The Late Mesozoic Formations and their Molluscan Fossils in West Chugoku and North Kyushu, Japan

By

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with 3 Tables, 6 Text-figures and 9 Plates

ABSTRACT: This paper treats of the problems concerning the stratigraphy and fossil faunas of the non-marine late Mesozoic formations developed in the province of West Chugoku and North Kyushu. On the basis of the data from the principal outcropping areas I summarize the stratigraphic classification and correlation of the formations, the distribution of the faunas and the geologic structure. In conclusion I discuss the geologic history of the province.

The paleontologic descriptions of some new or important molluscan species are given in the sixth chapter.

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I. Introduction and Acknowledgements

In the western Chugoku and northern Kyushu province, which belongs geotectonically to the Inner Zone of Southwest Japan, the late Mesozoic formations are extensively developed. They consist of the brackish sediments in the lower part and of the lacustrine ones accompanied with a considerable amount of lavas and pyroclastics in the main part. Studies of them have been pursued by many authors because of their significance on the Mesozoic stratigraphy and history of Eastern Asia.

As for the earlier investigations of geology, we must mention the geological maps and explanatory texts by Suzuki (1893, 1906), Kochibe (1903) and Ogura (1922a, b). The name of the Inkstone series was introduced by Inoue (1896) for the Mesozoic formations of this area. Koto (1909) pointed out the lithological resemblance between the Inkstone group and the Kyŏngsang group of South Korea. The definition and geological age of the Inkstone group were at first very ambiguous, but afterwards the name has been confined to the Cretaceous strata which are distributed in the Inner Zone of Southwest Japan and contain red or variegated rocks. Yabe (1927), thus, gave a concise description of the group in his comprehensive work entitled "Cretaceous Stratigraphy of the Japanese Islands".

Since the occurrence of fossil shells was first reported by Yokoyama (1902) from the Mesozoic on the sea-coast of Yoshimo, north of Shimonoseki City, Yamaguchi Prefecture, the stratigraphic position and geological age of the shell beds had been discussed by Kochibe (1903), Ogura (1922b), Kobayashi (1931a), Oishi (1933) and Toriyama (1938). Kobayashi and Suzuki (1939) clarified that the fauna is closely allied to the lowest Cretaceous Ryoseki fauna of the Outer Zone of Japan, especially that of the Yatsushiro district in South Kyushu. Prior to this, Kobayashi and Suzuki (1936) described 5 species of non-marine molluscs from the Mesozoic locality at Wakino, west of Nogata City, Fukuoka Prefecture. This shell-bearing formation was called the Wakino beds (Kobayashi & Ota, 1936) and was, from the close similarity in fossil assemblage, correlated to the Naktong series of South Korea, which was considered to be referable to the Lower Cretaceous.

After Kobayashi's epoch-making work entitled "The Sakawa Orogenic Cycle and its Bearing on the Origin of the Japanese Islands (1941)", a great advance in knowledge concerning the stratigraphy, tectonics and geologic history of the present province was brought about mainly by Matsumoto and his collaborators. The Yoshimo shell beds which were placed by Kobayashi and Toriyama at the top of the Toyora group, have been, together with a part of the underlying Oishi's Kiyosue plant beds, included in the newly-defined Toyonishi group (Matsumoto, 1949). What had been called the Inkstone group (s. l.) was so confused in usage that the Kwanmon group was proposed by Matsumoto (1951a). This consists of the two subgroups, the lower or Wakino and the upper or Shimonoseki (i. e. Inkstone s. s.). In addition to Kobayashi's view that the paraxysm of orogenesis in the Inner Zone of Southwest Japan occurred in early Cretaceous (i. e. his Oga phase), Matsumoto (1949) concluded that the tectonic deformation progressed step by step over a long

mobile period from late Jurassic to "Middle Cretaceous". At MATSUMOTO's suggestion OTA (1953–60) reexamined the Wakino subgroup and continued the paleontological study of its molluscan fossils, while UEDA (1957) carried out a new research of the type Shimonoseki subgroup.

Cooperating with them, I have since 1949 been engaged in the geological investigations through the districts of western Chugoku and northern Kyushu. The results were partly incorporated into "The Cretaceous System in the Japanese Islands", a compilation by the Cretaceous Research Committee (Editor, MATSUMOTO, 1954). Very recently, I have published the details of the stratigraphy and structure of the late Mesozoic formations with remarks on the faunas and discussions on the correlation and geologic history (HASE, 1958). This was, however, written in Japanese and contained no paleontological description. Therefore I will concisely summarize in this paper the stratigraphy and the geologic history, and describe some new or important molluscan species from the Toyonishi and the Kwanmon groups.

I wish to express my hearty thanks to Professor Tatsuro MATSUMOTO of Kyushu University who gave me helpful advice and encouragement in the course of this study, kindly offered at my disposal the field data and many specimens in the collections of Kyushu University, and critically read through the typescript. I am indebted much to Professor Sotoji IMAMURA of Hiroshima University for his valuable advice, continuous encouragement and kindness of reading a part of the manuscript, and to Mr. Yoshihisa OTA of Fukuoka College of Liberal Arts for his friendly cooperation in field work and giving me access to his collection of fossils.

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II. DESCRIPTIONS OF LOCAL STRATIGRAPHY

Being separated by the outcrops of older terrains, the intrusions of igneous rocks

* Their names are mentioned in the sixth chapter (Paleontologic descriptions).

and the blankets of younger sediments, the late Mesozoic formations are at present exposed rather discontinuously in West Chugoku and North Kyushu. The localities of the main exposures are as follows (see Pl. XXXIV).

(1) The Kodaijiyama-Oshima area, northeast of Akama-cho which lies halfway between Moji and Fukuoka, Fukuoka Prefecture.

(2) The Yamaguchi-mura area, south of Akama-cho, Fukuoka Prefecture.

(3) The Wakino area, about 10 km. southwest of Nogata City, Fukuoka Prefecture.

(4) The Yurino area, adjoining to the west of Nogata City, Fukuoka Prefecture.

(5) The Kokura-Yahata-Tobata-Wakamatsu area, the mountainous quarters of these four adjacent cities, Fukuoka Prefecture.

(6) The Moji-Shimonoseki area, along the Kwanmon strait between northeastern end of Kyushu and western extremity of Chugoku (Honshu).

(7) The Toyonishi-Utsui area, north of Shimonoseki City, Yamaguchi Prefecture.

(8) The Nishiichi-Takibe-Tawarayama-Senzaki-Hagi area, the wide and continuous exposure in the northwestern part of Yamaguchi Prefecture.

(9) The Asa area, north of Asa-cho which is about 25 km. to the east of Shimonoseki, Yamaguchi Prefecture.

Besides these, small exposures are scattered in places.

In general the late Mesozoic rocks under consideration have been classified as follows in ascending order: (1) the Toyonishi group of brackish water origin, (2) the Kwanmon group of lacustrine origin, comprizing two subgroups, namely, (a) the Wakino subgroup characterized by the common occurrence of black shale and (b) the Shimonoseki subgroup associated with a vast amount of andesitic rocks, and (3) the Yahata formation mostly of acid volcanic origin. The stratigraphy in the principal outcropping areas is concisely described below (see Pls. XXXI and XXXIV).*

1. *Yamaguchi-mura area*

According to Kazuyo FURUKAWA (MS., 1947) and OTA (1958), the Wakino subgroup, overlying unconformably the Paleozoic Sangun metamorphics, consists of sandstone and subordinate black shale with occasionally intercalated siliceous shale. The whole thickness of about 1400 m. is divisible into three conformable formations, each of which begins with a thin conglomerate. The lower formation contains *Brotiopsis wakinoensis* and is correlated to the Sengoku formation in the type area (see article 2). The middle formation characterized by the frequent occurrence of siliceous shale corresponds to the Nyoraida formation. The Shimonoseki subgroup, about 700 m. thick, consists mainly of tuff and tuff-breccia accompanied with hornblende-andesite in the upper part. This subgroup seems to be in contact with different horizons of the Wakino and is probably correlated to the Shiohama formation plus the lower part of the Kitahikoshima formation to be described in article 5.

*In the Kodaijiyama-Oshima area rocks referable to the Shimonoseki subgroup are considerably distributed, but their stratigraphy is not fully explored.

2. *Wakino area*

This is the type area of the Wakino subgroup. The following stratigraphic succession in ascending order is a brief abstract from OTA's research (1953; see also a summary in MATSUMOTO [Editor], 1954), with slight modification from my observation. The fossils are identified by OTA and myself.

Basement rocks: Paleozoic Aida formation

——A remarkable unconformity——

Wakino subgroup

(1) Sengoku formation, 350 m. thick.

a. Basal conglomerate and the succeeding sandstone with a small amount of shale, 50 m. or so. The matrix of the conglomerate is green or red in color and is sometimes volcanic in origin. *Brotiopsis wakinoensis* occurs.

b. Black shale with subordinate fine-grained sandstone, 250 m. or so. A few lenses of impure limestone and abundant fresh-water shells are contained. The identified species are *Brotiopsis wakinoensis*, *B.* aff. *wakinoensis*, *B.* cf. *kobayashii kobayashii*, *Gyraulus* (?) n. sp. (?), *Plicatounio naktongensis naktongensis*, *P. naktongensis multiplicatus*, "*P.*" *triangularis*, "*P.*" *kwanmonensis*, *Paranodonta ôtai*, "*Nippononaia*" *wakinoensis wakinoensis*, "*N.*" *sengokuensis* and *Sphaerium* cf. *anderssoni anderssoni*.

c. Fine-grained sandstone and shale in alternation, 40 m., containing *Brotiopsis wakinoensis*, *Limnoperna* (?) *sengokuensis*, *Sphaerium* cf. *anderssoni anderssoni* and an estherid.

(2) Nyoraida formation, 100 m. thick.

a. Conglomerate and the succeeding tuffaceous sandstone, usually green or red in color, 50 m. A slight disconformity is locally observed at the base.

b. Fine-grained sandstone and shale in alternation, 50 m.

(3) Lower Wakamiya formation, 400 m. thick.

a. Sandstone and subordinate shale with a conglomerate at the base, where a slight disconformity is locally found, 100 m. A thin siliceous shale rarely occurs.

b. Black shale with intercalated thin layers of sandstone, 200 m., containing *Brotiopsis wakinoensis* and some unioid shell.

c. Sandstone and shale, infrequently intercalating thin layers of siliceous shale, 100 m. Small lenses of impure limestone are included.

(4) Upper Wakamiya formation, more than 200 m.

a. Sandstone and shale in alternation with a conglomerate at the base, where a slight disconformity is locally observed.

b. Sandstone and shale with occasional intercalation of thin layers of siliceous shale.

The Shimonoseki subgroup is not exposed.

3. *Yurino area*

This area situated to the northeast of Wakino has been investigated by MATSUMOTO, OTA and myself (HASE, 1958). The boundary between the Cretaceous strata and the underlying Aida formation is concealed by the covering of the Tertiary strata. The following three conformable formations of the Wakino subgroup are exposed here.

(1) Equivalent of the Sengoku formation, 350 m. thick: Sandstone and shale repeated in various thickness, including lenses of limestone in the lower part. The sandstone is bluish or light greenish grey and usually fine-grained. The shale is black to dark blue and sometimes laminated. A very small amount of conglomerate and siliceous shale is contained. *Viviparus* (*Sinotaia* ?) cf. *onogoensis*, *Thiara* (*Siragimelania*) cf. *tateiwai*, *Brotiopsis kobayashii kobayashii*, *Sphaerium anderssoni anderssoni* and *Cladophlebis* sp. occur from the upper part.

(2) Equivalent of the Nyoraida formation, 200–350 m. thick: Sandstone and shale, often siliceous or calcareous or somewhat tuffaceous in composition, bluish or greenish or milky grey in color, well-bedded and sometimes laminated. Thin layers of conglomerate occur at or near the base. The identified species are *Viviparus* (*Sinotaia* ?) *onogoensis*, *Brotiopsis kobayashii kobayashii*, *Sphaerium anderssoni anderssoni* and *Cladophlebis* sp.

(3) Equivalent of the Lower Wakamiya formation, more than 600 m.: Black shale and sandstone in alternation, where shale is much more predominant than sandstone. A thin conglomerate locally occurs at the base and a few layers of siliceous shale are intercalated in the lower part. *Viviparus* (*Sinotaia* ?) *onogoensis*, *Brotiopsis kobayashii sinsyuensis*, *Sphaerium anderssoni anderssoni* and *S. anderssoni jeholense* have been obtained.

The Upper Wakamiya equivalent and the Shimonoseki subgroup are not exposed.

4. *Kokura-Yahata-Tobata-Wakamatsu area*

Here the Cretaceous strata are developed more extensively and more perfectly than in the preceding areas. The mountainous area to the south of Kokura and Yahata has been investigated by OTA, MATSUMOTO and myself assisted by some students of the Kyushu University (OTA, 1955, 57; HASE, 1958), and the hills near Tobata and the peninsula of Wakamatsu have been surveyed by MATSUSHITA and his collaborators (1957). The following stratigraphy in ascending order is a concise summary from these works.

Basement rocks: Composed mainly of the Paleozoic Aida formation and partly of the strata comparable with the Permian Kozaki formation of South Kyushu.

——A remarkable unconformity——

Wakino subgroup

This is exposed in the southern part of the present area and comprizes the following four conformable or slightly disconformable formations, which correspond respect-

ively to the four formations in the Wakino area.

(1) Equivalent of the Sengoku formation, 150–250 m. thick, consists of conglomerate in the basal part and of alternation of sandstone and shale in the main part. The conglomerate contains pebbles of chert, sandstone, slate and limestone, and intercalates locally red beds associated with tuff. The fossiliferous beds near the base contain *Brotiopsis wakinoensis*, *Melanoides* (*Yoshimonia*) *kokurensis*, *Plicatounio naktongensis naktongensis* and *P. naktongensis multiplicatus*.

(2) Equivalent of the Nyoraida formation, 200–300 m. thick, closely resembles in lithology the correlative in the Yurino area. Sandstone and shale are often siliceous or calcareous or somewhat tuffaceous, well-bedded, and locally interbedded with red beds. Thin layers of conglomerate are infrequently found. The identified shells are *Viviparus* (*Sinotaia* ?) *onogoensis* and *Brotiopsis kobayashii kobayashii*.

(3) Equivalent of the Lower Wakamiya formation, 200–350 m. thick, consists of alternation of sandstone and shale, in which black to dark grey shale generally predominates. Thin layers of conglomerate occur at and near the base. *Viviparus* (*Sinotaia* ?) *onogoensis*, *Brotiopsis kobayashii kobayashii*, *B. kobayashii sinsyuensis*, *Melanoides* (*Yoshimonia*) *katsukiensis*, *Plicatounio naktongensis multiplicatus*, "*Nipponomaia*" *wakinoensis wakinoensis*, *Sphaerium anderssoni anderssoni*, *Manchurichthys* (?) sp., *Euestheria kokurensis*, *Estherites imamurai* and ostracods have been collected.

(4) Equivalent of the Upper Wakamiya formation, 200–400 m. thick, consists mainly of sandstone and subordinate shale containing calcareous nodules. The sandstone is sometimes tuffaceous and a greenish grey color prevails in the upper part. The basal member, composed of conglomerate with alternating sandstone and shale and with rarely intercalated red beds, changes laterally in thickness, ranging from 10 m. to 150 m. The identified species are *Viviparus* (*Sinotaia* ?) *onogoensis*, *Brotiopsis kobayashii kobayashii*, *B. kobayashii sinsyuensis*, *Melanoides* (*Yoshimonia*) *katsukiensis*, *Plicatounio* aff. *naktongensis naktongensis*, *Trigonioides paucisulcatus suzukii*, *Sphaerium anderssoni anderssoni* and *Cladophlebis* sp.

——A local disconformity——

Shimonoseki subgroup

In the central and northern parts of the present area this subgroup overlies conformably the above-mentioned Upper Wakamiya equivalent; the greenish tuffaceous sandstone of the latter passes gradually to the red or variegated beds of the former. In the southern part of the area, namely, the marginal part of the depositional basin, however, the Upper Wakamiya equivalent is lacking and the Shimonoseki subgroup covers directly the Lower Wakamiya equivalent with or without a basal conglomerate. The following stratigraphy is correlative to that of the type area near Shimonoseki (see article 5).

(1) Equivalent of the Shiohama formation, more than 100 m., consists of conglomerate, tuffaceous sandstone, tuffaceous shale and tuff of hornblende-andesite ori-

gin. They are usually red or green or variegated in color, but change laterally to grey or dark grey. The conglomerate contains pebbles and cobbles of andesite besides those of sedimentary rocks. *Viviparus* (*Sinotaia* ?) *onogoensis* and *Sphaerium* cf. *anderssoni anderssoni* are very rarely found.

(2) Equivalent of the Kitahikoshima formation comprizes the following two subformations.

a. Lower subformation, 1200 m.: Agglomerate, tuff-breccia and tuff, changing irregularly to volcanic conglomerate, tuffaceous sandstone and tuffaceous shale and intercalating occasionally lavas of andesite. The lavas and pyroclastics are at least partly of hornblende-andesite origin.

b. Upper subformation, 1400 m.: Andesites including their tuff-breccias and tuffs, with intercalated tuffaceous sandstone and shale. There are pyroxene-andesite, pyroxene-hornblende-andesite and in part acid andesite.

(3) Equivalent of the Sujigahama formation, more than 280 m., consists of tuffaceous sandstone and volcanic conglomerate, the latter of which contains cobbles of chert, andesite, porphyrite and acid igneous rocks.

——A slightly oblique unconformity——

Yahata formation, 100–150 m.

Overlying in some places the Upper Wakamiya equivalent and in others the Shiohama equivalent, the Yahata formation develops on the synclinal part of the Kwanmon group. The main constituents are rhyolitic tuff, lapilli-tuff and volcanic conglomerate. Hornblende-dacite extruded through the Kwanmon group is also regarded as a member of this formation.

5. *Moji-Shimonoseki area*

The Mesozoic geology of the Kiku peninsula, where Moji City is located, has been researched by OTA (1959a). The hills in the vicinity of Shimonoseki City including Hikoshima, an islet lying at the entrance of the Kwanmon strait, have been investigated by MATSUMOTO (Editor, 1954), UEDA (1957) and their collaborators. Following is the outline of the stratigraphy in ascending order, as revealed by these authors, with slight modification from my observation.

Wakino subgroup

On both sides of the Kwanmon strait stretch the extensions of the three formations, the Nyoraida, the Lower Wakamiya and the Upper Wakamiya. Each of them is 300 m. or so in thickness and is composed of sandstone and subordinate shale with some conglomerates at the base. The Sengoku equivalent is lacking, and the Nyoraida overlies directly the Paleozoic Chichibu complex of the Kiku peninsula with an unconformity. It contains *Brotiopsis kobayashii kobayashii* and is characterized by the intercalation of red beds. Lenses of impure limestone and fossils of *Viviparus*

(*Sinotaia* ?) *onogoensis* and *Sphaerium anderssoni anderssoni* are contained in the Lower Wakamiya. The Upper Wakamiya, in which a tuffaceous sandstone prevails, was once called the Tanokubi member, a local disconformity being found at its base.

Shimonoseki subgroup

This is typically exposed in Hikoshima and along the west coast of Shimonoseki. The stratigraphic relation to the underlying Upper Wakamiya equivalent is not clear.

(1) Shiohama formation, 300–350 m., consists of volcanic conglomerate, tuffaceous sandstone and tuffaceous shale, with tuff and tuff-breccia of andesitic origin. They are usually purple-red or green in color.

(2) Kitahikoshima formation, about 700 m., comprizes the following members:

a. Lower member, 150–200 m.: Lavas of hornblende-andesite, with tuff-breccia in the upper part.

b. Middle member: Composed of lavas of pyroxene-andesite, 150–200 m., overlying the preceding member; dikes or sills of augite-hornblende-andesite, 70 m. ±; necks or dikes of pigeonitic augite-porphyrite; and quartz-bearing hornblende-andesite, intruded through the pyroxene-andesite.

c. Upper, or Odo member, 220 m.: Massive tuff of partly andesitic and partly dacitic origin, with a volcanic breccia at the base and a unit of 70-meter pyroxene-andesite in the middle part.

(3) Sujigahama formation, more than 800 m., overlies disconformably the Odo member with a basal conglomerate containing rock-fragments of andesite and tuff. Its main part consists of volcanic conglomerate, tuffaceous sandstone, tuffaceous shale and tuff in frequent alternation. They are usually dark grey or green in color and the conglomerate contains water-worn pebbles and cobbles of andesite, dacite and dellenite.

6. *Toyonishi-Utsui area*

The stratigraphy of the late Mesozoic rocks developed most perfectly in this area has been thoroughly researched by myself, based on the reconnaissances by MATSUMOTO (1949) and Takashi ENDO (MS., 1947). Some students of the Hiroshima University have rendered assistance to my work. The sequence of strata is as follows (MATSUMOTO [Editor], 1954; HASE, 1958).

Underlying: Utano formation of the Lower and Middle Jurassic Toyora group.

——A disconformity——

Toyonishi group

This is exposed in the hilly area to the north and east of Utsui and in the coastal area near Yoshimo.

(1) Kiyosue formation

a. Basal part, 200–250 m.: Coarse-grained quartzose sandstone with conglomerate consisting mainly of well-rounded pebbles of chert.

b. Main part: Coarse- to fine-grained quartzose sandstone and black to dark blue shale in alternation, with frequent intercalation of conglomerate. Among them the shale is more or less predominant, containing abundant plant remains, which are listed on Table 1 in Chapter VII. Thickness is about 250 m. at the type section in the marginal part of the depositional basin, but in the central part it attains 700 m.

(2) Yoshimo formation

a. Main part, 100–200 m.: Sandstone, medium- to fine-grained, light bluish or white grey, with subordinate black to dark blue shale and rarely intercalated thin siliceous tuffite. They are well-bedded, each bed ranging from 10 cm. to 1 m. in thickness. There are many fossiliferous beds containing brackish water shells, which are listed on Table 2 in Chapter VII.

b. Upper part, 50–100 m.: Ill-sorted conglomerate and sandstone, including small calcareous nodules. A slight erosion-surface is observable at the base.

——A distinct disconformity——

Wakino subgroup

The remarkable basal conglomerate of the Wakino subgroup overlies the different horizons of the Yoshimo formation, and in some places of the marginal area it directly covers the Kiyosue formation. As the Sengoku-Nyoraida equivalent is lacking, this subgroup comprizes the following two formations.

(1) Equivalent of the Lower Wakamiya formation, 200–400 m.

a. Basal conglomerate, alternating with layers of sandstone and shale in the upper part, 150–200 m. The conglomerate is ill-sorted, consisting usually of rounded to subangular pebbles and cobbles of chert and sandstone and sometimes exclusively of angular blocks derived from the underlying formation. Red beds occur locally.

b. Bedded sandstone with subordinate black shale containing calcareous nodules and fresh-water shells, such as *Brotiopsis kobayashii kobayashii*, *Trigonioides paucisulcatus suzukii*, *Limnoperna* (?) *sengokuensis* and *Sphaerium* cf. *anderssoni anderssoni*, 50–200 m. Thin layers of siliceous tuffite and red shale are infrequently intercalated in the upper part.

(2) Equivalent of the Upper Wakamiya formation, 350 m.

a. Basal conglomerate, alternating with layers of sandstone and shale, 50 m. or so. An erosion-surface is at the base.

b. Sandstone and black shale in thin-bedded alternation, with a very small amount of conglomerate, 100–200 m. As a rule the shale is prevailing.

c. Sandstone and shale, with a small amount of conglomerate, 200 m. In some places they are purple-red or green in color. A lenticular or nodular limestone, which contains sporadically *Viviparus* (*Sinotaia* ?) *onogoensis*, occurs near the middle part.

——An erosion-surface——

Shimonoseki subgroup

This is typically characterized by the predominance of red or variegated sediments and the frequent occurrence of pyroclastic matter, but the color changes laterally to grey or dark grey in the northern wing of the major anticline, the axis of which runs from Takachi-togé westwards to Yoshimo.

(1) Equivalent of the Shiohama formation, 500 m. ±, quite similar in lithology to the type formation in Hikoshima. A remarkable volcanic conglomerate is at the base, which contains cobbles of andesite.

(2) Equivalent of the lower member of the Kitahikoshima formation, 200 m. ±: Lavas of hornblende-andesite, partly quartz-bearing, locally alternating with tuff or tuffaceous rocks. The pyroxene-andesite and its allies which occur in the middle and upper members of the type Kitahikoshima formation seem to be lacking here.

(3) Equivalent of the Sujigahama formation, about 1000 m.: This resembles the type formation near Shimonoseki in thickness and general character of lithology. In the present area, however, the sediments of pyroclastic origin are as a whole more intermingled with the terrigenous matter. Thus the conglomerate consists of pebbles and cobbles of sedimentaries, such as chert, sandstone, phyllite and limestone, in addition to those of volcanics, and the color of rocks is predominantly red or variegated. The conglomerate develops most remarkably in the basal part and also in the upper half. The middle part has interbeds of light grey sandstone containing calcareous nodules and those of black shale containing indeterminable plant-drifts. Tuffs of dacitic to rhyolitic origin occur.

(4) Fukue formation, 200 m.: Lavas of andesite underlain by a unit of 50-meter volcanic breccia. Their exposure is restricted to the sea-coast of Fukue.

7. *Nishiichi-Takibe-Tawarayama-Senzaki-Hagi area*

The Kwanmon group is exposed most extensively and continously from Nishiichi to Hagi in the northwestern part of Yamaguchi Prefecture. The stratigraphy has been investigated in detail by myself assisted by some students of the Hiroshima University. This is summarized as follows (HASE, 1958).

Wakino subgroup

On the southern slope of Mt. Gesan, southwest of Nishiichi, this subgroup overlies the Utano formation of the Toyora group with a slightly oblique unconformity. Since this part of the Utano formation is Upper Toarcian to Callovian in age (MATSUMOTO & ONO, 1947), a considerable time gap may be represented by this unconformity. To the northeast of Nishiichi the subgroup is cut off by the fault of NE-SW trend from the questionable strata referable either to the Toyora group or to the Triassic Miné group. In many other places, however, the lower limit is not exposed.

The Wakino subgroup in the present area comprizes two conformable formations, the Lower Wakamiya equivalent (300 m. or so) and the Upper Wakamiya equivalent (600 m. in maximum thickness). Each consists of predominant conglomerate in the lower half and of sandstone with subordinate shale and a small amount of conglomerate in the upper half. Red beds occur locally, especially in the Upper Wakamiya equivalent in the Tawarayama area. A greenish tuffaceous sandstone intercalated with siliceous tuffite prevails in the uppermost Upper Wakamiya. *Sphaerium anderssoni anderssoni* and *S. anderssoni jeholense* were collected from the Lower Wakamiya equivalent and *Gyraulus* (?) n. sp. (?), "*Nippononaia*" *wakinoensis intermedia* and *Sphaerium anderssoni anderssoni* from the Upper Wakamiya.

