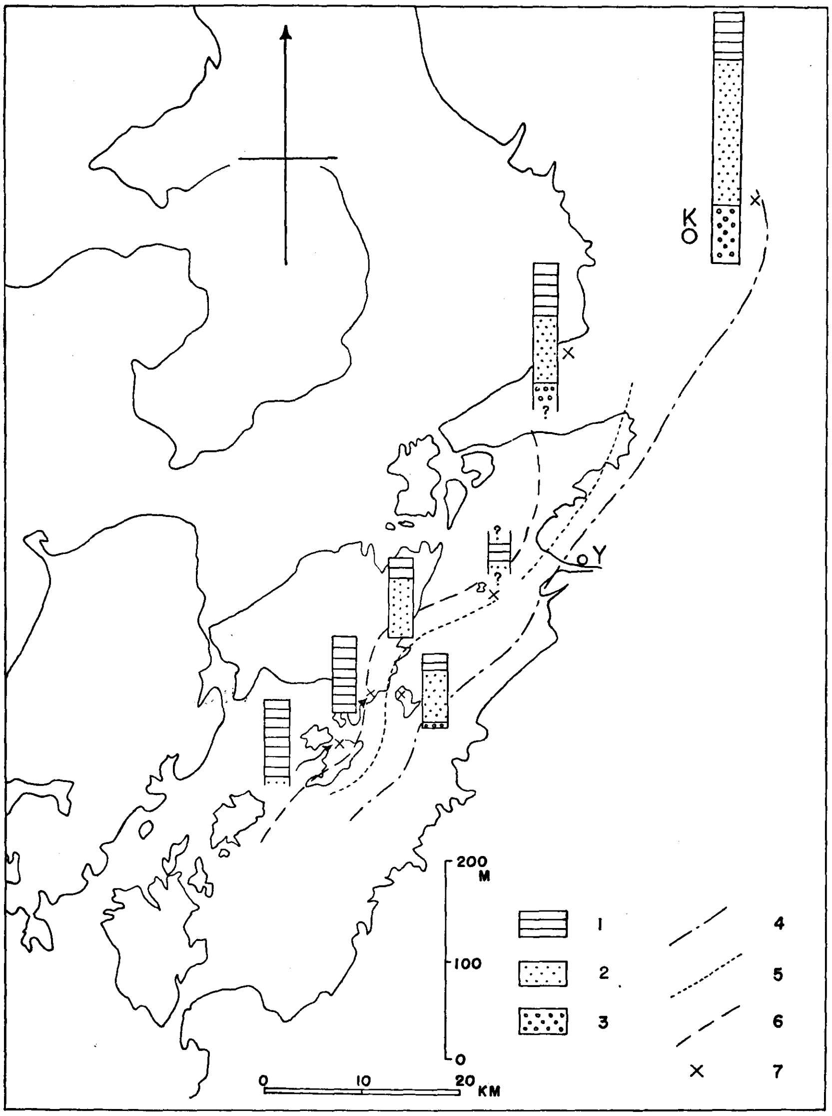


Fig. 7. A palaeogeographic map in the age of *Inoceramus amakusensis*, showing in columns the thickness and proportion of the constituting sediments at representative localities.

1 : mudstone or shale, 2 : sandstone, 3 : conglomerate, 4 : presumed margin of the Himenoura basin, 5 : boundary of the conglomerate and sandstone facies, 6 : boundary of the sandstone and mudstone facies, 7 : location of the measured section, K : Kumamoto city, Y : Yatsushiro city.

opened condition of the Himenoura embayment. When one and the same area is considered, the more fine-grained sediments are in the western belt than in the eastern, as can be clearly recognized in the type area (6 and 7), where the change along the strike is very gradual or almost imperceptible. There is no available evidence to lead a conclusion about the western margin of the Himenoura basin.

(c) *Upper Santonian* [K5 β_2].—This is the stage of *Inoceramus japonicus*. Fig. 8 shows the thickness and proportion of the composing sediments at several representative localities in the Himenoura basin. The zone of *Inoceramus japonicus* is represented in the southern part of the type area (6) by the relatively monotonous, dark grey mudstone and shale (II-a) with scattered ammonites, inocerami and other fossils, but in the northern part of the same area (6) by the alternating sandstone and shale of Member I-d, in which pebbles are contained in a lenticular or isolated form, cross-bedding and other unusual sedimentary features are sometimes observed and the

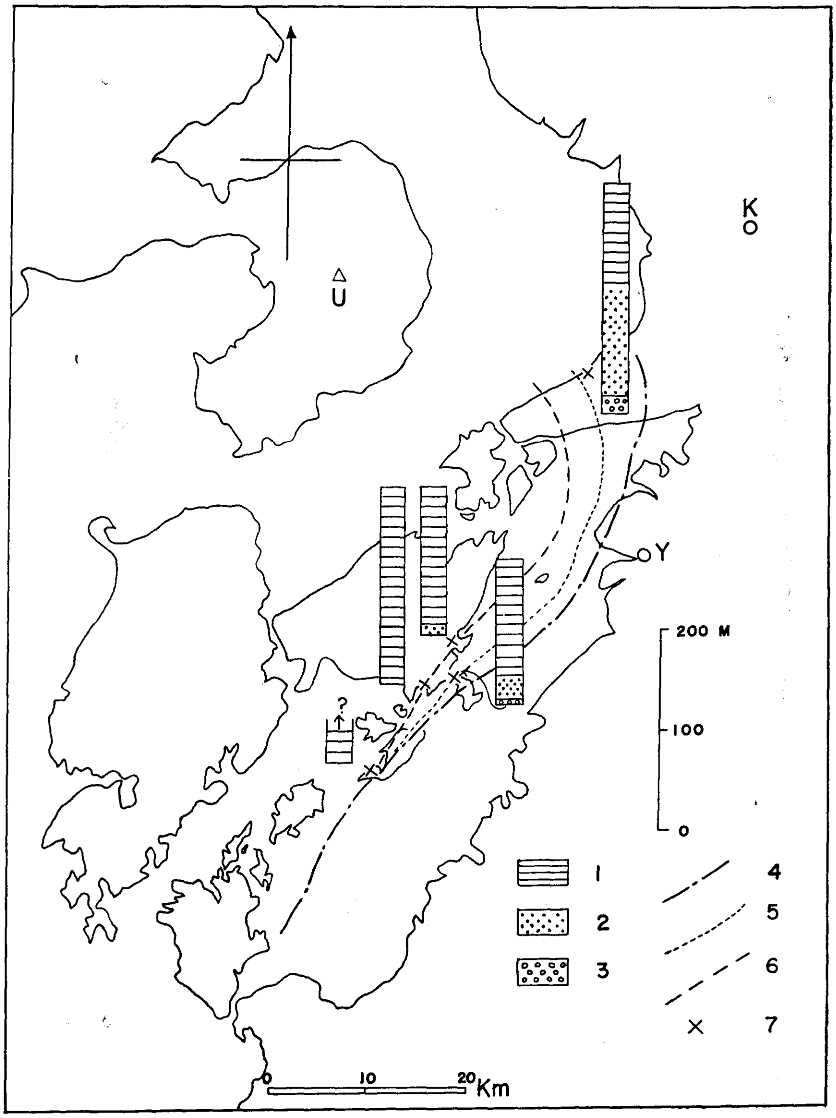


Fig. 8. A palaeogeographic map in the age of *Inoceramus japonicus*, showing in columns the thickness and proportion of the constituting sediments at representative localities. Legend same as in Fig. 7. U : Volcano Unzen.

fossils occur irregularly and often in a worn condition. The relatively shallow sea genera (such as *Glycymeris* and *Apiotrigonia*) are intermingled with the deeper or offshore ones (*Gaudryceras* and *Eupachydiscus*). Member I-d may be the foreset of the deltaic deposits and Member II-a may include the bottomset.

The sediments of this and the preceding stages in the Uto peninsula has a facies similar to that of Member I-d, but has more sandstone and conglomerate. Even the cobbles and boulders occur in some parts. Therefore the point (mark × of loc. 4) in Fig. 11 somewhat deviates from others. These features suggest the slumping of

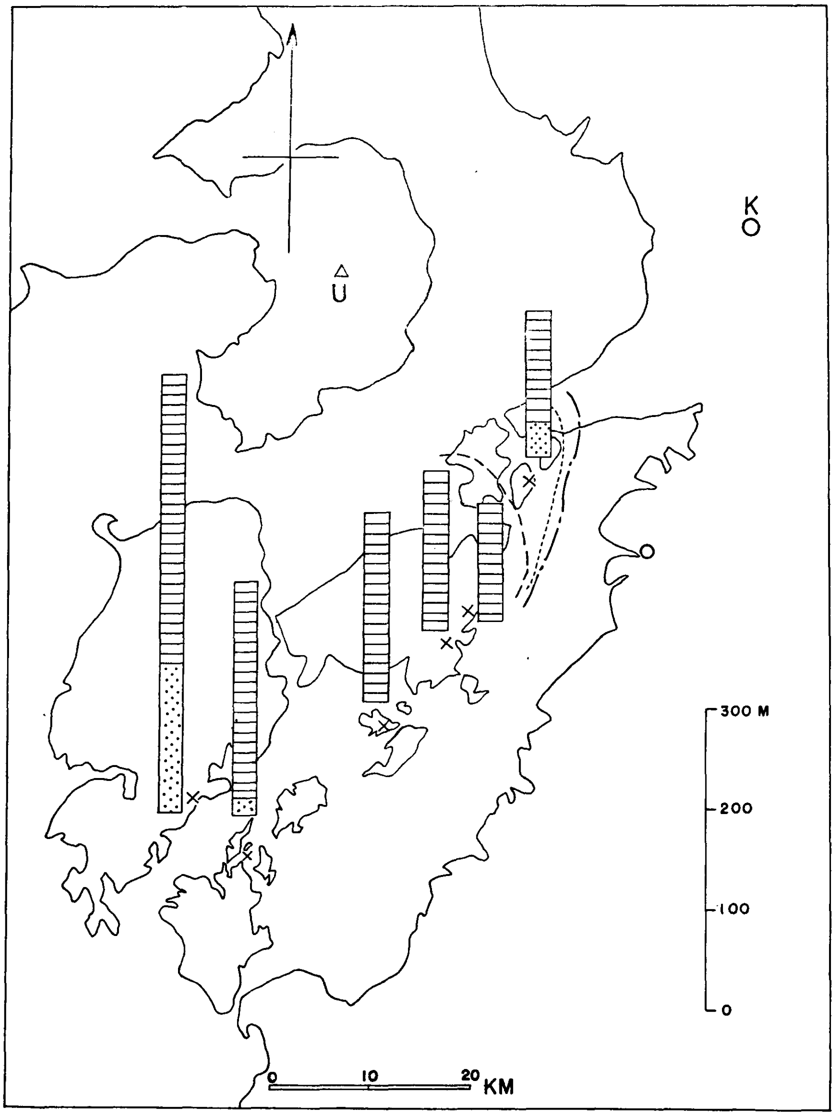


Fig. 9. A palaeogeographic map in the age of *Inoceramus orientalis*, showing in columns thc thickness and proportion of the constituting sediments at representative localities. Legend same as in Fig. 7.

