Geology and Paleontology of the Jurassic Somanakamura Group, Fukushima Prefecture, Japan

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(With tables 1–3, fig. 1, plates 21–23 and 1 map)

ABSTRACT

Geological, paleontological and paleoecological studies were undertaken of the Jurassic Somanakamura group distributed along the northeastern part of the Abukuma massif, Fukushima Prefecture, Japan. As the result, the respective geological ages of the distinguished stratigraphic units based upon the hexacorals, ammonites and other fossils, the paleoecological conditions under which the group was deposited and the paleontology of the hexacorals are described in this work. The 11 genera of hexacorals distinguished from the Koike limestone include 14 species among which four are new to science. From the fauna of the Koike limestone it is suggested that no true reef existed in the present area.

CONTENTS

PART I
GEOLOGY

Introduction ................................................................. 34
Acknowledgements .......................................................... 34
Historical Review of the Works on the Geology and Paleontology of the Jurassic Somanakamura Group ............................................... 35
General Outline of the Geology in the Environs of the Studied Area .................................................. 36
Description of the Stratigraphic Units

Somanakamura Group ................................................... 37
1. Kitazawa Formation .................................................... 38
2. Awazu Formation ...................................................... 39
3. Yamagami Formation .................................................. 39
4. Tachikubo Formation .................................................. 40
5. Nakanosawa Formation ................................................ 41
6. Tomizawa Formation .................................................. 43
7. Koyamada Formation .................................................. 44
8. Intrusives .............................................................. 44
9. Metamorphic Rocks .................................................... 45
10. Sediments ............................................................ 45

Geologic Age of the Somanakamura Group ........................................... 46
Correlation ................................................................. 47
Geologic Structures

1. Unconformities ........................................................ 48
2. Foldings ............................................................... 49
3. Faults ................................................................. 49
4. Joints ................................................................. 51
Geologic History .......................................................... 51
INTRODUCTION

The Jurassic rocks distributed in the vicinity of Soma City, Fukushima Prefecture extend for about 25 km in north-south direction with a breadth of 1–3 km had been known by the name of Soma Mesozoic. This district is an important field for the Jurassic stratigraphy and paleontology in Japan because of the good development of the Koike limestone (= Torimosu limestone) and the abundant occurrence of mollusks, brachiopods, corals and plants. Geographically the area occupies a position intermediate between the other Jurassic formations, especially of the south Kitakami massif and southwestern Japan, thus forms a link for their correlation.

The purpose of the present work is to clarify the geologic structure of the Soma Jurassic and to make a paleontological study on the hexacorals, and discriminated 14 species. Among the described specimens, four of the 14 distinguished species of hexacorals are new to science. Besides the paleontological study, another purpose is to interpret the paleocology of the Koike limestone. The present article consists of two parts, namely, the geology and the paleontology.

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HISTORICAL REVIEW OF THE WORKS ON THE GEOLOGY AND PALEONTOLOGY OF THE JURASSIC SOMANAKAMURA GROUP

Since Kochibe’s discovery of the Torinosu limestone, the Mesozoic formation of the Soma area has been studied by many authors.

Ishikawa and Matsuda (1899) reported on the geology of the Soma district and stated that the coral bearing oolitic limestone is Jurassic in age.

Yabe and Aoki (1924) pointed out that the Mesozoic deposits of the Soma district is the youngest member of the Basement Complex of the Abukuma Plateau.

Shimizu (1927) described Perispinicietes (Aulacosphinctes) cf. steigeri from the Koike limestone and concluded that the Koike limestone of the Nakanosawa formation is of Tithonian age.

Shimizu (1930) reported Perispinicietes (Aulacosphinctes) cf. steigeri and Perispinicietes (Virgatosphinctes) sp. from the Koike limestone.

Tokunaga and Otuka (1930) stated that the Jurassic rocks of the Soma district are complicated and the stratigraphic position of the limestone is older than the plant bearing sandstone and black shale (= Tochikubo formation).

Iwai (1932) surveyed the Soma area with special reference to the stratigraphy of the Soma Paleozoic and Mesozoic, and divided the Jurassic System into the Yamagami, Tochikubo and Tomizawa formations.

Oishi (1934) wrote on the geologic age of the plant beds of the Soma Jurassic. He stated that the Oyama formation (= Tomizawa and Koyamada formations) is of Lower Cretaceous age.

Kobayashi (1935) discussed the geologic age of the Torinosu series of Japan and summarized the opinions previously published.

Yabe and Sato (1942) described a new bivalve from the Soma Jurassic.

Yabe (1943) described a Perispinicioid Ammonite, an ally of Paraboliceras found in the Torinosu series of Jisahara.

Masatani (1950) accomplished a detailed study of the Soma Jurassic and concluded biostratigraphically as follows:

1. The Soma Mesozoic Group can be divided into the following seven formations from the lower to the upper; Hayama, Awazu, Sugaya, Tochikubo, Nakanosawa, Tomizawa and Koyamada formations.

2. This Group in some respects resembles the middle and upper Jurassic formations of the southern Kitakami massif and is similar to the Torinosu Group which is distributed in southwestern Japan from the occurrence of the Torinosu fauna.

3. By the study of Ammonites, the Awazu formation is Bathonian-Callovian in age, the Nakanosawa is Oxfordian-Kimmeridgian and the Koyamada is Tithonian-Portlandian.”

Eguchi (1951) summarized the hexacorals from the Torinosu series of Japan. In the same year, he described the hexacorals from the Koike limestone of the Nakanosawa formation.

Kimura (1951) described Somapecten kamimanensis, new genus and new species from the Nakanosawa formation. In the same year, he wrote about the Koike limestone.

Kimura (1953) also examined the sandstone and limestone of the Nakanosawa formation and made an analysis of the rock forming minerals. He made mention of the time when the pyrite was formed in the sandstone and limestone. In the next year (1954), he described lithologically the sandstone and limestone of the Nakanosawa formation and divided these into the following:

1. A-type sandstone (Graywacke and Subgraywacke)
2. B-type sandstone (Orthoquartzite)
3. C-type sandstone (Calcareous sandstone)
4. Oolitic limestone
5. Black dense limestone.

At the same time, he made mention on the depositional environment of these rocks. Kitamura and Shibata (1954) wrote on the geologic structure of the Soma Jurassic and the Tertiary sediments distributed in the Soma area.

Tamura (1954) reported on the distribution of the Jurassic Trigonion fossils. In the same year, he discovered nine zones of Trigoniniae from the Soma Jurassic.

Hanzawa (1954) summarized the geology of the Tohoku district and included the Soma Jurassic.

Kitamura, Shibata and Ueda (1955) wrote on the geology of the Jurassic rocks. Kobayashi and Tamura (1957) described the new genera and species of Trigonians from the Jurassic of Soma.

Kobayashi, Mori and Tamura (1959) reported on the bearing of the Trigonidi in the Jurassic stratigraphy of Japan and stated that the fossil evidence suggests Tithonian to Kimmeridgian or Oxfordian age for the Nakanosawa formation and Callovian to Bajocian for the three lower formations; namely the Hatsuno, Awazu and Sugaya formations in ascending order.

Tamura (1959) described some Taxodonta and Isodonta from the Nakanosawa and Koyamada formations and pointed out that the Soma fauna is similar to the upper Jurassic of southwestern Japan. In the same year, he summarized the Torinosu Pelecypod-fauna in the Soma Jurassic and stated that the fauna consists of 22 families, 38 genera and 61 species and among them nine species are known from the upper Jurassic of Himalaya, Ethiopia and Europe. He stated that the feature of the fauna constitutes a faunal province in which should be included those of Borneo and Mindoro Islands and suggested its separation from the Tethyan fauna.

Masatani and Tamura (1959) reported on the stratigraphy of the Jurassic Soma Group. They divided the Trigoninae bearing horizons into ten zones.

Tamura (1960) described Pteriacea from the Nakanosawa formation and stated that the occurrence of Aulacomyella? sp. is noteworthy because the genus is restricted to the Kimmeridgian in age. The same author (1960) wrote on the genus Neoburmesia and discussed its taxonomic position. Besides, he described Mytilids and Myacids from the Nakanosawa and Koyamada formations, and stated that they are very closely allied to those of the upper Jurassic of Shikoku and Kyushu.

Hayami (1961) wrote on the correlation between the Soma Jurassic and the upper Jurassic of the southern Kitakami. The same author (1961) described some Pelecypods from the Awazu and Yamagami formations.

**GENERAL OUTLINE OF THE GEOLOGY IN THE ENVIRONS OF THE STUDIED AREA**

The rocks developed in the northeastern part of the Abukuma massif can be subdivided into three provinces of (1) western, (2) central, and (3) eastern. Each of them is characterized by their own lithological features, distribution, geologic structure and structural history.

(1) The western province is distinguished from the central one by the Ogai fault. In the province, there are developed Paleozoic rocks, Miocene rocks, Green rocks and Granites. Paleozoic rocks are Devonian to Permian in age and consist of green schists, phyllites, black slates, sandstones, conglomerates and limestones which yield many fossils. The Miocene rocks are divided into the Shiode formation in the lower and the Tenmyozoan Agglomerate in the upper. The Shiode formation is distributed on the west side of the Soma Jurassic being separated there from by the Ogai fault. The rocks of the formation are conglomerates,
arkose sandstones, siltstones intercalated with thin lignite layers and tuff. They yielded plant fossils from the upper part and mollusks such as *Vicarya yokoyamae* Takeyama, *Vic. yatuensis* Yabe and Hatai and *Ostrea graviiesta* Yokoyama from the lower. The Shioide formation overlies the basement rocks of green schist and granite with irregular unconformity. The Jurassic rocks may also form a part of the basement of the Tertiary formations because they are found as gravels in the basal conglomerate of the younger formations. The Tenmyozan Agglomerate overlies the Shioide formation with conformity. The Agglomerate consists of various kinds of andesite, basalt and tuff. The east side of the Agglomerate and the Shioide formation are cut by the Ogai fault and by which they come into contact with the Jurassic rocks. The green rocks distributed sporadically in the west of Sugaya and in the west of Kayakura are epidote amphibolite and constitute the basement of the Miocene sediments. They may be included in the Matsugadaira formation of Devonian age. In the west of Kayakura, the green rock is cut and crushed by the Ogai fault and comes into contact with the Jurassic rocks. Granite has a large distribution and is considered to be one of the main constituents of the Abukuma Plateau. The Paleozoic rocks and green rocks are intruded by the granite and subjected to metamorphism. This granite is also cut by the Ogai fault. The intrusion of the granite is considered to be Cretaceous in age.