Shimonoseki subgroup

This overlies the different horizons of the Wakino subgroup. Near Tasuki and Futami, which are fairly distant from the outcropping basement complex, the lithological change from the uppermost Wakino to the basal Shimonoseki is gradual; no marked stratigraphic break can be recognized there. In most places, however, a remarkable conglomerate develops at the base of the Shimonoseki subgroup. It contains in some places pebbles, cobbles and boulders of andesite, dacite, chert and sandstone and in others exclusively those of limestone. It should be, moreover, worthy to note that near Ofuku, Kyowa and Hagi this subgroup overlies with a marked unconformity various older formations, such as the Toyora group (?), the Miné group, the Permian Beppu group, the Permo-Carboniferous Akiyoshi limestone group and the Sangun metamorphic complex.

(1) Lower formation: Purple-red, green or variegated tuffaceous strata corresponding, for the most part, to the Shiohama formation in Hikoshima. The lateral change of color is remarkable and volcanic conglomerate occurs repeatedly. The whole thickness is about 100–300 m. in the marginal part of the basin and attains 400–600 m. in the main part of the basin, where lapilli-tuffs or autobrecciated lavas of rhyodacite (sometimes with dacite and rhyolite) are alternated with light grey tuffaceous sandstone and shale especially in the upper half. These acid volcanic rocks in the upper part of this formation may be correlated to the lower member of the Kitahikoshima formation.

(2) Middle formation

a. Lavas of acid andesite and dacite, greenish, light bluish and partly reddish in color, alternating with and changing laterally to their agglomerates, tuff-breccias and tuffs. The dacite is often silicified. Thickness is presumably 400–500 m. In the upper part occurs a lentil composed mainly of tuffaceous sandstone and shale of purple-red or variegated color.

b. Hypersthene-augite-andesite and augite-andesite, dark green and partly purple-red, including their tuffs and tuff-breccias as well as lavas. Thickness is variable and probably attains 500–600 m. or more in maximum. Pigeonite-bearing augite-porphyrite and hypersthene-augite-porphyrite occur as necks, dikes and sills.

From the stratigraphic sequence and the lithologic characters, members a and b correspond to the acid andesite of the lower Kitahikoshima member and the basic andesites with porphyrites of the middle and upper Kitahikoshima respectively.

(3) Upper formation

a. Volcanic conglomerate, greenish tuffaceous sandstone and reddish tuffaceous shale in alternation, with intercalated lavas and tuffs of andesite or dacite, 300–400m.

b. Rhyodacite, bluish or light grey, fine-grained to breccia-bearing, intercalating thin layers of sandstone and shale, 200–300 m.

c. Bedded greenish sandstone with intercalated purplish shale, more than 150 m.

It is highly probable that the volcanic conglomerate of member a corresponds to that of the Sujigahama formation and that the acid volcanic activity represented by the rocks of member b is comparable to the abundant occurrence of cobbles of dellenite and the occasional intercalation of layers of acid tuff.

(4) Uppermost formation: Lavas of acid andesite, usually quartz-bearing, approximately 500 m. or more in thickness, covering member b of the Upper formation in the north of Tonoi. From the stratigraphic position this andesite may be tentatively correlated to the Fukue formation.

Some porphyrites, such as quartz-bearing hornblende-porphyrite exposed widely near Sanmi (west of Hagi), may be treated as a member of the Shimonoseki subgroup.

Equivalent of the Yahata formation, more than 500 m.

This is distributed on the structural basin of the Kwanmon group. Its base is in contact with the various members of the Shimonoseki subgroup and further with the Wakino. Its main part consists of lavas of rhyodacite, which are in some places alternating with lapilli-tuff and tuff, with intercalated sandstone and shale. The rhyodacite is light greenish to bluish grey and partly dark reddish, often showing fluidal or brecciated structure. It is cut by platy joints. The shale is sometimes black, containing indeterminable plant-drifts. The acid volcanics of the main part are succeeded by flows of rhyolite and intrusives of quartz-porphyry.

8. *Asa area*

This area has been surveyed by MATSUMOTO and myself (HASE, 1958). The Cretaceous rocks overlying unconformably the Upper Triassic Miné group are classified as follows.

Wakino subgroup

(1) Lower Wakamiya equivalent, 150 m. +, containing *Brotiopsis kobayashii kobayashii.*

(2) Upper Wakamiya equivalent, 350 m., containing *Brotiopsis kobayashii sinsyuensis*, *Sphaerium anderssoni anderssoni* and *S. anderssoni jeholense.*

Shimonoseki subgroup

(1) Shiohama equivalent, 500 m.

(2) Kitahikoshima equivalent

Each unit is quite similar in rock-facies to the corresponding unit in the preceding areas. An erosion-surface is observable between the Wakino and the Shimonoseki.

III. A Summary of Stratigraphy

On the basis of the local stratigraphy as briefly described in the foregoing chapter, I summarize here the general features of the distribution, stratigraphic relation and rock facies of the late Mesozoic formations in the province of West Chugoku and North Kyushu (see Fig. 1 and Pl. XXXIII).

1. *Toyonishi group*

The distribution of this group is restricted to the Toyonishi-Utsui area, and is closely connected with that of the Utano formation of the Toyora group, which underlies disconformably the former.

In the type sections near Kiyosue and Utsui the Toyonishi group begins with the basal conglomerate-sandstone member, passes upwards to the member of shale, sandstone and conglomerate in alternation, in which shale prevails over others, and ends with the sandstone member. Near Yoshimo a conglomerate occurs at the top of the group. Thus, the group in question seems to represent a cycle of sedimentation, but by no means typically so because of the frequent occurrence of conglomerate. The conglomerate in the lower or Kiyosue formation is moderately sorted, consisting chiefly of well water-worn pebbles of chert derived from the Paleozoic terrain and subordinately of those of sandstone and dacitic rock. Besides them, fragments of black shale are rarely found, which are probably derived from the underlying formation. The top conglomerate with an erosion-surface at its base is rather ill-sorted, containing abundantly large pebbles of sandstone in addition to those of chert.

The sandstone is usually quartzose, light bluish to white grey, massive to well bedded, partly cross-laminated, fine- to coarse-grained and sometimes pebbly. The shale is black to dark blue, intercalating, in the lower formation, plant-beds and unworkable coal seams. In the upper or Yoshimo formation numerous shell-beds are intercalated and small calcareous nodules are included. A thin tuffite also occurs there.

2. *Wakino subgroup*

This is typically divided into four formations on the basis of a minor cycle of sedimentation. Each formation corresponding to one cycle ranges in thickness from 100 m. to 600 m. (300 m. on the average) and begins with a conglomerate, at the base of which a disconformable plane is locally observed. In North Kyushu except the Moji area, the lower or Sengoku formation overlies the Paleozoic non-metamorphic rocks as well as the metamorphic rocks with a remarkable clino-unconformity. At Moji, however, the middle or Nyoraida formation covers directly the Paleozoic, and in

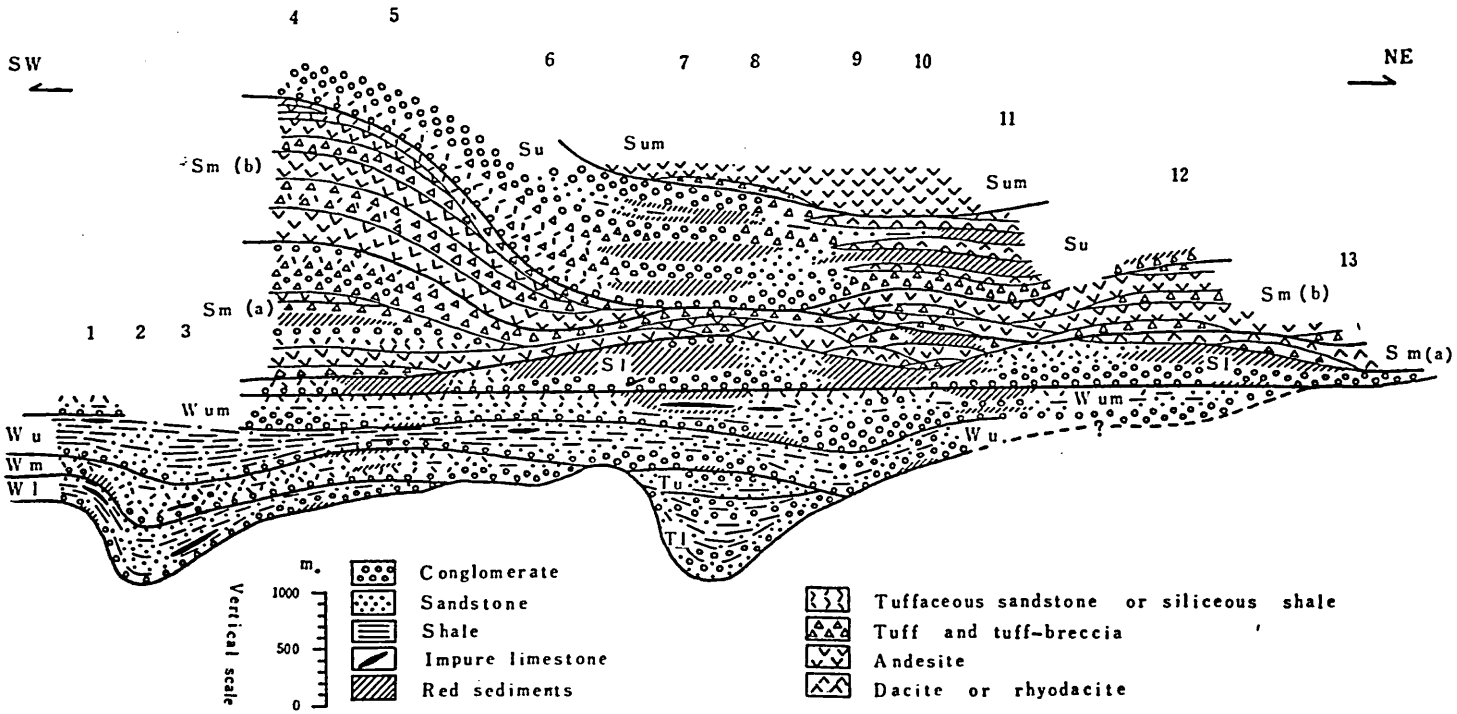

FIG. 1. Diagrammatic cross section of the Toyonishi and the Kwanmon groups in West Chugoku and North Kyushu.

Sum: Fukue formation, Su: Sujigahama formation, Sm (b): Upper part of the Kitahikoshima formation, Sm (a): Lower part of the Kitahikoshima formation, Sl: Shiohama formation, (S: Shimonoseki subgroup), Wum: Upper Wakamiya formation, Wu: Lower Wakamiya formation, Wm: Nyoraida formation, Wl: Sengoku formation, (W: Wakino subgroup), Tu: Yoshimo formation, Tl: Kiyosue formation, (T: Toyonishi group).

1: Wakino area, 2: Yamaguchi-mura area, 3: Yurino area, 4-5: Wakamatsu-Yahata-Kokura area, 6: Moji-Shimonoseki area, 7-8: Toyonishi-Utsui area, 9-10: Takibe-Nishiichi area, 11: Tawarayama area, 12-13: Senzaki-Hagi area.

West Chugoku the upper formation (the Lower Wakamiya formation) covers various older rocks, that is, the Toyonishi group with a disconformity, the Toyora group with a slight clino-unconformity and the Miné group with a moderate clino-unconformity. In Middle Chugoku, furthermore, the strata referable to the Upper Wakamiya formation seem to overlie the Paleozoic, as will be discussed in Chapter VIII. Thus, the Wakino subgroup overlaps the basement progressively towards the east. The structural difference between the basement rocks and the superjacent formations seems to increase as the time-interval becomes longer.

The main rock facies of the Wakino subgroup is sandstone and shale in alternation, intercalated with conglomerate and accompanied by calcareous or siliceous sediments together with red beds. The conglomerate develops more remarkably in West Chugoku than in North Kyushu. Compared with the conglomerate of the Toyonishi group, it is worse sorted and lithologically more heterogeneous, consisting mainly of pebbles and cobbles of chert, quartzite, sandstone, shale and slate. Pebbles of semi-schist, porphyrite and dacitic rock are also found. The basal conglomerate of each of the four formations contains locally abundant pebbles and cobbles of limestone, some of which include fusulinids. While the cobbles and the larger pebbles are rather well rounded, the smaller ones are more or less angular. The sandstone is mostly fine-grained and light bluish to greenish grey in color. Black to dark grey shale is common throughout the subgroup, and predominates especially in the Sengoku and the Lower Wakamiya formations in North Kyushu. Both the sandstone and the shale are often calcareous, containing lenses and nodules of impure limestone, in which pisolite and non-marine shells are occasionally found. Siliceous or somewhat tuffaceous strata associated locally with green or purple-red sediments of various coarseness characterize the Nyoraida and the Upper Wakamiya formations, although the "red beds" with tuff begin to occur in the basal Sengoku member.

3. *Shimonoseki subgroup*

The relation between the Shimonoseki subgroup and the Wakino subgroup is so intimate that they are combined under the name of the Kwanmon group. The two subgroups are developed usually in accompaniment with each other, being in some places conformable and in others disconformable. Generally speaking, the disconformable relationship is recognized by the lack of the uppermost Wakino in the marginal zone of the depositional basin. Near the northeastern border of the basin the Shimonoseki subgroup overlaps directly the older Mesozoic and late Paleozoic rocks.

This subgroup is characterized by the great thickness (attaining about 2000 m. in the type area), the frequent occurrence of purple-red or variegated sediments, the remarkable development of volcanic conglomerate and the association with a vast amount of lavas and pyroclasctics. The conglomerate is poorly sorted and usually polygenetic, containing rounded to angular pebbles, cobbles and boulders of andesite and dacite, besides those of chert, quartzite, sandstone, slate, semi-schist and limestone.

Cobbles and boulders of limestone are locally very abundant in the basal conglomerate, and those of acid volcanic rocks are characteristic of the Sujigahama formation, at the base of which occurs a disconformity. At horizons, purple-red sandstone and shale are abundantly contained as rock-fragments, which suggest the contemporaneous erosion.

Red sediments are mostly shaly, although the sandstone and conglomerate of the same color are not rare. They are, together with green or variegated sediments, the main constituents of the Shimonoseki subgroup, especially of the Shiohama formation. As in the Wakino subgroup, sandstone and shale are sometimes siliceous or calcareous, including nodules of impure limestone. Black shale is very rare.

The development of red sediments, the occasional occurrence of calcareous rocks and the scarcity of carbonaceous matter may suggest the special sedimentary environment of the Kwanmon group. If the recent interpretations introduced by some authors (PETTIJOHN, 1949; KRUMBEIN & SLOSS, 1951) about the environments of the red beds are warrantable, it might be suggested that the climatic condition at that time was the alternation of seasons of aridity and seasons of rains under warm or subtropical temperature. I have not obtained enough evidence for further discussions of the problem.

The sequence of volcanism in the Shimonoseki subgroup is not always entirely similar in every area, but shows a considerable parallelism within the West Chugoku-North Kyushu province. This is generalized as follows in ascending order.

a. Shiohama age: Pyroclastics of andesite (at least partly hornblende-andesite) spread over the whole province.

b. Early Kitahikoshima age: Lavas and pyroclastics of acid andesite or hornblende-andesite (sometimes quartz-bearing) were developed in Shimonoseki and its neighboring areas as well as near Nishiichi. The group of dacite, rhyodacite and rhyolite which was ejected in the northwestern part of Yamaguchi Prefecture is contemporary with a and b.

c. Middle and late Kitahikoshima age: The group of augite-andesite, hypersthene-augite-andesite and augite-hornblende-andesite, including their lavas and pyroclastics, was widely developed throughout the province. With close relation to them, pigeonite-bearing porphyrite and other porphyrites were intruded. Quartz-bearing hornblende-andesite or dacite occurred locally.

d. Sujigahama age: Rhyodacite was erupted in the northwestern part of Yamaguchi Prefecture. In Shimonoseki and its neighborhood this activity was replaced by the accumulation of volcanic conglomerate which contains cobbles of dellenitic rock and intercalates acid tuff.

e. Fukue age: Lavas and pyroclastics of andesite, at least partly acid and quartz-bearing, were erupted. The present distribution of them is restricted to a few areas near Toyonishi and Nishiichi probably owing to the erosion.

4. *Yahata formation*

The distribution and geologic structure of the Yahata formation are more intimately related to those of the Kwanmon group than to those of the Paleogene rocks. This may warrant the assignment of it to the Upper Cretaceous, although no available fossil has been found at the type locality. The Kwanmon group underlies the gently folded Yahata formation with a nearly parallel or slightly oblique unconformity, while at Kokura the Oligocene Otsuji group directly overlies the former with a remarkable angular unconformity. In the northwestern part of Yamaguchi Prefecture the Oligocene Ashiya group covers the rhyolite extruded through the main part of the Yahata formation.

This formation is characterized by lavas and pyroclastics of acid volcanic rocks such as dacite, rhyodacite and rhyolite. Sandstone and shale occur rarely.

IV. Brief Notes on Geologic Structure

As the geologic structure in each of the late Mesozoic areas has been described in detail in my previous paper (Hase, 1958), here a brief summary is given (see Fig. 2 and Pl. XXXIV).

The Toyonishi group and the Kwanmon group are similar to each other in tectonic behavior. The former is, furthermore, apparently parallel with the underlying Toyora group, and the latter comprizes two subgroups of the Wakino and the Shimonoseki which are also apparently parallel with each other. The general trends of them are in a direction of NE—SW or NEE—SWW, although a NW—SE trend occurs locally owing to the folding and prevails especially in the Yamaguchi-mura area near the western border of the depositional basin.

The late Mesozoic strata form asymmetric synclines and anticlines repeated a number of times. The intensity of the folding somewhat varies in accordance with the nature of the basement which is exposed to the south of the late Mesozoic terrain. In the Toyonishi-Utsui area, where a exceedingly thick series of the strata ranging from the basal Toyonishi to the uppermost Shimonoseki is developed on the basement built up of the Jurassic Toyora group, the folding is of moderate to considerable intensity, a high-angled isoclinal anticline being locally formed. On the other hand, when the Kwanmon group ovelies directly the Paleozoic rocks, it is in general more gently deformed. Even in that case, the moderately compressed folding is observable near the central part of the basin. In the marginal zone the strata incline apparently monoclinally with an angle of 30 degrees or so to the north, but the structure is by no means simple, because there are sometimes thrusts. This structure was called "marginal structure" by Matsumoto (1951b). The axes of the folds run generally in a direction of E—W or NEE—SWW (sometimes NWW—SEE) and pitch to the east or to the west. Consequently, the basin- and dome-shaped structures often appear.

The above-mentioned folding system is cut by numerous faults chiefly of NE—SW and NW—SE trends and partly of E—W and N—S ones. In many cases they appear

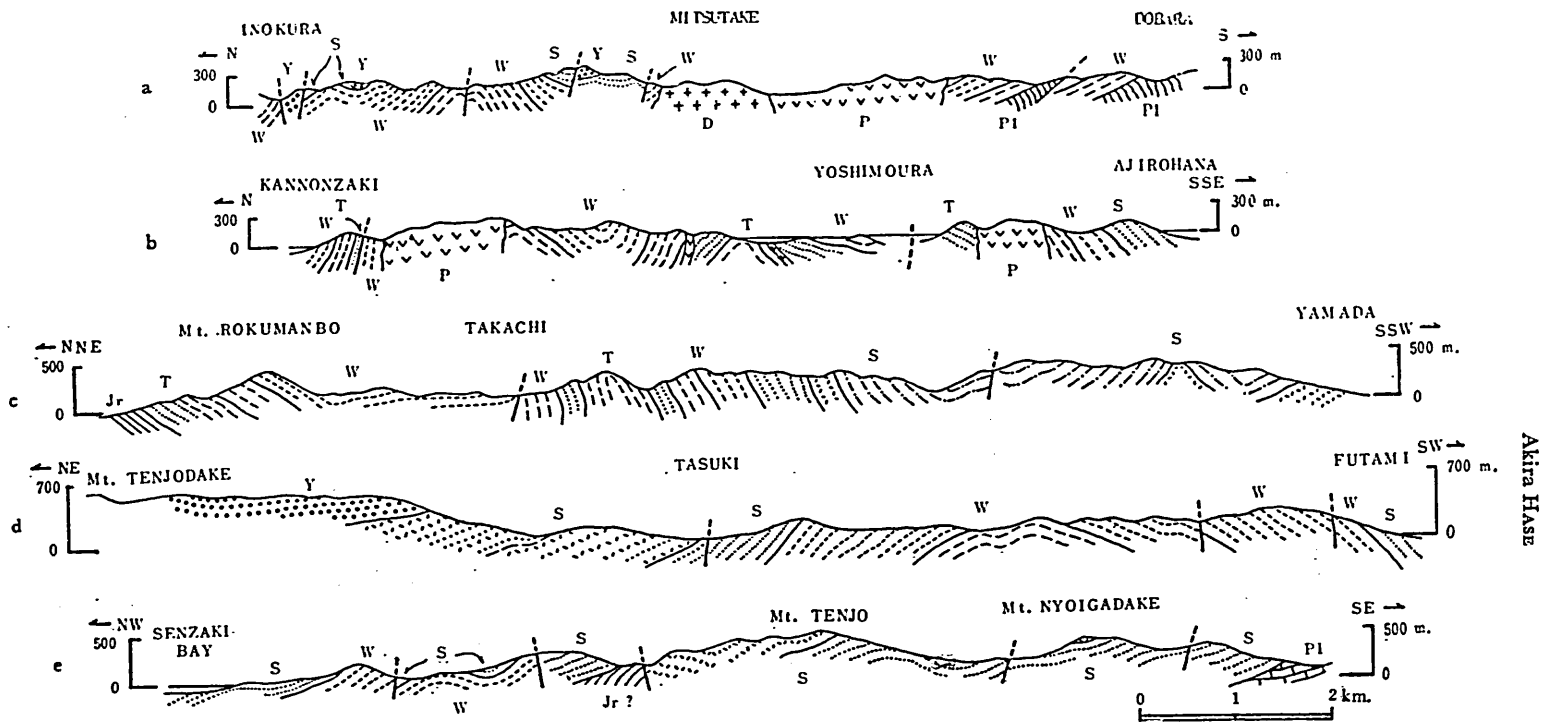

FIG. 2. Geological profiles showing the geologic structures of the late Mesozoic formations in West Chugoku and North Kyushu.

a: Profile of the hilly area to the south of Kokura and Yahata Cities, Fukuoka Prefecture.
b: Profile along the coast of Toyonishi-mura, Yamaguchi Prefecture.
c: Profile of the hilly area near Utsui-mura, Yamaguchi Prefecture.
d: Profile of the hilly area near Takibe-mura, Yamaguchi Prefecture.
e: Profile of the hilly area near Misumi-cho, Yamaguchi Prefecture.
Y: Yahata formation, S: Shimonoseki subgroup, W: Wakino subgroup,
T: Toyonishi group, Jr: Toyora group, Pl: Paleozoic rocks,
P: Porphyrites, D: Diorites.

at regular intervals. It should be noteworthy that the Yahata formation forms a gentler basin structure than the underlying Kwanmon group and that the former seems to have been scarcely dislocated by some of the faults which caused a considerable dislocation in the latter.

V. Fossil Localities

Before entering into the descriptions of the fossil molluscs from the Toyonishi and the Kwanmon groups, I present here a list of their localities.

Toyonishi group (All the localities are in Yamaguchi Prefecture.)

56 (block): In the small valley from the south of Takachi southwestwards to the bench mark 358 m., Utsui-mura.
57 (block): In the small valley from the northeast of Ohata southeastwards to the bench mark 358 m., Utsui-mura.
58—62: Along the valley from the south of Ohata southeastwards to Toishi-yama (bench mark 410. 2 m.), Utsui-mura.
  58 (block): In the mid-stream of the valley.
  59: About 1100 m. southeast of Ohata.
  60: About 1500 m. southeast of Ohata.
  61: About 1300 m. southeast of Ohata.
  62: About 900 m. southeast of Ohata.
63, 64: Along the coast to the northwest of Murotsu, Toyonishi-mura.
  63: East of Madara-ishi.
  64: 150 m. south of Kan'non-zaki.
65: About 900 m. north of Yoshimo-ura, along the byway from Yoshimo-ura to In'nai, Toyonishi-mura.
66—68: Along the coast near Yoshimo-ura, Toyonishi-mura.
  66, 67: 400—500 m. north of Yoshimo-ura.
  68: 600 m. northeast of Mesaki.
69: Just west of Ishioda, along the road from Yoshimi to Yoshimo-ura, Shimonoseki City.
70 (block): In the small valley from Ishioda northwards to the bench mark 178. 2 m., Shimonoseki City.
71: On the hill-side, about 250 m. east of Kanahata, Toyonishi-mura.
72: On the hill-side, about 300 m. east of In'nai, Toyonishi-mura.
73, 74: Along the path from In'nai to Okawara, Toyonishi-mura.
  73: About 300 m. west of In'nai.
  74: About 500 m. east of Okawara.
75: On the coast, about 200 m. south of Okawara, Toyonishi-mura.

Kwanmon group

Wakino area, Fukuoka Prefecture

1, 3, 4, 8: Along the highway from Wakino to Otara.
  1: About 1000 m. northwest of Otara, Kobukuro-cho.
  3: About 100 m. northwest of 1, Miyata-cho.
  4: About 100 m. northwest of 3, Miyata-cho.
  8: About 1300 m. south of Wakino, Miyata-cho.
2, 5, 6, 7, 9, 10: Along the Yagiyama river, Miyata-cho.

2: About 1000 m. east of Rikimaru.
5: About 600 m. northeast of Rikimaru.
6: Halfway between Rikimaru and Sengoku.
7: About 1000 m. southwest of Sengoku.
9, 10: Just west of Sengoku.
11: On the hill-side, about 700 m. northwest of Sengoku, Miyata-cho.
12: By the uphill path, about 1100 m. northeast of Rikimaru, Miyata-cho.

Yurino area, Fukuoka Prefecture

13a: Just northwest of Okatsu, Miyata-cho.
13: On the uphill path near Heitan, Kotaké-cho.
14, 15 (block): In the small valley, south of Yurino, Miyata-cho.
16: About 200 m. southeast of Tamuké-yama (bench mark 82. 2 m.), Nogata City.
17: Just north of Osaki, Nogata City.
18: About 400 m. northwest of Yorino, Miyata-cho.
19: On the north border of the smaller irrigation pond near Kamoda, Nogata City.
20: On the west border of the irrigation pond, southeast of Kami-shin'nyu, Nogata City.