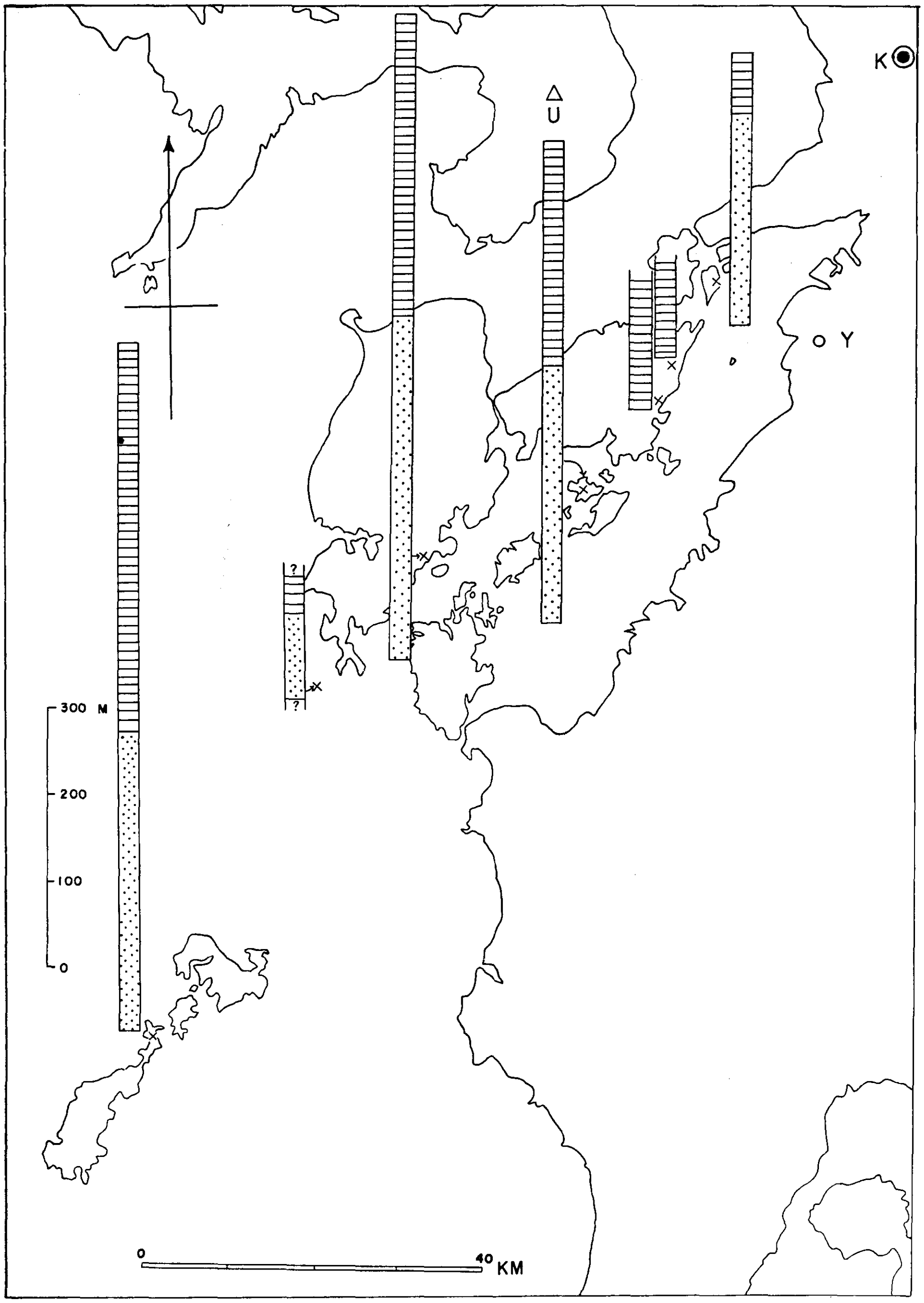


Fig. 10. A palaeogeographic map in the age of *Inoceramus balticus* (without *I. orientalis*), showing in columns the thickness and proportion of the constituting sediments at representative localities. Legend same as in Fig. 7

sediments from the land or shallower parts. The fossil contents are, however, essentially the same as those in Member I-d of the type area.

(d) *Uppermost Santonian-Lower Campanian* [mainly K5 γ, with a part of K5 β].—This is represented by the zone of *Inoceramus orientalis nagaoi* and its correlatives. In this stage the muddy sediments predominate, containing inocerami, ammonites and echinoids. Their thickness is less variable than in other stages, about 150-160 m in the type area, gradually increasing southwards to about 250 m (?) in the Nagashima area. In Amakusa-Shimojima and Koshiki-jima the vertical extent of the part corresponding to this stage is not accurately measured, but in the approximate estimation the sequence there seems to have more sandstone than in other areas. Fig. 9 may be of some aids for understanding the situation in this stage.

(e) *Middle to Upper Campanian* [K6 α].—This is represented by the zone of *Inoceramus balticus toyajoanus* and its correlatives. Fig. 10 shows the thickness and proportion of the constituents of the sediments at seven localities. The sediments of this stage are generally much thicker and provided with a larger amount of sandstone than those of the preceding stage. This suggests that a trough of subsidence was brought forth in this age into which material was supplied from a rising uplift. This is nearly contemporaneous with the development of the belt of thick sedimentation of the Izumi group in north Shikoku and middle Kinki. The existence of thinner sequences at certain localities between thicker ones is problematic (see Fig. 10). This may be at least partly due to the post-Cretaceous erosion, since there is a significant unconformity at the base of the Lower Tertiary, but may imply something else. The belt of maximum subsidence of the Himenoura basin may have shifted westward in this stage. A regressive phase is indicated by the *Ostrea*-beds and the arkose with coaly seams.

(f) *Maestrichtian* [K6 β]. This has not yet been precisely identified in the Amakusa region. It does not exist in the type area (Amakusa-Kamishima), but in Amakusa-Shimojima the thick sequence (unit 12-e) of sandstone, conglomerate and shale, containing *Pleurogrammatodon splendium* and other marine fossils, above the preceding part [K6 α] possibly represents the Upper Hetonaian [K6 β]. This suggests that the trough in the western part of the Himenoura basin was developed further in this age and that the material was supplied rapidly to the trough from a rising mountain.

4. *Post-Himenoura crustal movements*

The unconformity between the Upper Cretaceous Himenoura group and the overlying Lower Tertiary group of beds is very distinct. The basal conglomerate and red beds of the former not only cut obliquely the different horizons of the latter from place to place, but there is also a structural gap between the two. The details of the structural relationship were described by UEDA and FURUKAWA (1960) for the Kamishima area, by AMANO (1960) for the Maki-shima area and Senzokuzozo-Tobase-jima area, by TAKAI and MATSUMOTO (1961) for the Nagashima area, by HATAE (1960), MATSUSHITA et al. (1959) and recently by TAKAI (1962) for the Shimojima area.

The relations in the type area (Kamishima) can be concisely summarized by the

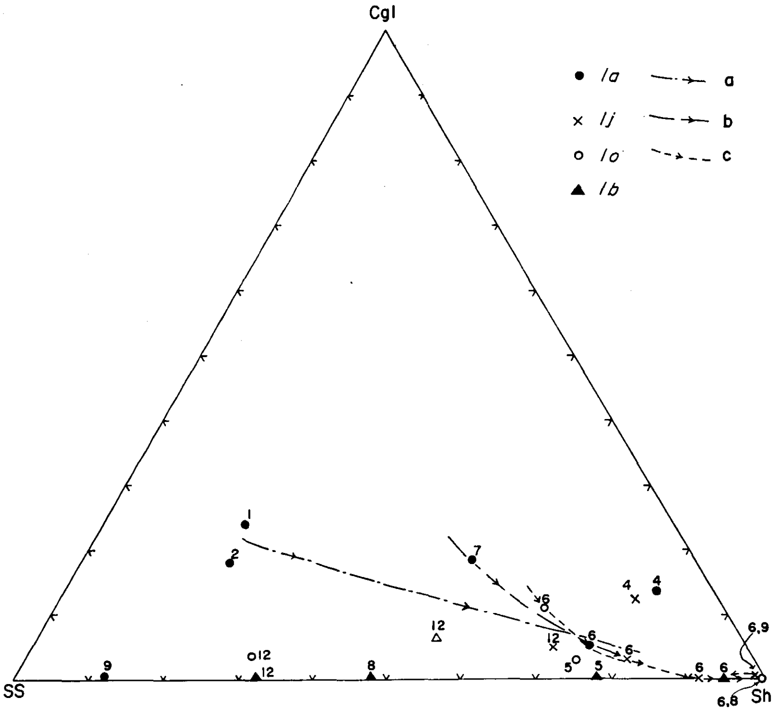


Fig. 11. A triangle diagram of conglomerate (Cgl), sandstone (Ss) and shale (Sh).
1-13: Localities numbered and indicated in Fig. 1,
a: Variation of facies from northeast to southwest in the stage of *Inoceramus amakusensis*,
b: Variation of facies from east to west in the type area in the stage of *I. amakusensis*,
c: Vertical change of facies in the type area from the *amakusensis* stage to the *balticus* stage,
Ia: *Inoceramus amakusensis* stage,
Ij: *Inoceramus japonicus* stage,
Io: *Inoceramus orientalis* stage,
Ib: *Inoceramus balticus* stage (without *I. orientalis*).

geological map and profiles in this paper (Fig. 4). There are many minor folds in the Himenoura group and the folding is more intense in this group than in the Lower Tertiary group of beds. Furthermore, the axis of the post-Eocene fold has proved to deviate from that of the post-Senonian pre-Eocene fold on account of the following reasoning. If the amount of eroded parts of the Himenoura group changed regularly, the erosion might be due to epeirogenic warping alone. Actually it is irregular. The amount of the eroded part is greater on the west side than on the east in the northern part of the type area and *vice versa* in the southern part. The belt of the maximum erosion would represent the axis of the anticline and that of the minimum erosion the axis of the syncline of the post-Himenoura pre-Akasaki folding. The trend estimated from this reasoning is NE-SW, which is really parallel to the predominant strikes of the beds in the Himenoura group. The trend of the post-Eocene folding is rather NNE–SSW.