(2) The central province is occupied by Jurassic rocks which are limited by the Ogai fault in the west and overlain with unconformity by the Tertiary sediments in the east. The Jurassic rocks is subdivided into the following seven formations from the lower to the upper; the Kitazawa, Awazu, Yamagami, Tochikubo, Nakanosawa, Tomizawa and Koyamada formations. Besides them there are exposed porphyrites and metamorphic rocks in the central province.

(3) The eastern province is occupied by the Miocene and Pliocene rocks and is distinguished from the central one with irregular unconformity. The Miocene Hatsuno formation in the vicinity of Hatsuno shows a trend of nearly north-south direction. It consists of conglomerate, siltstone and tuff, and has yielded marine mollusks. The formation is considered to overlie the Jurassic series with unconformity. The Pliocene rocks are divided into the Kayakura formation in the lower and the Tatsunokuchi formation in the upper. The Kayakura formation consists of conglomerate, tuff, siltstone with intercalations of lignite layers and arkose sandstone. Molluskan fossils occur from the lower part and plant fossils from the upper. The facies changes laterally and the strike of the formation is nearly north-south with dips of 5 to 10 degrees towards the east. In the west, the formation dips eastwards at 20 to 50 degrees and overlies the Jurassic rocks with irregular unconformity. The formation also overlies the Miocene Hatsuno formation with unconformity. The Tatsunokuchi formation distributed in the vicinity of Soma City consists mainly of compact dark bluish siltstone intercalated with fine sandstone. The formation trends N–S to NWSSE and dips gently eastwards, and overlies the Kayakura formation with conformity. The formation has yielded marine mollusks.

**DESCRIPTION OF THE STRATIGRAPHIC UNITS**

The stratigraphic units of the Jurassic rocks in the present area are described below.

**Somanakamura Group**

The group name “Somanakamura” is newly proposed for the Jurassic series distributed in the southwest of Somanakamura, because the group name of Soma is preoccupied for the Tertiary formations (Tokunaga and Otuka, 1930). The name “Soma Group” was originally applied to the Tertiary formations (Tokunaga and Otuka), and has appeared in subsequent
literatures (Kamada, 1950; Eguchi and Suzuki, 1960). However, the same name has been used during the past ten years for the Jurassic series, but from priority a new name should be chosen. And the problem arises as to usage and priority, both which may be subjected to change. To avoid further confusion the writer from priority proposes the new group name given above.

<table>
<thead>
<tr>
<th>Somanakamura Group</th>
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<tbody>
<tr>
<td>Koyamada formation</td>
<td>180 m</td>
<td>Sandy shale, fine grained sandstone and dacitic tuff</td>
</tr>
<tr>
<td>Tomizawa formation</td>
<td>400 m</td>
<td>Arkose coarse grained sandstone, Orthoquartzite, shale and conglomerate</td>
</tr>
<tr>
<td>Nakanosawa formation</td>
<td>50–165 m</td>
<td>Impure limestone, calcareous sandstone, arkose sandstone and orthoquartzite</td>
</tr>
<tr>
<td>Tochikubo formation</td>
<td>350 m</td>
<td>Frequent alternation of black shale and fine to medium grained sandstone</td>
</tr>
<tr>
<td>Yamagami formation</td>
<td>150–200 m</td>
<td>Arkose sandstone, sandy shale, fine grained sandstone and conglomerate</td>
</tr>
<tr>
<td>Awazu formation</td>
<td>200 m</td>
<td>Black shale, fine to medium grained sandstone and conglomerate</td>
</tr>
<tr>
<td>Kitazawa formation</td>
<td>250 m</td>
<td>Shale and arkose coarse grained sandstone</td>
</tr>
</tbody>
</table>

1. Kitazawa Formation

Designation and Synonyms: The Kitazawa formation is first proposed in this article because the name preoccupied. The Hayama sandstone of Masatani (1950) and the Hatsuno formation of Masatani and Tamura (1959) are synonyms. This is also equivalent with the lower part of the Yamagami formation of Iwai (1932) and the lower part of the Sugaya formation of Tokunaga and Otura (1936).

Type Locality and Thickness: The valley, southwest of Hatsuno. The maximum thickness is not known, but it is estimated to be about 250 meters.

Distribution: The distribution of the Kitazawa formation is shown in the annexed geological map. The formation is distributed from the west of Hatsuno to the south of Kitazawa, and gradually becomes narrower southwards to the north of Sugaya. In detail, the strikes and dips of the formation are as follows: N 7° E with dip of 55° E in the western valley of Hatsuno, N 33° E with dip of 50° E in the southwestern valley of Kayakura and N 9° E with dip of 58° E at Kitazawa. In the western distribution of the formation, they are N 32° E with dip of 52° W in the west of Kayakura and N 16° E with dip of 37° W in the northern valley of Kitazawa. The structure of the formation is rather complicated.

Lithology and Fossils: The formation consists mainly of arkose very coarse grained...
sandstone (most dominant), siliceous sandstone, dark gray fine to medium grained sandstone and shale. Shale is found only in the upper part of the formation. The formation is intruded by hornblende porphyrite. The formation is generally non-fossiliferous, but *Cuspidaria* sp., "*Corbicula*" sp., *Cucullaea* ? like pelecypod, *Lopha* sp. and "*Mytilus*" sp. were reported from the shale of the upper part of the Kitazawa formation by Masatani and Tamura (1959).

Field Relations: The lower limit of the Kitazawa formation is unknown because of being cut by the Ogai fault. This formation is overlain with unconformity by the Awazu formation in the area between Kayakura and Kitazawa, and by the Miocene Hatsuno formation between Hatsuno and Kayakura. Partly the formation comes into contact by faults with the Awazu formation and the Yamagami formation in the south of Kitazawa. At Hatsuno, the formation is cut by the Hatsuno fault which has a general trend of NW-SE. The northern border of the formation remains unknown.

2. **Awazu Formation**

Designation and Synonyms: The Awazu formation was proposed by Masatani (1950). This is equivalent with the middle part of the Sugaya formation of Tokunaga and Otuka (1930), and the middle part of the Yamagami formation of Iwai (1932).

Type Locality and Thickness: The western valley of Awazu. 200 m ±. The formation decreases in its thickness northwards and is ultimately overlain with unconformity by the Pliocene sediments.

Distribution: The Awazu formation is distributed in meridional direction from Kayakura in the north with nearly north-south strike with eastwards dip of 50–70 degrees to the northern valley of Sugaya in the south. The strike and dip of the Awazu formation at the type locality is N 12° E with dip of 46° E, at Kitazawa N 15° E with dip of 51° E, at north of Sugaya N 19° E with dip of 57° E, but partly N 36° E with dip of 56° E and N 51° E with dip of 51° E. As cited, the Awazu formation generally dips eastwards homoclinally, but in the southern valley of Kitazawa, the rocks are cut by a minor fault and the strike and dip change to N 4° W with dip of 58° W.

Lithology and Fossils: The formation consists of pebble- and cobble-sized conglomerate, an alternation of fine to medium grained sandstone and sandy shale, and black shale. The basal conglomerate is of rounded gravels of cherts, granitic rocks, slates and coarse grained sandstones with a maximum diameter of 20 cm. The thickness of the basal conglomerate is about 5 to 10 meters. In this formation, black shale and sandy shale are predominant. From the basal conglomerate and the fine grained sandstone of the middle part of the formation, there have been found *Chlamys awazuensis* Hayami, *Latitrignonia pyramidalis* Kobayashi and Tamura and *Vaugonia awazuensis* Kobayashi. According to Sato (1962), the Ammonite found by Kamada in a boulder of the black shale in the western valley of Awazu, belongs to *Bigotites*.

Field Relations: The Awazu formation overlies with disconformity on the Kitazawa formation in its larger part, but is cut by a fault and by which it comes into contact with the same formation. The formation is also overlain by the Yamagami formation with disconformity in its larger part and partly with irregular unconformity by the Pliocene Kayakura formation. The southern border is limited by a fault by which it comes into contact with the Yamagami formation.

3. **Yamagami Formation**

Designation and Synonyms: The Yamagami formation was proposed by Saito and Shimizu (1927). It is equivalent with the upper part of the Sugaya formation of Tokunaga
and Otuka (1930), and the upper part of the Yamagami formation of Iwai (1932). The Sugaya sandstone of Masatani (1950) and the Yamagami formation of Masatani and Tamura (1959) are also synonyms.

Type Locality and Thickness: Along a stream behind the Yamagami school, Sugaya, 150–200 m. The thickness of the formation is variable in north to south direction. At the west of Awazu, the thickness is about 200 meters and at the type locality about 150 meters.