Kokura-Yahata area, Fukuoka Prefecture

21 (block): In the small valley, east of Mukaikata, Kokura City.
22: About 400 m. west of Shingetsu, along the path from Shingetsu to Sugao, Kokura City.
23: Just south of Tokuriki, Kokura City.
24: By the uphill path, about 300 m. northwest of the Gamo Shrine, near Gamo, Kokura City.
25: On the uphill road, about 200 m. northeast of Washiminé-yama (bench mark 138 m.), near Gamo, Kokura City.
26: At the cliff, just south of Yamamoto, Kokura City.
27: Just southwest of Takatsuo, Kokura City.
28: By the road, about 150 m. southwest of the Osayuki Primary School, Osayuki, Kokura City.
29: About 600 m. north of Nakagawara, along the highway from Gamo to Kokumano, Kokura City.
31a, b; 32: On the southeast border of the Kochi reservoir, Kochi, Yahata City.
33: About 300 m. north of Eri, along the road from Eri to Shinozaki, Kokura City.
34: About 500 m. northeast of Inokura, along the road from Inokura to Tsukita, Yahata City.
35: About 1700 m. southeast of Okuhata, along the valley from Okuhata to Shaku-daké (bench mark 612. 6 m.), Katsuki-cho.
36: About 200 m. east of Hirabara, along the road from Gamo to Yamada, Kokura City.
37: On the hill-side, about 400 m. northeast of Hirabara, Kokura City.
38, 39: Along the path from Yamada to Yamaji, Kokura City.
38: About 1200 m. northwest of Yamada.
39: About 400 m. north of 38.
40: Just south of Hirabara, along the road from Gamo to Yamada, Kokura Cty.
41a, b: On the hill-side, about 500 m. northeast of Hirabara, Kokura City.
42: About 200 m. southwest of Hirabara, along the road from Gamo to Yamada, Kokura City.
43: About 700 m. northwest of Yamada, along the path from Yamada to Yamaji, Kokura City.
46, 47: Along the road from Yamaji to Mitsutaké, Kokura City.
46: About 700 m. south of Yamaji.
47: About 300 m. south of Yamaji.
48: About 1000 m. southwest of Okuhata, along the valley from the east of Katsuki to Kongo-san (bench mark 561. 9 m.), Katsuki-cho.
49: On the western slope of the small hill, north of Takatsuo, Kokura City.

Shimonoseki area, Yamaguchi Prefecture

50: About 500 m. west of Tanokubi, along the highway from Enoura to the southern end of Hikoshima, Shimonoseki City.

Toyonishi area, Yamaguchi Prefecture

76, 77, 79: Along the coast near Yoshimo and Yoshimi.
76: 350 m. northeast of Toyano-hana, Toyonishi-mura.
77: 300 m. northeast of Mesaki, Toyonishi-mura.
79: 800 m. north of Ajiroga-hana, Yoshimi Ward, Shimonoseki City.

Nishiichi-Takibe area, Yamaguchi Prefecture

80: At Hataeki, along the road from Kami-ota to Kami-hata, Tasuki-mura.
81: On the coast of Kanda-misaki, Kantama-mura.
82: Nearly halfway between Okochi and Jiyoshi, Nishiichi-cho.

Asa area, Yamaguchi Prefecture

83, 84: At Yamakawa, about 1400 m. northwest of Asa Station, Asa-cho.
85, 86: About 400 m. north of Yamakawa, along the road from Yamakawa to Seto, Asa-cho.

Repository: All the specimens described in this paper are kept in the Institute of Geology and Mineralogy, Faculty of Science, Hiroshima University, Hiroshima, Japan (registered mark IGSH-HA), except GK. H 6067 to 6096, which are deposited in the Institute of Geology, Faculty of Science, Kyushu University, Fukuoka, Japan.

VI. Paleontologic descriptions

Class Gastropoda

Family Viviparidae

Genus *Viviparus* Montfort, 1810

Type-species.– *Viviparus fluviorum* Montfort = *Helix viviparus* Linné

Subgenus *Sinotaia* Haas, 1939

Type-species (of the subgenus).– *Paludina quadrata* Benson

Viviparus (*Sinotaia* ?) *onogoensis* Kobayashi and Suzuki

Pl. XXXV, figs. 1–6

1937. *Viviparus onogoensis* Kobayashi & Suzuki, *Jap. Jour. Geol. Geogr.*, vol. 14, nos. 1–2, p. 48, pl. 5, fig. 13a, b.
1943. *Viviparus* (*Sinotaia* ?) *keisyoensis* Suzuki, *Jour. Sigen. Kenkyusyo*, vol. 1, no. 2, p. 199, pl. 14, figs. 1–16.
1958. *Viviparus* (*Sinotaia* ?) *onogoensis*, Hase, *Geol. Rep. Hiroshima Univ.*, no. 6, p. 12.
1960. *Viviparus onogoensis*, Ota, *Jour. Sci. Hiroshima Univ.*, ser. C, vol. 3, no. 1, p. 11, pl. 3, figs. 1–26.

Holotype.– A single, illustrated specimen of Kobayashi and Suzuki (1937, pl. 5,

fig. 13a, b), from the Tetori group, Izuki, Simo-anama-mura, Fukui Prefecture, Central Japan, as originally designated.

Material.– IGSH-HA 1 to 3 from locality 24 (Coll. T. MATSUMOTO & A. HASE); IGSH-HA 5 from loc. 42 (Coll. M. INOUE, T. M. & A. H.); GK. H 6067 from loc. 50 (Coll. N. NAMEISHI); IGSH-HA 11 from loc. 79 (Coll. A. H.). Besides them, there are numerous poorly preserved specimens from various localities in Chugoku and North Kyushu.

Measurements.– Owing to the secondary deformation, the measurements are approximate and more or less apparent.

Specimen	Height of shell (mm.)	Diameter of last whorl (mm.)	Height of spire (mm.)	Apical angle (degrees)
IGSH-HA 1	14	12.5	7.5	65
// 2	12	10.5	6	60
// 3	10	8	4.5	55
// 5	14.5	10.5	6	65
GK. H 6067	10.5	9	5.5	70
IGSH-HA 11	16.5+	12	8+	50

Descriptive remarks.– The present species is clearly distinguished from the Manchurian Mesozoic viviparids, such as *Viviparus* (*Bellamya*) *clavilithiformis clavilithiformis* (GRABAU) (1923b, p. 193, text-fig. 2a–d; SUZUKI, 1943a, p. 59), *V.* (*B.*) *clavilithiformis conradiformis* SUZUKI (1943a, p. 58, pl. 3, figs. 1–18), *V.* (*Sinotaia*) *matumotoi* SUZUKI (1943a, p. 61, pl. 4, figs. 14, 15) and *V.* (*Tulotomoides*) *talatzensis* SUZUKI (1941a, p. 86, pl. 1, figs. 6–14), by its rounded whorls which have neither distinct spiral keel nor marked subsutural shelf. In this respect, it is allied to *Viviparus* (*Sinotaia*) *tani* (GRABAU) from the Fuhsin group. Especially, the higher form with a considerably elevated spire [e.g. IGSH-HA 11 (Pl. XXXV, figs. 6)] is very similar to the broader form of the latter [SUZUKI's forma *omurai* (SUZUKI, 1943a, p. 60, pl. 4, figs. 16–21)], but its shell is a little smaller and its suture is as a rule shallower than in that form. Furthermore, the mean height-diameter ratio of this Japan-Korean species seems to be smaller than that of *V.* (*S.*) *tani*.

Occurrence.– Very rare and doubtful in the Sengoku formation (loc. 13a); common in the Nyoraida formation (locs. 14, 15, 16, 24); abundant in the Lower Wakamiya formation (locs. 19, 20, 35, 50) and in the Upper Wakamiya formation (locs. 42, 46, 47, 79). All mentioned above belong to the Wakino subgroup. Very rare in the Shiohama formation of the Shimonoseki subgroup (loc. 49). Abundant in the Yamaji shale of the Inakura formation (locs. Uneyama, Jokan-zan, etc., the Inakura-mura area, Oda-gun, Okayama Prefecture).

Family Thiaridae

Genus *Brotiopsis* SUZUKI, 1943

Type-species.– *Brotia wakinoensis* KOBAYASHI and SUZUKI

Brotiopsis wakinoensis (KOBAYASHI and SUZUKI)

Pl. XXXV, figs. 7–16; Text-fig. $3a_{1-4}$

1936. *Brotia wakinoensis* KOBAYASHI & SUZUKI, *Jap. Jour. Geol. Geogr.*, vol. 13, nos. 3-4, p. 256, pl. 29, figs. 14, 15.
1943. *Brotiopsis wakinoensis*, SUZUKI, *Jour. Sigen. Kenkyusyo*, vol. 1, no. 2, p. 206, pl. 15, figs. 1, 2.
1943. *Brotiopsis wakinoensis ryohoriensis* SUZUKI, *Ibid.*, p. 206, pl. 17, fig. 11 (except A, B).
1960. *Brotiopsis wakinoensis*, OTA, *Jour. Sci. Hiroshima Univ.*, ser. C, vol. 3, no. 1, p. 2, pl. 1, figs. 1-23; text-fig. 1.

Holotype.– The specimen designated and illustrated by KOBAYASHI and SUZUKI (1936, pl. 29, fig. 14a), from the Naktong subgroup, Ryohori, Kinyo-men, Keisho-nan-do, South Korea.

Material.– IGSH-HA 51 (Coll. Y. OTA); GK. H 6068 to 6070 (Coll. M. KUZUNA & S. AIBA). They came certainly from the Sengoku formation in the Wakino area, but the exact locality is not recorded. IGSH-HA 59 to 61 from loc. 5; IGSH-HA 66 from loc. 6; IGSH-HA 69 from loc. 7; IGSH-HA 72 from loc. 10; IGSH-HA 75 from loc. 21 (Coll. A. HASE). Besides them, there are numerous poorly preserved specimens from the Wakino and the Kokura areas.

Measurements (in approximation).–

Specimen	Height of shell (mm.)	Diameter of last whorl (mm.)	Apical angle (degrees)	Height of aperture (mm.)	Breadth of aperture (mm.)
IGSH-HA 51	29+	6	15	——	——
GK. H 6069	21+	6	20	——	——
IGSH-HA 59	33+	8	18	——	——
// 72	21+	6	22	7	3
// 75	22+	10	25	——	——

Descriptive remarks.– The ontogenetic development of the shell observed on the Wakino specimens at hand is as follows.

In the nepionic stage, the whorls are rounded and the surface is ornamented with longitudinal riblets and spiral threads. As described by KOBAYASHI and SUZUKI (1936, p. 257), the longitudinal riblets are less than ten in number, oblique, curved, fine but distinct, round-topped, and much narrower than the interspaces. Their number and strength increase gradually with growth. Noteworthy is the presence of a few or several spiral threads, which are, however, too faint to be discernible to the naked eye and are impressed only on the well-preserved specimens. The suprasutural thread is a little more distinct than the others. In IGSH-HA 60 (Pl. XXXV, figs. 13), an immature shell which has a height of about 12 mm. and preserves the apical part, the earlier ten whorls show the above-stated nepionic characters, and in HA 69 (Pl. XXXV, figs. 15) of about 10 mm. in height the earlier eight do. These nepionic features of *Brotiopsis wakinoensis* are so similar to immature and adult ones of *B. kobayashii kobayashii* SUZUKI (to be described below) that both are hardly distinguishable from each other in the immature stage.

In the neanic stage represented by two to four volutions succeeding the nepionic, a granule appears at about the middle of each longitudinal rib. The granules are connected by a transverse string and thus the whorls become more or less angulated. While the granules strengthen with growth, the ribs, though still distinct, tend to weaken towards both the upper and lower sutures.

In the adult stage represented by the last three volutions or so, the whorls are distinctly angulated owing to the development of the spiral costa which runs at about the middle of the whorl or at a point about one-third from the lower suture. The strong tubercles are arranged on the costa. Their number per whorl varies between 7 and 15, being predominantly 10 or 11. The longitudinal ribs become obsolete and

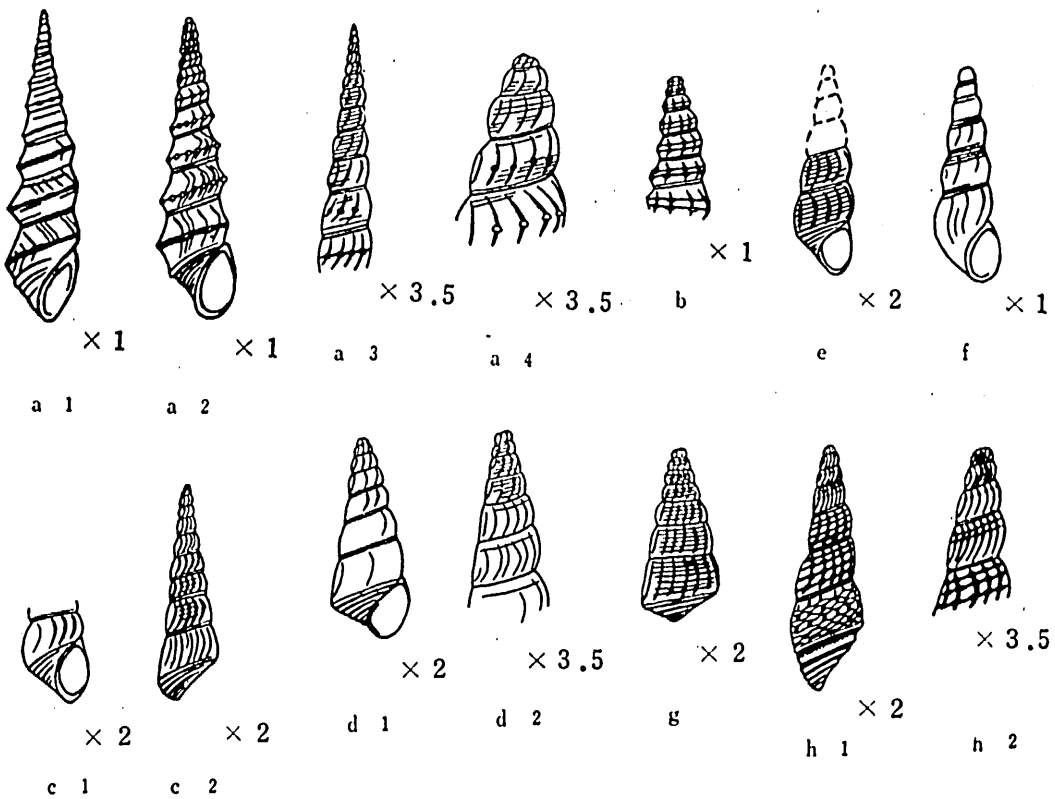

FIG. 3. Surface-ornament of *Brotiopsis* and *Melanoides* (*Yoshimonia*).

a_{1-4}: *B. wakinoensis* (KOBAYASHI and SUZUKI). $a_{1,}$ based on the holotype (KOBAYASHI & SUZUKI, 1936, pl. 29, fig. 14a); $a_{3,4}$ showing the ornament in the immature stage.
b: *B.* aff. *wakinoensis* (KOBAYASHI and SUZUKI).
$c_{1,2}$: *B. kobayashii kobayashii* SUZUKI.
$d_{1,2}$: *B. kobayashii sinsyuensis* SUZUKI. $d_{2,}$ showing the ornament in the immature stage.
e: *M.* (*Y.*) *yoshimoensis* OTA.
f: *M.* (*Y.*) aff. *yoshimoensis* OTA.
g: *M.* (*Y.*) *katsukiensis* OTA.
$h_{1,2}$: *M.* (*Y.*) *kokurensis* n. sp. $h_{2,}$ showing the ornament in the immature stage.

are replaced by numerous strongly curved and irregularly roughened growth-lines, although in many specimens the plicae are still in existence near the tubercles, especially below them. The spiral ornament is almost the same as KOBAYASHI and SUZUKI (1936, p. 256) described originally. On the last whorl of GK. H 6068 (Pl. XXXV, fig. 9), three feeble interstitial spiral threads are observed on the shoulder and one or two between the cardinal and peripheral costae, the longitudinal plicae being partly elevated into minute granules at the intersection with them. Thus the specimen somewhat approaches in sculpture *Melanoides* (*Yoshimonia*) *katsukiensis* OTA to be described below.

The tubercles tend to weaken in the senile stage. In some individuals [e. g. IGSH-HA 59 (Pl. XXXV, fig. 10)] they almost disappear and are replaced by the moderately elevated and irregularly roughened spiral costa, but this disappearance is usually confined to the last one volution or so. In the type form from the Naktong subgroup (KOBAYASHI & SUZUKI, 1936, pl. 29, fig. 14; SUZUKI, 1943b, pl. 15, fig. 1) the tubercles and the longitudinal ribs are less distinct than in the Wakino specimens.

Occurrence.– Very abundant in the Sengoku formation. (Main localities are 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 21 and 23.) Not common in the Lower Wakamiya formation (locs. 11, 12).

Brotiopsis aff. *wakinoensis* (KOBAYASHI and SUZUKI)

Pl. XXXVI, fig. 14; Text-fig. 3b

Compare.– *Brotiopsis wakinoensis* (KOBAYASHI and SUZUKI) (p. 305)

Holotype of Brotiopsis wakinoensis.– See p. 305.

Material.– IGSH-HA 89, a single incomplete external mould collected from loc. 5 by Y. OTA.

Descriptive remarks.– This specimen, attaining more than 23 mm. in height, is very similar to *Brotiopsis wakinoensis* (KOBAYASHI and SUZUKI) in size and shape of the shell as well as in surface-ornament. The only difference is that the former has two distinct shoulder costae on each of which the marked tubercles are arranged. The lower costa runs at a point about one-third from the lower suture and is a little stronger than the upper costa, which runs at about the middle of the whorl. The number of the tubercles is 5 or 6 a half volution, and the longitudinal plicae are rather distinct near them.

The present shell is clearly distinguished from *Brotiopsis kobayashii* SUZUKI and the species of *Melanoides* (*Yoshimonia*) by its larger size, angulated whorls and surface-ornament. Because of the scarcity of material I tentatively call it *Brotiopsis* aff. *wakinoensis*.

Occurrence.– Sengoku formation (loc. 5).

Brotiopsis kobayashii kobayashii SUZUKI

Pl. XXXV, figs. 17–25; Text-fig. $3c_{1,2}$

1943. *Brotiopsis kobayashii* SUZUKI, *Jour. Sigen. Kenkyusyo*, vol. 1, no. 2, p. 207, pl. 17, figs. 10a, b, 11B.

1960. *Brotiopsis kobayashii*, OTA, *Jour. Sci. Hiroshima Univ.*, ser. C, vol. 3, no. 1, p. 6, pl. 1, figs. 24–35.
1960. *Brotiopsis kobayashii kobayashii*, OTA, *Mem. Fac. Sci., Kyushu Univ.*, ser. D, vol. 9, no. 3, p. 201.

Holotype (of the subspecies).– The illustrated specimen of SUZUKI (1943b, pl. 17, fig. 11B), from the Kinbu formation of the Naktong subgroup, Ryohori, Kinyo-men, Keisho-nan-do, South Korea.

Material.– IGSH-HA 91 from loc. 13 (Coll. Y. KONDO & A. HASE); IGSH-HA 93 and 95 from loc. 17 (Coll. Y. K. & A. H.); GK. H 6071 and 6072 from loc. 32 (Coll. N. NAMEISHI); IGSH-HA 99 from loc. 33 (Coll. A. H.); IGSH-HA 105 from loc. 41 (Coll. A. H.); IGSH-HA 106 and 107 from loc. 77 (Coll. H. KAJINO & A. H.); IGSH-HA 110 and 112 from loc. 83 (Coll. A. H.). Besides them, many specimens are available to me.

Measurements (in approximation).–

Specimen	Height of shell (mm.)	Diameter of last whorl (mm.)	Apical angle (degrees)	Height of aperture (mm.)	Breadth of aperture (mm.)
IGSH-HA 91	13+	3	15	——	——
GK. H 6071	13+	5	27	——	——
// 6072	14	5	23	3.5	2
IGSH-HA 105	12.5	4.5	25	——	——
// 106	20+	5	18	——	——
// 107	10.5+	2.3	15	2	1.3
// 110	15.5+	6.5	28	——	——

Descriptive remarks.– The Wakino specimens before me can be identified to *Brotiopsis kobayashii kobayashii* SUZUKI by their small size, conically turreted outline, rounded whorls and oblique and curved longitudinal ribs.

In addition to the distinct sutural and basal cords, several very weak spiral threads which run across the longitudinal ribs are discernible on the well-preserved specimens. The examples are IGSH-HA 91 (Pl. XXXV, fig. 17), HA 93 (Pl. XXXV, fig. 18) and HA 99 (Pl. XXXV, fig. 25). *Melanoides* (*Yoshimonia*) *yoshimoensis* OTA (1960a, p. 7, pl. 2, figs. 12–15; text-fig. 3) and *M.* (*Y.*) *katsukiensis* OTA (to be described below) are provided with a cancellate sculpture on the spire and body whorls, but the threads of the specimens in question are much less distinct than those of the two species and seem to be obsolete on the last whorl.

The longitudinal ribs increase gradually in number and strength as the shell grows, but tend to weaken in the latest growth-stage. In some individuals [e. g. IGSH-HA 95 (Pl. XXXV, fig. 19), HA 110 (Pl. XXXV, fig. 20)] they almost disappear on the last volution. Therefore, these specimens are regarded as an intermediate form between this subspecies and *Brotiopsis kobayashii sinsyuensis* SUZUKI (to be described below). The number of the ribs on the adult whorl varies from 10 to 20 or so and most frequently from 13 to 15.

The aperture is, like that of *B. wakinoensis*, subvertical or somewhat oblique, oblong-ovate in outline, narrowed and sharply rounded above and moderately rounded below; the peristome is entire.

Occurrence.– Not common in the Sengoku formation (loc. 13); rather rare in the Nyoraida formation (locs. 15 ?, 17, 24 ?, 25); abundant in the Lower Wakamiya formation (locs. 31b, 32, 33, 35 ?, 77, 83, 84); common in the Upper Wakamiya formation (locs. 36 ?, 37, 41a, 42 ?).

Brotiopsis kobayashii sinsyuensis Suzuki

Pl. XXXV, figs. 26–31, 32a, b, 33a, b; Text-fig. $3d_{1,2}$

1943. *Brotiopsis kobayashii sinsyuensis* Suzuki, *Jour. Sigen. Kenkyusyo*, vol. 1, no. 2, p. 208, pl. 16, figs. 11–13.

1960. *Brotiopsis kobayashii sinsyuensis*, Ota, *Jour. Sci. Hiroshima Univ.*, ser. C, vol. 3, no. 1, p. 6, pl. 2, figs. 1, 2.

Holotype (of the subspecies).– The illustrated specimen of Suzuki [1943b, pl. 16, fig. 13 (the specimen at the center of the figure)], from the Shinshu formation of the Naktong subgroup, about 500 m. north of Tokusanri, Nado-men, Keisho-nan-do, South Korea.

Material.– IGSH-HA 116 to 119 from loc. 18 (Coll. Y. Kondo & A. Hase); IGSH-HA 120 from loc. 31 (Coll. A. H.); GK. H 6073 from loc. 32 (Coll. N. Nameishi); IGSH-HA 124 from loc. 41 (Coll. A. H.); IGSH-HA 125A to D from loc. 85 (Coll. A. H.). Besides them, there are many poorly preserved specimens.

Measurements (in approximation).–

Specimen		Height of shell (mm.)	Diameter of last whorl (mm.)	Apical angle (degrees)
IGSH-HA	116	14+	5.5	25
//	117	14+	5	23
//	118	18+	5.5	18
//	120	17+	5.5	22
GK. H	6073	14.5	4+	18
IGSH-HA	125B	14+	5	20

Descriptive remarks.– As originally described by Suzuki (1943b, p. 208), the longitudinal ribs disappear on the last two to four whorls (rarely on five or six ones). This disappearance is not always perfect, but a few rudimentary ribs sometimes remain. The spiral cords are rather distinct both on the base and on the sutural zone; eight basals which are as broad as the interspaces are countable on IGSH-HA 119 (Pl. XXXV, fig. 29). On the earlier whorls the longitudinal ribs are intersected with a few or several spiral threads, the latter of which are too feeble to be discernible to the naked eye and become obsolete before the disappearance of the longitudinal ribs. IGSH-HA 125B (Pl. XXXV, fig. 33a, b) and HA 125D (Pl. XXXV, fig. 32a, b) are the examples which preserve such ornament.

Occurrence.– Common in the Lower Wakamiya formation (locs. 18, 31a, 32, 33) and abundant in the Upper Wakamiya formation (locs. 38, 41b, 42, 85).

Genus *Melanoides* OLIVIER, 1804

Type-species.– *Melanoides fasciolata* OLIVIER=*Nerita tuberculata* O. F. MÜLLER

Subgenus *Yoshimonia* OTA, 1960

Type-species (of the subgenus).– *Melanoides* (*Yoshimonia*) *yoshimoensis* OTA

Remarks.– The diagnostic character of *Melanoides* (*Yoshimonia*) is, according to OTA (1960a, p. 7), the distinct combination of longitudinal ribs and several spiral cords (or threads). The spiral threads are, as described before, seen also in *Brotiopsis*, although they are not so distinct as those of the subgenus in question. Furthermore, the type-species of this subgenus is very similar to *B. kobayashii kobayashii* in many respects and differs only in the strength of the spiral ornament. Therefore, *M.* (*Yoshimonia*) and *Brotiopsis* are apparently closely related with each other and their taxonomic position seems to need future reexamination. The available material is insufficient for further discussion.

Melanoides (*Yoshimonia*) *katsukiensis* OTA

Pl. XXXVI, figs. 7, 8; Text-fig. 3g

1960. *Melanoides* (*Yoshimonia*) *katsukiensis* OTA, *Jour. Sci. Hiroshima Univ.*, ser. C, vol. 3, no. 1, p. 9, pl. 2, figs. 16, 17; text-fig. 4.

Holotype.– TGWu. K 811, from the upper formation of the Wakino subgroup, Hata, Katsuki-cho, Fukuoka Prefecture, Kyushu, as originally designated by OTA (1960a, pl. 2, fig. 16).

Material.– IGSH-HA 114 and 115 from loc. 36 (Coll. A. HASE).

Measurements.– One of the figured specimens (IGSH-HA 115) measures roughly 12 mm.+ in height, 5.5 mm. in width and 30 degrees in apical angle.

Descriptive remarks.– The specimens before me are referred to *Melanoides* (*Yoshimonia*) *katsukiensis* OTA by their distinctly cancellate sculpture which consists of 14 or 15 longitudinal ribs and 7 or 8 spiral threads. They are broader and have larger apical angle than the holotype, but the difference is slight enough to be regarded as variation.

Occurrence.– Very rare in the Lower Wakamiya formation (loc. 35) and in the Upper Wakamiya formation (loc. 36).

Melanoides (*Yoshimonia*) *kokurensis* n. sp.

Pl. XXXVI, figs. 9a, b, 10a, b, 11, 12; Text-fig. $3h_{1,2}$

Material.– Holotype, GK. H 6074 (Pl. XXXVI, fig. 9a, b); paratype, GK. H 6075 (Pl. XXXVI, fig. 10a, b). Other specimens, GK. H 6076 and 6077. All are the external moulds collected from loc. 22 by M. KUGA.

Diagnosis.– Shell rather small, conically turreted in outline, about 3–4 times higher

than broad. Spire with an apical angle of about 25 degrees, highly conical, occupying about 3/5 the height of the shell, almost straight in outlines; apex not preserved. Whorls more than 7 in number, gradually and regularly increasing in width, gently convex; suture shallow but distinct; last whorl fairly inflated, weakly carinated at periphery, tapering towards the lower end; base convex.