The structural angularity is more remarkably manifested in the Makishima and the Nagashima areas, as has been precisely described by the previous authors (AMANO, 1960; TAKAI and MATSUMOTO, 1961). The angularity observed is almost 90° in some places. In Amakusa-Shimojima there was a debate about the relations, but now the base of the beds with *Nummulites* and *Colpospira* have proved to rest on the Upper Cretaceous beds with a distinct unconformity (TAKAI, 1962 in press).

On the occasion of the comprehensive summary of the Tertiary crustal movements in the Japanese Islands, OTUKA (1939) proposed the term Amakusa folding for the deformation of the Lower Tertiary and underlying Senonian beds. He considered that the folding took place at the end of Eocene and that the post-Himenoura pre-Akasaki movement was only a gentle epeirogenic warping. From the up-to-date evidence the Amakusa folded structure should be regarded as a combination of the post-Himenoura pre-Akasaki and post-Eocene foldings. The faulting in younger Cenozoic times gave subsequent modifications, of which the fault system of the NW trend is most predominant.

The warping may have really happened from the end of Cretaceous to the beginning of Tertiary, but, in my opinion, it cannot be separated from the crustal movements which have resulted in the folding. As I have explained in the preceding pages, the Upper formation of the Himenoura group not only represents the regressive phase of the cycle of sedimentation but also records the development of the rapidly sinking trough and rising uplift, which probably indicates the crustal mobility already coming to existence. The folding of the Izumi group in Southwest Japan is fairly intense near the Median Tectonic Line. The main epoch of the folding is post-Izumi (Campanian-Maestrichtian) pre-Kuma (Eocene *Eofabiania* bearing formation), but the tectonically labile condition is manifested by the enormously thick deposition of repeated conglomerate, sandstone and shale of the Izumi group itself. Similarly the Himenoura group is affected by the pre-Senonian crustal mobility in its basal part and foreshadows the post-Senonian crustal movements in its upper part.

The Akasaki formation and the succeeding Eocene marine sediments are exposed roughly in parallel with the Himenoura group in the Amakusa area, but their distribution in a more general region remarkably deviates from that of the Himenoura. For an explanation MATSUSHITA (1949) postulated the Paleo-Ariake embayment which runs from SSW to NNE in northwest Kyushu. The basal conglomerate and red beds of the Lower Tertiary group of beds rest not only on the Himenoura group but also on metamorphic group and granitic bodies (most of which are of Cretaceous intrusion). Judging from the ill-sorted conglomerate, the high topographical relief must have existed at the beginning of the Tertiary. This means again a result of the crustal mobility. Anyhow, the shift of sedimentary basins is evident from the Goshonoura-Mifuné, through the Himenoura, to the Paleo-Ariake. Each basin is of a relatively short time-span and has a relatively small elongation and breadth, although the sites of the three basins overlap, and, therefore, apparently continuous in certain parts (e.g. Shishi-jima) of the region. The folding of the strata in each basin is of rather shallow type, without metamorphism. The three basins of successive ages were altogether called the Paleo-Shiranuhi embayment. They represent the step by step introduction of the structural element of the Ryukyu arc or the peri-Tunghai [East China Sea] trend, modifying or superposing upon the older equatorial trend of Southwest Japan.

Appendices

Palaeontological Notes

By

Tatsuro MATSUMOTO and Yoshiro UEDA

In this chapter palaeontological notes are given for the following eight species, which are especially important among others as zonal indices in the Himenoura group.

Inocerami

1. *Inoceramus amakusensis* NAGAO and MATSUMOTO
2. *Inoceramus balticus toyajoanus* NAGAO and MATSUMOTO
3. *Inoceramus japonicus* NAGAO and MATSUMOTO
4. *Inoceramus orientalis nagaoi*, nom. nov.

Ammonites

5. *Texanites oliveti* (BLANCKENHORN)
6. *Texanites kawasakii* (KAWADA)
7. *Texanites amakusensis* (YABE)
8. *Protexanites fukazawai* (YABE and SHIMIZU)

The described specimens are preserved in the type-specimen room of the Department of Geology, Kyushu University, unless otherwise stated.

Before entering into the description we wish to express gratitude to Professor Teiichi KOBAYASHI of the University of Tokyo, Professor Kotora HATAI of Tohoku University and Dr. Masahisa AMANO of the University of Kumamoto for facilities afforded to us to study the specimens preserved there and also to Messrs. Takeo ICHIKAWA, Chushiro UEKI and Ikuwo OBATA for the preparation of the plaster casts and pictures of the type specimens.

1. *Inoceramus amakusensis* NAGAO and MATSUMOTO

Pl. 22, figs. 1, 2, 3; Text-fig. 12

1940. *Inoceramus amakusensis* NAGAO and MATSUMOTO, *Jour. Fac. Sci., Hokkaido Imp. Univ.*, ser. 4, vol. 6, no. 1, p. 13, pl. 3, fig. 6; pl. 4, figs. 1, 3, 4; pl. 5, fig. 1.

1959. *Inoceramus amakusensis*, MATSUMOTO, *Mem. Fac. Sci., Kyushu Univ.*, ser. D, Geol., vol. 9, no. 2, p. 86, pl. 11, fig. e.

Lectotype.—NAGAO and MATSUMOTO (1940, p. 14) designated the syntypes, of which the one preserved in the University of Tokyo (register no. I-960) (NAGAO and MATSUMOTO, 1940, pl. 5, fig. 1; reproduced in this paper, Text-fig. 12) from Hinoshima, Amakusa is designated here as the lectotype. Other syntypes are also identified to the present species even in our present knowledge.

Additional material.—Although several specimens have subsequently obtained from the type locality, the lectotype is better preserved than them. A specimen of a right-

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Fig. 12. *Inoceramus amakusensis* NAGAO and MATSUMOTO.
Lectotype, University of Tokyo, No. I-960, a large left valve, ×2/3, collected by T. MATSUMOTO, from loc. K60, a quarry in the western part of Hinoshima, Amakusa, Member Ic of Himenoura group (reproduced from NAGAO and MATSUMOTO, 1940, pl. 5, fig. 1).

valve, GK. H6108 with a well impressed ligamental pits of the hinge, is illustrated in this paper (Pl. 22, fig. 3.) Two other specimens from new localities mentioned in Chapter IV are illustrated too. The localities in the type Himenoura group are listed below. There are also numerous specimens in the collections from Hokkaido.

Descriptive remarks.—From the study of syntypes and additional material, the specific diagnosis given by NAGAO and MATSUMOTO (1940, p. 13-14) is confirmed to be adequate. To quote* from them:

" Shell large, presumably equivalve, compressed, with somewhat convex umbonal region, steep but narrow anterodorsal marginal area, and almost flat ventral and posterior portions.

Outline of shell inequilateral, subpentagonal or subquadrate, higher than long in the adult, and nearly as high as long in the young stage. Anterodorsal margin slightly excavated beneath the umbo, passing below into the broadly rounded antero-ventral angle; ventral margin asymmetrically curved, continuing gradually with the long, slightly convex and nearly vertical posterior margin. Hinge-line long, forming a nearly right angle with the posterior margin. Beak angle fairly obtuse. Umbo subterminal, prominent, not much incurved. Posterior wing broad, indistinctly limited, but often depressed, especially in its dorsal portion.

Surface sculptured with concentric undulations and rings; undulations usually low, broad, round-topped, somewhat irregular in size and distance, and asymmetrically curved; rings numerous, low and round-topped, covering the elevations and interspaces. Undulations fading away toward the ventral portion where concentric lines are the sole ornamentation. Wing ornamented with direct prolongation of the sculpture of the flank."

The authors furthermore gave remarks on the change of characters with growth and the variation.

The only indistinct point in the above description was the equivalveness. For some reason the two valves occur in a separated condition in the Himenoura group. The lectotype is represented by the left valve alone. The right valve in other syntypes is that of another individual. Judging, however, from many examples from Kyushu and Hokkaido, the shell of this species is regarded as equivalve.

Inoceramus mihoensis MATSUMOTO (1957, p. 65, pl. 21, figs. 1-4), which is allied to *I. inconstans* WOODS, was regarded as a probable ancester of *I. amakusensis*. This is indeed possible from both the morphologic features and the stratigraphic occurrence, but the former has a somewhat inequivalve and much more inflated shell, sharper head of the concentric ridges and less distinct concentric rings than the latter. A precisely intermediate form has not been found yet.

In the chalky shale or chalk of the Niobrara formation fragments of large *Inoceramus* are infrequently found, but are mostly too fragmentary for exact identification. An unnamed specimen (external mould) of a large *Inoceramus*, about 270 mm in height, in the collection of Kansas University (KU. 10748), from the chalk of the Niobrara formation in southwestern Nebraska, deserves special attention in its close affinity with *Inoceramus amakusensis*, although its very beak is unpreserved.

Occurrence.—Loc. K60, a quarry in the western part of Hinoshima*1, muddy fine-grained sandstone of member I-c, Himenoura group (the type locality); loc. K16, a pass north of Takagushi*2, Ryugatake-mura, Amakusa-Kamishima, member I-c.

* The journal and the reprints of NAGAO and MATSUMOTO (1939-1940) are now out of stock.

*1 熊本県天草郡竜ヶ岳村樋島西部の石切場

*2 熊本県天草郡竜ヶ岳村高串北方峠

A locality discovered by K. KANMERA at Neshima*[1] in Yatsushiro Bay between Amakusa and Yatsushiro, in a sandy thin layer intercalated in a shaly formation; another locality discovered by Toshio NAGAME, September 1956, in a bed of granule bearing very coarse sandstone, on a foot of a hill called Oyama, east of Kumamoto*[2]. The illustrated specimen, GK. H6121, was collected by MATSUMOTO from a medium sandstone bed in a small stream cutting the eastern part of the same hill.

The species occurs commonly in the lower part of the Upper Urakawan in the Cretaceous sequence of Hokkaido. This is probably Lower Santonian.

2. *Inoceramus balticus toyajoanus* NAGAO and MATSUMOTO

Pl. 23, figs. 6, 7

1915. *Inoceramus* cf. *regularis*, YABE, *Sci. Rep. Tohoku Imp. Univ.*, 2nd ser. Geol., p. 22, pl. 3, fig. 3.
1940. *Inoceramus balticus* BOEHM var. *toyajoanus* NAGAO and MATSUMOTO, *Jour. Fac. Sci., Hokkaido Imp. Univ.*, ser. 4, vol. 6, no. 1, p. 20, pl. 9, fig. 3.
1961. *Inoceramus balticus toyajoanus*, MATSUMOTO, *in* TAKAI and MATSUMOTO, *Mem. Fac. Sci., Kyushu Univ.*, vol. 11, no. 2, p. 274, pl. 11, fig. 1; pl. 12, fig. 3.

Lectotype.—The specimen figured by YABE (1915, pl. 3, fig. 3), from Toyajo, Wakayama Prefecture, as designated by MATSUMOTO (*in* TAKAI and MATSUMOTO, 1961).