Distribution: The formation is distributed from the east of Kitazawa to Sugaya. It can be divided into two blocks that are separated from one another by the Sugaya fault. In the eastern block, the formation has a general trend of nearly N-S to NNE-SSW dipping 30–40 degrees eastwards. In the western block, the formation has a trend of E-W to NE-SW dipping 30–40 degrees southwards to southwestwards. In detail, the strike and dips of the formation are as follows: N 4–10° E with dip of 31–36° E in the western valley of Awazu, N 55–57° E with dip of 31–40° SE at a stream behind the Yamagami school and N 62° E with dip of 77° SE at Nasukoda.

Lithology and Fossils: The rocks of the Yamagami formation consists of conglomerate, brownish massive fine to medium grained sandstone, arkose coarse grained sandstone and an alternation of sandstone and black shale. The conglomerate in the lower most part of the formation is of relatively rounded and subangular pebbles of cherts, sandstones and black shales with a maximum diameter of 10 cm. Among them, the pebbles of black shale which are considered to be reworked pebbles of the Awazu formation are predominant and subangular compared with the roundness of the pebbles of chert and sandstone. The matrix of the conglomerate is medium to coarse grained sandstone. The thickness of the conglomerate is about 5 meters. On the basal conglomerate, there is a thick sandstone intercalated with conglomerate of which thickness is 0.5 to 1 meter, an alternation of sandstone and shale, and arkose coarse grained sandstone. The thin conglomerate cited above is dominated by the rounded gravels of black shales, sandstones, limestones and granites. The fossils hitherto found from this formation are Isognomon sp., Plagiostoma sp., Plicatula sp., Astarte sp., Lophia sp., Mesolinga masatani Hayami, Fimbria somensis Hayami, Pronoea sugayensis Hayami, Latitrigonia unicolorata Kobayashi and Tamura, Latitrigonia unicarinata Kobayashi and Tamura, Ibotochonia masatani Kobayashi and Tamura, Scaphitrigonia somensis Kobayashi and Tamura, Nipponitrigonia sagawai (Yehara), Myoporella (Promyoporella) sugayensis Kobayashi and Tamura and Myoporella (Promyoporella) sugayensis var. geniculata Kobayashi and Tamura.

Field Relations: In the eastern block, the Yamagami formation overlies the Awazu formation with disconformity in the western valley of Awazu. In the east, it is overlain with irregular unconformity by the Pliocene Kayakura formation, and at the south it is cut by a fault. In the western block, the formation shows a triangular distribution. In the west, the formation is cut by the Ogai fault. At the northern side it is cut by a fault by which it comes into contact with both the Kitazawa and Awazu formations. At the south side, it is limited by the Yamagami fault at the side of the Uda river, Nasukoda and is in contact with the Tochikubo formation.

4. Tochikubo Formation

Designation and Synonyms: The Tochikubo formation was proposed by Saito (1927). The Nakanosawa formation here used was included in the Tochikubo formation. This is equivalent with a part of the Oyama formation of Tokunaga and Otuka (1930), and the lower part of the Tochikubo formation of Iwai (1932). The Tochikubo formation of Masatani (1950) and Masatani and Tamura (1959) are synonyms.

Type Locality, Subtype Locality and Thickness: Funasaka, the southwestern valley of Koyamada, Kashima-machi; Aratozawa near Fukono, Haranomachi City. The
thickness of the Tochikubo formation is not definite because the lower limit of the formation is cut by a fault and complicated by many minor folds and faults. But it is estimated to be more than 350 meters in thickness.

Distribution: The formation is most widely distributed from the vicinity of Sugaya with nearly north-south trend to the vicinity of Baba, southwest of Haranomachi City. The formation is cut by many faults and is subdivided by its distribution into the three parts; (1) the northern part of Tochikubo, (2) the western part of the Kitakuchi fault, and (3) the eastern part of the Kitakuchi fault.

1) In the northern part of Tochikubo, the formation is well observed in the valleys in the north of Tochikubo, Minaminosawa, Nakanosawa, etc. where it shows complicated structure. The eastern wing in the Minaminosawa and Nakanosawa valleys shows homoclinal structure with nearly N-S to NNE-SSW trends with eastward dip of 30 to 65 degrees. But in the western wing, the formation is cut by many strike fault with nearly N-S trends, but its dip is either W or E dip.

2) In the western part of the Kitakuchi fault, the formation extends from the south of Minahara to the west of Baba with nearly N-S trend, and show a complicated geostucture as in the northern part of Tochikubo.

3) The formation in the eastern part is traced from the southwest of Yamashita to the south of Shidazawa where it is apparently homoclinal in structure with a general trend of N-S dipping 40 to 75 degrees to the east.

Lithology and Fossils: The rocks of the formation consists of dark gray fine to medium grained sandstone and black shale in frequent alternation intercalated with rather thin coaly seams. Near the fault zone, these rocks are more or less deformed and crushed, and are phyllitic in some cases. The formation is intruded by hornblende porphyrite and slightly metamorphosed. The plant fossils found from more than 5 horizons of the sandstone and black shale of the formation comprise; Cladophlebus exiliformis (Geyler) Oishi, Cl. isikawaensis Oishi, Cl. lobifolia (Phillips) Brongniart, Cl. actinopennis Oishi, Cl. undulata Oishi, Cl. distans (Heer) Yabe, Cl. sp., Nillssonia schaumburgensis (Dunker) Nathorst, Nil. nipponensis Yokoyama, Nil. orientalis Heer, Nil. sp., Onychiopsis elongata (Geyler) Yokoyama, Podozamites sp., Pseudocrenites cf. lanei Thomas, Phyllostylonpecten (Phillips) Morris, Pt. pachyrrhisis Oishi, Squenopterus petiolata Oishi, Sag. sp., nov., Zamiophylla cf. buchanum (Ettingshausen) Nathorst, Zam. sp., Zamites yabei Oishi and Z. sp.

These plant fossils are well preserved and especially abundant in the eastern part of the Kitakuchi fault.

Field Relations: The northern border of the formation is cut by the Yamagami fault and is in contact with the Yamagami formation. Its relation can be observed at the side of the Uda River, Nasukoda. The western border of the formation is cut by several faults by which it comes into contact with the Nakanosawa, Tomizawa formations, granites and the Tertiary sediments. The eastern border of the formation is overlain with conformity by the Nakanosawa formation in the larger part, but partly with irregular unconformity by the Pliocene Kayakura formation in the southern border of the formation.

5. Nakanosawa Formation

Designation and Synonyms: The formation was proposed by Tokunaga and Otuka (1930). This is equivalent with the upper part of the Tochikubo formation of Iwai (1932). The Nakanosawa formation of Masatani (1950) and Masatani and Tamura (1959) are synonyms.

Type Locality, Subtype Locality and Thickness: The valley of Nakanosawa, Tomizawa; Cliff of the Kamimano River at Koike. The thickness is estimated to be 165 meters at the type locality, 130 meters at Minaminosawa, 95 meters at Nakachuki of
Koyamada, about 160 meters at Koike, 140 meters at Tatenosawa and at Nakayama, and about 50 meters at Takanokura.

Distribution: The formation is distributed in three areas of western, central and eastern. In the western part, it is distributed sporadically in the west of Tochikubo, Minahara, Jisahara and Takanokura. It is cut by faults and forms a complicated geostructure. In the central part, the formation at Kabeuzawa in the west of Koyamada shows synedlinal structure with north-south trending axis and occupies the uppermost part of the syncline. In the eastern part, the formation shows the most extensive distribution among the three parts. It is distributed from the type locality to the vicinity of Shidazawa with a general trend of nearly N-S dipping to the east at 30 to 60 degrees forming a homoeolinal structure. The formation is cut by faults with trends of NNE-SSW at Minaminosawa.