Surface ornamented with longitudinal ribs, spiral cords and tubercles, besides the fine growth-lines. Longitudinal ribs about 12 to 15 in number, distinctly elevated along the growth-lines, oblique and curved still more forwards near the lower end, a little narrower than the interspaces, round-topped, weakened towards both the upper and lower sutures, in the adult stage raised into the conspicuous round-topped tubercles at the junction with the spiral cords, becoming less elevated on the last one or two whorls and disappearing on the base. Spiral ornament in the adult consisting of 4 or 5 cords which run across the longitudinal ribs and 3 cords on the upper half of the base, with a few obscure strings on the lower part of it, low but distinct, round-topped, narrower than the interspaces; uppermost basal cord strongest and exposed as a suprasutural one on the spire-whorls.

Aperture subvertical or somewhat oblique, oblong-ovate in outline, rounded above and below; peristome probably continuous.

Measurements (in approximation).–

Specimen	Height of shell (mm.)	Diameter of last whorl (mm.)	Apical angle (degrees)
GK. H 6074	17+	5	25
// 6075	16+	5	25±
// 6076 (immature shell)	11+	3. 5	25–

Remarks.– In the early growth-stage, surface is ornamented with longitudinal riblets and several faint spiral threads. An obscure granule appears, in the holotype specimen, first on the upper part of each longitudinal rib on the fifth whorl from the last. There are 4 rows of tubercles on the adult whorls of the holotype and 5 rows on those of the paratype. The aperture is not well observable in the holotype but is better preserved in the paratype.

From the shell-outline, the apertural feature and the surface-ornament, the present shell fits to *Melanoides* (*Yoshimonia*). It is easily distinguished from *M.* (*Y.*) *yoshimoensis* OTA and *M.* (*Y.*) *katsukiensis* OTA by its much stronger spiral cords and tubercles. The morphic characters and the stratigraphic occurrence may suggest that *M.* (*Y.*) *yoshimoensis* is the ancestral form of this species.

Occurrence.– Rare in the Sengoku formation (loc. 22).

Genus *Thiara* (BOLTEN) RÖDING, 1798

Type-species.– *Helix amarula* LINNÉ

Subgenus *Siragimelania* SUZUKI, 1940

Type-species (of the subgenus).– *Thiara* (*Siragimelania*) *tateiwai* SUZUKI

Thiara (*Siragimelania*) cf. *tateiwai* SUZUKI

Pl. XXXVI, fig. 13

Compare.–

1940. *Thiara* (*Siragimelania*) *tateiwai* SUZUKI, *Jap. Jour. Geol. Geogr.*, vol. 17, nos. 3-4, p. 224, pl. 22, figs. 1-23; pl. 23, figs. 1-32; text-figs. 2-16.

Types.–The species comprizes two subspecies, the holotype of each of which is as follows by original designation.

T. (*S.*) *tateiwai tateiwai* SUZUKI: The illustrated specimen of SUZUKI (1940, pl. 22, fig. 1a–c), from the Taikyu formation of the Shiragi subgroup, Hyakuan-do, Hokuan-men, Keisho-hoku-do, South Korea.

T. (*S.*) *tateiwai acuticostata* SUZUKI: The illustrated specimen of SUZUKI (1940, pl. 23, fig. 3a–c), from the Kansenri formation of the Shiragi subgroup, northwest of Kunkoku-ri, Sei-men, Keisho-hoku-do, South Korea.

Material.– IGSH-HA 31, a single, poorly preserved specimen from loc. 13 (Coll. Y. KONDO & A. HASE).

Measurements (in approximation).– Height of shell, 13 mm.; diameter of last whorl, 7 mm.; height of spire 6 mm.; apical angle 45 degrees.

Descriptive remarks.– The shell is small, conically ovate in outline and about twice as high as broad, having a considerably elevated conical spire. The surface of the relatively large and rounded last whorl is ornamented with spiral cords and longitudinal growth-lines. The spiral cords are 12 in number, a little narrower than the interspaces, low but distinct near the aperture and become obsolete backwards, the lower two being slightly stronger than the others. The growth-lines are often strengthened into the gently sigmoidal wrinkles, which are set at irregular intervals and are sometimes elevated into obscure tubercles at the intersection with the spiral cords. The second and the third whorls from the last are apparently shouldered, obliquely ascending and subvertically descending from the shoulder angle. The longitudinal ribs and the indistinct spiral cords and tubercles are observable on them.

From the above-stated characters, the present shell is best comparable with *Thiara* (*Siragimelania*) *tateiwai* SUZUKI. This species is considerably variable in size and general shape of the shell as well as in the degree of development of the ornament. Although the specimen in question differs in some respects from the holotype, it closely resembles some other examples of SUZUKI (1940, pl. 22, figs. 6b, 8b; text-fig. 13) in its small size, comparatively high shell and weak spiral cords. As the available material is insufficient, I hesitate to conclude definite identity.

Occurrence.– Sengoku formation (loc. 13).

Family Planorbidae

Genus *Gyraulus* CHARPENTIER, 1837

Type-species.– *Planorbis hispidus* DRAPARNAUD=*Planorbis albus* O. F. MÜLLER

Gyraulus (?) n. sp. (?)

Pl. XXXVI, figs. 15–22

1943. *Anisus* (*Gyraulus* ?) sp., SUZUKI, *Jour. Sigen. Kenkyusyo*, vol. 1, no. 2, p. 208, pl. 14, figs. 31–33.

Material.– IGSH-HA 41 to 47 from loc. 81 (HA 41 to 43 collected by S. IMAMURA & K. WADA, HA 44 to 47 by Y. SHIGEOKA & A. HASE). IGSH-HA 48 from the Wakino area (exact locality not recorded; Coll. Y. OTA).

Description.– Shell minute in size, nearly planispiral, discoidal in outline. Whorls 4 or 5 in number so far as preserved, regularly and fairly rapidly increasing in width, rounded; outer whorls in contact with but scarcely embracing the inner ones; last whorl relatively large, probably carinated at periphery; base convex; umbilicus very wide and shallow. Surface on the basal side ornamented with numerous, fine, sigmoidal growth-lines often roughened at irregular intervals and a few, rather distinct, irregular spiral threads; surface on the apical side not well preserved, probably with numerous growth-lines.

Measurements.– The largest specimen (IGSH-HA 48), which is considerably deformed, is 6. 5 mm. in major axis and 2. 5 mm.+ in minor one. IGSH-HA 42, 43, 44 and 46 are 4. 5 mm., 2. 7 mm., 3 mm. and 3 mm. in diameter respectively.

Remarks.– As the apical side of the shell is scarcely preserved, the shell-height, the features of the spire, the convexity of the whorls and the ornament of the upper surface are not clearly observable.

In size and shape of the shell and in surface-ornament, *Gyraulus* (?) sp. described by SUZUKI from the Kinbu formation of the Naktong subgroup is identical with the present shell. This is a little smaller than *G.* (?) sp. (SUZUKI, 1942, p. 99, pl. 1, fig. 5) from the Upper Cretaceous Nengkiang formation of the Sungari group in Manchuria, but the distinction between the two is not clear, because the latter is only a single incomplete internal mould. This shell may represent a new species, but the available material is too incomplete for exact distinction from the well established species. Therefore, it seems better to leave it unnamed for the time being.

Occurrence.– Very rare in the Sengoku formation in the Wakino area; rare in the Upper Wakamiya formation in the Takibe area (loc. 81).

Class Pelecypoda

Family Unionidae

Genus *Plicatounio* KOBAYASHI and SUZUKI, 1936

Type-species.– *Plicatounio naktongensis* KOBAYASHI and SUZUKI

Plicatounio aff. *naktongensis naktongensis* KOBAYASHI and SUZUKI

Pl. XXXIX, fig. 1

Compare.–

1936. *Plicatounio naktongensis* KOBAYASHI & SUZUKI, *Jap. Jour. Geol. Geogr.*, vol. 13, nos. 3-4, p. 252, pl. 28, figs. 1-4, 6-8.
1938. *Plicatounio naktongensis manchuricus* YABE & HAYASI, *Jap. Jour. Geol. Geogr.*, vol. 15, nos. 1-2, p. 31, pl. 4, figs. 1-6.
1943. *Plicatounio naktongensis*, SUZUKI, *Jour. Sigen. Kenkyusyo*, vol. 1, no. 2, p. 211, pl. 16, figs. 14, 15; pl. 17, fig. 11A.
1959. *Plicatounio naktongensis*, OTA, *Trans. Proc. Pal. Soc. Japan*, new ser., no. 33, pl. 3, figs. 4-8.
1960. *Plicatounio naktongensis naktongensis*, OTA, *Mem. Fac. Sci., Kyushu Univ.*, ser. D, vol. 9, no. 3, p. 200.

Holotype of Plicatounio naktongensis naktongensis.– The specimen illustrated by KOBAYASHI and SUZUKI (1936, pl. 28, fig. 1a, b), from the Naktong subgroup, Ryohori, Kinyo-men, Keisho-nan-do, South Korea, as originally designated.

Material.– GK. H 6078, the internal mould of a bivalved shell collected from loc. 48 by Y. KAMURA.

Measurements (in approximation).– Length, 66 mm. +; height, 21 mm.

Descriptive remarks.– This specimen is best comparable with *Plicatounio naktongensis naktongensis* KOBAYASHI and SUZUKI in the elongated elliptical outline, the large and prominent umbo situated about 1/3 the length of the shell from the anterior end and several weak postero-ventral plications probably corresponding to the thick external ones. In the present shell, however, the anterior teeth are more regularly and strongly crenulated than in any of the individuals of *P. naktongensis* hitherto illustrated by the above-listed authors. The posterior teeth are elongated, lamellar and smooth as in *P. naktongensis*.

Occurrence.– Upper Wakamiya formation (loc. 48).

Genus *Nippononaia* SUZUKI, 1941

Type-species.– *Unio* (*Nippononaia*) *ryosekiana* SUZUKI

"*Nippononaia*" *wakinoensis* OTA

Specific diagnosis.– Shell medium in size, subelliptical or subtrapezoidal in outline, longer than high, somewhat inequilateral or subequilateral, rounded in front, subquadrate behind, moderately convex. Dorsal margin long, broadly arched, passing insensibly into the well rounded anterior margin, forming an obtuse angle with the posterior one which is nearly straight or weakly curved and descends rapidly; ventral margin long, nearly straight or gently arched, ascending gradually into the anterior, bent upwards into the posterior, showing a moderate curve.

Umbo fairly prominent, situated at a point about 2/5 to 1/2 of the shell-length from the anterior end. Obtuse ridge extending from the umbo towards the postero-ventral corner, at first rather distinct and then gradually flattened. Surface ornamented with numerous radial ribs besides the irregularly roughened concentric growth-lines; radial ribs low but distinct, round-topped, as broad as or broader than the interspaces, narrower and more closely set in the anterior than in the posterior,

typically forming acute Vs on the median area and reversed Vs on both the posterior and anterior sides, but sometimes effaced in a greater or less degree on the anterior half of the shell.

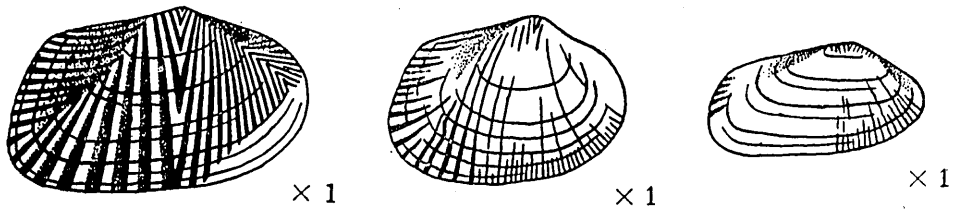

FIG. 4. Surface-ornament of "*Nippononaia*".
a: "*N.*" *wakinoensis wakinoensis* OTA.
b: "*N.*" *wakinoensis intermedia* n. subsp.
c: "*N.*" (?) *obsoleta* n. sp.

Hinge well developed; distinct pseudocardinal teeth 2 on the right valve and 1 on the left, short, narrow but high, regularly and finely crenulated; lower one stronger than the upper; left valve sometimes provided with a small and indistinct median tooth inside of the pseudocardinal and a narrow and low anterior tooth outside of it; lateral teeth 1 on the right valve and 2 on the left, fairly long, lamellar, lower and more weakly crenulated than the pseudocardinals. Inner ventral margin crenulated.

Remarks.– This species comprizes two subspecies, "*N.*" *wakinoensis wakinoensis* OTA and "*N.*" *wakinoensis intermedia* n. subsp. to be described below. They are distinguished from each other by the degree of effacement of the radial ribs, although the morphic change from one to the other is apparently gradual.

"*Nippononaia*" *wakinoensis wakinoensis* OTA

Pl. XXXVII, figs. 1–4; Text-fig. 4a

? 1955. *Trigonioides kodairai* KOBAYASHI & SUZUKI, COX, *Geol. Mag.*, vol. 92, no. 4, p. 346, text-fig. 1A.
? 1956. *Plicatounio naktongensis multiplicatus* SUZUKI, KOBAYASHI, *Jap. Jour. Geol. Geogr.*, vol. 27, no. 1, p. 80, pl. 5, fig. 3; text-fig. 1.
1959. "*Nippononaia*" *wakinoensis* OTA, *Trans. Proc. Pal. Soc. Japan*, new ser., no. 34, p. 107, pl. 11, figs. 1–7, 11 ?; text-fig. 1a?

Holotype (of the subspecies).– The specimen designated and illustrated by OTA (1959d, pl. 11, fig. 1), from the Sengoku formation of the Wakino subgroup, Rikimaru, Miyata-cho, Fukuoka Prefecture, Kyushu.

Material.– GK. H 6079 and 6080 from the same formation as the holotype (exact locality not recorded; Coll. M. KUZUNA & S. AIBA). The hinge-structure is well seen on them. There are several other specimens in which the surface-ornament is well preserved.

Subspecific diagnosis.– Radial sculpture distinct on almost the whole surface, consisting of the median V-ribs and the posterior and anterior chevron ribs.

Remarks.– In some specimens the radial sculpture becomes obsolete on the limited antero-ventral area, but the posterior and median ribs are always conspicuous.

Occurrence.– Not rare in the Sengoku formation in the Wakino area; very rare in the Lower Wakamiya formation in the Yahata area (loc. 35).

"Nippononaia" wakinoensis intermedia n. subsp.

Pl. XXXVII, figs. 5–9; Pl. XXXVIII, figs. 2, 3; Text-fig. 4b

Material.– Holotype, IGSH-HA 136, a bivalved specimen (Pl. XXXVII, fig. 5). Paratypes, IGSH-HA 137, a right valve (Pl. XXXVII, fig. 6) and IGSH-HA 138, a left external mould (Pl. XXXVII, fig. 7). Other specimens, IGSH-HA 139 to 142. All were collected from loc. 81 (HA 136 to 141 by S. IMAMURA & K. WADA, HA 142 by Y. SHIGEOKA & A. HASE).

Subspecific diagnosis.– Closely allied to *"Nippononaia" wakinoensis wakinoensis*, but dissimilar in the more advanced obsolescence of the radial ribs. About 10 distinct ribs branching off obliquely from the posterior ridge towards the posterior margin and 4 to 6 arranged in front of the ridge; the radial sculpture on the rest of the surface very weak and sometimes almost effaced.

Measurements.–

Specimen	Length (mm.)	Height (mm.)	Thickness (mm.)
IGSH-HA 137	31	21	4± × 2
// 138	31	25	——

Remarks.– Most of the specimens are subtrapezoidal in outline, being nearly one and a half times as long as high, but IGSH-HA 138 is a little taller and more rounded. In surface-ornament the present subspecies is intermediate between *"Nippononaia" wakinoensis wakinoensis* OTA and *"N."* (?) *obsoleta* n. sp. (to be described below). The degree of obsolescence of the radial ribs varies among the individuals. In IGSH-HA 137 the surface of the anterior and median areas is almost smooth except for the growth-lines, while in HA 136 (holotype) and especially in HA 138 numerous weak riblets remain on rather broad areas. Therefore, the last mentioned is closest to *"N." wakinoensis wakinoensis*. This shell is, in turn, similar in sculpture to *Trigonioides paucisulcatus paucisulcatus* SUZUKI (1940, p. 229, pl. 24, figs. 1–5, text-figs. 18–20; OTA, 1959c, p. 101) from the Shiragi subgroup in South Korea. Compared with the holotype of that subspecies, however, it is longer and more quadrilateral. Moreover, its posterior ribs are not so thick as in that form.

The hinge is not well preserved. The pseudocardinal teeth seen on IGSH-HA 142 (Pl. XXXVIII, fig. 3) are crenulated but not strong.

Occurrence.– Confined to the Upper Wakamiya formation (loc. 81).

"*Nippononaia*" (?) *obsoleta* n. sp.

Pl. XXXVII, figs. 10a–d, 11; Pl. XXXVIII, fig. 1a, b; Text-fig. 4c

Material.– Holotype, IGSH-HA 166, a bivalved specimen (Pl. XXXVII, fig. 10 a–d). Paratypes, IGSH-HA 167, a bivalved specimen (Pl. XXXVIII, fig. 1 a, b) and GK. H 6082, a right valve (Pl. XXXVII, fig. 11). They were collected from loc. 82 (HA 166 and 167 by K. SUMIKAWA & A. HASE, GK. H 6082 by K. KIKUCHI, K. HARADA & H. MITSUSHIO).

Diagnosis.– Shell medium in size, transversely elongated, subelliptical in outline, about twice as long as high, inequilateral, short and rounded in front, prolonged and subquadrate behind, moderately convex. Dorsal margin long, broadly arched; postero-dorsal margin fairly long, nearly straight, sloping gradually into the posterior margin without forming a marked angle; posterior margin nearly straight or weakly curved, rapidly descending and then bent forwards into the ventral margin, showing a moderate curve; ventral margin very long, nearly straight, ascending gradually into the well rounded anterior margin, which merges with the short antero-dorsal one without forming a marked angle.

Umbo rather large, somewhat prominent, situated at a point about one-third of the shell-length from the anterior end. Obtuse ridge extending from the umbo towards the postero-ventral corner, at first rather distinct and then gradually flattened. Surface with rudimentary radial sculpture in addition to numerous concentric growth-lines often elevated into wrinkles at irregular intervals; fine but rather distinct radial ribs arranged on the very limited umbonal area, figuring a V-shaped pattern; radial undulations on the posterior area extremely low and almost imperceptible; indistinct radial striae or riblets seen on a part of the ventral area.

Hinge not well preserved; pseudocardinal teeth 2 on the right valve, short and narrow.

Measurements.–

Specimen	Length (mm.)	Height (mm.)	Thickness (mm.)
IGSH-HA 166	28	15	3×2
〃 167	34	17	——
GK. H 6082	35	18	——

Remarks.– Among 15 to 17 ribs on the umbonal area of the right valve of the holotype the median 4 converge to form Vs.

Although the generic position of the shell in question is indefinite, it can be provisionally referred to "*Nippononaia*" by the shell-outline and the characteristic V-ribs as well as by the hinge-teeth, which are poorly preserved in GK. H 6082 (paratype). This species somewhat resembles "*N.*" *wakinoensis intermedia* n. subsp. and *Trigonioides paucisulcatus paucisulcatus* SUZUKI, but is distinguished by its more elongated shell. Furthermore, the effacement of the radial ornament is more evident in the former

than in the latter two, the posterior ribs being much more obsolete.

Occurrence.– Very rare in the Shiohama formation of the Shimonoseki subgroup (loc. 82).

Family Mytilidae

Genus *Limnoperna* ROCHEBRUNE, 1882

Type-species.– *Dreissena siamensis* MORELET

Limnoperna (?) *sengokuensis* n. sp.

Pl. XXXVI, figs. 23–29

Material.– Holotype is IGSH-HA 161 (Pl. XXXVI, fig. 23), a left valve from loc. 10 (Coll. A. HASE). Other examples are IGSH-HA 163 and 164 from loc. 77 (Coll. H. KAJINO & A. H.) and several immature shells such as IGSH-HA 162A–D from the same locality as the holotype (Coll. A. H.).

Diagnosis.– Shell rather small, subtriangular in outline, longer than high, highly inequilateral, moderately convex, extremely short and narrow in front, expanded and flattened postero-ventrally; test thin. Postero-dorsal margin fairly long, straight, scarcely sloping, merging with the posterior margin without forming a marked angle; posterior margin fairly long, nearly straight, gently descending and then bent forwards into the ventral margin, describing a semicircle; ventral margin very long, nearly straight, gradually ascending and then passing insensibly into the anterior margin, which is very narrowly rounded and merges with the exceedingly short antero-dorsal one without forming a marked angle.

Beak subterminal. Obtuse ridge extending obliquely from the umbo, at first rather distinct and then gradually flattened towards the postero-ventral margin. Surface with numerous fine concentric growth-lines roughened at irregular intervals.

Measurements.– The holotype measures 16 mm. in length and 9 mm. in height.

Remarks.– The umbo is relatively large, prominent and somewhat projected above the hinge-margin in the holotype specimen. This may possibly be due to the secondary deformation. In the immature stage the shell is not distinctly produced postero-ventrally but is transversely elongated, and the beak is seemingly rather small and low. Although the hinge-structure is not observable in any of the specimens, a fine and straight groove, which may be the impression of ligament, is seen along the postero-dorsal margin of IGSH-HA 163 (Pl. XXXVI, fig. 29).

The present shell is clearly distinguished from "*Modiolus*" *manchuricus* (SUZUKI) (1942, p. 104, pl. 1, figs. 14, 15) from the Upper Cretaceous Sungari group in Manchuria by its smaller size and subtriangular outline with much more narrowly rounded anterior margin, and also from *Modiolus* (?) *ishidoensis* (YABE and NAGAO) (1926, p. 63 [31], pl. 13 [2], fig. 42) from the Lower Cretaceous Ishido formation in the Kwanto Massif in Central Japan by its general shape of the shell with the ventral margin not parallel to the dorsal. In these respects this species closely resembles *Limnoperna*

lacustris (v. MARTENS), a recent freshwater mytilid distributed in Korea, Formosa and the mainland of China, but its shell is less inflated, its posterior margin descends more gently and its anterior end is somewhat narrower than in the latter species.

Occurrence.– Not common in the Sengoku formation (loc. 10); very rare in the Lower Wakamiya formation (loc. 77).

Family Sphaeriidae

Genus *Sphaerium* SCOPOLI, 1777

Type-species.– *Tellina cornea* LINNÉ

Sphaerium anderssoni (GRABAU)

Remarks.– This species includes two subspecies, *S. anderssoni anderssoni* and *S. anderssoni jeholense.* They were originally described by GRABAU (1923b) as independent species under the genus *Corbicula.* Subsequently, SUZUKI (1943a) assigned them to *Sphaerium* and regarded "*C. jeholense*" as a subspecies of *S. anderssoni* by reason that the two forms "are closely connected by many graduations of intermediate forms" (p. 64). Examining the Kwanmon specimens, *S. anderssoni jeholense* has generally higher and more equilateral shell than *S. anderssoni anderssoni*, but the difference is not clear, because the latter shows a wide range of variation in outline of the shell. The more marked difference is, as GRABAU described, that the posterior margin of *S. anderssoni jeholense* is narrowly rounded, while that of *S. anderssoni anderssoni* is broadly rounded or truncated. In West Japan the former subspecies coexists with but is much less abundant than the latter, while in North China they have been reported from different localities. I agree with SUZUKI in separating the two forms subspecifically.

Sphaerium anderssoni anderssoni (GRABAU)

Pl. XXXVII, figs. 12–15; Pl. XXXVIII, figs. 4–8, 9a, b, 10–23, 24a, b; Text-fig. 5a–c

1923. *Corbicula anderssoni* GRABAU, *Bull. Geol. Surv. China*, vol. 5, no. 2, p. 188, text-fig. 1a, b.
1943. *Sphaerium anderssoni*, SUZUKI, *Bull. Sigen. Kenkyusyo*, vol. 1, no. 1, p. 62, pl. 4, figs. 1-4.

Holotype (of the subspecies).– The specimen designated and illustrated by GRABAU (1923b, p. 189, text-fig. 1a), from the Hunyüan argillutites, near An Chun, Hun-Yüan-Hsien, Shansi, North China.

Material.– Among a number of specimens collected from the Kwanmon group (including the Inakura formation) at various localities, the better preserved ones are as follows. IGSH-HA 171 to 173 from loc. 18 (Coll. Y. KONDO & A. HASE); IGSH-HA 174 from loc. 19 (Coll. Y. K. & A. H.); IGSH-HA 176 from loc. 20 (Coll. Y. K. & A. H.); IGSH-HA 177 to 179 from loc. 26 (Coll. A. H.); IGSH-HA 181 and 182 from loc. 27 (Coll. A. H.); IGSH-HA 185 from loc. 31 (Coll. A. H.); IGSH-HA 186 and 187 from loc. 41 (Coll. A. H.); IGSH-HA 189 from loc. 42 (Coll. T. MATSUMOTO, M.

INOUE & A. H.); GK. H 6083 from loc. 50 (Coll. N. NAMEISHI); IGSH-HA 194 and 195 from loc. 81 (Coll. Y. SHIGEOKA & A. H.); IGSH-HA 196 to 199 from loc. 85 (Coll. A. H.); IGSH-HA 201 to 212 from the Inakura-mura area (Coll. H. KUSUMI).

Measurements.–

Specimen IGSH-HA	Length (mm.)	Height (mm.)	Specimen IGSH-HA	Length (mm.)	Height (mm.)
171	9	6	195	8	7
172	9	5.5	196	9	6
173	12	7.5	197	8.5	6
174	10.5	8.5	198	9	5.5
177	7	4.5	201	12.5	9.5
178	8	6	202	10	6.5
179	6.5	4	203	19	11
185	7	4	204	11.5	7
186	10.5	6	205	11	7
187	8.5	5	208	12	6
189	7	5	209	11.5	5
194	8	6	211	14	11
			212	9.5	6.5

Descriptive remarks.– The Kwanmon specimens before me are identified to *Sphaerium anderssoni anderssoni* (GRABAU), which has been reported from the late Mesozoic strata in the Shansi and Fengtien provinces of North China, by the following characters.

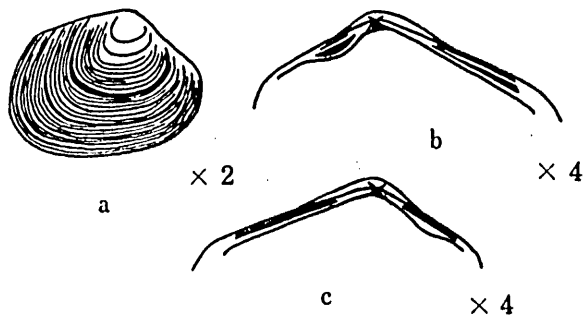

FIG. 5. Surface-ornament and hinge-structure of *Sphaerium anderssoni anderssoni* (GRABAU).
a: Right valve, b: Right valve, c: Left valve.

The shell is relatively large for this genus, inequilateral and transversely subovate to subelliptical in outline, with a well rounded anterior margin and a broadly rounded or truncated posterior one. The beak is generally located at a point about 1/4 to 2/5 of the shell-length from the anterior end. The surface-ornament consists of numerous very fine, subregular concentric growth-lines and a few or several irregularly spaced concentric wrinkles. The right valve is provided with two cardinal, two antero-lateral and two postero-lateral teeth. The cardinals are very small and converge to form a chevron, the posterior one being slightly stronger than the anterior. The laterals are lamellar and smooth. The posterior laterals are longer than the anterior, and the lower one on each side is longer, broader and higher than the upper. The

lower antero-lateral is concave towards the dorsal margin. The left valve has a lateral tooth on each side of the minute cardinals. Each is as strong as or slightly stronger than the lower lateral of the opposite valve.