Material.—In addition to the specimens from the Himenoura group of Takenoshima (Nagashima area), which were described by MATSUMOTO (*op. cit.* 1961), there are many specimens from the type area of the Himenoura group, of which a representative ones (GK. H6114, 6115) are illustrated in this paper.

Descriptive remarks.—*Inoceramus balticus* BOEHM (1907) is widespread but so variable that the subspecific separation is to be attempted. As far as the Japanese material is concerned *Inoceramus balticus toyajoanus* NAGAO and MATSUMOTO is distinguished from *Inoceramus balticus balticus*. The definition of the subspecies and the grounds of the separation have recently been given by MATSUMOTO (*in* TAKAI and MATSUMOTO, 1961).

The specimens from the type Himenoura area are mostly referred to *I. balticus toyajoanus*, like those from the Nagashima area. An example, GK. H6122, from loc. K42 is considerably inflated and thus apparently intermediate.

Occurrence.—K44, Uchinokochi, Matsushima-machi*[3]; K48, near Aizu Primary School, Matsushima-machi*[4]; K392, Futamado, Himedo-mura; and other comparable specimens from K37, K41, K42, K43, K44, K45, K47, K63, etc,[5]*, all from the Middle formation (II) of the Himenoura group in the type area; also loc. K18, west of Kuzusaki, Ryugatake-mura,[6]* in the lower part of the Upper formation (III) of the Hime-

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*[1] 熊本県八代郡植柳村根島
*[2] 熊本県飽託郡託麻村小山山
*[3] 熊本県天草郡松島町内野河内変電所北方道路崖
*[4] 熊本県天草郡松島町合津小学校講堂前
*[5] See UEDA and FURUKAWA, 1960, p. 31-32.
*[6] 熊本県天草郡竜ヶ岳村葛崎西方の崖

noura group.

The examples from Bed III of Shimo-koshiki-jima (AMANO, 1957) (unit 12-c in this paper) and those from Oshima off Ushibuka, Amakusa-shimojima (HATAE, 1960) indicate wider occurrence in the upper part of the Himenoura group.

The type locality of *I. balticus toyajoanus* is in Toyajo, Toyajo formation (Campanian).

3. *Inoceramus japonicus* NAGAO and MATSUMOTO

Pl. 22, fig. 4; Pl. 24, fig. 1

1940. *Inoceramus japonicus* (SASA, MS.) NAGAO and MATSUMOTO, *Jour. Fac. Sci., Hokkaido Imp. Univ.*, ser. 4, vol. 6, no. 1, p. 24, pl. 5, fig. 2; pl. 6, figs. 2-3; pl. 7, figs. 2-3; pl. 8, figs. 1-4; pl. 9, figs. 1-2.

1959. *Inoceramus japonicus*, MATSUMOTO, *Mem. Fac. Sci., Kyushu Univ.*, ser. D, Geol., vol. 9, no. 2, p. 86, pl. 11, fig. f.

Lectotype.—The specimen figured by NAGAO and MATSUMOTO, 1940, pl. 9, fig. 1 (illustrated in this paper, pl. 24, fig. 1a, b), from Kunitan, Kunitan formation (Santonian) of Kuji group, Iwate Prefecture, collected by Yasuo SASA and now preserved at the Geological Institute, University of Tokyo (I-1013). (See remarks below.)

Material.—Many specimens of this species occur in the Himenoura group, forming a particular zone in the middle formation. They are often so delicately preserved that only several examples have been brought to the laboratory. The illustrated specimen, GK. H6120, which is a smaller example, from loc. K594; others from locs. K25 [=790], 32, 38 and 39.

Descriptive remarks.—This species is very variable. NAGAO and MATSUMOTO established it on many syntypes, describing the variation under the headings forma α, β and γ. On the other hand its close resemblance to the widespread *Inoceramus undulatoplicatus* ROEMER has been pointed by NAGAO and MATSUMOTO (1940, p. 27) themselves, STEPHENSON (1950) and MATSUMOTO (1959), who all suggest the possibility of the specific identity.

This possibility still remains, but in this paper the specific name *I. japonicus* is held, because we still hesitate to conclude the precise identity between *I. japonicus* represented by the lectotype and other syntypes and *I. undulatoplicatus* represented by the type of ROEMER (1852, p. 59, pl. 7, fig. 1) and also another example in the collection of Kyushu University, GK. H9202 (Pl. 25, fig. 1), from the Austin Chalk, Texas. The distinctions between the two groups are as follows. (1) The anterior margin is evenly convex from anterodorsal to anteroventral margins in *I. japonicus*, while it is nearly straight in *I. undulatoplicatus*. (2) The angle between the hinge-line and the anterodorsal margin is on the average larger in the former than in the latter. (3) The anterodorsal part is fairly inflated in the former, but seems to be flattened in the latter. (4) The former shows a regular combination of the concentric ribs and concentric rings (or lines)—in other words it has regularly arranged major ribs and interspaces both of which are covered with fine concentric rings (or lines), although this may be modified on the ventral part of the valve where the divergent ribs predominate. The latter, as seen in the Texas examples, has irregularly arranged concentric lines, rings and relatively small ribs and does not show the regular combination as seen in the Japanese examples. The above distinctions are well manifested by the lectotype of *I. japonicus* (Pl. 24, fig. 1 of this paper) and the holotype (by monotypy) of *I. undulatoplicatus* ROEMER (1852, pl. 7, fig. 1).

There are of course variations in the two species. Therefore a few of the specimens from Japan may approach to, if not coincide with, the type from Texas. The variation on the Japanese side has already been described by NAGAO and MATSUMOTO, but I do not know precisely the extent of variation in Texas and in Europe. WOODS (1912, p. 304) was evidently too comprehensive in the understanding of *I. undulatoplicatus*, because he included in it *I. schmidti* MICHAEL, *I. sachalinensis* SOKOLOW [=*I. digitatus*, JIMBO, 1894, p. 43, pl. 8, fig. 9 only] and *I. orientalis* SOKOLOW [=*I. digitatus*, JIMBO, 1894, p. 43, pl. 8, fig. 8 only], the three of which belong to the group of *Inoceramus naumanni* and genetically unrelated to *I. undulatoplicatus* or to *I. japonicus* of distinctly earlier age. One of unfigured specimen (BM. L17322*[1]), from Haldon, England, seems to approach considerably to the Japanese form, but unfortunately its umbilical part is broken. We expect that the statistic studies of the numerous specimens from selected provinces in the future might reveal that the variations overlap between the Japanese and the Texas or European provinces and that the distinction on the average be rather subspecific. Until that the specific name *I. japonicus* is to be kept. The difference in the geological age between *I. japonicus* and *I. undulatoplicatus* cannot also be overlooked. Whether the immediate ancestor is common or not is, therefore, another question to be settled.

In the variation of *Inoceramus japonicus* the examples from the Himenoura group mostly, but not all, belong to the one which was described as forma α by NAGAO and MATSUMOTO (1940, p. 24). This is less oblique and is more oval in outline than others. Such a form is occasionally found in Hokkaido, where, however, a more fan-shaped form (β of NAGAO and MATSUMOTO, 1940, p. 24) predominates. The lectotype from the Kuji area in Honshu, for which SASA (MS.) intended to give the specific name *I. japonicus*, is very oblique and elongated from the beak to the posteroventral extremity and was described under forma γ by NAGAO and MATSUMOTO (1940, p. 25). The divergent ribs appear sometimes very late in growth-stage, sometimes in the moderate stage and some other times very early. This is seen in both Hokkaido and Kyushu groups of examples. As far as the available evidence is concerned, all of these variable forms are geologically contemporary. In our present knowledge it is, thus, unnecessary to give subspecific names for these variants.

Occurrence.—Locs. K594, western part of Kugushima*[2]; K25 [=K790], a quarry south of Himenoura*[3]; K32, a road cutting, 500 m NW of Himenoura*[4]; K39, back of Futamado Primary School*[5], and many other localities in the Middle formation (II)

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*[1] British Museum (Natural History).
*[2] 熊本県天草郡竜ヶ岳村椚島西海岸
*[3] 熊本県天草郡姫戸村姫浦南方石切場
*[4] 熊本県天草郡姫戸村姫浦北西 500 m 崖道路
*[5] 熊本県天草郡姫戸村二間戸小学校裏

of the Himenoura group; K38 west of Maruyama*[1], and several other localities in Member I-d of the Lower formation of the Himenoura group. The localities found by OBATA in the Uto peninsula seems to belong to Member I-d too. Thus the species occurs characteristically above the beds with *Inoceramus amakusensis*, forming a distinct zone. The same stratigraphic occurrence is recognized in Hokkaido (MATSUMOTO, 1959, pls. 7, 8).

4. *Inoceramus orientalis nagaoi*, nom. nov.

Pl. 23, figs. 1-5

1940. *Inoceramus orientalis* var. *ambiguus* NAGAO and MATSUMOTO, *Jour. Fac. Sci., Hokkaido Imp. Univ.*, ser. 4, vol. 6, no. 1, p. 37, pl. 15, figs. 3-4; pl. 17, figs. 1-2.
1960. *Inoceramus orientalis* var. *ambiguus*, AMANO, *Kumamoto Jour. Sci.*, ser. B, sec. 1, Geol., vol. 4, no. 1, p. 9, pl. 1, figs. 1-3, 6, 8, 10.

Lectotype.—The specimen preserved at Hokkaido University, reg. no. 3808, from the *Anapachydiscus* bed at Osachinai, Hidaka province, Hokkaido, collected by K. OTATUME and described and illustrated by NAGAO and MATSUMOTO (1940, p. 37, pl. 17, fig. 1) as one of the syntypes of var. *ambiguus*, a name preoccupied by von EICHWALD (1865, p. 493, pl. 21, fig. 8a, b) for a different Jurassic species[2]* and here substituted with a new subspecific name *nagaoi**[3].

Subspecific diagnosis.—*Inoceramus orientalis* SOKOLOW (1914, p. 32 and 73) has the same shell form and the same type of concentric rings as *Inoceramus naumanni* YOKOYAMA (1890, p. 174, pl. 18, figs. 3-5) (emended by NAGAO and MATSUMOTO, 1940, p. 31, pl. 13, fig. 4; pl. 14, figs. 1-10; pl. 15, figs. 1-2; pl. 17, fig. 6; text-figs. 2-4) (see also MATSUMOTO, 1959, pl. 11, fig. h), but is somewhat larger and has major concentric ribs and a shallow radial depression in the posterior part of the flank. The oblique ribs may or may not be developed in the anterior part.