Lithology and Fossils: The rocks of the formation consist mainly of from the lower, calcareous sandstone, dark gray fine grained sandstone, arkose very coarse grained sandstone, calcareous sandstone and impure limestone at the type locality, but the facies changes in north to south direction. The calcareous sandstone at the base of the formation is developed only at the type locality and at Tatenosawa, and in other areas there are found arkose sandstones at the base of the formation. The calcareous sandstone changes upwards into fine grained sandstone and arkose very coarse grained sandstone which can be traced from north to south although their thickness varies laterally. In the arkose sandstone, rounded pebbles of chert are sometimes found. The calcareous sandstone in the middle part of the formation is superposed on the above mentioned sandstone and it changes gradually upwards into limestone. This calcareous sandstone is sometimes intercalated with lenses of sandy limestone. The thickness of the calcareous sandstone is more than 20 meters at the entrance of Minaminosawa, but in general it is less than 10 meters. The sandstone in the lower part of the Nakanosawa formation has yielded abundant fossils such as Ammonites, Pelecypods and Brachiopods which can be classified into three horizons. The fossils hitherto found are Virgatosphinctes sp., Streblites sp., Neumayricularas sp., Neum. cf. callicerum Oppel, Aulacosphinctoides cf. steigeri (Shimizu), Aespiloceras sp., Biplaces sp., Dichotomosphinctes sp., Indosphinctes sp., Perisphinctes cf. plicatilis Waagen, Per. sp., Lithacoceras sp., Pseudopelloceras sp., Grammatodon takiensis Kimura, Gr. (Indogrammatodon) densistriatus Tamura, Parallelo gon koi kensis Tamura, Catella (Torinoscutella) kobayashi Tamura, Modiolis cf. bipartitus Sowerby, M. (Inoperna) plicatus Sowerby, Myoconcha ? sp., Chlamys sp., Chl. (Radaulopaent) ogawensis Kurata and Kimura, “Aequipentac. kotsue” (Kimura) “Aeq.” vulgaris Kimura, Camptonectes sp., Brachidontes (Arcumtylusch) lautmairiensis (de Lorian), Pteria masatanii Tamura, Pteroperna lingulata Tamura, P. paoziradiatora Tamura, Pt. sp., Aulacomyella ? sp., Gervillia tatenosauensis Tamura, Pinna cf. mitis Phillips, Chlamys camptonectes Tamura, Epecten punctus (Kimura), Soma- penten kaminanensis Kimura, Plicatula dichotomocosta Tamura, Lima (Plagiostoma) enornicosta Tamura, L. (Plagiostoma) sp., L. (Ctenoides) tosana Kimura, Ctenostreon probo- scideum (Sowerby), Myophorella (Myophorella) dekaiboda Kobayashi and Tamura, My. (Haidaia) crenulata Kobayashi and Tamura, My. (H.) crenulata var. lunulata Kobayashi and Tamura, My. (H.) subcircularis Kobayashi and Tamura, Oistotrigonia prima Kobayashi and Tamura, Nipponitrigonia sagawa (Yehara), Astarte ogawensis Kimura, As. deflecta Tamura, As. sakamotoensis Tamura, As. kambarensis Kimura, As. subdepressa Blake and Hudleston, As. (Coelastarte) somensis Tamura, Opis (Trigonopsis) torinosauensis Kimura, Op. (Coelopsis ?) sp., Arctica (Somarctica) abukumensis Tamura, Pleuromya ? punctostriae Tamura, Thracia fukushimaensis Tamura, Protocardia tosensis Kimura, Myopholas cf. acuticostata (Sowerby), Pholadomya stefanni Tamura, Neoburmesia iwakiensis Yabe and Sato, and Goniomya non- vscripta Tamura.
The impure dark gray limestone called the Koike limestone occupies the upper part of the Nakanosawa formation. The most characteristic feature of the Koike limestone is its extensive distribution, being traced from Nakanosawa to the south of Nakayama for a distance of about 9 km in meridional direction. Elsewhere in Japan, the Torinosu limestone are distributed as small lenses. The limestone is very impure and often contains shaly and sandy intercalations. It is sometimes oolitic especially in the lower and middle parts. The Koike limestone has yielded abundant fossils, and those hitherto found are Diplarea somaensis Eguchi, Goniocora ? sp., Latomeandra somaensis Eguchi, Lat. ? eguchi Mori, Acanthogyrus sp., Aplosomilla somaensis Eguchi, Apl. ? tochikuboensis Mori, Astrocoenia sp., Enalhellia nipponica somaensis Eguchi, Meandraracea sp., Monilivaltia sp., Myriophyllia sp., Styliina (Convexastrea) somaensis Mori, Sty. sp., Stylosmilia sp., Thamnasteria abukumaensis Mori, Thom. torinosuensis Eguchi, Thom. sp., Thecosmilia tosaensis Eguchi, Stromatopora (Parastromatopora) japonica (Yabe), Str. (Parastr.) memoriam-naumannii (Yabe), Str. (Parastr.) kotoi Yabe and Sugiyama, Str. (Parastr.) mitodosensis Yabe and Sugiyama, Styr. (Parastr.) minutissima Yabe and Sugiyama, Milleporidium somaense Yabe and Sugiyama, Mill. styliferum Yabe and Sugiyama, “Terebratula” hataii Mori, “Terebratula” iwaii Mori and “Tereb.” sp.

Field Relations: In the western part, the formation is cut and made complicate by many faults. It comes into contact with the Miocene formations, biotite schist, the Tochikubo, the Tomizawa and the Koyama formaions. In the central part, the formation forms a syncline and overlies with conformity the Tochikubo formation. In the eastern part, the formation overlies with conformity the Tochikubo formation and is superposed with conformity by the Tomizawa formation.

6. Tomizawa Formation

Designation and Synonyms: The Tomizawa formation was first designated by Iwai (1932), but he used the name in the sense that the Koyama formation was included. This is equivalent with a part of the Oyama formation of Tokunaga and Otuka (1930). The Tomizawa formation of Masatani (1950) and Masatani and Tamura (1959) are synonyms.

Type Locality and Thickness: The road side cliff at the entrance of Minaminosawa, Tomizawa. Maximum thickness about 400 meters at Umazawa, the southern valley of Koyama, but changes in north to south direction and thins out in the vicinity of Shidazawa in the south.

Distribution: The Tomizawa formation is distributed in the western and the eastern blocks. In the western block, the formation extending from Minahara to the south of Jisahara with a general trend of N-S, shows a complicated structure and is cut by many faults. In the eastern block, it is distributed from Nakanosawa to Shidazawa with a homoclinal structure and a general trend of nearly N-S, dipping at 25 to 50 degrees eastwards.

Lithology and Fossils: The formation consists mainly of thick arkose coarse grained sandstone intercalated with coal seams, pebbly sandstone, dark gray fine grained sandstone and shale. The formation is very rich in arkose coarse grained sandstone which sometimes laterally changes to orthoquartzite. At least three layers of coal seams of several centimeters to one meter in thickness are found at the type locality. The coal seams sometimes thin out laterally. The pebbly sandstone in the middle part of the formation is well observed at Koike and the type locality. The pebbles consists mainly of rounded pebble to cobble-sized cherts and biotite granites. Although these pebbles are found sporadically in the arkose coarse grained sandstone in the larger part of the area, they laterally change to a one meter thick conglomerate at Nakakuchi, Koyama and forms a local unconformity. Shales and fine grained sandstone are less common than the arkose
sandstone. The following plant fossils were found from the coal seams and shales. *Podozamites lanceolatus* (Lindley and Hutton), *Onychiopsis elongata* (Geyler) Yokoyama, *Otozamites* sp., *Ptilophyllum* sp., and *Podozamites* sp.

Field Relations: In the western block, the formation of very complicated structure and cut by many faults comes into contact with biotite schist, the Tochikubo, the Nakamosawa formations and the Tertiary sediments at several localities. In the eastern block, the formation overlies with conformity the Nakamosawa formation and is overlain with conformity by the Koyamada formation in the larger part of the area, but is partly superposed with irregular unconformity by the Pliocene Kayakura formation.

7. Koyamada Formation

Designation and Synonyms: The Koyamada formation was first proposed by Honma (1943) and introduced by Masatani (1950). This is equivalent with a part of the Oyama formation of Tokunaga and Otuka (1950) and the upper part of the Tomizawa formation of Iwai (1932). The Koyamada formation of Masatani and Tamura (1959) is synonym.

Type Locality and Thickness: Stream cliff at the entrance of Umazawa, southwest of Koyamada. About 180 meters.

Distribution: The Koyamada formation is distributed in the western and eastern blocks. In the western block, the formation occurs in a small area in the south of Jisahara and shows a general trend of N 5–20° E dipping to the west at angles of 40 to 85 degrees. In the eastern block, it is distributed from the west of Oyama to the north of Koike with nearly N-S trend dipping to the east at angles of 35 to 55 degrees.


Field Relations: In the western block, both western and eastern sides of the formation are cut by faults and the formation comes into contact with the limestone of the Nakamosawa formation in the west side and with porphyrite in the east side. In the eastern block, the formation overlies with conformity the Tomizawa formation. The boundary between the Koyamada and the Kayakura formation is considered to be an irregular unconformity.

8. Intrusives

The intrusive rock distributed in the area studied is hornblende porphyrite. Phenocryst consists of plagioclase and hornblende, and the groundmass is of plagioclase, hornblende and quartz. On the other hand, there are found sphene and magnetite as accessory minerals, and chlorite, epidote and calcite as secondary minerals. The porphyrite is sometimes intruded as sheets along the bedding planes or as dykes. By its intrusions, the Jurassic rocks are more or less metamorphosed.

9. Metamorphic Rocks

Along the Ogai fault, a metamorphic rock is distributed on the east side of the
crystallized limestone of the Nakanosawa formation. It is chlorite-biotite schist and can be traced from Minahara to north of Jishara. It is cut by two faults, one along the east and the other on the west sides with trends of nearly N-S. The metamorphic rock may be considered as a basement rock of the Jurassic sediments, but the details remain unknown.

10. Sediments

Characteristic and predominating rocks of the Jurassic Somanakamura Group are clastics such as sandstones, shales with rocks of intermediate character and limestones. Conglomerates are few and restricted to some horizons. On the other hand, tuffaceous rocks are found only in the Koyamada formation. The rocks of the Somanakamura Group are as follows.

1. Conglomerate: The distribution of the conglomerate is limited to some narrow areas of the Jurassic Somanakamura Group. Basal conglomerates of the Awazu and Yamagami formations are most striking. The former consists of rounded pebble- and cobble-sized gravels of cherts, granitic rocks, slates and sandstones. The matrix is of coarse grained sandstone. The latter is characterized by having many pebble reworked from the Awazu formation. The gravels consist of rounded chert, sandstones and subangular black shales. The matrix is also of coarse grained sandstone. In the lower part of the Yamagami formation is found another thin conglomerate bed of 0.5 to 1 meter in thickness. It consists of rounded gravels of granites, black slates, sandstones and limestones. Less conspicuous conglomerate is exposed in the arkose coarse grained sandstone of the middle part of the Tomizawa formation. The pebbles are mostly well rounded cherts, sandstones, biotite granites and other granitic rocks. The matrix is of arkose coarse grained sandstone. This conglomerate is observed only along the stream of Nakakuchi at Koyamada, and it changes laterally to the pebbly arkose coarse grained sandstone.

2. Shale: Shales are predominant in the Awazu, Tochikubo and Koyamada formations. They are divided into two types as follows.

2-a. Neritic Shale: Neritic shales are developed in the Awazu and Koyamada formations. They are mostly dark brown or dark gray in colour. In the Awazu formation pure black shale is dominant, but in the Koyamada formation shales are mostly sandy and show dark brown or dark gray in colour. Ammonites and other pelecypods occur from these shales.