In the Kwanmon specimens a considerable variation is shown in outline of the shell and position of the beak. This seems to be furthermore modified by the secondary deformation. Although the length-height ratio ranges from 1. 1 to 2. 0 or so, many specimens are about 1. 4 to 1. 6 times longer than high and are quite similar to the holotype (GRABAU, 1923b, text-fig. 1a) and the SUZUKI's fig. 2 of pl. 4. Certain individuals [e. g. GK. H 6083 (Pl. XXXVIII, fig. 11), IGSH-HA 195 (Pl. XXXVII, fig. 15)] are higher and shorter and very similar to the SUZUKI's fig. 4 and the GRABAU's text-fig. 1b. The ridge extending from the umbo towards the postero-ventral corner is in some individuals rather distinct and in others very obtuse. The specimens from the Wakino subgroup in the West Chugoku-North Kyushu province are generally not so large as the Fengtien form, but some of them are as large as the Shansi form. Those from the Inakura formation in Central Chugoku are relatively large, attaining about 15 to 20 mm. in length.

Superficially, the present subspecies resembles the immature shell of *Nakamuranaia chingshanensis* (GRABAU) from the Naktong subgroup [SUZUKI, 1943b, p. 213, pl. 19, figs. 9, 10, 12–16; synonym: *Corbicula* (*Leptesthes* ?) *coreanica* KOBAYASHI and SUZUKI, 1936, p. 255, pl. 29, figs. 1–6, 8; *Cristaria* ? sp. aff. "*Leptesthes*" *chingshanensis* GRABAU, KOBAYASHI & SUZUKI, 1936, p. 254, pl. 29, figs. 11, 12], but its shell does not attain such a large size as the latter species often does. Furthermore, the hinge-structure differs between them.

Occurrence.– Rare in the Sengoku formation (locs. 5?, 6?, 10?, 13); very rare in the Nyoraida formaton (loc. 16); very abundant and widely distributed in the Lower Wakamiya formation (locs. 18, 19, 20, 26, 27, 28, 31a, 32, 33, 34, 35, 50, 77 ?, 80) and in the Upper Wakamiya formation (locs. 37, 38, 39, 41a, 41b, 42, 48, 81, 85, 86). Very rare and doubtful in the Shiohama formation (loc. 49). Very abundant in the Yamaji shale of the Inakura formation (locs. Uneyama, Yamaji, Jokan-zan, etc., the Inakura-mura area, Oda-gun, Okayama Prefecture).

Sphaerium anderssoni jeholense (GRABAU)

Pl. XXXVIII, figs. 25–30

1923. *Corbicula jeholense* GRABAU, *Bull. Geol. Surv. China*, vol. 5, no. 2, p. 192, text-fig. 1c.
1943. *Sphaerium anderssoni jeholense*, SUZUKI, *Bull. Sigen. Kenkyusyo*, vol. 1, no. 1, p. 63, pl. 4, figs. 5–13.

Holotype (of the subspecies).– Cat. 633, a single, illustrated specimen of GRABAU (1923b, p. 189, text-fig. 1c), from the Jehol fish-beds, Ling Yuan Hsien, Jehol, North China, as originally designated.

Material.– IGSH-HA 216 from loc. 19 (Coll. Y. KONDO & A. HASE); IGSH-HA 217 to 220 from loc. 80 (Coll. A. H.); IGSH-HA 221 from loc. 85 (Coll. A. H.); IGSH-HA 222 from the Inakura-mura area (Coll. H. KUSUMI).

Measurements.–

Specimen IGSH-HA	Length (mm.)	Height (mm.)	Specimen IGSH-HA	Length (mm.)	Height (mm.)
216	10.5	8±	218	9±	8
217	11	10.5	219	8±	6
			220	9.5	7.5

Descriptive remarks.– The present shell is closely allied to *Sphaerium anderssoni anderssoni* (GRABAU) described above. Compared with the latter, however, the former has a more equilateral shell, with a roundly subtrigonal outline, a subcentral beak and a narrower posterior end which is not distinctly truncated. Moreover, the average length-height ratio of the shell is smaller in this than in that subspecies. Therefore, it is identical to *S. anderssoni jeholense* (GRABAU) from the late Mesozoic rocks in the Jehol and Fengtien provinces of North China. The illustrated Kwanmon specimens have a more trigonal outline with a smaller umbonal angle than the holotype, but are very similar to some examples of SUZUKI (1943a, pl. 4, figs. 5, 6, 7, 9, 13).

Occurrence.– Rare in the Lower Wakamiya formation (locs. 19, 80) and in the Upper Wakamiya formation (loc. 85). Rare in the Yamaji shale of the Inakura formation (loc. Uneyama). This subspecies coexists with but is less abundant than *S. anderssoni anderssoni*.

Family Corbulidae

Genus *Corbula* BRUGUIÈRE, 1797

Type-species.– *Corbula nucleus* LAMARCK

Corbula matsumotoi n. sp.

Pl. XXXIX, figs. 5a–d, 6a–d, 7–9, 10a, b, 11a, b, 12–21; Text-fig. 6a, b

Material.– Holotype, GK. H 6084, a bivalved specimen (Pl. XXXIX, fig. 5a–d). Paratypes, GK. H 6085, a bivalved specimen (Pl. XXXIX, fig. 6a–d); GK. H 6086, a right valve (Pl. XXXIX, fig. 7); GK. H 6087, a left valve (Pl. XXXIX, fig. 8). All the above types were collected by K. KANMERA from the Kawaguchi formation

FIG. 6. Internal structure of *Corbula matsumotoi* n. sp.
a: Right valve, b: left valve.

at Saka-yori-kami, Kawamata-mura, Yatsushiro-gun, Kumamoto Prefecture and were provided me for study. Other specimens from the same locality are GK. H 6088 to 6095 (Coll. K. K.), and the comparable ones from the Yoshimo formation at loc. 67 are IGSH-HA 296 to 300 (Coll. H. KAJINO & A. HASE). Besides them, there are a considerable number of poorly preserved specimens from both the Kawaguchi and Yoshimo formations.

Diagnosis.– Shell small, roundly subtrigonal to subovate in outline, about one and a half times longer than high, slightly inequivalve, somewhat inequilateral, rounded and fairly inflated in front, more or less rostrated and compressed behind; test thick. Right valve a little more convex than the left. Dorsal margin fairly long, arched; postero-dorsal margin gently or distinctly sloping, usually excavated, forming an obtuse angle with the posterior margin, which is short, nearly straight or very weakly curved, rapidly descending and then bent forwards into the ventral margin, forming a subangulated corner; ventral margin fairly long, broadly arched, passing insensibly into the short and rounded anterior margin; antero-dorsal margin almost as long as the postero-dorsal, nearly straight or slightly convex, distinctly sloping into the anterior one without forming a marked angle.

Umbo rather large, prominent, incurved, subcentral; umbo of the right valve usually slightly overtopping that of the left. Blunt ridges extending from the umbo towards both the anterior end and the postero-ventral corner; anterior one much more distinct than the posterior. Antero-dorsal area bent inwards, flattened; postero-dorsal area usually not well defined, sometimes flattened or slightly concave. Surface ornamented with numerous fine, closely set, irregularly roughened concentric growth-lines and a few gentle concentric undulations.

Hinge-plate rather wide; right valve provided with a prominent triangular tooth just below the beak, behind which is a shallow socket for receiving the low and uneven chondrophore of the opposite valve; a profound trigonal cavity for receiving the tooth situated a little behind the beak of the left valve. Pallial line forming a right angle at the postero-ventral corner, scarcely sinuated. Inner margin smooth.

Measurements.–

Specimen	Length (mm.)	Height (mm.)	Thickness (mm.)
GK. H 6084	13.5	9	5.3
// 6085	11.5+	8.5	6.8
// 6086	16.5+	11	——
// 6087	14.5+	9	——
// 6088	13+	8.5	——
// 6089	14.5	10	——
// 6091	16+	12	——
// 6092	13+	8.5	——
IGSH-HA 296	10	6.5	——
// 297	8.5	6.5	——
// 298	7	6	——
// 299	11	7.5	——
// 300	10.5	7	——

Remarks.– The length-height ratio of the shell ranges from 1.2± to 1.7±, being

predominantly about 1.5. The umbo is located at a point about 2/5 to 1/2 of the shell-length from the anterior end. The specimens from the Yoshimo formation are specifically identical with the types from the Kawaguchi formation, although the shell is generally slightly smaller in the former than in the latter.

The present species can be distinguished from *Corbula* (*Caryocorbula*) *higoensis* (MATSUMOTO) (1938, p. 19, pl. 2, fig. 8, text-fig. 9a, b) from the Gyliakian Beds III and IId of the Goshonoura group in Middle Kyushu by its truncated posterior end and more irregularly roughened growth-lines, and also from *Corbula globosa* TAMURA (1959, p. 114, pl. 12, figs. 1–4) from the Upper Jurassic Sakamoto formation in South Kyushu by its somewhat larger size and subcentral umbo. In outline this is very similar to *C. striatuloides* FORBES (STOLICZKA, 1870, p. 43, pl. 16, fig. 13, 14) from the Trichinopoly group in South India, but the latter has a more inequivalve shell, in which the left valve is considerably smaller and more coarsely striated than the right. *C. striatula* SOWERBY (WOODS, 1908, p. 212, pl. 34, figs. 6–12) from the Lower Greensand in England is another resembling species, but is a little smaller and has a much more acute posterior ridge. *C. pyriformis* MEEK from the Upper Cretaceous in Wyoming, Idaho and Utah, U. S. A. also resembles this in outline, but the shell is larger and the posterior ridge is more distinct in the former than in the latter. The higher and shorter form of *C. matsumotoi* has some similarity to *C. inflata* STEPHENSON (1941, p. 239, pl. 44, figs. 9, 10) from the Navarro group in Texas, U. S. A., but its shell is somewhat larger and less inflated and its surface is more distinctly striated than in that species.

The specific name is dedicated to Professor Tatsuro MATSUMOTO of the Kyushu University.

Occurrence.– Kawaguchi formation of the Ryoseki group at Saka-yori-kami, Kawamata-mura, Yatsushiro-gun, Kumamoto Prefecture. Yoshimo formation of the Toyonishi group at locs. 59, 65?, 66, 67, 71, 72 and 73.

Corbula (?) *imamurae* n. sp.

Pl. XXXVII, figs. 16–21, 22a, b; Pl. XXXIX, figs. 2–4

Material.– Holotype, IGSH-HA 271, a right valve (Pl. XXXVII, fig. 16). Paratypes, IGSH-HA 272, a right valve (Pl. XXXVII, fig. 17), IGSH-HA 273, a left valve (Pl. XXXVII, fig. 18) and IGSH-HA 274, a left valve (Pl. XXXVII, fig. 19). All the above types came from loc. 59 (Coll. A. HASE). Other specimens, IGSH-HA 275 to 277 from loc. 59, IGSH-HA 278 from loc. 61, IGSH-HA 279 and 280 from loc. 67, IGSH-HA 282 from loc. 72, GK. H 6096, etc. (HA 275 to 280 collected by A. H., HA 282 by H. KAJINO & A. H., GK. H 6096 by E. TAKAHASHI).

Diagnosis.– Shell medium in size, inequivalve, inequilateral, transversely elongated, subelliptical in the right valve and subovate in the left, rather short and rounded in front, somewhat prolonged and truncated behind, moderately inflated; test thin. Right valve somewhat larger and more convex than the left. Dorsal margin long,

broadly arched; postero-dorsal margin fairly long, nearly straight or slightly concave and scarcely sloping in the right valve, very weakly convex and gently sloping in the left, forming an obtuse angle with the posterior margin; posterior margin nearly straight or weakly curved, longer in the right valve than in the left, rapidly descending and then bent forwards into the ventral margin, forming a rounded angle; ventral margin long, gently arched, passing insensibly into the anterior margin, which is well rounded and merges with the rather short antero-dorsal one without forming a marked angle.

Umbo fairly large, prominent, incurved, projected above the hinge-margin, located at a point about one-third to two-fifths of the shell-length from the anterior end, fissured downwards. Obtuse ridge extending obliquely from the umbo, at first rather distinct and then becoming obsolete towards the postero-ventral corner; postero-dorsal area somewhat concave, especially in the left valve. Surface ornamented with numerous concentric growth-lines and a few or several gentle concentric undulations; growth-lines fine, closely set, somewhat irregularly developed, sometimes strengthened near the posterior ridge; a few slender radial ridges seen on the postero-dorsal area of the right valve.

Hinge not well preserved; right valve provided with a prominent tooth below the beak.

Measurements.–

Specimen IGSH-HA	Length (mm.)	Height (mm.)	Specimen IGSH-HA	Length (mm.)	Height (mm.)
271	23.5	10.5	276	15.5	10.5
272	23.5	12	277	20	12.5
273	22	11.5	278	18.5	11
274	19.5	11	279	23	15
275	18.5	10	282	18.5	11

Remarks.– The length-height ratio of the shell ranges from 1.5 ± to 2.2 ±. Although both valves are in most cases isolated from each other and have suffered the secondary compression in some degree, it seems that the shell is more convex and the umbo is slightly more prominent in the right valve than in the left. Furthermore, the postero-dorsal margin of the right valve considerably protrudes over that of the left.

Viewed from the right valve, the present shell closely resembles a *Laternula*, having a subelliptical outline, a fissured umbo and a thin test. However, by the inequivalve shell and the strong cardinal tooth, the latter of which is impressed on IGSH-HA 280 (Pl. XXXIX, fig. 4), it can be provisionally referred to *Corbula*. This species is clearly distinguished from *Corbula matsumotoi* n. sp. described above by its larger and more inequivalve shell, broader posterior end of the right valve and thinner test. It also differs from *Corbula* (*Caryocorbula*) *higoensis* (MATSUMOTO) in size, outline and surface-ornament.

The specific name is dedicated to Professor Sotoji IMAMURA of the Hiroshima University.

Occurrence.– Rather common in the Yoshimo formation of the Toyonishi group (locs. 57 ?, 59, 61, 67, 72).

VII. FAUNAS AND FLORA

The following fossil assemblages are distinguished in the late Mesozoic of the West Chugoku-North Kyushu province.

(1) The Upper Jurassic Kiyosue flora.

(2) The lowest Cretaceous Yoshimo molluscan fauna, corresponding to the Ryoseki fauna of the Outer Zone of Southwest Japan.

(3) The Lower Cretaceous Wakino molluscan fauna, corresponding to the Naktong fauna of South Korea. This is subdivided into two faunules, (a) the lower Wakino or Sengoku and (b) the upper Wakino or Wakamiya.

(4) The molluscan fossils from the late Lower Cretaceous — early Upper Cretaceous Shimonoseki subgroup.

The elements of each assemblage are listed and some remarks are given below.

1. *Kiyosue flora*

This is distributed in the Kiyosue formation of the Toyonishi group. When OISHI (1933, 40) monographed the Mesozoic floras in Japan, he included in his "Kiyosue plant beds" the deltaic facies of the Utano formation in addition to the Kiyosue formation (s.s.) in the present definition. In reality, however, the Kiyosue formation is underlain by the Utano formation with a distinct disconformity and has a floral assemblage somewhat different from that of the Utano. After the preliminary work by Takashi ENDO (in MATSUMOTO [Editor], 1954, p. 160) who first revised OISHI's list of fossil plants with stratigraphic consideration, TAKAHASHI (1957, 59) has carried on the paleobotanical study and added many species on the basis of new collections including those of mine. The species identified by them are shown on Table 1. Many fossil localities are found in the mountainous areas near Kami-nanami (Toyohigashi-mura), Ono (Kiyosue Ward of Shimonoseki City), Takachi-togé (Utsui-mura), Ohata (do.) and Yoshimo (Toyonishi-mura), all in Yamaguchi Prefecture.

The Kiyosue flora is said to be allied to the Upper Jurassic and Lower Cretaceous floras, such as the Utano, Kuzuryu, Itoshiro, Ryoseki and Naktong floras. From the evidence of ammonites (MATSUMOTO & ONO, 1947) the Utano formation must range in age from upper Toarcian to Callovian. On the other hand, the Yoshimo formation, which overlies conformably the Kiyosue formation, is most reasonably referred to the lower Neocomian. Therefore, the flora under consideration may be of latest Jurassic age as has hitherto been believed, although there is a possibility that it could range up to the basal Cretaceous.

TABLE 1. LIST OF THE KIYOSUE FLORA OF THE TOYONISHI GROUP IN YAMAGUCHI PREFECTURE. [After T. ENDO (in MATSUMOTO [Editor], 1954) and TAKAHASHI (1957, 59)]

Bryophyta					
Thallites Yabei (KRYSHTOFOVICH)	U	?K	I	R	N
Filicales					
Onychiopsis elongata (GEYLER) YOKOYAMA	U	K	I	R	N
Adiantites Sewardi YABE	U		I		N
Sphenopteris (*Ruffordia*) *Goepperti* DUNKER	U	K	I	R	
Cladophlebis denticulata (BRONGNIART)	U	K	I	R	N
C. deltifolia OISHI					
C. toyoraensis OISHI	U				
C. (*Klukia* ?) *koraiensis* YABE					N
C. sp.					
Cycadophyta					
Nilssonia orientalis HEER	U	K	I	R	N
Dictyozamites falcatus (MORRIS) OLDHAM		K	I		N
D. Kawasakii TATEIWA			I		N
D. sp.					
Otozamites Beani (LINDLEY and HUTTON) BRONGNIART	U				
O. Klipsteinii (DUNKER) SEWARD	U	?K	I	R	
Pterophyllum propinquum GOEPPERT	U				
P. sp.					
Zamites toyoraensis OISHI					
Cfr. *Z. Hoheneggri* (SCHENK)					
Sagenopteris petiolata OISHI	U				
Ginkgophyta					
Ginkgoites digitata (BRONGNIART) SEWARD	U	K	I		
Phoenicopsis sp.					
Coniferales					
Brachyphyllum sp.					
Elatocladus constricta (FEISTMANTEL) OISHI	U				
Podozamites sp.					

The species which occur also from the related floras are indicated by the following symbols.
U: Utano flora, K: Kuzuryu flora, I: Itoshiro flora,
R: Ryoseki flora, N: Naktong flora.

2. *Yoshimo molluscan fauna*

The brackish Yoshimo fauna, which is distributed in the Yoshimo formation of the Toyonishi group, was already described by KOBAYASHI and SUZUKI (1939). At that time a shore-cliff near Yoshimo-ura was the only locality of the fossil shells. Subsequently, many new localities have been found by Takashi ENDO and myself not only in the vicinity of Yoshimo but also in the area of Utsui. They are listed in Chapter V. The species identified on the basis of the new collections are shown on Table 2.

As pointed out by KOBAYASHI and SUZUKI, this fauna is closely related to the Ryoseki fauna of the Outer Zone, especially to the faunule of the Kawaguchi formation

Table 2. List of the Molluscan Fossils from the Toyonishi Group in Yamaguchi Prefecture.

Horizon	Tua																	Tub	Common species
Locality number	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	
Gastropoda																					
Melanoides (*Yoshimonia*) *yoshimoensis* Ota	—	—	—	?	—	—	—	—	—	?	×	×	—	—	—	—	—	—	—	—	— — — — — — — —
M. (*Y.*) aff. *yoshimoensis* Ota	—	—	—	—	—	—	—	—	—	×	×	×	—	—	—	—	×	—	—	—	— — — — — — — —
Glauconia (?) *neumayri* (Nagao) Yabe	—	—	—	—	—	—	—	—	—	—	—	×	—	—	—	—	—	—	—	—	— — — d — — — h
Pelecypoda																					
Bakevellia shinanoensis (Yabe and Nagao)	—	—	—	—	—	×	—	—	—	—	×	×	—	—	—	—	—	?	—	—	a b — — — — g h
Anomia pseudotruncata Yabe and Nagao	—	—	—	×	×	×	—	—	—	—	—	—	—	—	—	—	—	—	—	—	a — — — — — — (h)
Ostrea (?) *ryosekiensis* Kobayashi and Suzuki	—	—	—	—	×	—	×	?	?	—	×	×	×	?	?	—	—	?	×	×	— — — — — f g (h)
O. (*Crassostrea*) *yoshimoensis* Kobayashi and Suzuki	—	—	—	—	—	—	—	—	—	—	×	—	—	—	?	—	—	—	—	—	— — c — — — — —
Astarte (?) *sakawana* Kobayashi and Suzuki	×	—	×	×	—	×	—	—	—	×	×	×	—	—	—	—	—	?	—	—	— — c — — f — h
Polymesoda (*Isodomella*) *naumanni* (Neumayr)	—	—	—	×	×	×	—	—	—	×	×	×	—	—	—	—	×	—	—	—	a b c d e f g h
P. (*Paracorbicula*) *sanchuensis* (Yabe and Nagao)	—	—	—	—	—	?	—	—	—	×	×	×	—	×	—	—	—	—	—	—	a b c — e — — —
Corbula matsumotoi n. sp.	—	—	—	×	—	—	—	—	—	?	×	×	—	—	—	×	×	×	—	—	— — — — — — — h
C. (?) *imamurae* n. sp.	—	?	—	×	—	×	—	—	—	—	—	×	—	—	—	—	×	—	—	—	— — — — — — — —

Stratigraphic horizon

Tua: Main part of the Yoshimo formation, Tub: Upper part of the Yoshimo formation.

Common species

a: Shiroi formation in the Sanchu graben in the Kwanto Massif.

b: Matsuo formation in the Shima peninsula, Mié Prefecture.

c: Yuasa formation in the Yuasa district, Wakayama Prefecture.

d: Tatsukawa formation in the Katsuragawa valley, Tokushima Prefecture.

e: "Ryoseki group" in the Monobegawa valley and the Kochi district, Kochi Prefecture.

f: "Ryoseki group" in the Sakawa district, Kochi Prefecture.

g: "Ryoseki group" in the Usuki district, Oita Prefecture.

h: Kawaguchi formation in the Yatsushiro district, Kumamoto Prefecture.

(h): Affinitive species.

of South Kyushu. Therefore, its age is Kochian (lower Neocomian).

3. *Wakino molluscan fauna*

A peculiar fresh-water fauna is developed in the Wakino subgroup and a few elements of it range up to the lower part of the Shimonoseki subgroup. KOBAYASHI and SUZUKI (1936) first described five species from the Sengoku black shale of the Wakino subgroup in the type area, and rightly correlated this fossil-assemblage to the Naktong fauna of South Korea. Subsequently, as a result of the stratigraphical investigations by OTA, MATSUMOTO and myself with some students of the Kyushu and Hiroshima Universities, many fossils have been added from more localities of various horizons. The identified molluscan species are listed on Table 3, together with estherids, a fresh-water fish and a plant. The localities are listed in Chapter V. There are several species which are common between the Wakino and the Naktong faunas, but the apparent vertical ranges of each species in the two provinces of Japan and Korea are not always concordant with each other.

Brotiopsis is one of the diagnostic genera of the Naktong-Wakino fauna. A larger form of the genus, that is *B. wakinoensis*, is very abundant in the lower Wakino and the lower Naktong formations, although it ranges up in some places to the upper Wakino. The upper half of the Wakino subgroup is characterized by the abundant occurrence of smaller forms of the genus, *B. kobayashii kobayashii* and *B. kobayashii sinsyuensis*. The latter subspecies is a derivative from the former and seems to show its acme somewhat later than the typical form of the species.

The effacement of the radial sculpture is observed in the lineage of "*Nippononaia*" *wakinoensis wakinoensis*— "*N.*" *wakinoensis intermedia*—"*N.*" (?) *obsoleta*, as in that of *Trigonioides kodairai*— *T. paucisulcatus paucisulcatus* on the Korean side. "*N.*" *wakinoensis wakinoensis* occurs rather commonly from the lower Wakino formation and very rarely from the upper Wakino formation, while the occurrence of "*N.*" *wakinoensis intermedia* is confined to the uppermost Wakino.

The maximum development of *Plicatounio* is in the lower Wakino formation. According to OTA (1959b), *P. naktongensis naktongensis* is abundant in the Sengoku formation and rare in the upper half of the Wakino subgroup, while *P. naktongensis multiplicatus*, a more advanced form than the typical form of the species, is commoner in the latter than in the former.

Viviparus (*Sinotaia* ?) *onogoensis* and *Sphaerium anderssoni anderssoni* are abundant and widely distributed in the upper half of the Wakino subgroup, although they range down in some places to the Sengoku formation. *S. anderssoni* has been reported from the late Mesozoic in North China and is of significance for the correlation problem, as will be discussed in article 5 of Chapter VIII.

Summarizing Table 3, the Wakino fauna can be divided into two faunules, the lower and the upper, although the difference between them is not very great. A similar conclusion has recently been drawn by OTA (1960b), with whom I agree in the general view, if not at every point.

a. Lower Wakino or Sengoku faunule, developed in the Sengoku formation, consists of the following molluscan species.

Viviparus (*Sinotaia* ?) cf. *onogoensis*
◦ *Brotiopsis wakinoensis*
B. aff. *wakinoensis*
B. *kobayashii kobayashii*
◦ *Melanoides* (*Yoshimonia*) *kokurensis*
Thiara (*Siragimelania*) cf. *tateiwai*
Gyraulus (?) n. sp. (?)
◦ *Plicatounio naktongensis naktongensis*
Plicatounio naktongensis multiplicatus
◦ "*P.*" *triangularis*
◦ "*P.*" *kwanmonensis*
◦ *Paranodonta ôtai*
◦ "*Nippononaia*" *wakinoensis wakinoensis*
◦ "*N.*" *sengokuensis*
Limnoperna (?) *sengokuensis*
Sphaerium anderssoni anderssoni

Among these, the species or subspecies marked with ◦ are common or diagnostic.

According to SUZUKI (1943b), the Kinbu formation, a correlative of the Sengoku on the Korean side, contains the following species.

Viviparus (*Sinotaia* ?) *onogoensis*
Hydrobia (*Parhydrobia*) *gyokusoensis*
Bulimus rakutoensis
Micromelania (?) *katoensis*
Brotiopsis wakinoensis
B. *kobayashii kobayashii*
Gyraulus (?) n. sp. (?)
Plicatounio naktongensis naktongensis
Trigonioides kodairai
Nakamuranaia chingshanensis
Schistodesmus antiqus

The Nyoraida formation, as the Kasando formation of South Korea, is poor in fossils.

b. Upper Wakino or Wakamiya faunule, developed in the Lower Wakamiya and Upper Wakamiya formations, consists of the following molluscan species.