This comprises the two subspecies:

(1) *Inoceramus orientalis orientalis* SOKOLOW (1914, p. 73, pl. 3, fig. 5; pl. 4, figs. 2-3) (NAGAO and MATSUMOTO, 1940, p. 37, pl. 16, figs. 4-5; pl. 17, figs. 3, 7; pl. 18, figs. 1-4) (MATSUMOTO, 1959, pl. 11, fig. i) (this paper, Pl. 25, fig. 2), which has oblique ribs normally arranged *en echelon* with one another on the anterior part, displacing or interrupting the concentric ridges on crossing. Radial ribs may or may not be developed on the ventral part.

Of the three illustrated syntypes of SOKOLOW the better preserved one (SOKOLOW, (1914, pl. 3, fig. 5) from the Amba, north Sakhalin is designated here as the lectotype. Its preservation is incomplete, but NAGAO and MATSUMOTO showed better preserved specimens from Hokkaido. A good example in the collection of Kyushu University (GK. H603), from loc. H100a3, bed IVa, Lower sandstone of the Hakobuchi group in the Tomiuchi [=Hetonai]—Osachinai area collected by T. MATSUMOTO is illustrated in this paper (Pl. 25, fig. 2).

*[1] 熊本県天草郡姫戸村丸山西方
*[2] We appreciate Dr. I. HAYAMI's work (1960) in which the situation is notified.
* Dedicated to the late Professor Takumi NAGAO.

(2) *Inoceramus orientalis nagaoi*, nom. nov., which has no oblique ribs nor radial ribs. The concentric double rings of the *naumanni* type are more distinctly shown in this subspecies than in *I. orientalis orientalis*. The posterior wing, which is distinct from the flank and has no ornaments, is as narrow as that of *I. naumanni* in this subspecies but is often somewhat broader in *I. orientalis orientalis*. *I. orientalis nagaoi*, thus, shows intermediate characters between *I. naumanni* and *I. orientalis orientalis*.

In addition to the morphologic differences as described above, there is a separation in the occurrence. *I. orientalis nagaoi* appears earlier than and becomes extinct in the earlier date than *I. orientalis orientalis*, although the geological ranges of the two subspecies overlap each other in a certain limited period (K5 γ). In other words *I. orientalis nagaoi* ranges from the late life period of *I. naumanni* to the early period of *I. orientalis orientalis*. Its number of individuals is as numerous as either of the latter two and it is normally found at a locality separated from that of *I. orientalis orientalis*.

From the above grounds the subspecific separation is most reasonable and natural, and probably *I. orientalis orientalis* was evolved from *I. naumanni* by way of *I. orientalis nagaoi*.

Material from the Himenoura group.—Representative examples from the type area of the Himenoura group are GK. H6109, 6112, 6113 from loc, K36, collected by Y. UEDA and I. OBATA; GK. H6111 and many others from loc. K43, collected by Y. UEDA. The specimens from Shiohama, Senzokuzozo-jima, collected and described by AMANO (1960, p. 9, pl. 1, figs. 1-3, 6, 8, 10) have been examined too.

Descriptive remarks.—The material from Amakusa confirms the subspecific diagnosis given above. Some of the specimens approach to *Inoceramus naumanni* when the concentric major ribs are weak, but they are associated with the typical examples as seen at the prolific localities K36 and K43.

The similarity and distinction between the group of *Inoceramus naumanni*—*I. orientalis nagaoi* and that of *I. lingua* GOLDFUSS—*I. lobatus* GOLDFUSS was discussed by NAGAO and MATSUMOTO (1940, p. 52), with whom we are quite agreeable. A few specimens probably referable to "*Inoceramus patootensis* LORIOL" have recently been discovered from the Tombets area, northern Hokkaido (facing the Ochotsk Sea), from which *I. naumanni* and *I. orientalis ambiguus* are well distinguished.

Occurrence.—Abundant at localities K36, on the coast, 1500 m northeast of Nagame, Himedo-mura*[1]; K43, a road cutting northwest of Uchinokochi, Matsushima-machi*[2]; K34 on the coast, 250 m east of Nagame*[3]; K40, Futamado, Himedo-mura*[4]; K44, close to K43; K48, Aizu Primary School, Matsushima-machi*[5]; common at locs. K46, all in the upper part of the Middle formation (II); also loc. K18, west of Kuzusaki, Ryugatake-mura*[6] in the lower part of the Upper formation (III) of the Himenoura

*[1] 熊本県天草郡姫戸村永目東北方 1500 m 海岸
*[2] 熊本県天草郡松島町内野河内変電所北西方道路崖
*[3] 熊本県天草郡姫戸村永目東方 250 m 海岸
*[4] 熊本県天草郡姫戸村二間戸（墓下の崖）
*[5] 熊本県天草郡松島町会津小学校講堂前
*[6] 熊本県天草郡竜ヶ岳府葛崎西方崖

group. AMANO's locality in Senzokuzozo-jima is probably to be referred to the lower part of the Upper formation.

The occurrence in Hokkaido is mentioned above.

5. *Texanites oliveti* (BLANCKENHORN)

Pl. 26, fig. 2; Text-fig. 13

1877. *Ammonites texanus*, LARTET (non ROEMER, 1852), *Exploration géologique de la Mer Morte, de la Palestine et de l'Idumée*, p. 113, pl. 8, fig. 4.
1905. *Schloenbachia oliveti* BLANCKENHORN, *Zeitsch. d. deutsch. Palaestina-Ver.* vol. 28, p. 104.
1907. *Mortoniceras oliveti*, PERVINQUIÈRE, Études de Paléontologie Tunisienne, Céphalopodes, p. 241.
1920. *Schloenbachia quiuquenodosa* var. *oliveti*, TAUBENHAUS, *Zeitsch. d. deutsch. Palaestin Ver.*, vol. 43, p. 30, pl. 5, figs. 3 and 5.
1948. *Texanites oliveti*, COLLIGNON, *Ann. géol. serv. Mines*, fasc. 13, p. 72, pl, 8[2], figs. 3–5; text-figs. 5–8.

Syntypes.—BLANCKENHORN (1905) established this species for the specimens from several localities near Jerusalem. He specially mentioned the largest specimen (with a diameter of 30 cm) from Ölberg but gave no illustration. He referred to the figure of LARTET (1877, p. 113, pl. 8, fig. 4), but did not designated the holotype. No subsequent authors designated the lectotype. We have no opportunity of studying the syntypes from the Near East, so we hesitate to do the designation in this paper. It would be desirable to designate the illustrated specimen of LARTET as the lectotype.

Material.—GK. H6117, about a quarter of a large specimen (internal mould) from a quarry of Hinoshima [=Loc. K60 of UEDA] collected by T. MATSUMOTO, 1938. Another smaller specimen from the same locality in T. MATSUMOTO's collection is preserved in the University of Tokyo.

Descriptive remarks.—Although the available specimen is incompletely preserved, it shows certain characteristic features. The last whorl, which represents a living chamber, has a height of about 95 mm. Its breadth is estimated at about 65 mm and the diameter of the entire shell would be about 290 mm. This is nearly as large as the examples from the Near East. The whorl is fairly compressed (b/h=0.68), subelliptical in intercostal section and subrectangular in costal section. The next inner whorl is about 60 mm in height and the involution is slight.

The ribs are coarse, separated by the interspaces which are somewhat wider than the ribs themselves. They are rectiradiate on the flank but may be slightly inclined backward near the umbilical margin and forward on the ventrolateral shoulder. The ventral keel is continuous with a slight undulation—a wavy uplift corresponding to a rib. Each rib has five distinct tubercles. They are nearly equidistant, but the two lateral ones are slightly more separated than others. The two ventrolateral ones are more or less clavate; others are conical or may be spinose on the well preserved shell.

The principal part of the suture is exposed on the next inner whorl (Pl. 5, fig. 2). This is of texanitine type, resembling that of *Texanites texanus* (ROEMER) (see COLLIGNON, 1948, pl. 8 [2], fig. 1, 1a) or that of *T. stangeri* (BAILY) (see SPATH, 1921,

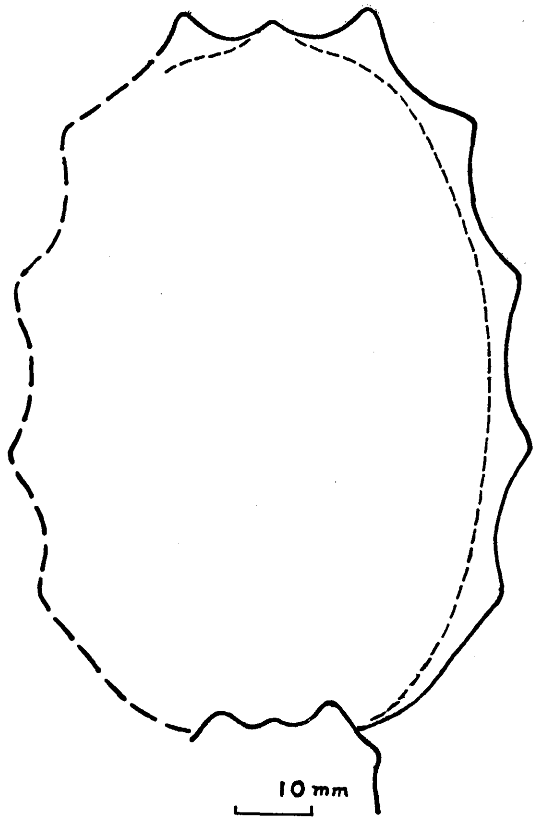

Fig. 13. *Texanites oliveti* (BLANCKENHORN) Whorl-section of a specimen, GK. H6117, collected by T. MATSUMOTO from a quarry of Hinoshima (loc. K60), Member I-c of the Himenoura group. Natural size.

p. 297, text-fig. Dla-c).

Texanites oliveti (BLANCKENHORN) shows a certain extent of variation in shell characters, as has been already demonstrated by the previous authors. The Japanese example described herein closely resembles a variety of this species described under the name of *T. oliveti* var. *spinosa* COLLIGNON (1948, p. 74, pl. 8[2], fig. 4, 4a) from Madagascar. In BLANCKENHORN's original description the inner lateral tubercle is said to be weaker and relatively more separated from the umbilical tubercle than other tubercles. Such an example is recognized in COLLIGNON's collection from Madagascar (1948, p. 73, pl. 8 [2], fig. 3, 3a). In the whorl-section our example is rather similar to this one (compare text-fig. 13 with COLLIGNON's 1948, text-fig. 5).

Admitting such an extent of variation, we thus identify the Himenoura specimen to *Texanites oliveti* (BLANCKENHORN).

Occurrence.—Locality K60 of UEDA, Hinoshima, Amakusa-gun, Kumamoto Prefecture, in dark colored muddy fine-grained sandstone, belonging to Member I-c of the Himenoura group. *Ostrea* like shells are sporadically associated with this ammonite in the same rock matrix. In the same member I-b of this quarry the lectotype and other specimens of *Inoceramus amakusensis* were obtained.