2-b. Embayment or Estuarine Shale: Shales of embayment or estuarine origin are developed typically in the Tochikubo formation. They are more darker in colour than those of neritic origin. These shales are more or less carbonaceous and yielded abundant plant fossils. They are often accompanied by sandstones and frequently form an alternation. Shales of this type are also found in the Tomizawa formation. They are dark gray in colour.

3. Coal Seam: Coal seams are conspicuous in the Tochikubo and Tomizawa formations. In the Tochikubo formation, several layers of which maximum thickness is 0.5 to 1 meter are developed. They are frequently crushed and very rich in plant fragments. In the Tomizawa formation, they are found in the arkose coarse grained sandstone and well observed at the type locality of the formation. The thickness of the seams attains 1 meter, but lateral variation is conspicuous. They yielded abundant plant fragments. At least three coal seams are developed in the Tomizawa formation.

4. Sandstone: Sandstones are the most predominant and main constituent rocks in the Jurassic Somanakamura Group. They are divided into three types by their lithologic features as follows.

4-a. Dark Gray Fine to Medium Grained Sandstone: The sandstones of this type are dominant in the Tochikubo formation. They are sometimes carbonaceous or siliceous
and frequently form an alternation with shales. The sandstones of the Tochikubo formation yielded many plant fossils. The sandstones are also developed in the Yamagami, Lower Nakanosawa, Tomizawa and Koyama formations, although less conspicuous than those of the Tochikubo formation.

4-b. Whitish Arkose Coarse Grained Sandstone and Orthoquartzite: The sandstones of this type are the main constituent rocks of the Kitazawa, Lower Nakanosawa and Tomizawa formations. They are most conspicuous in the Tomizawa formation. Particles of the sandstone are generally coarse to granular in size and subangular. Quartz and feldspars are dominant in this sandstone, but sometimes the feldspars are very few and in some cases the particles of subangular quartz are outstanding. These may belong to the typical orthoquartzite in Pettijohn’s classification. They sometimes contain the pebbles of cherts and granites which maximum diameter is about 20 cm.

4-c. Calcareous Sandstone: The sandstone of this type is developed only in the lower part of the Nakanosawa formation. The grains consists mainly of quartz and feldspars, and the matrix of calcite. This sandstone can be traced from the type locality to the south of Tatenosawa. Sometimes it contains small lenses of impure or oolitic limestones. This is typically developed in the lower part of the Koike limestone and changes upwards into limestone. The sandstone also changes laterally to the impure limestone by which reason the thickness of this sandstone is variable. The sandstone like the Koike limestone is very fossiliferous.

5. Limestone: The limestone occupies the upper part of the Nakanosawa formation. This consists of dark gray dense limestone, oolitic limestone with sandy and shaly intercalations and crystalline limestone along the Ogai fault. Although it is crystallized and had been considered to be of unknown age, the writer includes this limestone in the upper Nakanosawa formation because its development is similar to that of the Koike limestone and from the previously reported fossil evidence. Yabe and Sugiyama (1935) reported Stromatopora (Parastromatopora) japonica (Yabe) from this limestone at Jisahara, but unfortunately the writer could find no fossils. It is considered that the crystalline limestone was metamorphosed by the intrusions of the igneous rocks and influenced by the structural movements. The Koike limestone in the eastern part of the Jurassic terrain is a typical Torinosu-type limestone and is developed as a long strip extending from Nakanosawa to the south of Nakayama. Its long distribution is a characteristic compared with the Torinosu limestone distributed in other areas of Japan. The limestone consists mainly of calcarenites and calcilutites by Pettijohn’s classification. There have been found many coralline fossils and other fragments, but no bioherms or biostromes. The above cited facts and the absence of calcilutite may indicate that the Koike limestone is not a true reef limestone.

6. Tuffaceous Rock: Tuffaceous rock is found only in the Koyamada formation of the Jurassic Somanakamura Group. It is dacitic tuff. Phenocryst consists of quartz, plagioclase and biotite. The groundmass consists of chlorite and sericite, and sometimes contains potash feldspars. The maximum thickness of the tuff is estimated to be several meters.

**GEOLOGIC AGE OF THE SOMANAKAMURA GROUP**

With regard to the geological age of the Jurassic Somanakamura Group, there have been many works; ammonites by Shimizu (1927), Masatani (1950), Sato (1956) and Sato (1962); pelecypods by Yabe and Sato (1942), Kimura (1951), Kobayashi, Mori and Tamura (1959), Tamura (1959) and Hayami (1961); hexacorals by Eguchi (1951); and the stromatoporoids by Yabe and Sugiyama (1935). From these studies and from the writer’s survey, the geological age of each formation of the Somanakamura Group is concluded as
follows. The Awazu formation is Bajocian-Bathonian from the occurrence of Biqotites sp., Latitrigonia pyramidalis, Vaugonia avazuensis, etc. The Yamagami formation is Callovian from the occurrence of Latitrigonia unicolorata, Lat. unituberculata, Ibotrigonia masatanii, Soaphotrigonia somensis, Myophorella sugayensis, etc. The Nakanoswa formation is Oxfordian-Kimmeridgian from the occurrence of abundant Torinosus-type mollusks, corals and brachiopods. The Koyamada formation is Tithonio-Berriasian from the occurrence of Kilhanella sp., Dalmisiceras sp., Parabollucites cf. fascicostatus, Virgatosphinctes cf. rotundicurs Uhlig and other mollusks.

The geological ages of the Kitazawa, Tochikubo and Tomizawa formations cannot be determined because no guide fossils have been found, but from their stratigraphical positions, they are considered as follows; the Kitazawa formation is Bajocian; The Tochikubo formation is Oxfordian; and the Tomizawa formation is Kimmeridgiao-Tithonian.

**CORRELATION**

The Jurassic Somanakamura Group is an important field for the correlation with the similar formations of the Kitakami massif and of southwestern Japan. In the Kitakami, the Jurassic rocks are developed forming three belts, namely the western, central and eastern belts. The western belt consists of the Lower Jurassic Shizukawa and Middle-Upper Jurassic Hashiura Groups, while the central belt of the Middle-Upper Jurassic Karakuwa and Ojika Groups, and the eastern belt of the Iwaizumi formation. Among them, although the lower part of the Somanakamura Group is more or less difficult to correlate with the Jurassic sediments of the Kitakami massif, the sediments of the upper part of the Somanakamura Group show a more or less similar vertical change in the litho- and bio-facies with those of the central belt.

The main part of the Mone formation is characterized by the frequent alternation of shales and sandstones which yielded abundant plant fossils such as Cladophlebis browniana, Clad. dundens, Nilssonia osoana, Podozamites lanceolatus, Ptyrophyllum cf. pecten, Zamites buchnerum, etc. On the other hand, the Ogino-hama formation of the Ojika district is composed of shales and sandstones, and yielded also plant fossils such as Cladophlebis browniana, Clad. denticulata, Nilssonia orientalis, Ptyrophyllum pecten, Zamiophyllum buckianum, etc. The lithology and fossils are quite identical with those of the Tochikubo formation of the Soma area.

The upper part of the Mone formation and the lower part of the Kogoshio formation consist from the lower, of shales, massive sandstones and whitish arkose sandstones and yielded such mollusks as Myophorella (Haidahia) crenulata, Myo. sp., Nuculana sp. They are correlated to the lower part of the Nakanoswa formation. In the lower part of the Kogoshio formation calcareous and oolitic sandstone lies on the arkose sandstone above mentioned. This sandstone contains reworked pebbles of limestone, and hexacraedals and other fossil fragments in the pebbles of the limestone. This calcareous sandstone is correlated to the Koike limestone of the upper part of the Nakanoswa formation, although their thickness are considerably different.

In the Ojika district, the Kozumitoge formation consists mainly of black shale and has yielded Perisphinctes (Virgatosphinctes) sp., and Per. sp. This is correlated to the upper part of the Nakano-sawa formation from the yield of the same guide fossils.

The middle part of the Kogoshio formation consists of an alternation of shale and fine grained sandstone, and massive arkose coarse grained sandstone. The lithology of this part is remarkably similar to the Tomizawa formation of the Soma area. The Makinosaki formation of the Ojika district is also correlated to the Tomizawa formation.

The upper part of the Kogoshio formation is composed mainly of black shale and
yielded *Substenuoceras* sp., *Parallelodon kesennumensis*, *Par. kobayashii*, *Entolium kimurai*, *Gervillia* sp., *Grammatodon* sp., and *Pleturomya* sp.

The geological age of the upper part of the Kogoshio formation is considered to be upper Tithonian. This is correlated to the Koyama formation of the Soma area, based upon the similarity in the lithology and fossils. The Kukunari formation can be correlated to the Koyama formation by the lithology.

The correlation of the Middle-Upper Jurassic series of northeast Japan is summarized in Table 2 although the correlation of the Somanakamura Group with the western and eastern belts of the Kitakami massif is difficult because of the different lithology and discontinuous occurrence of the fossils in the western and eastern belts.

On the other hand, the correlation of the Somanakamura Group with the Jurassic of southwestern Japan is not easy because of the different lithology. But the Nakanošawa formation of the upper Somanakamura Group is characterized by the Koike limestone which yielded abundant mollusks, brachiopods and hexacorals. These fossils are of the Torinosu-type, and the Nakanošawa formation is thus correlated to the Torinosu Group of southwestern Japan.