◦ *Viviparus* (*Sinotaia* ?) *onogoensis*
Brotiopsis wakinoensis
◦ *B.* *kobayashii kobayashii*
◦ *B.* *kobayashii sinsyuensis*
◦ *Melanoides* (*Yoshimonia*) *katsukiensis*
Gyraulus (?) n. sp. (?)
Plicatounio naktongensis naktongensis
P. aff. *naktongensis naktongensis*
Plicatounio naktongensis multiplicatus
"*Nippononaia*" *wakinoensis wakinoensis*
◦ "*N.*" *wakinoensis intermedia*
◦ *Trigonioides paucisulcatus suzukii*
Limnoperna (?) *sengokuensis*
◦ *Sphaerium anderssoni anderssoni*
◦ *S.* *anderssoni jeholense*

Among these, the species or subspecies marked with ◦ are common or diagnostic.

According to SUZUKI (1943b), the Shinshu formation of South Korea, which may be correlated to the Lower Wakamiya formation, contains the following species.

Itomelania basicordata
Brotiopsis kobayashii sinsyuensis
Plicatounio naktongensis naktongensis
Plicatounio naktongensis multiplicatus
Trigonioides kodairai
Nakamuranaia chingshanensis

In North Kyushu the Sengoku formation always covers directly the Paleozoic rocks, while in West Chugoku this is entirely lacking and the Yoshimo formation underlies disconformably the Lower Wakamiya formation. The Wakino and the Naktong subgroups are overlain in some places conformably and in others disconformably by the Shimonoseki and the Shiragi subgroups respectively. The Shiragi subgroup is Miyakoan (Aptian–Albian) plus Gyliakian (Cenomanian–Turonian) in age (see Chap-

TABLE 3. LIST OF THE FOSSILS FROM THE WAKINO AND THE SHIMONOSEKI SUBGROUPS IN FUKUOKA AND YAMAGUCHI PREFECTURES.

Horizon / Locality number	Wl 1	2	3	4	5	6	7	8	9	10	X	13_a	13	21	22	23	Y
Gastropoda																	
1. *Viviparus (Sinotaia?) onogoensis* Kobayashi and Suzuki	—	—	—	—	—	—	—	—	—	—	—	?	—	—	—	—	—
2. *Brotiopsis wakinoensis* (Kobayashi and Suzuki)	C	A	A	A	VA	VA	A	A	C	VA	VA	—	—	VA	—	R	VA
3. *B.* aff. *wakinoensis* (Kobayashi and Suzuki)	—	—	—	—	VR	—	—	—	—	—	—	—	—	—	—	—	—
4. *B. kobayashii kobayashii* Suzuki	—	—	—	—	—	—	—	—	—	—	?	—	C	—	—	—	—
5. *B. kobayashii sinsyuensis* Suzuki	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
6. *Melanoides (Yoshimonia) katsukiensis* Ota	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
7. *M. (Y.) kokurensis* n. sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—
8. *Thiara (Siragimelania)* cf. *tateiwai* Suzuki	—	—	—	—	—	—	—	—	—	—	—	—	VR	—	—	—	—
9. *Gyraulus* (?) n. sp. (?)	—	—	—	—	—	—	—	—	—	—	VR	—	—	—	—	—	—
Pelecypoda																	
10. *Plicatounio naktongensis naktongensis* Kobayashi and Suzuki	—	—	—	—	C	—	VR	—	—	—	C	—	—	—	—	—	VR
11. *P.* aff. *naktongensis naktongensis* Kobayashi and Suzuki	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
12. *P. naktongensis multiplicatus* Suzuki	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	VR
13. "*P.*" *triangularis* Kobayashi and Suzuki*	—	—	—	—	—	—	—	—	—	—	VR	—	—	—	—	—	—
14. "*P.*" *kwanmonensis* Ota**	—	—	—	—	—	—	—	—	—	—	VR	—	—	—	—	—	—
15. *Paranodonta ôtai* Kobayashi and Suzuki*	—	—	—	—	?	—	—	—	—	—	VR	—	—	—	—	—	—
16. "*Nippononaia*" *wakinoensis wakinoensis* Ota	—	—	—	—	R	—	—	—	—	—	C	—	—	—	—	—	—
17. "*N.*" *wakinoensis intermedia* n. subsp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
18. "*N.*" *sengokuensis* Ota**	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—
19. "*N.*" (?) *obsoleta* n. sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
20. *Trigonioides paucisulcatus suzukii* Ota	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
21. *Limnoperna* (?) *sengokuensis* n. sp.	—	—	—	—	—	—	—	—	—	C	—	—	—	—	—	—	—
22. *Sphaerium anderssoni anderssoni* (Grabau)	—	—	—	—	?	?	—	—	—	?	?	—	VR	—	—	—	—
23. *S. anderssoni jeholense* (Grabau)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Crustacea																	
24. *Euestheria kokurensis* Kusumi***	—	—	—	—	—	—	—	—	—	?	—	—	—	—	—	—	—
25. *Estherites imamurai* Kusumi***	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pisces																	
26. *Manchurichthys* (?) sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Plant																	
27. *Cladophlebis* sp.	—	—	—	—	—	—	—	—	—	—	—	VR	—	—	—	—	—

Horizon / Locality number	Wm 14	15	16	17	24	25	Wu 11	12	18	19	20	26	27	28	29	31_a	31_b	32	33	34	35	50	76	77	80	83	84
Gastropoda																											
1. *Viviparus (Sinotaia?) onogoensis* Kobayashi and Suzuki	R	VR	R	—	C	—	—	—	—	C	VA	—	—	—	—	—	—	—	—	—	R	A	—	—	—	—	—
2. *Brotiopsis wakinoensis* (Kobayashi and Suzuki)	—	—	—	—	—	—	A	A	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
3. *B.* aff. *wakinoensis* (Kobayashi and Suzuki)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
4. *B. kobayashii kobayashii* Suzuki	—	?	—	R	?	R	—	—	—	—	—	—	—	—	—	—	C	VA	R	—	?	—	—	C	—	C	R
5. *B. kobayashii sinsyuensis* Suzuki	—	—	—	—	—	—	—	—	VA	—	—	—	—	—	—	R	—	VR	R	—	—	—	—	—	—	—	—
6. *Melanoides (Yoshimonia) katsukiensis* Ota	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	VR	—	—	—	—	—	—
7. *M. (Y.) kokurensis* n. sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
8. *Thiara (Siragimelania)* cf. *tateiwai* Suzuki	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
9. *Gyraulus* (?) n. sp. (?)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pelecypoda																											
10. *Plicatounio naktongensis naktongensis* Kobayashi and Suzuki	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
11. *P.* aff. *naktongensis naktongensis* Kobayashi and Suzuki	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
12. *P. naktongensis multiplicatus* Suzuki	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	VR	—	—	—	—	—	—
13. "*P.*" *triangularis* Kobayashi and Suzuki*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
14. "*P.*" *kwanmonensis* Ota**	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
15. *Paranodonta ôtai* Kobayashi and Suzuki*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
16. "*Nippononaia*" *wakinoensis wakinoensis* Ota	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	VR	—	—	—	—	—	—
17. "*N.*" *wakinoensis intermedia* n. subsp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
18. "*N.*" *sengokuensis* Ota**	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
19. "*N.*" (?) *obsoleta* n. sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
20. *Trigonioides paucisulcatus suzukii* Ota	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	C	—	—	—	—
21. *Limnoperna* (?) *sengokuensis* n. sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	VR	—	—	—
22. *Sphaerium anderssoni anderssoni* (Grabau)	—	—	VR	—	—	—	—	—	R	A	VA	VA	A	R	—	VA	—	C	A	VA	VR	A	—	?	A	—	—
23. *S. anderssoni jeholense* (Grabau)	—	—	—	—	—	—	—	—	—	VR	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—
Crustacea																											
24. *Euestheria kokurensis* Kusumi***	—	—	—	—	—	—	—	—	—	—	—	—	—	—	A	—	—	—	—	—	—	—	—	—	—	—	—
25. *Estherites imamurai* Kusumi***	—	—	—	—	—	—	—	—	—	—	—	—	—	—	A	—	—	—	—	—	—	—	—	—	—	—	—
Pisces																											
26. *Manchurichthys* (?) sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—
Plant																											
27. *Cladophlebis* sp.	—	VR	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Horizon / Locality number	Wum 36	37	38	39	40	41_a	41_b	42	43	46	47	48	79	81	85	86	Sl 49	82	Common species or subspecies					
Gastropoda																								
1. *Viviparus (Sinotaia?) onogoensis* Kobayashi and Suzuki	—	—	—	—	—	—	—	A	—	VA	R	—	R	—	—	—	R	—	a	—	—	d	—	1.
2. *Brotiopsis wakinoensis* (Kobayashi and Suzuki)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	a	—	—	—	—	2.
3. *B.* aff. *wakinoensis* (Kobayashi and Suzuki)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3.
4. *B. kobayashii kobayashii* Suzuki	?	R	—	—	—	C	—	?	—	—	—	—	—	—	—	—	—	—	a	—	—	—	—	4.
5. *B. kobayashii sinsyuensis* Suzuki	—	—	C	—	—	—	VA	VR	—	—	—	—	—	—	A	—	—	—	—	b	—	—	—	5.
6. *Melanoides (Yoshimonia) katsukiensis* Ota	VR	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6.
7. *M. (Y.) kokurensis* n. sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7.
8. *Thiara (Siragimelania)* cf. *tateiwai* Suzuki	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	c	—	—	8.
9. *Gyraulus* (?) n. sp. (?)	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	a	—	—	—	—	9.
Pelecypoda																								
10. *Plicatounio naktongensis naktongensis* Kobayashi and Suzuki	—	—	—	—	—	—	—	—	?	—	—	—	—	—	—	—	—	—	a	b	—	—	—	10.
11. *P.* aff. *naktongensis naktongensis* Kobayashi and Suzuki	—	—	—	—	—	—	—	—	—	—	—	VR	—	—	—	—	—	—	—	—	—	—	—	11.
12. *P. naktongensis multiplicatus* Suzuki	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	b	—	—	—	12.
13. "*P.*" *triangularis* Kobayashi and Suzuki*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	13.
14. "*P.*" *kwanmonensis* Ota**	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	14.
15. *Paranodonta ôtai* Kobayashi and Suzuki*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	15.
16. "*Nippononaia*" *wakinoensis wakinoensis* Ota	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	16.
17. "*N.*" *wakinoensis intermedia* n. subsp.	—	—	—	—	—	—	—	—	—	—	—	—	—	C	—	—	—	—	—	—	—	—	—	17.
18. "*N.*" *sengokuensis* Ota**	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	18.
19. "*N.*" (?) *obsoleta* n. sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	VR	—	—	—	—	—	19.
20. *Trigonioides paucisulcatus suzukii* Ota	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	20.
21. *Limnoperna* (?) *sengokuensis* n. sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	21.
22. *Sphaerium anderssoni anderssoni* (Grabau)	—	VR	VR	VR	—	C	R	C	—	—	—	VR	—	VA	C	VR	?	—	—	—	—	—	e	22.
23. *S. anderssoni jeholense* (Grabau)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	VR	—	—	—	—	—	—	—	e	23.
Crustacea																								
24. *Euestheria kokurensis* Kusumi***	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	24.
25. *Estherites imamurai* Kusumi***	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	25.
Pisces																								
26. *Manchurichthys* (?) sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—						26.
Plant																								
27. *Cladophlebis* sp.	—	—	—	—	VR	—	—	—	—	—	—	—	—	—	—	—	—	—						27.

Stratigraphic horizon
Wakino subgroup —— Wl: Sengoku formation, Wm: Nyoraida formation, Wu: Lower Wakamiya formation, Wum: Upper Wakamiya formation. Shimonoseki subgroup —— Sl: Shiohama formation.

Locality
X: East of Rikimaru, Wakino area (exact locality uncertain), Y: Near Dobara, Kokura area (exact locality uncertain).

Occurrence
VA: Very abundant, A: Abundant, C: Common, R: Rare, VR: Very rare.

Common species or subspecies
a, b: Naktong subgroup (a: Kinbu formation, b: Shinshu formation). c, d: Shiragi subgroup (c: Taikyu formation, d: Sansuido and Takkitsu formations). e: Fuhsin group.

* After Kobayashi and Suzuki (1936). ** After Ota (1959 b, d). *** After Kusumi (1960).

ter VIII, article 4) and the Yoshimo formation is Kochian (lower Neocomian). Therefore, the upper Wakino faunule is considered to be of Aritan (upper Neocomian) age. A possibility of the contemporaneity between the Sengoku and the Yoshimo formations was recently suggested by MATSUMOTO (Editor, 1954) and myself (1958). *Melanoides* (*Yoshimonia*) *katsukiensis* is very similar to *M.* (*Y.*) *yoshimoensis*, one of the characteristic species of the Yoshimo fauna, and "*Nippononaia*" *wakinoensis wakinoensis* is allied to *N. ryosekiana* from the Ryoseki group to which the Yoshimo formation can undoubtedly be correlated. However, there is no further fossil evidence to settle the correlation problem. At any rate, the age of the lower Wakino faunule may be Kochian (lower Neocomian) or early Aritan (early upper Neocomian).

Peculiar environmental factors under non-marine condition might have caused the decrease in number of species and the increase in that of individuals in the Wakino fauna as well as in the Yoshimo. Each species of *Viviparus*, *Brotiopsis* and *Sphaerium* has a tendency to form a pure assemblage, often excluding the other species. The shells of small size, such as *V.* (*S.* ?) *onogoensis*, *B. kobayashii kabayashii*, *B. kobayashii sinsyuensis* and *Sphaerium anderssoni anderssoni* made remarkable development in the upper half of the Wakino subgroup. This dwarfing might have also related to the later phase of the long continued but changing fresh-water condition.

4. *Fossils from the Shimonoseki subgroup*

The following molluscan species are found from the lower Shimonoseki or Shiohama formation.

Viviparus (*Sinotaia* ?) *onogoensis*
"*Nippononaia*" (?) *obsoleta*
Sphaerium cf. *anderssoni anderssoni*

From the stratigraphic sequence and the lithologic characters the Shimonoseki subgroup has been correlated to the Shiragi subgroup in South Korea. The diagnostic species of the latter are, according to SUZUKI (1940), *Thiara* (*Siragimelania*) *tateiwai tateiwai*, *T.* (*S.*) *tateiwai acuticostata* and *Trigonioides paucisulcatus paucisulcatus*, and none of them has yet been known from the former. However, it should be noted that "*N.*" (?) *obsoleta* is similar to *T. paucisulcatus paucisulcatus* in the radial surface-sculpture effaced to a high degree. Moreover, *Viviparus* (*Sinotaia* ?) *onogoensis* is known also from the Sansuido and Takkitsu formations of the Shiragi subgroup (SUZUKI, 1943b).

VIII. CORRELATION

The correlation among the late Mesozoic formations of various areas within the West Chugoku-North Kyushu province is summarized in Plate XXXI. For this purpose, not only the fossil-evidence but also the stratigraphic records including sequence of strata, characters of sediments, cycles of sedimentation, disconformities and volcanism are taken into consideration. In the following the correlation of these formations

with the late Mesozoic non-marine strata in some other provinces of the Japanese Islands and the Asiatic continent is also briefly discussed (see Pl. XXXII).

1. *The so-called Inkstone group in Central Chugoku*

In Central Chugoku occur many small and separated exposures of the Cretaceous strata, among which the typical is in the Inakura-mura area, Okayama Prefecture. According to IMAMURA and KUSUMI (1951; see also MATSUMOTO [Editor], 1954), the Inakura formation (or the Inakura Inkstone group) is divided into two subformations, the upper and the lower. The lower subformation begins with a basal conglomerate with some red sediments (the Nishinotani conglomerate) and passes upwards to black shale with a small amount of sandstone (the Yamaji shale). Therefore, it represents one cycle of sedimentation and resembles in lithology the Wakino subgroup. The upper subformation (the Ishizuchiyama "red tuff"), covering the different horizons of the Yamaji shale, consists mainly of red or green taffaceous sediments, and is accordingly very similar in lithology and stratigraphic position to the Shiohama formation of the Shimonoseki subgroup.

The Yamaji shale contains *Viviparus* (*Sinotaia* ?) *onogoensis*, *Sphaerium anderssoni anderssoni* and *S. anderssoni jeholense*, besides estherids and plants. The abundant occurrence of these molluscan species suggests that the lower Inakura subformation can be correlated to the upper or uppermost Wakino formation. It should be noted that the diagnostic species of the lower Wakino faunule have not yet been found anywhere in the Chugoku district. According to KOBAYASHI and KIDO (1947), the estherids from the Naktong subgroup have somewhat larger carapace than those from the Shiragi subgroup and the growth-lines are more numerous in the former than in the latter. In these respects, the Inakura estherian fauna seems to be allied rather to the Naktong than to the Shiragi. I (1958) preliminarily suggested that the Inakura estherian fauna is closely allied also to the Kutsangkou fauna in the lower Fusung formation of South Manchuria, which, in turn, is assigned to the "Lower or Middle" Cretaceous (KOBAYASHI & KUSUMI, 1953). The estherids are now being examined carefully by Hisashi KUSUMI and I hope that the results will be published in the nearest future.

Lavas and pyroclastics of andesite, which may be comparable with the Kitahikoshima volcanic formation, are exposed here and there in Central Chugoku. There are also extensive exposures of rhyolite and rhyodacite with their tuffs and tuff-breccias. The Sensui formation is an example and may possibly be correlated to the Yahata formation.

2. *Kyŏngsang and Bukkokuji groups in South Korea*

OTA (1953, 60b) pointed out that the four formations of the Naktong subgroup correspond respectively to the four formations of the Wakino subgroup lithostratigraphically. From the biostratigraphic point of view, the lower and the upper faunules

of the Wakino subgroup are respectively correlated to the Kinbu and the Shinshu faunules.

The correlation between the Shimonoseki and the Shiragi subgroups, as well as that between the Yahata formation and certain members of the Bukkokuji group, depends almost entirely upon the lithostratigraphic data, such as rock-facies, sequence of strata, positions of disconformities and characters of volcanism. In these respects the two provinces of South Korea (TATEIWA, 1929) and West Chugoku-North Kyushu are considerably harmonic with each other, and it might be suggested that the Kakubo and Saiyakusan volcanic formations correspond to the Kitahikoshima formation and the Shushazan volcanic formtion to the Fukue formation. As stated in the preceding page, "*Nippononaia*" (?) *obsoleta* from the Shimonoseki subgroup resembles *Trigonioides paucisulcatus paucisulcatus* from the Shiragi subgroup.

3. *Tetori group in Central Honshu*

The Tetori group, a thick series of the paralic late Mesozoic strata developed in the Hokuriku-Hida province, has recently been divided by MAEDA (1952–58; see also MATSUMOTO [Editor], 1954 and KAWAI, 1956, 59) into three subgroups of the Kuzuryu, the Itoshiro and the Akaiwa in ascending order.

From the evidence of ammonites the Kuzuryu subgroup is said to range in age from Callovian to Oxfordian or to Kimmeridgian. There is a debate about the age of the Itoshiro subgroup. Although it has long been regarded as Upper Jurassic, some of the recent investigators consider that it ranges up to the Lower Cretaceous. OTA (1960b) suggested that the upper part of this subgroup (the Kuwashima and the Okurodani formations containing *Nippononaia* sp.) might be correlated with the Sengoku formation. I would also support these opinions. The fresh-water fauna listed by MAEDA (1958b) from the Kitadani formation of the Akaiwa subgroup gives us the impression that it is closely allied to the Naktong-Wakino fauna. MAEDA (1959) has very recently described *Polymesoda* (*Paracorbicula*) *sanchuensis* (YABE and NAGAO) and *P.* (*Isodomella*) *kobayashii* MAEDA from the Tochio formation of the same subgroup, considering that the latter resembles *P.* (*I.*) *naumanni* (NEUMAYR). Although the two species seemingly suggest some connection between the Akaiwa and the Ryoseki-Yoshimo faunas, we must remember that some of the Ryoseki elements range up to the Aritan and even to the Miyakoan (see MATSUMOTO [Editor], 1954). As suggested by OTA (1960b), it might be most appropriate to correlate the Akaiwa subgroup excluding the plant-bearing Omichidani formation to the upper half of the Wakino subgroup or thereabouts.

According to KAWAI, the Asuwa group generally overlies unconformably the Akaiwa subgroup and in some places overlaps directly the older basement. It consists of conglomerate, sandstone and shale, associated with tuff and volcanic breccia of rhyolitic origin, and is conformably overlain by the Omodani rhyolites. The fossil florules of Upper Cretaceous age (the Omichidani florule, AMANO and ENDO, 1952; the Asuwa florule, MATSUO and KIDA, 1953; MATSUO, 1954) are said to be contained

in this group, although MAEDA (1952) placed the Omichidani plant-beds at the top of his Akaiwa subgroup. Therefore, the Asuwa group may be correlated rather to the Yahata formation than to the Shimonoseki subgroup.

4. *Cretaceous formations in Central and South Kyushu*

As to the correlation of the continental late Mesozoic strata with the marine ones developed in the Middle and Outer Zones of Southwest Japan, remarks have been presented by some authors. For reference, the correlation summarized by MATSUMOTO (Editor, 1954) is shown in Pl. XXXII, and the common or affinitive species between the Kwanmon-Kyŏngsang group and the non-marine deposits intercalated in the marine Cretaceous are listed below. (As to those between the Yoshimo and the Ryoseki faunas, the readers are requested to see Table 2).

Kochian, or the Ryoseki (lower Neocomian) series:

Nippononaia ryosekiana (SUZUKI) ..... This is closely allied to "*Nippononaia*" *wakinoensis wakinoensis*, and is said to have been collected either from the Katsuragawa valley (Shikoku) or from the Sanchu graben (Kwanto Massif). (SUZUKI, 1954b).

Lower Miyakoan (Aptian) stage:

Brotiopsis cf. *kobayashii kobayashii* SUZUKI

Nakamuranaia (?) sp. cf. *N. chingshanensis* (GRABAU)

Thiara (*Siragimelania*) aff. *japonica* (MATSUMOTO)

They came from the Hinagu formation of the Upper Monobegawa subgroup in the Yatsushiro district (MATSUMOTO & KANMERA, 1952).

Upper Miyakoan (Albian) or the Lower Gyliakian (Cenomanian) stage:

Thiara (*Siragimelania*) *tateiwai acuticostata* SUZUKI ..... From the lower formation of the Mifune group in Kumamoto Prefecture (MATSUMOTO, 1939; SUZUKI, 1940).

T. (*S.*) *japonica* (MATSUMOTO)..... From the lower formation of the Goshonoura group in Amakusa, Kumamoto Prefecture (MATSUMOTO, 1938; SUZUKI, 1940).

Gyliakian (Cenomanian and Turonian) series:

Trigonioides paucisulcatus paucisulcatus SUZUKI

T. matsumotoi KOBAYASHI and SUZUKI

Both from the upper formation of the Goshonoura group in Amakusa (MATSUMOTO, 1938; KOBAYASHI & SUZUKI, 1941; OTA, 1959c).

It should be noted that the species of the Shiragi type are distributed in the Miyako-Gyliakian and are found from the Lower Miyakoan in association with the Naktong-Wakino elements.

5. *Some late Mesozoic strata in China*

According to GRABAU (1923b) and SUZUKI (1943a), the Fuhsin group, which is

developed in the Jehol and Fengtien provinces of South Manchuria, contains the following molluscan shells besides estherids, fresh-water fishes and plants: *Viviparus (Bellamya) clavilithiformis clavilithiformis* (GRABAU), *V. (B.) clavilithiformis conradiformis* SUZUKI, *V. (Sinotaia) tani* (GRABAU), *V. (S.) matumotoi* SUZUKI, *Sphaerium anderssoni anderssoni* (GRABAU) and *S. anderssoni jeholense* (GRABAU). When GRABAU first described these shells, he considered that the Jehol fish-beds in Jehol are of Lower Cretaceous age and that the Yihsien formation in Fengtien and the Hunyüan formation in Shansi are possibly of Upper Cretaceous age, although another possibility of their early Cretaceous age remains. Subsequently, the group in question has come to be assigned to the Upper Jurassic from the analysis of its fauna and flora and has been treated as a representative of the contemporaneous non-marine strata in East Asia (KOBAYASHI, 1942; KOBAYASHI, SUZUKI & TAKAI, 1942; SUZUKI, 1943a, 49; MATSUMOTO [Editor], 1954).

Sphaerium anderssoni is a dominant species of the upper Wakino faunule, ranging from North Kyushu to Central Chugoku. The broader form of *Viviparus (Sinotaia) tani* (SUZUKI's forma *omurai*) is very similar to the narrower form of *V. (S.* ?) *onogoensis*. From the stratigraphic sequence and the paleontological data, the Lower Cretaceous age of the upper half of the Wakino subgroup admits of no doubt. Therefore, it might be allowed to suggest that the Fuhsin group and its equivalent are at least partly referred to the early Cretaceous. If so, the Sunchiawan and the Chengteh formations, which overlie disconformably the Fuhsin group and consist of red sediments with volcanic conglomerate, may possibly be correlated to the Shimonoseki-Shiragi subgroup.

In Shantung, the Laiyang formation is disconformably (?) overlain by the Chingshan formation which contains *Nakamuranaia chingshanensis* (GRABAU). OTA (1960 b) correlated tentatively the latter to the upper half of the Naktong-Wakino subgroup. The former might be also assigned to the early Cretaceous, for it contains *Lycoptera* and *Euestheria* which are respectively comparable with those from the Fuhsin group. I hope that the geological age of the limnic late Mesozoic strata in Manchuria and other parts of China should be in future reexamined through the studies of the fossil flora and fauna including estherids and fishes.

IX. GEOLOGIC HISTORY

As to the late Mesozoic geologic history of West Chugoku (the Nagato province), MATSUMOTO (1949, p. 242) published the following opinion: "During a long period from late Jurassic to a certain age in the middle Cretaceous, a mobile geological condition prevailed, and a tectonic deformation and a remarkable magmatism took place successively. The tectonic deformation does not seem to have been completed in a short epoch, but must have continued and progressed step by step over a comparatively long period,..... In the course of the evolutionary history of the tectogenesis, there are a number of progressive stages or phases, when a record is intensely impres-

sed." At that time, he recognized the following five phases: (1) Post-Toyora-pre-Toyonishi, (2) during the deposition of the Toyonishi group, (3) post-Toyonishi-pre-Inkstone, (4) during the deposition of the middle of the Inkstone group, and (5) post-Inkstone and before the main intrusion of the acid igneous rocks.

From what has been described in the foregoing chapters, the geologic history of the province of West Chugoku and North Kyushu during the late Mesozoic period may be summarized as follows (see Pl. XXXI).

1) Post-Toyora-pre-Toyonishi phase in the late Jurassic

With the retreat of the Toyora sea, the marine environment had come to an end. Subsequently, the Toyonishi group was deposited in a new sedimentary basin of restricted extension, covering the eroded Utano formation of the Toyora group with a remarkable basal facies, which is relatively constant in thickness and lithofacies. This basin was of brackish water environment at least in the later stage.

2) Late- or post-Toyonishi and pre-Wakino phase in the early Lower Cretaceous

At the later stage of the deposition of the Toyonishi group or immediately after the end of it, another sedimentary basin appeared in North Kyushu. A considerably thick series of lacustrine sediments was accumulated there, covering directly the older basement with a basal conglomerate. This is the Wakino subgroup. The birth of this basin, however, is not dated definitely. The Toyonishi group is characterized by the repeated intercalation of conglomerates. Especially in its uppermost part occurs a rather remarkable ill-sorted conglomerate with an erosion-surface at the base, which may show the sedimentation under tectonically unstable condition. Almost simultaneously with the movement of this phase broke out a weak volcanism.