Texanites oliveti is widespread, known from Near East (Syria—Israel), northern Africa (Tunisia and Algeria) and Madagascar. Its distribution is extended to Kyushu, western Japan. There is a probable example of this species (a broadly whorled variety ?) in the collection of Dr. W. A. COBBAN from loc. USGS. 1467, *Clioscaphites vermiformis* bearing bed in western Texas.

Thus the species is a good indicator of Lower Santonian, and its occurrence in the *Inoc. amakusensis* zone in Japan is quite reasonable.

6. *Texanites kawasakii* (KAWADA)

Pl. 26, fig. 1 ; Pl. 27, fig. 2

1929. *Mortoniceras kawasakii* KAWADA, *Jour. Geol. Soc. Tokyo*, vol. 36, p. 4 (English), pl.

14, figs. 2-4.
1959. *Texanites* cf. *kawasakii*, MATSUMOTO, *Mem. Fac. Sci., Kyushu Univ.*, ser. D, Special vol. 1, p. 124, pl. 28, fig. 2.

Holotype.—A single specimen described and illustrated by KAWADA (1929, p. 4, pl. 14, figs. 2-4), from the Miho group of the Naibuchi area, South Sakhalin. It is preserved in the University of Tokyo (I-553).

Material.—An external mould of a large specimen (plaster cast preserved in Kyushu University, GK. H6116, Pl. 26, fig. 1) and two other smaller specimens from Hinoshima (?)*, formerly in the collection of Hinoshima Primary School, now preserved in Kumamoto University. All in the matrix of dark colored muddy sandstone.

The specimens from Naibuchi (Sakhalin) and Ikushumbets (Hokkaido) are examined, too.

Descriptive remarks.—Although the specimens from Hinoshima are incompletely preserved, they show the following diagnostic features.

The whorl is fairly widely umbilicate, with an umbilicus 44 percent of the whole diameter (215 mm) in a large example. The involution is so slight that the inner ventrolateral tubercles of the inner whorl are partly visible. The flank is flattened and slightly convex; the umbilical wall is steep; the whorl section would be subrectangular, if completely preserved.

The ribs are all simple, nearly rectiradiate or slightly concave and separated by the interspaces as broad as or slightly broader than the ribs themselves. They are strong but tend to be weakened on the outermost whorl. They are numerous on the outer whorls, for example 27 or 28 per a whorl at a diameter of 140 mm, but less numerous in the immature stage.

The tubercles are at first in three rows, umbilical, inner and outer ventrolateral. At a whorl diameter of 40 to 50 mm a lateral tubercle begins to develop and sooner or later another indistinct tubercle is added between it and the lower ventrolateral one. At the same time the bullate umbilical tubercle is doubled, so that apparently there are 6 rows of tubercles of unequal distance in the middle and mature stages. In these stages the tuberculation is the most prominent, except for the upper lateral tubercle. The last is normally very weak and close to the adjacent ones, but in an exceptional case it has a moderate intensity and distance. On the last whorl the tubercles are much weakened; and the lateral and umbilical ones are almost absorbed in the rib. The ventrolateral tubercles are clavate throughout life, especially the outer ones are more distinctly so.

The suture is not impressed on the large external mould, but exposed on another smaller one. This follows the characteristic pattern as seen on the better preseved whorls from Sakhalin and Hokkaido. It is of general texanitine type but the lateral lobe (L) is broader and more widely opened than that of *Texanites texanus* (ROEMER) (see COLLIGNON, 1948, text-fig. 10, pl. 8 [2], fig. 1, 1a).

From all these characters the described specimen from Hinoshima are certainly identified to *Texanites kawasakii* (KAWADA).

* The locality record of one of them (Pl. 27, fig. 2a-c) is not clear.

In many respects this species is allied to *Texanites soutoni* (BAILEY) (1855, p. 455, pl. 11, fig. 1a-c; WOODS, 1906, p. 337, pl. 43, fig. 1a-b; HOEPEN, 1921, p. 38, text-figs. 19-22, pls. 10 and 11; SPATH, 1922, p. 136, pl. 7, fig. 4; COLLIGNON, 1948, p. 78, pl. 7, fig. 1, 1a, 1b, pl. 10, fig. 1, 1a) from South Africa and Madagascar, but it has more rigid ribs than that species and the doubled umbilical tubercles. The lateral lobe of the African species is narrower than in the present species.

Occurrence.—Hinoshima, probably from a quarry of the muddy fine sandstone of member I-c, Himenoura group. The type locality is in the Santan, a tributary of the Naibuchi, zone Nh6, South Sakhalin. The same species was obtained from the zone of *Inoceramus amakusensis* in the Ikushumbets valley, Hokkaido.

7. *Texanites amakusensis* (YABE)

Pl. 27, fig. 4

1902. *Peroniceras amakusense* YABE, *Jour. Geol. Soc. Tokyo*, vol. 9, no. 100, p. 8, pl. 1, fig. 1a, b.

1925. *Peroniceras amakusense*, YABE and SHIMIZU, *Sci. Rep. Tohoku Imp. Univ.*, vol. 7, no. 4, p. 136.

Lectotype.—YABE (1902) established this species on two specimens, an internal and another external mould, both of which are preserved at the Geological Institute, University of Tokyo. The former, with no. Cr. 1714, reillustrated in this paper (Pl. 27, fig. 4), is herein designated as the lectotype, a plaster cast of which is preserved in Kyushu University, H. 6123.

Description.—The lectotype, about 90 mm in diameter, is so much deformed that the measurements cannot be accurately done. The whorl increases rather slowly with a little overlap. The umbilicus is, therefore, moderately wide (about 42 percent of the diameter in the deformed condition). The original shape of the whorl section cannot be known, as the specimen is secondarily compressed. The ribs are simple, rectiradiate or slightly prorsiradiate (?), and separated by the interspaces slightly broader than the ribs themselves. The umbilical tubercle is strong and in the middle growth stage bullate and tends to be doubled. The lower lateral tubercle is of moderate intensity and situated a little below the mid-flank. The upper lateral tubercle is very weakly developed in the late growth stage. The inner ventrolateral tubercle is strong and somewhat clavate; the outer ventrolateral one is extremely clavate. Probably owing to the secondary compression, the latter apparently forms a serrated keel. The true, continuous keel is at the mid-venter. No suture is exposed.

Remarks.—The lectotype is not a *Peroniceras*, because it is not truly tricarinate. It is very closely allied to *Texanites kawasakii* (KAWADA) which is described in the preceding pages. Unfortunately its whorl is so much deformed and its suture is so poorly preserved that the specific identity cannot be concluded. Since the type locality was not precisely recorded, we cannot study the topotype to examine the possible identity. In these circumstances it would be unwise to put *Texanites kawasakii* (KAWADA) on a list of synonymy of *Texanites amakusensis* (YABE).

The other syntype, Cr. 1715 of the University of Tokyo, is deformed in the same way as the lectotype, so it was regarded as another example of "*P. amakusense*". Actually it has broader, more numerous and less distant ribs than the lectotype. Its ribs are somewhat prorsiradiate, sometimes slightly flexuous and periodically branching, it has no upper lateral tubercles and its umbilical tubercles are not doubled at all. It is, therefore, more reasonably compared to *Protexanites fukazawai* (YABE and SHIMIZU) than to the present species. The drawing by YABE (1902, pl. 1, fig. 1a, b) seems to have depended primarily on the lectotype but to have been modified from the synthetic judgement from the two syntypes. The photographs of the actual specimens are shown in this paper (Pl. 27, fig. 4 for the lectotype; Pl. 27, fig. 3 for the plaster cast, GK. H6124, of the other syntype.).

Occurrence.—The type locality is not precisely recorded. It was described only as Amakusa. The matrix is a black silty rock. As YABE (1902, p. 8) suggested, it may have come from somewhere in the eastern coastal area of Amakusa-Kamishima, where the Himenoura group is typically exposed, but the conjecture is by no means certain.

8. *Protexanites fukazawai* (YABE and SHIMIZU)

Pl. 27, figs. 1, 3

1925. *Mortoniceras fukazawai* YABE and SHIMIZU, *Sci. Rep. Tohoku Imp. Univ.*, 2nd ser., vol. 7, no. 4, p. 130 (6), pl. 30 (1), fig. 1; pl. 31 (2), figs. 1–2, 6–7; pl. 33 (4), figs. 1–2.

1938. *Texanites amakusensis*, MATSUMOTO, *Jour. Geol. Soc. Japan*, vol. 45, no. 532, p. 12 (listed only).

1948. *Texanites fukazawai*, COLLIGNON, *Ann. géol. serv. Mines*, fasc. 14, p. 54.

1955. *Protexanites fukazawai*, MATSUMOTO, *Trans. Proc. Palaeont. Soc. Japan*, N. S., No. 18, p. 38.

Lectotype.—YABE and SHIMIZU established this species on three syntypes, of which the larger one, IGPT 8045, of the figured specimens (YABE and SHIMIZU, pl. 30, fig. 1 and pl. 31, fig. 6) collected by the late Prof. T. NAGAO from a locality between Ôda and Akase in Ôda-mura, Himenoura group, is designated herein as the lectotype.

Material.—Several fragmentary specimens of various sizes probably referable to the present species were collected by I. OBATA from the Ôda-mura area, of which the one, GK. H6119, showing the ornament of immature stage, from a locality between Toguchiura and Hiraiwa, is illustrated. A poorly preserved fragment, GK. H6118, collected by UEDA and OBATA from the Himenoura area is probably referable to the present species. There are many other specimens in MATSUMOTO's (1938) collection, preserved at the University of Tokyo, from the Himenoura group on the northern coast of Goshonoura island.

Descriptive remarks.—The specific diagnosis may be concisely written as follows.

The whorl grows rather slowly with little overlap. It is higher than broad, subrectangular in costal section, roughly elliptical in intercostal section and broadest in the lower part.

Ribs are more or less prorsiradiate and slightly concave, moderately strong, separated by somewhat broader interspaces, and provided with tubercles in four rows. The umbilical tubercle is bullate and considerably strong; the lateral is bullate and feeble, lying a little below the mid-flank, the inner ventrolateral prominent, nodose (rounded) and slightly oblique; the outer ventrolateral clavate and elevated. The immature whorl has some secondary or intercalatory ribs which are slightly flexuous and trituberculate without a lateral tubercle.

The suture is similar to that of *Protexanites bourgeoisi* (D'ORBIGNY) (GROSSOUVRE, 1894, p. 73, text-fig. 32, pl. 13, fig. 2, pl. 14, figs. 2-5), but the lateral lobe (L) is relatively broader than in that species.