Table 2. Correlation of the Jurassic System of Northeast Japan

<table>
<thead>
<tr>
<th>Region</th>
<th>Abukuma</th>
<th>Central Belt of Kitakami</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berriasian</td>
<td>Koyama F</td>
<td>Kukunari F</td>
</tr>
<tr>
<td>Tithonian</td>
<td>Tomizawa F</td>
<td>Makinosaki F</td>
</tr>
<tr>
<td>Kimmeridgian</td>
<td>Nakanosawa F</td>
<td>Kazunitoge F</td>
</tr>
<tr>
<td>Oxfordian</td>
<td>Tochikubu F</td>
<td>Oginojama F</td>
</tr>
<tr>
<td>Callovian</td>
<td>Yamagami F</td>
<td>Samurahama F</td>
</tr>
<tr>
<td>Bathonian</td>
<td>Awazu F</td>
<td>Kitazawa F</td>
</tr>
<tr>
<td>Bajocian</td>
<td>Unknown</td>
<td>Inai Group</td>
</tr>
</tbody>
</table>

**GEOLOGIC STRUCTURES**

The geological structures will be described as to unconformities, foldings, faults and joints in the order named.

1. Unconformities

1-a. Unconformity between the Kitazawa formation and the Awazu formation: This unconformity is observed in a river side cliff in the western valley of Kayakura. Here the conglomerate at the base of the Awazu formation lies upon the eroded surface of the Kitazawa formation. The Kitazawa and Awazu formations are discordant, but the time interval of this unconformity cannot be determined in detail.

1-b. Disconformity between the Awazu formation and the Yamagami formation: Although the basal conglomerate of the Yamagami formation is observed in the western valley of Awazu, the actual boundary between it and the Awazu formation is not exposed. But the writer considers the relation to be a disconformity because the basal conglomerate
of the Yamagami formation contains abundant subangular pebbles reworked from the Awazu formation. This relation may indicate a short time interval.

1-c. Local unconformity in the Tomizawa formation: This local unconformity is exposed only in the stream bed at Nakakuchi in Koyamada. This is developed in the middle part of the Tomizawa formation. Here the conglomerate lies upon the slightly eroded surface of the shale. The conglomerate changes laterally to pebbly sandstone and the unconformity becomes obscure.

1-d. Angular unconformity between the Somanakamura Group and the Tertiary sediments: The relation between the Somanakamura Group and the Tertiary System in the eastern province could not be observed directly. But their relation from structural discordance is considered to be an angular unconformity. The conglomerate at the base of the Miocene Hatsuno formation may indicate the existence of an unconformity between it and the Jurassic Kitazawa formation. The Pliocene Kayakura formation is developed on the east side of the Jurassic rocks. The formation covers the Awazu formation in the vicinity of Ono, the west of Soma City; the Yamagami formation in the west of Awazu; the Tochikubo formation in the vicinity of Ikegami; the Nakanosawa formation in the vicinity of Tomizawa; the Tomizawa formation in the southwest of Tomizawa and in the vicinity of Nakayama; and lies on the Koyamada formation in the vicinity of Koyamada. Therefore, it is considered that the Kayakura formation abuts against the Jurassic rocks with strong relief.

2. Foldings

One anticlinorium structure and one syncline structure as well as minor foldings were recognized.

2-a. Tochikubo anticlinorium: In the main distribution of the Jurassic rocks, the geologic structure is characterized by the Tochikubo anticlinorium. This anticlinorium is traced from Hayama to Fukono in north-south direction, and includes the Kabesu syncline described below. In the western wing of the anticlinorium, the rocks are cut by many faults and do not make a perfect succession as in the eastern wing. In the eastern wing of the anticlinorium, the rocks dips eastwards homoclinaly. As above mentioned, the structures are more or less complicated and do not suggest a simple anticlinorium.

2-b. Kabesu syncline: This syncline is developed at Kabesuzawara in the west of Koyamada. The axis trends nearly in north-south direction. The western wing of the syncline dips eastwards at 15–40 degrees. Along the axis, the Nakanosawa formation lies upon the Tochikubo formation. Both western and eastern sides of the Kabesu syncline are cut by faults with N-S trends. This structure may be related with the Ogai fault and the Kitakuchi fault.

3. Faults

Many faults are recognized in the area studied, although only a few of them have been named because of their importance. These faults can be divided into three groups by their trends, namely (a) north–south trend, (b) NNE-SSW trend and (c) NW-SE trend. Among them, the north-south trending faults are well developed, and these are parallel with the distribution of the strata distributed in the area. In short, the structure within the area studied is characterized by folds and faults with north-south trends, and other faults with different trends are less conspicuous. The descriptions of each fault are as follows.

3-a. North-south trend faults

3-a-1. Ogai fault: This fault occurs in the western part of the surveyed area and extends nearly N-S to NNW-SSE in direction. In the present area, this is the largest fault and is traced from Hatsuno to Baba. The fault separates the western province from the
central one, and the Miocene formations, green rocks and granites in the west come into contact with the Jurassic rocks in the east. The disturbed zone attains 50 meters or more in width in some cases, and fault clay, fault breccia and crushed graphite are developed. In general, the western side of the fault is not so much disturbed as the eastern. The northern extension of the Ogai fault is traced from the west of Hatsuno to near Iwanuma via the west side of the so-called Wariyama formation, although it is cut by the Hatsuno fault which trends nearly NW-SE. The southern extension of the Ogai fault is related with the Futaba tectonic line (Hisanohama-Iwanuma dislocation line).

3-a-2. Futaba tectonic line (Hisanohama-Iwanuma dislocation line): Ogai fault is considered the extension of the Futaba tectonic line, and one along the eastern side of the Jurassic terrain to have developed and activated at the same time. (Post-Lower Miocene to Pre-Pliocene). Although the line along the eastern side of the Jurassic terrain cannot be observed in the present area, the existence of it can be judged from a consideration of the geologic history of the Soma area and its environs. In the area surveyed, the line is hidden, but its northern and southern extensions can be traced, namely in the southern part of the studied area it is recognized from Baba to near Hisanohama in the Joban coal field with a trend of NNW-SSE. In the northern part, the line is traced from Hatsuno to the east of Karozan with a trend of nearly north-south direction. In the Joban coal field, it is a reverse fault dipping westwards and the basement rocks are pushed up over the Pliocene sediments from the west. On the other hand, on the eastern side of the Jurassic, it is also probably a reverse fault, but the Pliocene sediments are not cut. These features may suggest that the line first developed at the end of the Miocene and was subjected to different movements thereafter. In the northern part of Hatsuno, it is also a reverse fault being pushed from the west.

3-a-3. Kitakuchi fault: This fault occurs in the central part of the studied area and extends almost with north-south trend from Tochikubo to the east of Takanokura. This fault divides the Jurassic terrain into two blocks; the western and the eastern. This fault is cut by faults with nearly NNE-SSW trends. In general, the fault zone is 5 to 10 meters or more in width, and fault breccia and fault clay are developed. Near the fault, the rocks are crushed and the dips are rather high. This reverse fault dips at about 60 degrees towards the east.

3-a-4. North-south trend minor faults: A number of faults with north-south trends are recognized in the studied area. They are small scale compared with the Ogai fault and the Kitakuchi fault or not mappable in the scale of 1:25000. In the western side of the Kabusu syncline, three faults are developed parallel with the Ogai fault, but no disturbed zone or development of a breccia zone or fault clay has been observed. The faults are recognized by the abrupt changes in the lithological characters. The natures of these faults, whether normal or reverse remains unknown. Besides them, minor faults with north-south trends are found, but they are omitted here.

3-b. NNE-SSW trend faults

3-b-1. Yamagami fault: The Yamagami fault occurs in the northern part of the studied area and extends in NNE to SSW direction from the southwest of Awazu to the north of Shiokeyama. By this fault the Somanakamura Group is divided into two parts of lower and upper. The fault is seen in a cliff of the Uda river where fault breccia is found. The nature of the fault remains unknown because of the lack of good outcrops, but it is probably a reverse fault.

3-b-2. Nasukoda fault: The Nasukoda fault occurs in the southern part of the Yamagami fault. This fault is exposed in a cliff of the Uda river and extends in NNE-SSW direction parallel with the Yamagami fault, from the west of Yamagami to the east of Shiokeyama. The crushed zone is 1 to 2 meters in width, and the dip of the fault is about
40 degrees to the southwest.

3-b-3. Minaminosawa fault: The Minaminosawa fault occurs in the middle part of the surveyed field and extends with NNE-SSW trend, from the west of Tomizawa to Tochikubo via Minaminosawa of Tomizawa. The fault is hardly discernible in the field because of the heavy vegetation and the nature of the fault is unknown. But the lateral displacement of the rocks on both sides of the fault attains about 500 meters at Minaminosawa.

3-e. NW-SE trend fault

3-c-1. Hatsuno fault: The Hatsuno fault occurs in the northern part of the studied area and extends in northwest to southeast direction from near Hatsuno to northwestwards. The fault zone attains 50 meters or more in width and crushed graphite is well developed at the east of Hatsuno. The fault cuts the Ogai fault. The writer considers that the Miocene Hatsuno and Pliocene Kayakura and Tatsunokuchi formations are cut by the fault.

3-c-2. Sugaya fault: The Sugaya fault occurs in the northern valley of Sugaya and extends in northwest to southeast direction, from the north of Sugaya to Sugimori. The fault is a disturbed zone accompanied with fault breccia. The dips and other details of the fault could not be observed in the field.