The birth of the Naktong basin in South Korea may correspond to this phase.

3) Mid-Wakino phase in the middle Lower Cretaceous

The Wakino lake which had existed as a restricted basin was extensively expanded towards the east. This expansion seems to have taken place progressively. Although the Wakino subgroup in the type area and its neighborhood is mainly composed of fine-grained sediments, thin layers of conglomerate and slight disconformities (or diastems) are inserted at horizons. They may reflect the occasional upheavals of the depositional basin and the surrounding hinterland. At the northeastern extremity of Kyushu the middle formation of the Wakino subgroup overlaps directly the Paleozoic rocks, and in West Chugoku the upper formation of the same subgroup covers in some places the Toyonishi group disconformably and in others the older Mesozoic strata unconformably. In Central Chugoku, furthermore, the equivalent of the uppermost Wakino formation seems to overlie the basement complex.

The disconformity between the Itoshiro and the Akaiwa subgroups in the Hokuriku-Hida province may be regarded as a product of the movement roughly correlated to

this phase.

The second or the third phase mentioned above may correspond to what has been called the Oga phase by KOBAYASHI (1941). They were, as MATSUMOTO stated, admittedly conspicuous from the paleogeographical point of view, and had some influences also on geologic structure, as suggested by a slight clino-unconformity between the upper Wakino formation and the Utano formation.

4) Post-Wakino-pre-Shimonoseki phase in the late Lower Cretaceous

The depositional basin was extensively upheaved and a part of the Wakino subgroup was eroded away. Subsequently, a new series of sedimentation began with the accumulation of a remarkable conglomerate, which is ill-sorted and consists of cobbles and boulders of various kinds of both sedimentary and volcanic rocks. This is the basal formation of the Shimonoseki subgroup. The renewed basin (i. e. the Inkstone lake) spread over the area which had formerly been covered with the Wakino lake. Generally the Shimonoseki subgroup overlies the Wakino with a marked disconformity, although in some places the change from the latter to the former is gradual and continuous. In West and Central Chugoku, furthermore, the Shimonoseki subgroup sometimes overlaps directly the basement complex. With the beginning of the deposition of the Shimonoseki subgroup the volcanism became active. It was mostly andesitic and partly dacitic to rhyolitic.

The epeirogenetic movement of this phase occurred also in Central Chugoku (the movement immediately before the sedimentation of the upper Inakura formation) and South Korea (the pre-Shiragi movement).

5) Mid-Shimonoseki phase in the latest Lower Cretaceous or earliest Upper Cretaceous

In the course of the intense volcanic activity which showed its climax in the Kitahikoshima age, a moderate epeirogenetic movement took place. A disconformity is inserted between the Kitahikoshima and the Sujigahama formations, the latter of which is characterized by a vast amount of ill-sorted, volcanic or polygenetic cobble-conglomerate.

The corresponding earth-movement is recognized in South Korea (the disconformity between the Saiyakusan and the Kansenri formations).

6) Post-Shimonoseki-pre-Yahata phase in the middle Upper Cretaceous

The Kanmon group, together with the underlying Toyonishi group, seems to have been folded and faulted to some extent, and at the same time suffered a considerable erosion. Subsequently, the Yahata formation composed of lavas and pyroclastics with a small amount of terrigenous sediments was accumulated in several new basins of restricted extension; its base is in contact in some places with the Shimonoseki subgroup and in others with the Wakino. The volcanism of this age was exclusively dacitic to rhyolitic.

The Pre-Asuwa movement in the Hokuriku-Hida province and the pre-Bukkokuji

one in South Korea may correspond to this phase.

7) Post-Yahata phase in the late Upper Cretaceous

All the late Mesozoic strata including the Yahata formation were gently or moderately or in some cases rather intensely folded. The intensity of the folding varies according to the thickness of strata and the character of foundation. After the folding and faulting, acid igneous rocks such as quartz-porphyry, granite-porphyry and granite were extensively intruded. (Porphyrite, gabbro, diorite and quartz-diorite are considered to be related to the volcanic activity during the Shimonoseki epoch.) The late Mesozoic igneous history of West Chugoku is now being investigated carefully by Nobuhide MURAKAMI.

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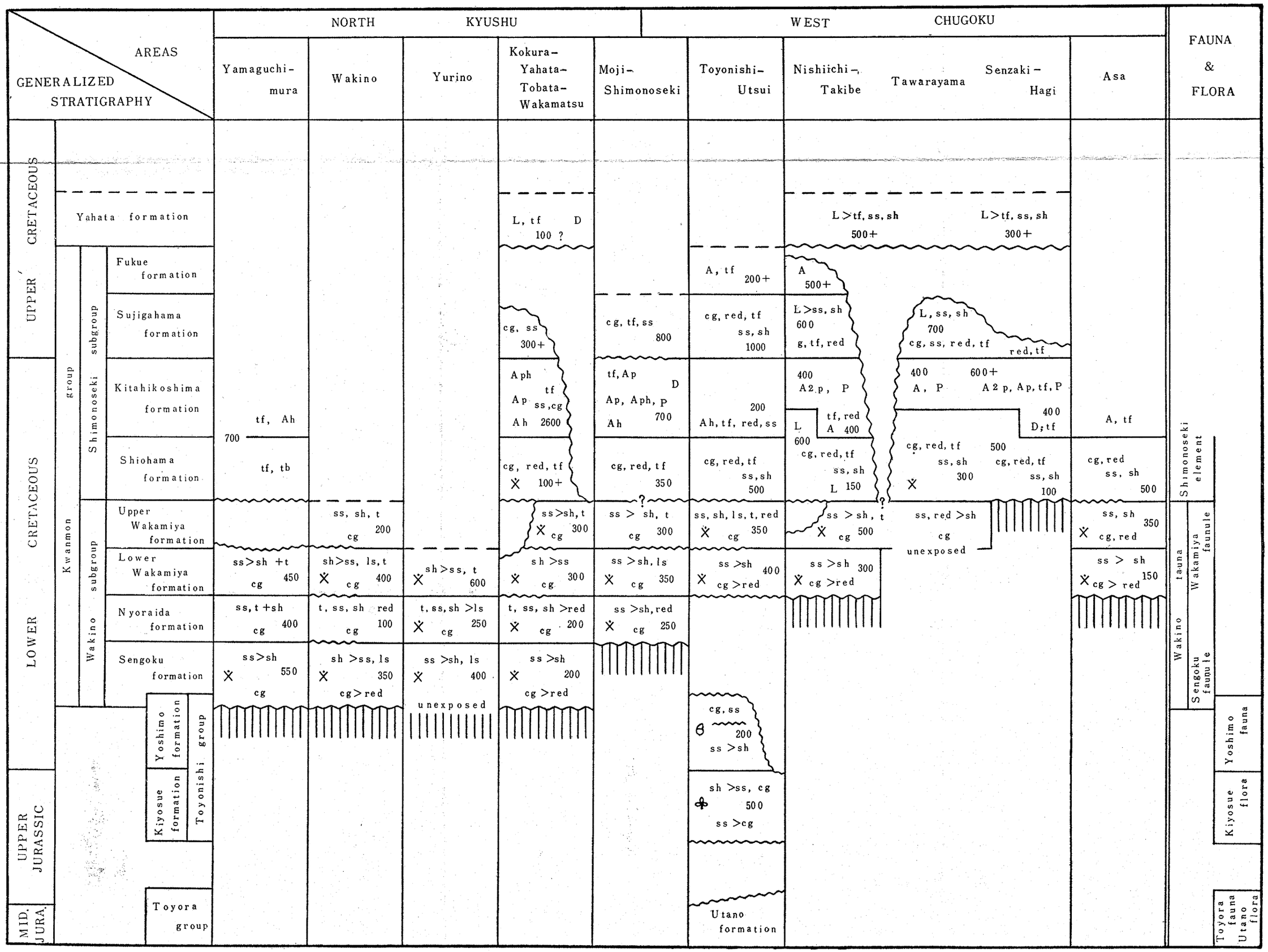
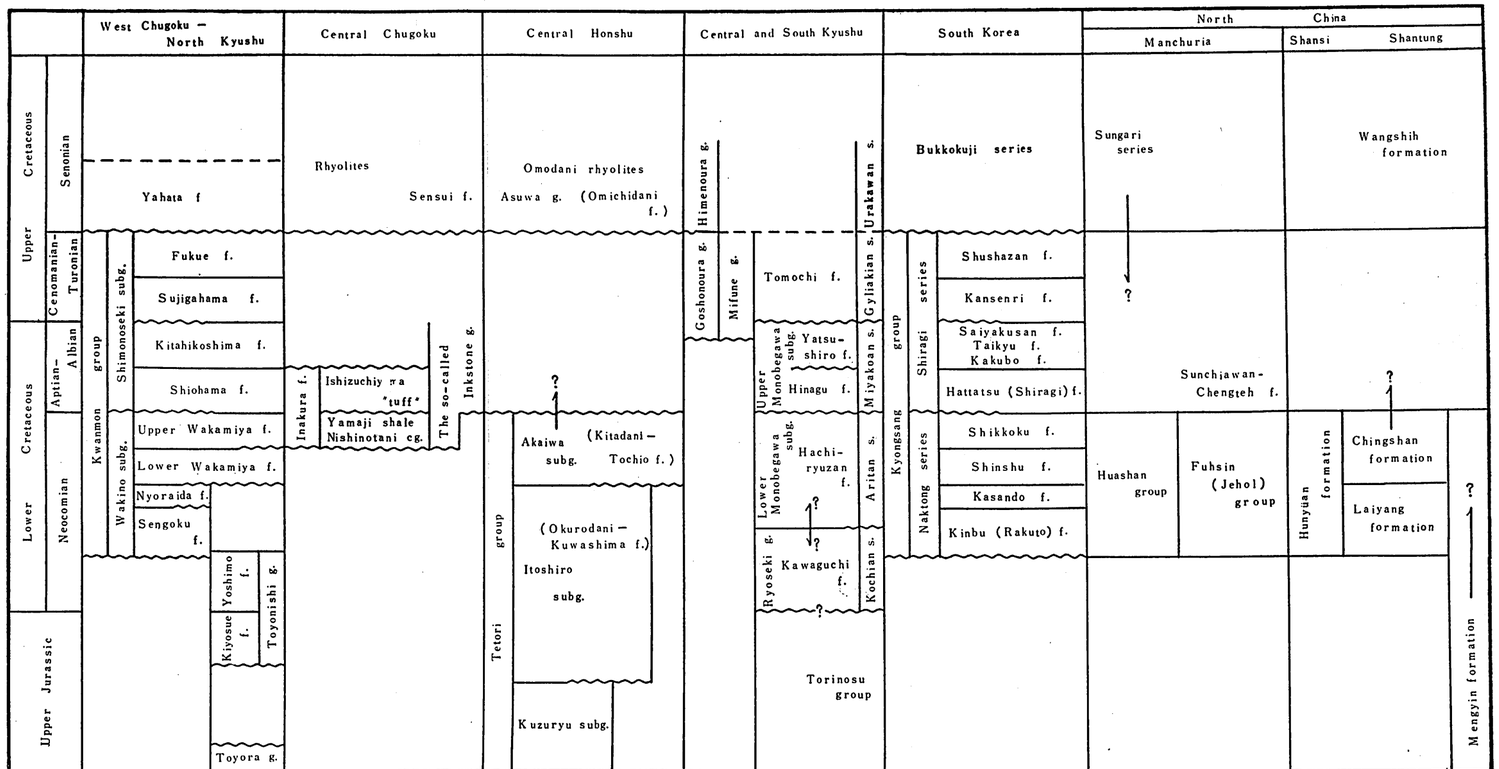


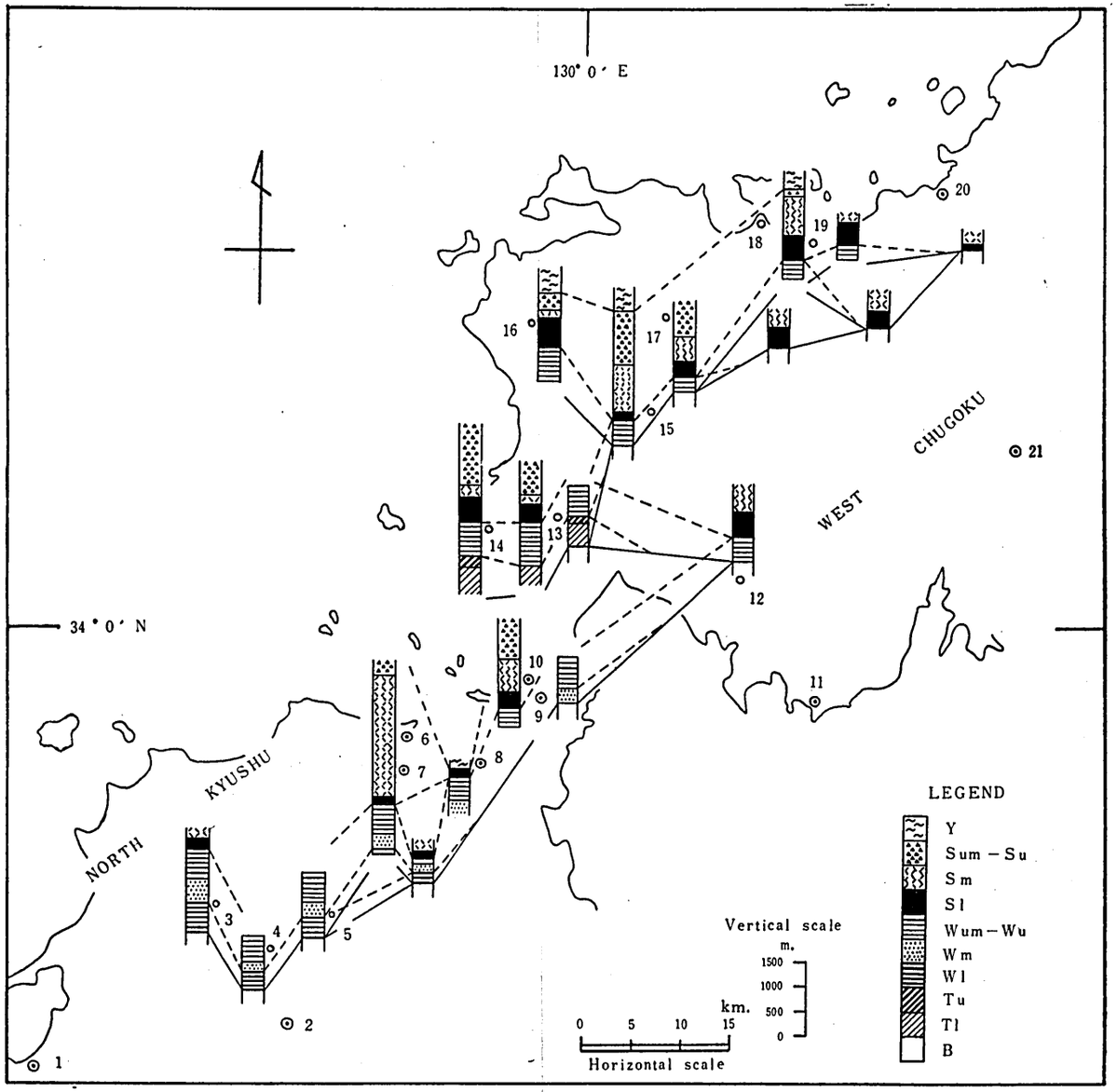
PL. XXXI. CLASSIFICATION AND CORRELATION OF THE LATE MESOZOIC FORMATIONS IN WEST CHUGOKU AND NOTRH KYUSHU.

Basement rocks, Unconformity, Disconformity, Fossil plants, Brackish water shells, Fresh-water shells,
Numerals: Approximate thickness, cg: Conglomerate, ss: Sandstone, sh: Shale, ls: Limestone, t: Tuffaceous sandstone or siliceous shale, red: Red sediments, tf: Tuff and tuff-breccia, A: Andesite, Ah: Hornblende-andesite, Aph: Pyroxene-hornblende-andesite, Ap: Pyroxene-andesite, A2p: Two-pyroxene-andesite, P: Porphyrite, D: Dacite, L: Rhyodacite or rhyolite.



PL. XXXII. A TENTATIVE CORRELATION OF SOME LIMNIC AND PARALIC LATE MESOZOIC STRATA IN WEST JAPAN, SOUTH KOREA AND NORTH CHINA.

s.: series, g.: group, subg.: subgroup, f.: formation.



PL. XXXIII. DIAGRAMMATIC ILLUSTRATION OF THE STRATIGRAPHY OF THE LATE MESOZOIC FORMATIONS IN WEST CHUGOKU AND NORTH KYUSHU.

Y: Yahata formation, Sum-Su: Fukue & Sujigahama formations, Sm: Kitahikoshima formation, Sl: Shiohama formation, (S: Shimonoseki subgroup), Wum-Wu: Upper Wakamiya & Lower Wakamiya formations, Wm: Nyoraida formation, Wl: Sengoku formation, (W: Wakino subgroup), Tu: Yoshimo formation, Tl: Kiyosue formation, (T: Toyonishi group), B: Basement rocks.

1: Fukuoka, 2: Izuka, 3: Yamaguchi, 4: Wakino, 5: Yurino, 6: Wakamatsu, 7: Yahata, 8: Kokura, 9: Moji, 10: Shimonoseki, 11: Ube, 12: Asa, 13: Utsui, 14: Toyonishi, 15: Nishiichi, 16: Takibe, 17: Tawarayama, 18: Senzaki, 19: Misumi, 20: Hagi, 21: Yamaguchi.

GEOLOGICAL MAP OF THE LATE MESOZOIC IN WEST CHUGOKU AND NORTH KYUSHU

130° 30′

131° 0′ E

131° 30′

34° 20′

34° 0′ N

33° 40′

OMI-JIMA
HAGI
SANMI
SEN-ZAKI
YUYA-WAN
TSUNO-SHIMA
AWANO
MISUMI
TAKIBE
KANDA-MISAKI
TAWARA-YAMA
TONOI
OFUKU
KAMA
OTA
NISHIICHI
YAMAGUCHI PREFECTURE
OMINE
YAMAGUCHI
OGUSHI
GESAN
FUTAI-JIMA
TABE
UTSUI
OGORI
YOSHIMO
OZUKI
KIYOSUE
ASA
FUNAKI
YASUOKA
CHOFU
SHIMONO-SEKI
THE KWANMON STRAIT
HIKOSHIMA
O-SHIMA
WAKAMATSU
TOBATA
KOKURA
MOJI
ASHIYA
ORIO
YAHATA
TOGO
AKAMA
KATSUKI
FUKUMA
NOGATA
YAMAGUCHI
FUKUMARU
YURINO
ONO
FUKUOKA PREFECTURE
YUKUHASHI
WAKINO
IZUKA

0 5 10 15 20 km.

- Quaternary
- Tertiary
- Granite
- Granodiorite, diorite and gabbro
- Rhyolite and quartz-porphyry
- Porphyrite and diorite
- Yahata formation
- Undivided
- Fukue and Sujigahama formations
- Kitahikoshima formation
- Shiohama formation

  } Shimonoseki subgroup

- Upper Wakamiya, Lower Wakamiya and Nyoraida formations
- Sengoku formation

  } Wakino subgroup

- Yoshimo formation
- Kiyosue formation

  } Toyonishi group

- Jurassic Toyora group and Triassic Miné and Atsu groups
- Paleozoic Chichibu supergroup
- Paleozoic Sangun metamorphic group

PL. XXXIV. COMPILED GOELOGICAL MAP OF THE LATE MESOZOIC IN WEST CHUGOKU AND NORTH KYUSHU.

Explanation of Plate XXXV

Viviparus (*Sinotaia* ?) *onogoensis* Kobayashi and Suzuki ..... p. 303

Fig. 1. Back view, × 1. 5. IGSH-HA 1; loc. 24; Nyoraida formation (Coll. T. Matsumoto & A. Hase).

Fig. 2. Back view, × 1. 5. IGSH-HA 2; loc. 24; Nyoraida formation (Coll. T. M. & A. H.).

Fig. 3. Back view, × 1. 5. IGSH-HA 3; loc. 24; Nyoraida formation (Coll. T. M. & A. H.).

Fig. 4. Back view, × 1. 5. GK. H 6067; loc. 50; Lower Wakamiya formation (Coll. N. Nameishi).

Fig. 5. Back view, × 1. 5. IGSH-HA 5; loc. 42; Upper Wakamiya formation (Coll. M. Inoue, T. M. & A. H.).

Fig. 6. Back view of the internal mould, × 1. 5. IGSH-HA 11; loc. 79; Upper Wakamiya formation.

Brotiopsis wakinoensis (Kobayashi and Suzuki) ..... p. 305

Fig. 7. External moulds, × 1. IGSH-HA 51; loc. uncertain in the Wakino area; Sengoku formation (Coll. Y. Ota).

Fig. 8. External mould, × 1. 5. GK. H 6069; loc. uncertain in the Wakino area; Sengoku formation (Coll. M. Kuzuna & S. Aiba).

Fig. 9. External mould, × 1. 5. GK. H 6068; loc. uncertain in the Wakino area; Sengoku formation (Coll. M. K. & S. A.).

Fig. 10. External mould, × 1. IGSH-HA 59; loc. 5; Sengoku formation.

Fig. 11. External moulds, × 1. IGSH-HA 66; loc. 6; Sengoku formation.

Fig. 12. External mould, × 1. IGSH-HA 75; loc. 21; Sengoku formation.

Figs. 13–16. External moulds of immature shells, showing the details of surface-ornament, × ca. 3. 5.

13: IGSH-HA 60; loc. 5; Sengoku formation.

14: IGSH-HA 61; loc. 5; Sengoku formation.

15: IGSH-HA 69; loc. 7; Sengoku formation.

16: GK. H 6070; loc. uncertain in the Wakino area; Sengoku formation (Coll. M. K. & S. A.).

Brotiopsis kobayashii kobayashii Suzuki ..... p. 307

Fig. 17. Back view, × 2. IGSH-HA 91; loc. 13; Sengoku formation (Coll. Y. Kondo & A. Hase).

Fig. 18. Back view, × 2. IGSH-HA 93; loc. 17; Nyoraida formation (Coll. Y. K. & A. H.).

Fig. 19. Back view, × 2. IGSH-HA 95; loc. 17; Nyoraida formation (Coll. Y. K. & A. H.).

Fig. 20. A compressed specimen, × 2. IGSH-HA 110; loc. 83; Lower Wakamiya formation.

Fig. 21. External mould, × 2. IGSH-HA 112; loc. 83; Lower Wakamiya formation.

Fig. 22. Back view, × 1. 5. IGSH-HA 106; loc. 77; Lower Wakamiya formation (Coll. H. Kajino & A. Hase).

Fig. 23. Front view, × 2. IGSH-HA 107; loc. 77; Lower Wakamiya formation (Coll. H. K. & A. H.).

Fig. 24. External mould, × 2. GK. H 6072; loc. 32; Lower Wakamiya formation (Coll. N. Nameishi).

Fig. 25. External mould, showing the details of surface-ornament in the immature stage, × ca. 3. 5. IGSH-HA 99; loc. 33; Lower Wakamiya formation.

Brotiopsis kobayashii sinsyuensis Suzuki ..... p. 309

Fig. 26. External mould, × 2. IGSH-HA 116; loc. 18; Lower Wakamiya formation (Coll. Y. Kondo & A. Hase).

Fig. 27. External mould, × 2. IGSH-HA 117; loc. 18; Lower Wakamiya formation (Coll. Y. K. & A. H.).

Fig. 28. External mould, × 2. IGSH-HA 118; loc. 18; Lower Wakamiya formation (Coll. Y. K. & A. H.).

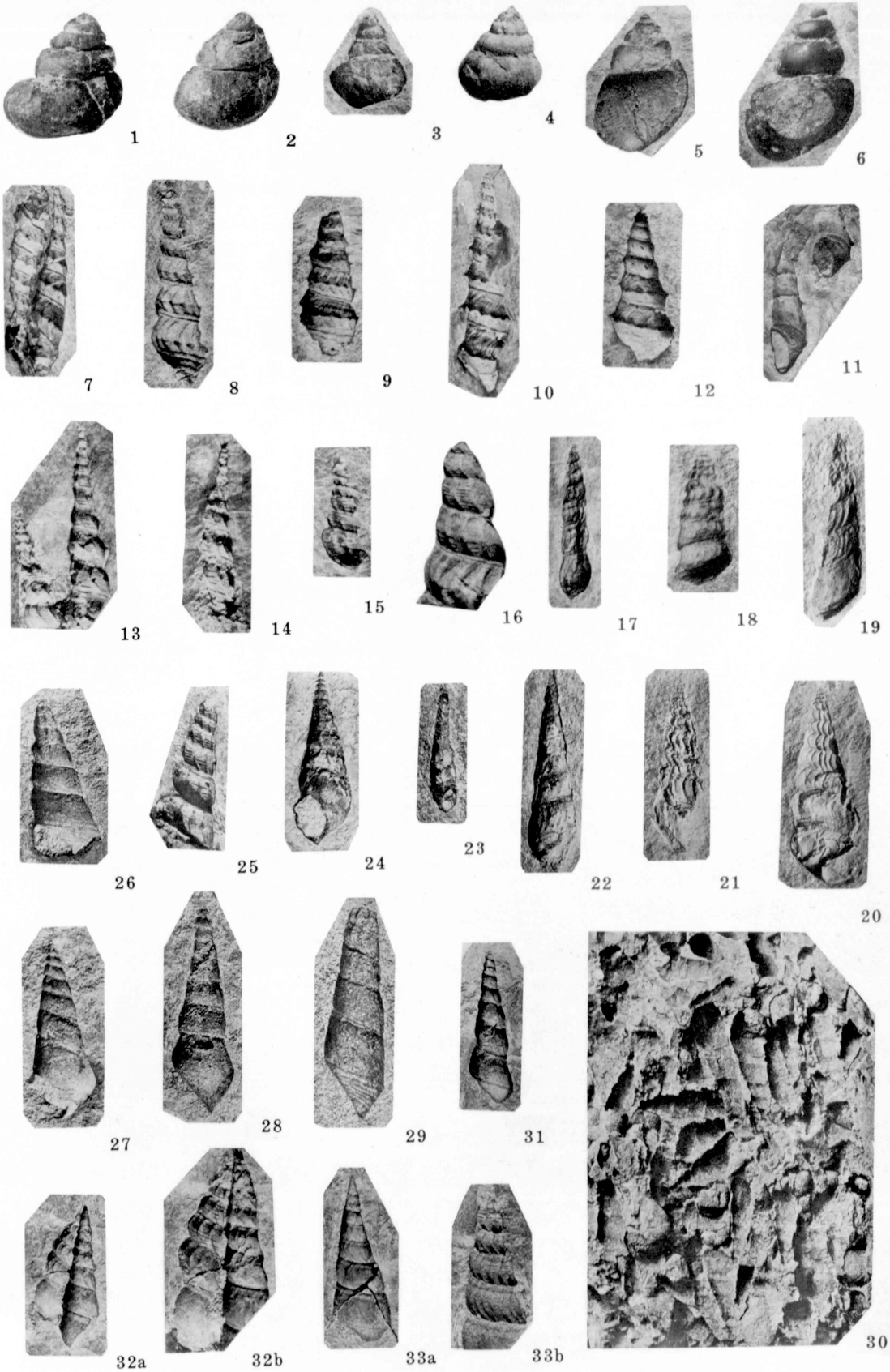
Fig. 29. An incomplete external mould, × 2. IGSH-HA 119; loc. 18; Lower Wakamiya formation (Coll. Y. K. & A. H.).