There are numerous specimens of various sizes from the Himenoura group of the Uto peninsula, Goshonoura island and satellitic islets of Mayu-shima. Although they are imperfectly preserved, some of them represent the immature stage and others the intermediate stage between the immature one and the full-grown one like the lectotype. A young shell has slightly prorsiradiate, sometimes gently flexuous ribs, some of which are intercalatory or branching, bullate umbilical and two ventrolateral tubercles (see Pl. 27, fig. 1, an example from Ôda-mura). It is thus very similar to immature examples of *Protexanites bourgeoisi* (D'ORBIGNY) (GROSSOUVRE, 1894, p. 73, pl. 14, figs. 2-5), but a very faint lateral tubercle begins to appear in the later part of our examples. This supports MATSUMOTO's view (1955, p. 38) of regarding *Mortoniceras fukazawai* YABE and SHIMIZU as a later, relatively advanced species of *Protexanites*.

One of the two syntypes, an unillustrated specimen, Cr. 1715 of the University of Tokyo (Pl. 27, fig. 3 for its plaster cast, GK. H6124), of *Peroniceras amakusense* YABE is distinguished from the lectotype of that species (see remarks in the preceding page) and is rather comparable to the present species.

Occurrence.—Several localities in Ôda-mura Uto-gun at several horizons in the probable extension of Member I-d of the Himenoura group. A comparable specimen from loc. K21, west of Nishikawauchi, Himedo-mura in Amakusa-Kamishima, came from Member I-d of the type Himenoura group.

In the island of Goshonoura and Mayu-shima islet the specimens were obtained at locs. G3, G4, G100, G101, G300, and G357. The black siltstones and silty very fine-grained sandstones of these localities all belong to Member IVc of MATSUMOTO (1938) and range from the upper part of the *Inoceramus amakusensis* zone to the lower part of the *Inoceramus japonicus* zone.

Alphabetic list of the Romanized place names with their Japanese writings

Aizu (合津)
Akasaki (赤崎)
Amakusa (天草)
Amakusa-Kamishima (天草上島)
Amakusa-Shimojima (天草下島)
Fukuregi (福連木)
Furukojiro (古神代)
Futamado (二間戸)
Gankaizan (雁回山)
Goshonoura-jima (御所浦島)
Hankoyama (飯高山)
Higashiura (東浦)
Himenoura (姫浦)
Hinoshima (樋島)

Ikenoura (池浦)
Imaizumi (今泉)
Imamura (今村)
Kamenoura (亀浦)
Kakise (砒瀬)
Kamikoshiki-jima (上甑島)
Kojima (小島)
Kôjiro (神代)
Kompira-yama (昆比羅山)
Koshiki-jima (甑島)
Kugu-shima (椚島)
Kumamoto (熊本)
Kuzuzaki (葛崎)
Mae-shima (前島)
Maki-shima (牧島)
Maruyama (丸山)
Matsugahana (松ケ鼻)
Matsushima-machi (松島町)
Matsuyama (松山)
Mayu-shima (眉島)
Mifuné (御船)
Mifunezuka (御船塚)
Mureyama (群山)
Muta (牟田)
Nagamé (永目)
Nagasaki (長崎)
Nagashima (長島)
Nakanoura (中ノ浦)
Nenju-dake (念珠岳)
Neshima (根島)
Nishikawachi (西川内)
Nishiura (西浦)
Ôda (網田)
Ôe (大江)
Ônogawa (大野川)
Ônoura (大野浦)
Ôshima (大島)
Ôtonomisaki (大戸ノ岬)
Otsuki-jima (大築島)
Oyama-yama (小山山)
Ryuga-dake (竜ヶ岳)
Sakitsu (崎津)
Senzokuzozo-shima (千束蔵々島)
Shimoda (下田)
Shimokoshiki-jima (下甑島)
Shinsono-yama (神園山)
Shirakikochi (白木河内)
Shirama (白間)
Shiranuhi (不知火)
Shira-take (白岳)
Shishi-jima (獅子島)
Shishimi-dake (鹿見岳)
Taira-jima (平良島)
Takagushi (高串)
Tobase-jima (戸馳島)
Toshima-yama (戸島山)
Toyoaki (豊秋)
Uchinokochi (内野河内)
Unzen (雲仙)
Ushibuka (牛深)
Usuki (臼杵)
Uto (宇土)
Wadanohana (和田鼻)
Yatsushiro (八代)
Yokoura-jima (横浦島)
-dake=mountain
-jima=island, islet
-shima=island, islet
-take=mountain
-yama=hill, mountain

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Tatsuro MATSUMOTO and Yoshiro UEDA

Palaeontological Notes

in

Yoshiro UEDA

The Type Himenoura Group

Plates 22–27

Plate 22

Explanation of Plate 22

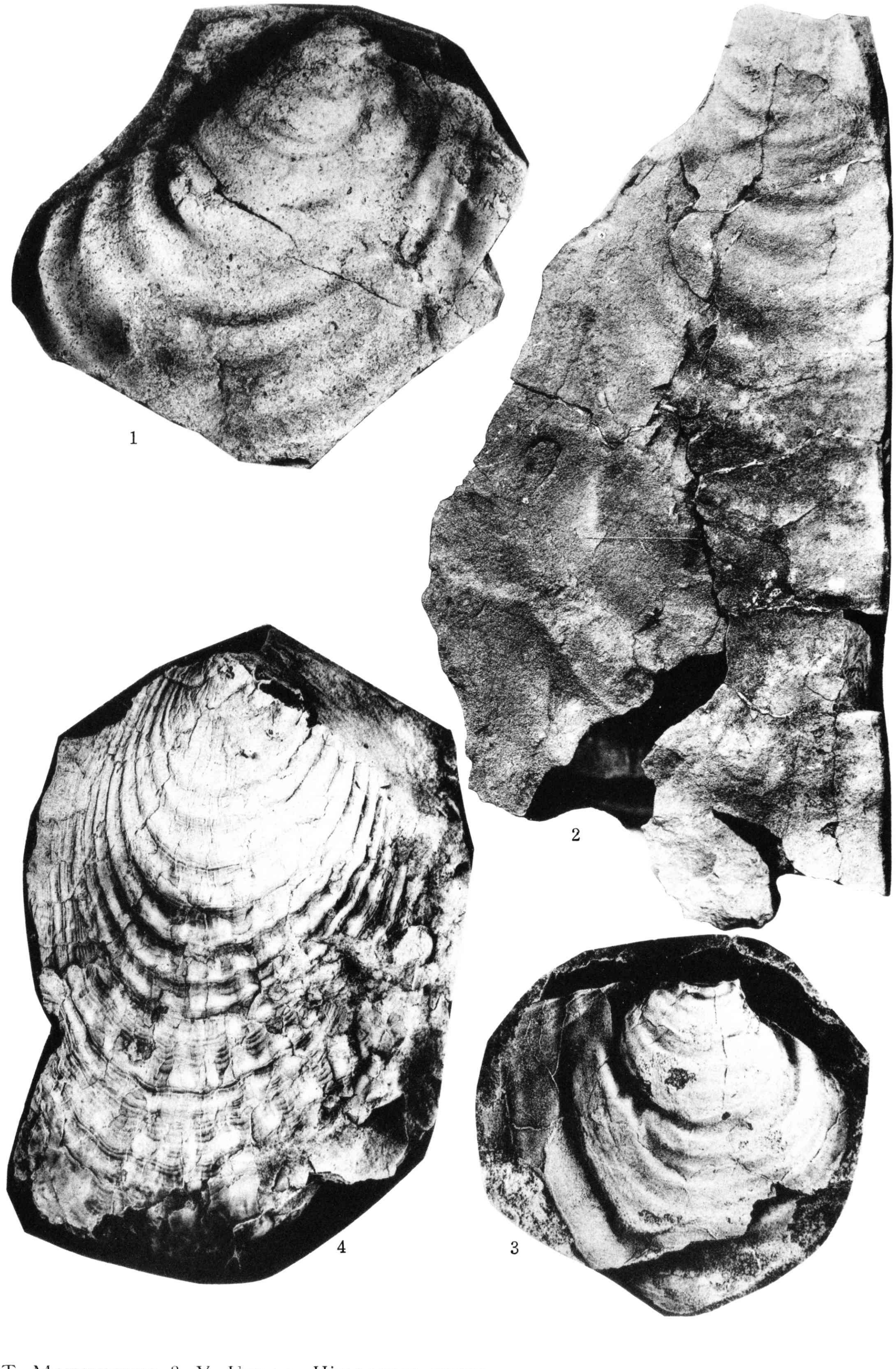
Figs. 1–3. *Inoceramus amakusensis* NAGAO and MATSUMOTO ....p. 161

1. Internal mould of a left valve. ×1. GK. H6121, from a medium sandstone bed in a small stream cutting the eastern part of the Oyamayama, east of Kumamoto City. (Coll. T. MATSUMOTO)
2. Internal mould of a left valve. ×2/3. GK. H6107, from Neshima, in Yatsushiro Bay, between Amakusa and Yatsushiro, in a sandy thin layer intercalated in a shaly formation. (Coll. K. KANMERA)
3. Internal mould of a right valve. ×1. GK H6108, from loc. K60, a quarry in the western part of Hinoshima, Ryugatake-mura, Amakusa-gun, Kumamoto Prefecture, muddy fine-grained sandstone of Member I–c, Himenoura group (the type locality) (Coll. E. INOUYE)

Fig. 4. *Inoceramus japonicus* NAGAO and MATSUMOTO ....p. 165

A left valve. ×1. GK. H6120, from loc. K594, western part of Kugushima, Ryugatake-mura, Amakusa-gun, Kumamoto Prefecture, mudstone of Member I–d, Himenoura group. (Coll. N. FURUKAWA)

Photos by Y. UEDA, with whitening.