4. Joints: The joints developed in the Jurassic rocks were measured at 20 stations. In general, although two sets of joints are developed at each exposure, there are many unsystematic joints. The most dominant joints here called Set 1 trend WNW to ESE. The trend of this set shows a deflection at places and is concentrated in the range from N 60° W to N 85° W. The dips of the joints are rather high; 50 to 80 degrees and sometimes vertical. The next dominant joints called Set 11 trend ENE to WSW. The trend of this set also shows a slight deflection from N 60° E to N 80° E. The dips of the joints in Set 11 are also high as in Set 1. Another joint set with north-south trend are found and they almost coincide with the trend of the strata. The diagram of fig. 1 is constructed from the frequency distribution of the total joints. Although in these joints, deviations are often found at places, it is considered that the relation between Set 1 and Set 11 suggest a system of stress field and that these joint patterns may be in close relation to the other structures. These joints may indicate that the direction of the major stress is nearly east-west trend.

![Fig. 1. Strike frequency diagram of joints in the Soma district](image)

**GEOLOGIC HISTORY**

After the lower Jurassic age, there occurred an extensive marine (Bajocian) transgression in the Soma district, and the Kitazawa formation of arkose coarse grained sandstone was deposited along the ancient coastal region of Paleozoic rocks of the Soma district.
After deposition of the Kitazawa formation, and local uplift by which a slight unconformity was developed at the base of the Awazu formation. Subsequently, the marine sediments became finer and the facies changed from coastal to neritic, and the Awazu formation mostly composed of black shale was deposited. This shale yielded Brigitites sp., Latitrigonia pyramidalis, and Vaugonia awazuensis.

After deposition of the Awazu formation, slight regression took place and a disconformity was made at the base of the Yamagami formation. Thereafter, the sediments became coarser again and the sedimentary environment changed from neritic to coastal. This is suggested by the deposition of the coarse grained sandstone and conglomerate of the Yamagami formation of Bathonian-Callovian age.

Progressed regression lead to the deposition of the Tochikubo formation of Oxfordian age; it is of embayment or estuarine origin, and yielded abundant plant fossils. The Ogino-hama formation of Ojika and the Mone formation of Karakuwa have litho- and bio-facies similar to the Tochikubo formation. Such features show that the formation was deposited under similar sedimentary environments.

After Tochikubo time, there occurred marine transgression and the partly calcareous and partly arkosic fossiliferous sandstone of the lower Nakanosawa formation was deposited. The fossil assemblages is of near-shore origin.

Continued transgression of the Nakanosawa sea lead to the deposition of the Koike limestone of the upper Nakanosawa formation. The Koike limestone is impure and often contains shaly and sandy intercalations. Although the limestone yields mollusks, hexacorals and stromatoporoids, no true reef was built in the Nakanosawa sea because of the large supply of detritus. As suggested from the litho- and bio-facies of the Koike limestone, the upper Jurassic sea along the Pacific coast of Japan was rather warm. This limestone and the calcareous sandstone of the Kogoshio formation of Karakuwa imply a similar condition was extensive during the Kimmeridgian. By regression of the Nakanosawa sea, there was deposited arkose coarse grained sandstone and orthoquartzite with thin lignite layers of the Tomizawa formation. The lagoonal aspect during Tomizawa time is indicated by the carbonaceous and lignite accumulations with plants fragments. The middle part of the Kogoshio formation of Karakuwa shows a facies similar to the Tomizawa formation.

After deposition of the Tomizawa formation, there occurred another transgression, and the shale dominant Koyamada formation of Tithonian-Berriasian age was deposited. The shale is sometimes sandy and is of neritic origin from the occurrence of Killianella sp., Dalmasiceras sp., Paraboliceras cf. fascicostatus, Virgatosphinctes sp. etc.

In the lower part of the Koyamada formation, there is found dactitic tuff, the only record of volcanic activity in the Soma Jurassic. The maximum thickness of the tuff is only several meters, thus this volcanic activity was of a small scale.

After a period of subaerial denudation throughout Valanginian to Baremian time, there occurred a crustal disturbance called the Oshima orogeny (post-Oshima to pre-Miyako) as indicated by the faults or folding in the Somanakamura Group and the Neocomian and earlier deposits of the south Kitakami massif.

These sediments are intruded by granites and porphyrites, and subjected to metamorphism. In the Soma district, the Jurassic sediments were strongly crushed and folded by this orogeny and granite intrusion. This seems to be the first stage of the Futaba sheared zone. There is no evidence of sedimentation during the upper Cretaceous in the Soma district, but it is judged that the Soma district was subjected to subaerial denudation and no sediments of Cretaceous age were deposited. After this period, the lower Miocene Shidoe formation, Tenmyozan pyroclastic rocks and Hatsuno formation were deposited upon the eroded uneven surface of the Paleozoic, Jurassic and granitic rocks.

After deposition of the lower Miocene formation, another crustal movement occurred
(post-Lower Miocene to pre-Pliocene) in the Abukuma massif. The basement complex of the Abukuma Plateau was subjected to shifting along and on the foreland intense movements from the west towards the east along the weak zone previously formed by the Oshima Orogeny. This is named the Hisanohama-Iwanuma dislocation line and is a reverse fault. This is the second stage of the Futabe sheared zone.

After this disturbance, the Pliocene Kayakura and Tatsunokuchi formations were deposited on the eroded surface of the basement rocks and covered the crushed sediments of the earlier age. However, during post-Pliocene to pre-Pleistocene time, the Futaba crushed zone was again subjected to disturbance and this was the third stage. In the Soma district, the Jurassic rocks were uplifted as a horst, cut by the Ogai fault and came into contact with the lower Miocene formations in the western part of the present area. In the district, this disturbance indicate a movement from the east toward the west, but in the Joban coal field, the faults were developed by intense movements from the west towards the east, and the green rock was pushed up on the Pliocene Tomioka formation (= Tatsunokuchi formation) by a large reverse fault. Therefore, the Futaba sheared zone shows different movement according to places.

PART II
PALEONTOLOGY

INTRODUCTION

The present part treats the hexacorals from the Koike limestone distributed in the south-western part of the Soma district. The material from the Koike limestone described in this part was collected by the writer during 1961 to 1962. The collection comprises 14 species of scleractinian corals including those previously described by Eguchi (1951). Among them, five species have already been described by Eguchi, four are new to science and the others are specifically unnamed because of their poor preservations.

Most of the Soma Jurassic corals are fragments of corallites embedded in limestone, and very few show their external structure. Therefore, they have been studied mostly from their sections, and in many cases the internal structure has been partially obliterated by replacement and recrystallization.

Among the upper Jurassic fossils, ammonites are of primary importance for the determination of geological age and for correlation. However, the hexacorals seem to be important as indicators of the paleogeographical and paleoecological conditions. From above mentioned reasons, the horizon of the Koike limestone is not definitely identified by the corals but it has been concluded from the study of ammonites, pelecypods and brachiopods that it may be Oxfordian to Kimmerridgian in age.

The specimens described are all deposited in the collection of the Institute of Geology and Paleontology, Tohoku University.

PREVIOUS WORKS

The records and descriptions of hexacorals from the Koike limestone are contained in two papers by Eguchi (1942 and 1951). In 1942, Eguchi described Enallhelia nipponica somaensis from Tomizawa, Soma City. In 1951, the same author summarized the Mesozoic hexacorals from Japan and recorded from five localities of the Soma district; Nakayama, Koike, Hayama, Tochikubo and Tomizawa, the following corals:

- Aplosmilia somaensis Eguchi
- Enallhelia nipponica somaensis Eguchi
- Diplarea somaensis Eguchi
- Gonioora somaensis Eguchi
- Latomeandra somaensis Eguchi
- Stylomella ? sp.
- Stylina sp.
- Thecosmilia somaensis Eguchi
Among the species, *Goniocora somaensis* and *Styliina* sp. were left undescribed.

**LIST OF MATERIALS**

The materials to be described in this paper are:

- *Acanthogyra* sp.
- *Aplosmilia somaensis* Eguchi
- *Apl. tochkuboensis* Mori, n. sp.
- *Astrocoenia* sp.
- *Enallhelia nipponica somaensis* Eguchi
- *Goniocora* ? sp.
- *Latomeandra? eguchii* Mori, n. sp.
- *Montilvatia ?* sp.
- *Myriophyllia* sp.
- *Styliina (Convexastrea) somaensis* Mori, n. sp.
- *Thamnasteria abukumaensis* Mori, n. sp.
- *Thamm. torinosuensis* Eguchi
- *Thamm. sp.*
- *Thecosmilia tosaensis* Eguchi

**LIST OF FOSSIL LOCALITIES OF THE CORALS**

(1) Nakanosawa, west of Tomizawa, Soma City.
(2) Minaminosawa, southwest of Tomizawa, Soma City.
(3) About 500 m southwest of locality 2 of Minaminosawa.
(4) A valley in the northern part of Hayama, Kashima-machi, Soma-gun.
(5) A valley in the northern part of Tochikubo, Kashima-machi, Soma-gun.
(6) Cliff of the Mano River at Hayama, Kashima-machi, Soma-gun.
(7) A valley in the western part of Yamashita, Kashima-machi, Soma-gun.
(8) Kitakuchi of Koyamada, Kashima-machi, Soma-gun.
(9) Kabesuzawa, about 1 km west of locality 8 of Koyamada, Kashima-machi, Soma-gun.
(10) Nakakuchi of Koyamada, Kashima-machi, Soma-gun.
(11) Umazawa, a valley in the southern part of Koyamada, Kashima-machi, Soma-gun.
(12) Koike, Kashima-machi, Soma-gun.
(13) Tatenosawa, a valley in the southern part of locality 12, Kashima-machi, Soma-gun.
(14) Nakayama, about 1.5 km south of Koike, Haranomachi City.