Fig. 30. External moulds, × 2. IGSH-HA 124; loc. 41b; Upper Wakamiya formation.

Fig. 31. External mould, × 2. IGSH-HA 125A; loc. 85; Upper Wakamiya formation.

Fig. 32. External moulds; general view (32a, × 2) and the partial enlargement showing the details of surface-ornament in the immature stage (32b, × ca. 3. 5). IGSH-HA 125C, D; loc. 85; Upper Wakamiya formation.

Fig. 33. External mould; general view (33a, × 2) and the partial enlargement showing the details of surface-ornament in the immature stage (33b, × ca. 3. 5). IGSH-HA 125B; loc. 85; Upper Wakamiya formation.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33a
33b

Explanation of Plate XXXVI

Melanoides (*Yoshimonia*) *yoshimoensis* Ota

Fig. 1. External mould, apertural (1a) and back (1b) sides, ×2. IGSH-HA 251; loc. 66; Yoshimo formation (Coll. H. Kajino & A. Hase).

Melanoides (*Yoshimonia*) aff. *yoshimoensis* Ota

Fig. 2. Front view, ×1. IGSH-HA 256; loc. 67; Yoshimo formation.

Fig. 3. Front view, ×1. IGSH-HA 257; loc. 67; Yoshimo formation.

Fig. 4. Back view, ×1.5. IGSH-HA 262; loc. 67; Yoshimo formation.

Fig. 5. A fragmentary shell, ×1.5. IGSH-HA 263; loc. 67; Yoshimo formation.

Fig. 6. Back view, ×1.5. IGSH-HA 258A; loc. 67; Yoshimo formation.
Coll. H. Kajino & A. Hase.

Melanoides (*Yoshimonia*) *katsukiensis* Ota ..... p. 310

Fig. 7. External mould, ×2. IGSH-HA 115; loc. 36; Upper Wakamiya formation.

Fig. 8. External mould, showing the details of surface-ornament in the immature stage, ×ca. 3.5. IGSH-HA 114; loc. 36; Upper Wakamiya formation.

Melanoides (*Yoshimonia*) *kokurensis* n. sp. ..... p. 310

Fig. 9. External mould; general view (9a, ×2) and the partial enlargement showing the details of surface-ornament in the immature stage (9b, ×ca. 3.5). Holotype, GK. H 6074; loc. 22; Sengoku formation.

Fig. 10. External mould, apertural (10a) and back (10b) sides, ×2. Paratype, GK. H 6075; loc. 22; Sengoku formation.

Fig. 11. External mould, ×2. GK. H 6076; loc. 22; Sengoku formation.

Fig. 12. A fragmentary external mould, ×2. GK. H 6077; loc. 22; Sengoku formation.
Coll. M. Kuga.

Thiara (*Siragimelania*) cf. *tateiwai* Suzuki ..... p. 312

Fig. 13. Back view, ×2. IGSH-HA 31; loc. 13; Sengoku formation (Coll. Y. Kondo & A. Hase).

Brotiopsis aff. *wakinoensis* (Kobayashi and Suzuki) ..... p. 307

Fig. 14. An incomplete external mould, ×1. IGSH-HA 89; loc. 5; Sengoku formation (Coll. Y. Ota).

Gyraulus (?) n. sp. (?) ..... p. 313

Fig. 15. Basal view, ×5. IGSH-HA 41; loc. 81; Upper Wakamiya formation (Coll. S. Imamura & K. Wada).

Fig. 16. External mould, basal side, ×5. IGSH-HA 44; loc. 81; Upper Wakamiya formation (Coll. S. I. & K. W.).

Fig. 17. A depressed specimen, ×5. IGSH-HA 42; loc. 81; Upper Wakamiya formation (Coll. S. I. & K. W.).

Fig. 18. External mould, basal side, ×5. IGSH-HA 43; loc. 81; Upper Wakamiya formation (Coll. Y. Shigeoka & A. Hase).

Fig. 19. Basal view, ×5. IGSH-HA 45; loc. 81; Upper Wakamiya formation (Coll. Y. S. & A. H.).

Fig. 20. External mould, basal side, ×5. IGSH-HA 46; loc. 81; Upper Wakamiya formation (Coll. Y. S. & A. H.).

Fig. 21. Basal view of a fragmentary specimen, ×5. IGSH-HA 47; loc. 81; Upper Wakamiya formation (Coll. Y. S. & A. H.).

Fig. 22. Basal view of a deformed internal mould, ×5. IGSH-HA 48; loc. uncertain in the Wakino area; Sengoku formation (Coll. Y. Ota).

Limnoperna (?) *sengokuensis* n. sp. ..... p. 318

Fig. 23. Left valve, ×1.5. Holotype, IGSH-HA 161; loc. 10; Sengoku formation.

Fig. 24. Left valve of immature stage, ×2. IGSH-HA 162A; loc. 10; Sengoku formation.

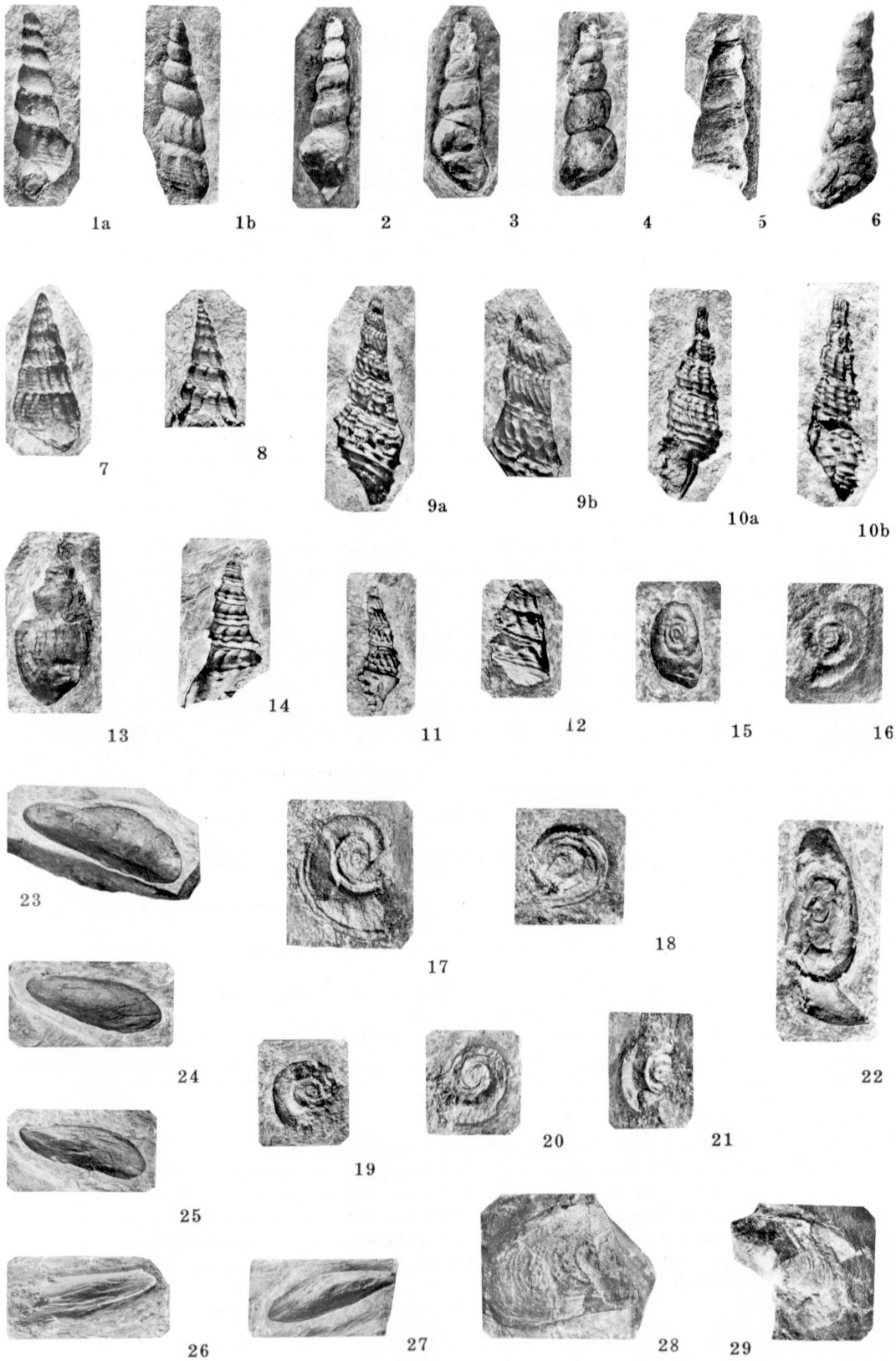
Fig. 25. Left valve of immature stage, ×2. IGSH-HA 162B; loc. 10; Sengoku formation.

Fig. 26. Right valve of immature stage, ×2. IGSH-HA 162C; loc. 10; Sengoku formation.

Fig. 27. Right valve of immature stage, ×2. IGSH-HA 162D; loc. 10; Sengoku formation.

Fig. 28. A fragmentary right valve, ×1.5. IGSH-HA 164; loc. 77; Lower Wakamiya formation (Coll. H. Kajino & A. Hase).

Fig. 29. Left valve, ×2. IGSH-HA 163; loc. 77; Lower Wakamiya formation (Coll. H. K. & A. H.).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Explanation of Plate XXXVII

"Nippononaia" wakinoensis wakinoensis Ota ..... p. 315

Fig. 1. Right internal mould, showing the hinge-character, × 1. GK. H 6079; loc. uncertain in the Wakino area; Sengoku formation (Coll. M. Kuzuna & S. Aiba).

Fig. 2. An incomplete left internal mould, showing the hinge-character, × 1. GK. H 6080; loc. uncertain in the Wakino area; Sengoku formation (Coll. M. K. & S. A.).

Fig. 3. An incomplete right external mould, × 1. IGSH-HA 131; loc. uncertain in the Wakino area; Sengoku formation (Coll. Y. Ota).

Fig. 4. Right valve of immature stage, × 1. GK. H 6081; loc. 35; Lower Wakamiya formation (Coll. Y. Kamura).

"Nippononaia" wakinoensis intermedia n. subsp. ..... p. 316

Fig. 5. Internal mould of a bivalved shell with surface-ornament impressed upon it, × 1. Holotype, IGSH-HA 136; loc. 81; Upper Wakamiya formation.

Fig. 6. Right internal mould with surface-ornament impressed upon it, × 1. Paratype, IGSH-HA 137; loc. 81; Upper Wakamiya formation.

Fig. 7. Left external mould, × 1. Paratype, IGSH-HA 138; loc. 81; Upper Wakamiya formation.

Fig. 8. An incomplete right external mould, × 1. IGSH-HA 140; loc. 81; Upper Wakamiya formation.

Fig. 9. An incomplete right internal mould with surface-ornament impressed upon it, × 1. IGSH-HA 139; loc. 81; Upper Wakamiya formation.
Coll. S. Imamura & K. Wada.

"Nippononaia" (?) *obsoleta* n. sp. ..... p. 317

Fig. 10. Right (10a), left (10b) and dorsal (10c, d) views of conjoined valves; a, b and c, × 1; d, showing the V-sculpture on the umbonal area of the right valve, × 2. Holotype, IGSH-HA 166; loc. 82; Shiohama formation (Coll. K. Sumikawa & A. Hase).

Fig. 11. Right valve, × 1. Paratype, GK. H 6082; loc. 82; Shiohama formation (Coll. K. Kikuchi, K. Harada & H. Mitsushio),

Sphaerium anderssoni anderssoni (Grabau) ..... p. 319

Fig. 12. Right internal mould, × 2. IGSH-HA 171; loc. 18; Lower Wakamiya formation (Coll. Y. Kondo & A. Hase).

Fig. 13. Left internal mould, × 2. IGSH-HA 172; loc. 18; Lower Wakamiya formation (Coll. Y. K. & A. H.).

Fig. 14. Internal mould of a bivalved shell, × 2. IGSH-HA 177; loc. 26; Lower Wakamiya formation.

Fig. 15. Left internal mould with surface-ornament impressed upon it, × 2. IGSH-HA 195; loc. 81; Upper Wakamiya formation (Coll. Y. Shigeoka & A. Hase).

Corbula (?) *imamurae* n. sp. ..... p. 324

Fig. 16. Right valve, × 1. 2. Holotype, IGSH-HA 271; loc. 59; Yoshimo formation.

Fig. 17. Right valve, × 1. 2. Paratype, IGSH-HA 272; loc. 59; Yoshimo formation.

Fig. 18. Left valve, × 1. 2. Paratype, IGSH-HA 273; loc. 59; Yoshimo formation.

Fig. 19. Left valve, × 1. 5. Paratype, IGSH-HA 274; loc. 59; Yoshimo formation.

Fig. 20. Right valve, × 1. 5. IGSH-HA 275; loc. 59; Yoshimo formation.

Fig. 21. Left view of conjoined valves, × 1. GK. H 6096; loc. Ohata, Utsui-mura, Yamaguchi Pref.; Yoshimo formation (Coll. E. Takahashi).

Fig. 22. Right internal mould (21a) and its dorsal view (21b), × 1. IGSH-HA 279; loc. 67; Yoshimo formation.

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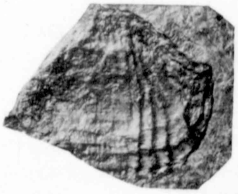

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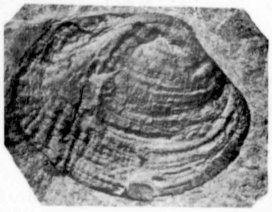

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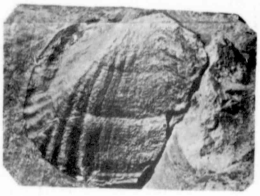

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Explanation of Plate XXXVIII

"Nippononaia" (?) *obsoleta* n. sp. ..... p. 317

Fig. 1. Internal mould of a bivalved shell (1a) and its ventral view (1b), × 1. Paratype, IGSH-HA 167; loc. 82; Shiohama formation (Coll. K. Sumikawa & A. Hase).

"Nippononaia" wakinoensis intermedia n. subsp. ..... p. 316

Fig. 2. An incomplete left external mould, × 1. IGSH-HA 141; loc. 81; Upper Wakamiya formation (Coll. S. Imamura & K. Wada).

Fig. 3. Internal mould of a bivalved shell, × 1. IGSH-HA 142; loc. 81; Upper Wakamiya formation (Coll. Y. Shigeoka & A. Hase).

Sphaerium anderssoni anderssoni (Grabau) ..... p. 319

Fig. 4. Right internal mould, × 2. IGSH-HA 176; loc. 20; Lower Wakamiya formation (Coll. Y. Kondo & A. Hase).

Fig. 5. Right internal mould, × 2. IGSH-HA 174; loc. 19; Lower Wakamiya formation (Coll. Y. K. & A. H.).

Fig. 6. Internal mould of a bivalved shell, × 2. IGSH-HA 178; loc. 26; Lower Wakamiya formation.

Fig. 7. Right internal mould, × 2. IGSH-HA 179; loc. 26; Lower Wakamiya formation.

Fig. 8. Right internal mould with some shell adhering, × 2. 2. IGSH-HA 181; loc. 27; Lower Wakamiya formation.

Fig. 9. Internal (9a) and external (9b) moulds of an incomplete right valve, showing the hinge-character and the surface-ornament respectively, × 2. IGSH-HA 182; loc. 27; Lower Wakamiya formation.

Fig. 10. Right internal mould, × 2. IGSH-HA 185; loc. 31a; Lower Wakamiya formation.

Fig. 11. Left valve, × 2. GK. H 6083; loc. 50; Lower Wakamiya formation (Coll. N. Nameishi).

Fig. 12. Right internal mould, showing the hinge-character, × 2. 2. IGSH-HA 186; loc. 41a; Upper Wakamiya formation.

Fig. 13. Right internal mould, × 2. IGSH-HA 189; loc. 42; Upper Wakamiya formation (Coll. T. Matsumoto, M. Inoue & A. Hase).

Fig. 14. Internal mould of a bivalved shell with surface-ornament impressed upon it, × 2. IGSH-HA 194; loc. 81; Upper Wakamiya formation (Coll. Y. Shigeoka & A. Hase).

Fig. 15. Left internal mould, × 2. IGSH-HA 196; loc. 85; Upper Wakamiya formation.

Fig. 16. Dorsal view of the internal mould of conjoined valves, × 2. IGSH-HA 199; loc. 85; Upper Wakamiya formation.

Fig. 17. Left internal mould with surface-ornament impressed upon it, × 1. 5. IGSH-HA 203; loc. Yamaji, Inakura-mura, Oda-gun, Okayama Pref.; Yamaji shale of the Inakura formation (Coll. H. Kusumi).

Fig. 18. Left internal mould, × 2. IGSH-HA 212; loc. Jokan-zan, Inakura-mura, Oda-gun, Okayama Pref.; Yamaji shale (Coll. H. K.).

Fig. 19. Right internal mould, × 2. IGSH-HA 202; loc. Uneyama, Inakura-mura, Oda-gun, Okayama Pref.; Yamaji shale (Coll. H. K.).

Fig. 20. Left internal mould, × 2. IGSH-HA 205; loc. Uneyama; Yamaji shale (Coll. H. K.).

Fig. 21. A deformed right internal mould, showing the hinge-character, × 2. 2. IGSH-HA 210; loc. Uneyama; Yamaji shale (Coll. H. K.).

Fig. 22. Left internal mould, × 1. 5. IGSH-HA 211; loc. uncertain in the Inakura-mura area; Yamaji shale (Coll. H. K.).

Fig. 23. Left internal mould, × 2. IGSH-HA 204; loc. uncertain in the Inakura-mura area; Yamaji shale (Coll. H. K.).

Fig. 24. External (24a) and internal (24b) moulds of a right valve, showing the surface-ornament and the hinge-character respectively, × 2. IGSH-HA 201; loc. uncertain in the Inakura-mura area; Yamaji shale (Coll. H. K.).

Sphaerium anderssoni jeholense (Grabau) ..... p. 321

Fig. 25. Right internal mould, × 2. IGSH-HA 216; loc. 19; Lower Wakamiya formation (Coll. Y. Kondo & A. Hase).

Fig. 26. An incomplete left internal mould, × 2. IGSH-HA 218; loc. 80; Lower Wakamiya formation.

Fig. 27. Left internal mould, × 2. IGSH-HA 219; loc. 80; Lower Wakamiya formation.

Fig. 28. An incomplete right internal mould with surface-ornament impressed upon it, × 2. IGSH-HA 217; loc. 80; Lower Wakamiya formation.

Fig. 29. Right view of the internal mould of conjoined valves, × 2. IGSH-HA 221; loc. 85; Upper Wakamiya formation.

Fig. 30. Left internal mould, × 1. 5. IGSH-HA 222; loc. Uneyama, Inakura-mura, Oda-gun, Okayama Pref.; Yamaji shale of the Inakura formation (Coll. H. Kusumi).

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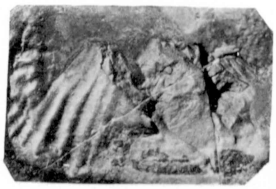

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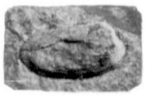

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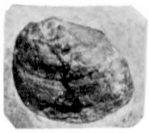

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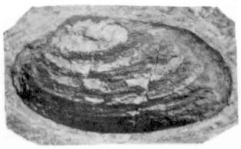

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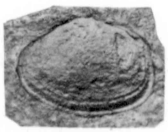

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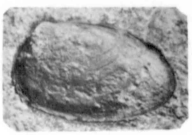

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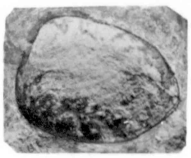

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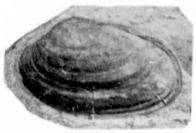

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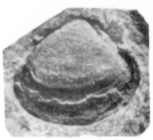

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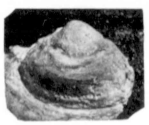

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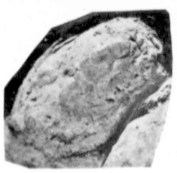

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Explanation of Plate XXXIX

Plicatounio aff. *naktongensis naktongensis* Kobayashi and Suzuki ..... p. 313

Fig. 1. Dorsal view of the internal mould of conjoined valves, × 1. GK. H 6078; loc. 48; Upper Wakamiya formation (Coll. Y. Kamura).

Corbula (?) *imamurae* n. sp. ..... p. 324

Fig. 2. Left valve, × 1. 5. IGSH-HA 278; loc. 61; Yoshimo formation.

Fig. 3. Left valve, × 1. 5. IGSH-HA 276; loc. 59; Yoshimo formation.

Fig. 4. Left internal mould, showing the hinge-character, × 1. IGSH-HA 280; loc. 67; Yoshimo formation.

Corbula matsumotoi n. sp. ..... p. 322

Fig. 5. Right (5a), left (5b), dorsal (5c) and anterior (5d) views of conjoined valves, × 2. Holotype, GK.[1]H 6084; loc. Saka-yori-kami, Kawamata-mura, Yatsushiro-gun, Kumamoto Pref.; Kawaguchi formation.

Fig. 6. Right (6a), left (6b), dorsal (6c) and anterior (6d) views of conjoined valves, × 2. Paratype, GK. H 6085; loc. and form. do.

Fig. 7. Right valve, × 1. 5. Paratype, GK. H 6086; loc. and form. do.

Fig. 8. Left valve, × 2. Paratype, GK. H 6087; loc. and form. do.

Fig. 9. Left valve, × 2. GK. H 6088; loc. and form. do.

Fig. 10. Right (10a) and left (10b) views of conjoined valves, × 1. 5. GK. H 6089; loc. and form. do.

Fig. 11. Right (11a) and left (11b) views of conjoined valves, × 1. 5. GK. H 6090; loc. and form. do.

Fig. 12. Right valve, × 1. 5. GK. H 6091; loc. and form. do.

Fig. 13. Left valve, × 2. GK. H 6092; loc. and form. do.

Fig. 14. Left valve, × 2. GK. H 6093; loc. and form. do.

Fig. 15. Right internal mould, showing the hinge-character, × 2. GK. H 6094; loc. and form. do.

Fig. 16. Left internal mould, showing the hinge-character, × 2. GK. H 6095; loc. and form. do.

Coll. K. Kanmera.

Fig. 17. Right internal mould, × 2. IGSH-HA 296; loc. 67; Yoshimo formation.

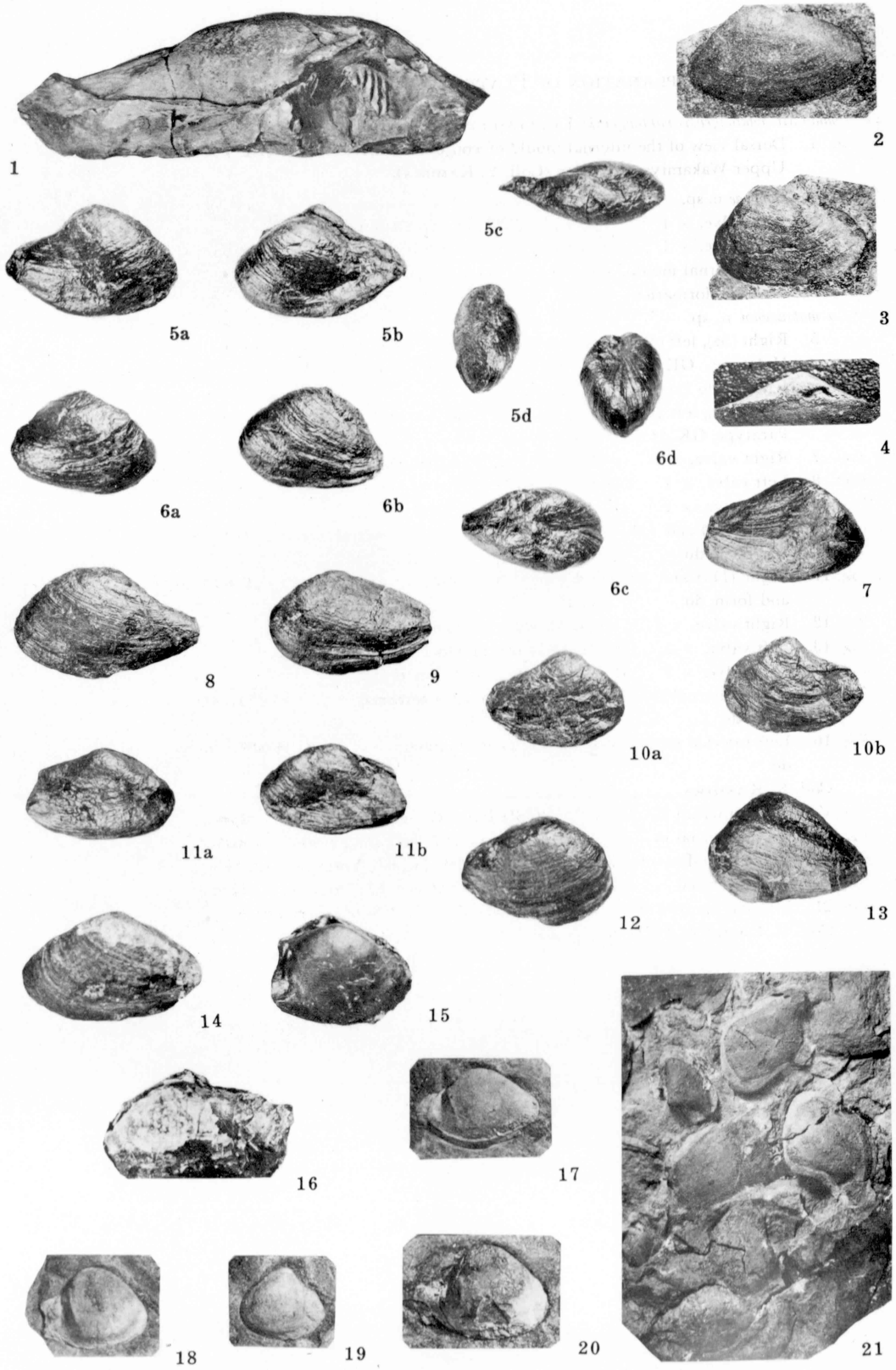
Fig. 18. Right internal mould, × 2. IGSH-HA 297; loc. 67; Yoshimo formation.

Fig. 19. Left internal mould, × 2. IGSH-HA 298; loc. 67; Yoshimo formation.

Fig. 20. Right internal mould, × 2. IGSH-HA 299; loc. 67; Yoshimo formation.

Fig. 21. Internal moulds, × 2. IGSH-HA 300; loc. 67; Yoshimo formation.

Coll. H. Kajino & A. Hase.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