T. MATSUMOTO & Y. UEDA: Himenoura group

Plate 23

Explanation of Plate 23

Figs. 1–5. *Inoceramus orientalis nagaoi* nom. nov. ....p. 167

1. A right valve, GK. H 6112, ×3/2
2. A left valve, GK. H 6110, ×3
3. A left valve, GK. H 6113a, ×1
4. A left valve, GK. H 6113b, ×1
5. A left valve, GK. H 6109, ×3

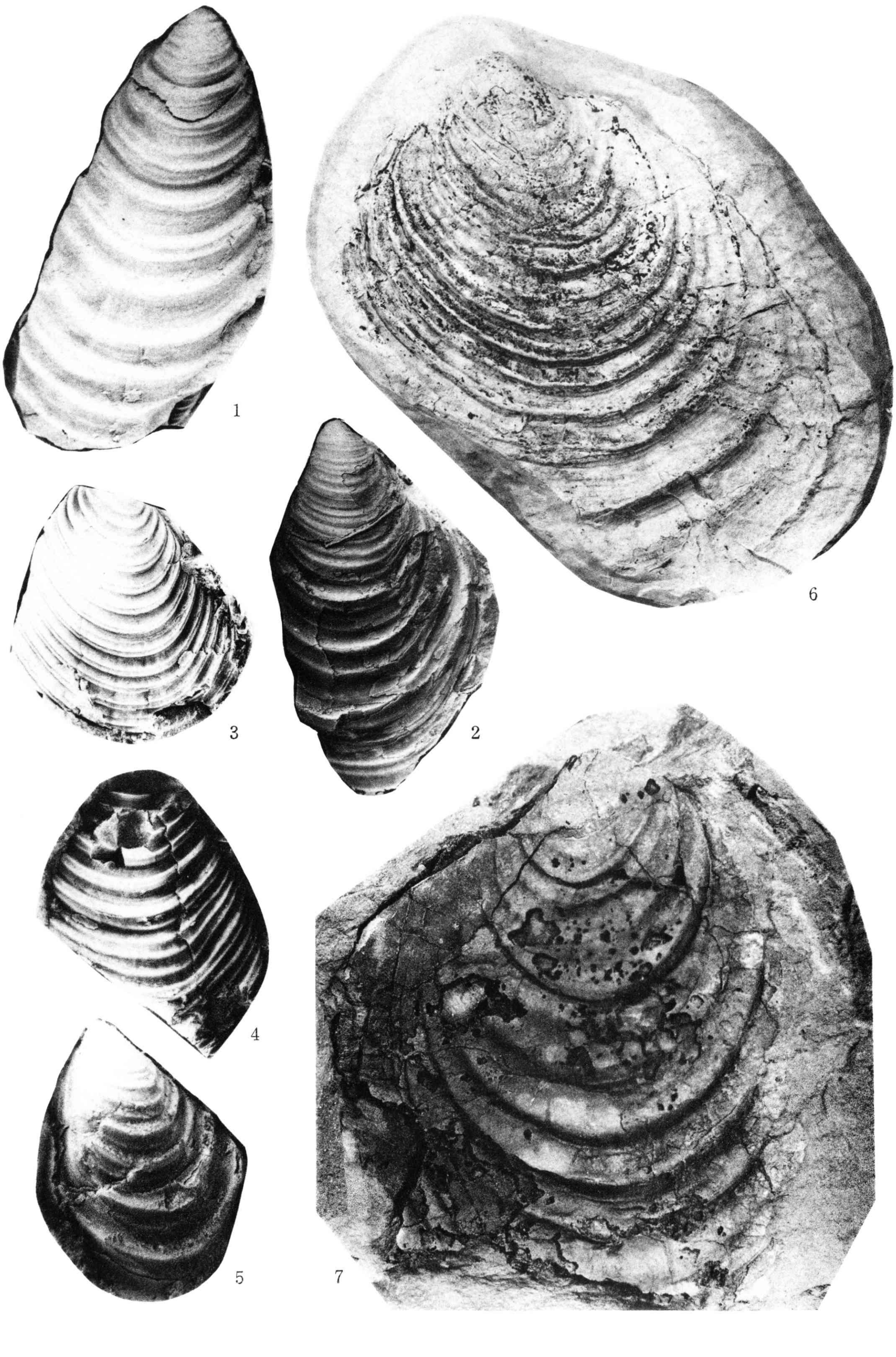
all from loc. K 36, on the coast 1500 m notheast of Nagame, Himedo-mura, Amakusa-gun, Kumamoto Prefecture, a thin layer of calcareous shale in the Middle formation, Himenoura group (Coll. Y. UEDA and I. OBATA).

Figs. 6–7. *Inoceramus balticus toyajoanus* NAGAO and MATSUMOTO ....p. 164

6. Plaster cast of a left valve, GK. H 6114, ×2/3
7. Internal mould of a right valve, GK. H 6115, ×1.2

both from loc. K 44, Uchinokawachi, Matsushima-machi, Amakusa-gun, Kumamoto Prefecture, mudstone of the Middle formation, Himenoura group (Coll. Y. UEDA).

Photos by Y. UEDA, with whitening.



T. MATSUMOTO & Y. UEDA: Himenoura group

Plate 24

Explanation of Plate 24

Fig. 1. *Inoceramus japonicus* NAGAO and MATSUMOTO ....p. 165
Left (a) and right (b) valves of the lectotype, University of Tokyo, No. I-1013, collected by Y. SASA from Kunitan, Kunitan formation (Santonian) of the Kuji group, Iwate Prefecture, Northeast Honshu, natural size.

Photos by C. UEKI.

1a

1b

T. MATSUMOTO & Y. UEDA: Himenoura group

Plate 25

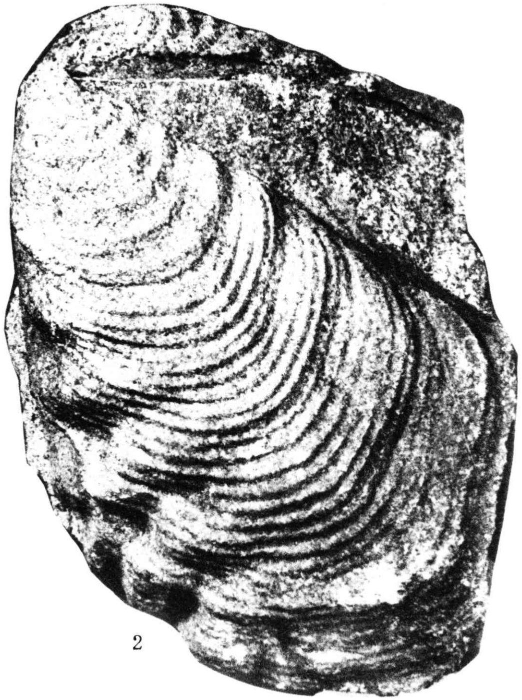
Explanation of Plate 25

Fig. 1. *Inoceramus undulatoplicatus* ROEMER..p. 165
GK. H 9202, a left valve, ×1, from USGS Mes. loc. 1514, Cow Creek, Austin Chalk, Texas, donated through the late Dr. J. B. REESIDE, Jr.

Fig. 2. *Inoceramus orientalis orientalis* SOKOLOW ....p. 167
GK. H 603, a left valve, ×1, collected by T. MATSUMOTO from loc. H. 100a, bed IV a, Lower sandstone of the Hakobuchi group in the Osachinai area, Hokkaido.

Photos by Y. UEDA, without whitening.


1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T. Matsumoto & Y. Ueda: Himenoura group

Plate 26

Explanation of Plate 26

Fig. 1. *Texanites kawasakii* (KAWADA) ....p. 170
Plaster cast, GK. H 6116, of an external mould of a large specimen, ×2/3, from loc. K 60, Hinoshima, Ryugatake-mura, Amakusa-gun, Kumamoto Prefecture, in a muddy fine-grained sandstone of Member I–c, Lower formation of the Himenoura group. The original specimen in the collection of Hinoshima Primary School, now preserved at the University of Kumamoto.

Fig. 2. *Texanites oliveti* (BLANCKENHORN) ....p. 169
Lateral view of a specimen, GK. H 6117, ×1/2, collected by T. MATSUMOTO from loc. K 60, a quarry in the western part of Hinoshima, Ryugatake-mura, Amakusa-gun, Kumamoto Prefecture, Member I–c, Lower formation of the Himenoura group.

Photos by I. OBATA.

1

2

T. MATSUMOTO & Y. UEDA: Himenoura group

Plate 27

Explanation of Plate 27

(Figures of natural size)

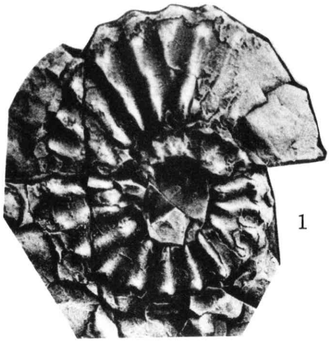
Fig. 1. *Protexanites fukazawai* (YABE and SHIMIZU)....................................p. 173
Lateral view of an immature example, GK. H 6119, collected by I. OBATA, from a locality between Toguchiura and Hiraiwa in Oda-mura, Uto-gun, Kumamoto Prefecture, Member I-d, Himenoura group.

Fig. 2. *Texanites kawasakii* (KAWADA) ....p. 170
Two lateral (a, b) and ventral (c) views of a fragmentary specimen, from the Himenoura group, in the collection of the Hinoshima Primary School, now preserved in the University of Kumamoto. The locality record of this specimen is not clear.

Fig. 3. *Protexanites* cf. *fukazawai* (YABE and SHIMIZU)................................p. 173
Lateral view of a plaster cast, GK. H 6124, for one of the syntypes of *Peroniceras amakusense* YABE, Cr. 1715 of the University of Tokyo, from Amakusa.

Fig. 4. *Texanites amakusensis* (YABE)..p. 172
Lateral view of the lectotype, No. Cr. 1714 of the University of Tokyo, from Amakusa.

Photos by Y. UEDA (1, 2), I. OBATA (3) and C. UEKI (4).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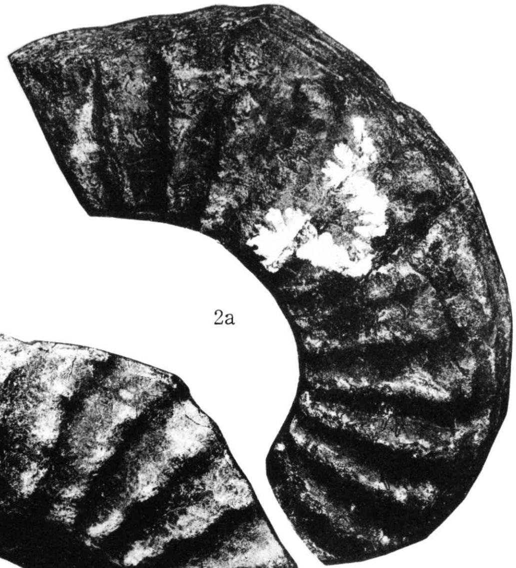
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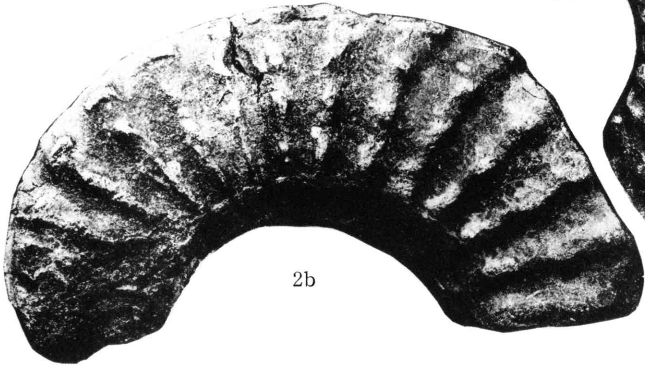
2b


2c


3


4