**Table 3. List of the hexacorals from the Koike limestone**

<table>
<thead>
<tr>
<th>Loc. No.</th>
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<td>Nakakuchi</td>
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<td>Kitakuchi</td>
<td>Hayama</td>
<td>Tochikubo</td>
<td>North of Hayama</td>
<td>Minaminosawa 2</td>
<td>Minaminosawa 1</td>
<td>Nakanosawa</td>
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<td><em>Styliina (Convexastrea) somaensis</em> Mori, n.sp.</td>
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<td><em>Thamm. torinosuensis</em> Eguchi</td>
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<td><em>Thecosmilia tosaensis</em> Eguchi</td>
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**CORRELATION AND BIONOMIC NOTE**

Among the described species, *Enallhelia nipponica somaensis* is most abundant and was found in almost all the localities. It sometimes occurs as a mass of fragments. The
genus *Enallhelia* is well known in the Soma area, but few in other localities of the Torinosu limestone in Japan, although it ranges from middle Jurassic to lower Cretaceous in foreign countries. *Aplosmilia somaensis* is dominant in the Koike limestone, it is known only from the present area in Japan.

*Thecosmilia tosaensis* and *Tannmnesia torinosuensis* first described by Eguchi (1951) from the Torinosu limestone of Iwasayama and Mitoda, both in Kochi Prefecture, show that the Soma localities have intimate relation with the Torinosu limestone of Shikoku, southwestern Japan.

*Goniocora* and *Aplosmilia* which have not been recorded from the Torinosu limestone of southwestern Japan are represented in the Soma area. On the other hand, the well known genera of worldwide distribution in the upper Jurassic, such as *Astrocoenia*, *Tannmnesia*, *Montlivaltia*, *Myriophylla* and *Thecosmilia* have been found from the Koike limestone.

As mentioned above, dendroid or phacoid corals such as *Enallhelia* or *Aplosmilia* occur abundantly but massive corals are few and sporadic in occurrence. None of the specimens under consideration seem to occur in situ at the localities and all show signs of rolling and breaking by water action. The species described are almost hermatypic or reef-building types. The coral species from the Koike limestone belong the reef-building genera, but do not occur in their original position of growth. They have been subjected to rolling on the bottom of the shallow sea of the Soma district. It is inferred that they may have grown on a submarine bank and did not build true reefs, or they may represent an assemblage indicating quiet shallow waters, lagoon-like in features behind the true reefs as is suggested by the occurrence of many branching forms and the comparative absence of massive agitated-water or reef-face forms.

Although the so-called Torinosu limestone is distributed from South Kyushu to Central Hokkaido and has been considered comparable with the Great Barrier Reef of Australia by some paleontologists, the Koike limestone shows no positive features of a reef. When reef builders are considered, it should be noted that those builders are not only hexacorals but also stromatoporoids, foraminifera and algae. Although the Koike limestone contains these fossils, their occurrence are relatively few compared to the hexacorals. This may also indicates the non-existence of true reefs in the Soma district.

In northeastern Honshu, the upper Jurassic limestones or calcareous rocks which yielded hexacorals and stromatoporoids are distributed also in the northeast of Cape Shiriya (Onuki, 1959), Aomori Prefecture. From near Cape Shiriya, Murata (1962) described:

*Calamophyllia* ? sp.  
*Kobya shiriyaensis* Murata  
*Thecosmilia* ? sp'  
*Stromatopora (Parastromatopora) crassiflora* Yabe and Sugiyama

These fossils are very rare and their state of preservation is not favourable for specific identification. The rocks aside from the limestone distributed near Cape Shiriya consist of conglomerates, sandstones, slates and clasts which do not indicate near shore sediments, and the limestone does not suggest the existence of a true reef so far as judged from the mode of occurrence of the hexacorals.

Hase (1952) found some hexacorals from the Mesozoic rocks in Iwaizumi-machi, Iwate Prefecture. These fossils were found in limestone pebbles of conglomerate and their occurrence is also rare.

In the south Kitakami region, the occurrence of upper Jurassic rocks had been known for a long time and calcareous rocks comparable with the Koike limestone are also developed. But in those calcareous rocks hexacorals are few and their preservation is not good. The hexacorals from both Iwaizumi and the south Kitakami have not been studied in detail.
As mentioned, in northeast Honshu upper Jurassic calcareous rocks are known from the Soma district to Cape Shiriya and they have yielded corals, but to date there is no evidence of the existence of reefs.

**SYSTEMATIC DESCRIPTION**

Suborder Astrocoeniina Vaughan and Wells, 1943  
Family Astrocoeniidae Koby, 1890  
Subfamily Astrocoeniinae Koby, 1890  
Genus *Astrocoenia* Milne Edwards and Haime, 1848  
*Astrocoenia* sp.  
Pl. 21, fig. 8.

**Description:** Corallum ceroid, corallites small and polygonal, closely united by walls, 0.9–2.0 mm in diameter. Septa thin, hexameral, partly octameral; 24–32 in number alternating in size; 6 or 8 septa of first cycle largest, extending to center, united at their inner ends; septa of second cycle much narrower and shorter; septa of third cycle slightly developed. Walls usually distinct, thin; 0.1–0.3 mm in thickness. Columella present, inner margin of principal setpa united therewith. Synapticulae and disseipements not observable distinctly.

**Remarks:** The present specimen is very small and fragmental, but its septa and the structures of the corallites are relatively well observable. The corallites of this specimen are with partly octameral septa, generally smaller and with walls thinner than those of *Astrocoenia japonica* reported by Eguchi from the lower Cretaceous Hiraigasa ndstone. Although the described structures are similar to *Astrocoenia japonica*, exact identification with *japonica* is difficult. In the center of the ocorrallites, paliform lobes-like structure can be observed, but this is not developed in all of the ocorrallites. *Astrocoenia japonica* is very abundant in the Hiraiga sandstone, but from the Soma Jurassic only a single indeterminable specimen was found. The specimen is very thin, so only its surface was examined. **Locality:** Loc. no. 12, Koike, Kashima-machi, Soma-gun, Fukushima Prefecture. IGPS coll. cat. no. 85522.

Family Stylinidae d'Orbigny, 1851  
Subfamily Euveliini de Fromentel, 1861  
Genus *Enallhelia* Milne Edwards and Haime, 1849  
*Enallhelia nipponica samaensis* Eguchi  
Pl. 23, fig. 3.


**Description:** Corallum dendroid, branching and irregularly flexuous. Corallites circular or more or less oval, 0.5–1.8 mm in diameter. Septa of three complete hexameral cycles in adult stage, sizes differ according to cycles; 6 of first cycle extending to near columella, 6 of second cycle much narrower, 12 of third cycle slightly developed, but in younger form not developed; diminishing in breadth from early to later cycles. Columella styliform well developed.

**Remarks:** The present species is the most dominant one in the Koike limestone and sometimes occurs as a crowded mass which appears to have been of secondary deposition. In the original description of *Enallhelia nipponica samaensis*, Eguchi (1942) stated the number of septa to be 12, but in the present specimen the septa of the third cycle are developed in mature form and the corallum has larger corallities (maximum about 1.8 mm) compared with the original one.
Locality: Loc. no. 2, 3, 4, 6, 7, 8, 9, 10, 12, 13, 14, Minaminosawa, Soma City; Hayama, Kitakuchi, Kabesu-sawa, Nakakuehi, Koike and Tatenosawa, all of Kashima-machi, Soma-gun; Nakayama, Haranomachi City. IGPS coll. cat. no. 85523, 85524.

Subfamily Stylininae d’Orbigny, 1851
Genus *Myriophyllia* d’Orbigny, 1849

*Myriophyllia* sp.
Pl. 21, fig. 1.

Description: Corallum massive. Valleys long, parallel, sometimes short and meandroid. Corallites in series, united directly by walls, fused with parallel septa. Septa short, 4–5 per 2 mm in cross-section of corallites. Columella well developed, discontinuous.

Remarks: The present specimen is ill preserved and the outer features are unknown, the septal structure can be partly observed in section.

_Eugryra sugiyamae_ Eguchi (1951, p. 54, pl. 19, figs. 1–4) from the Torinosu lime stone of Furuya, Oshima-mura, Minamisaku-gun, Nagano Prefecture resembles the present specimen, but the former has no columella.

_Eugryra oshimaensis_ Eguchi (1951, p. 45, pl. 15, fig. 5) from the Oshima formation of Yogai, Oshima, Kesennuma City, Miyagi Prefecture is distinguished from the present one by different growth form and size of septa.

Locality: Loc. no. 2, Minaminosawa, Tomizawa, Soma City, Fukushima Prefecture. IGPS coll. cat. no. 85530.

Genus *Stylinia* Lamark, 1816

*Stylinia* (*Convexastrea*) _somaensis_ Mori, n. sp.
Pl. 21, figs. 4–5.

Description: Corallum massive, of cylindrical corallites. Corallites circular or somewhat oval in cross-section, subequal in size; generally 1.5–2.0 mm in diameter, sometimes up to 3 mm broad. Exothelial area in section very narrow, corallites rather crowded. Septa 16, radially arranged in two cycles, distinctly octameral in plan, 8 of first cycle extending to near center, always thicker and longer than those of second, more or less regular in arrangement. Walls extremely thin, costae distinct, but not so prominent. Columella absent.

Remarks: The genus *Convexastrea* d’Orbigny is now included in the genus *Stylinia* in a wide sense. In 1942, Eguchi recognized *Convexastrea* as a subgenus *Stylinia* based upon the absence of columella in the corallites, and this view is accepted by the writer. The present species is characteristic by having corallites with octameral septa. In appearance, this is similar to *Convexastrea orientalis* Neumayr (1890, Denk, d. K. Acad. d. Wiss., Bd. 57, pp. 30–31, Taf. 5, Fig. 6) from Mitoda, Shikoku, but the latter has distinct hexameral septa.

*Stylinia kachensis* Gregory (1900, *Pal. Ind.*, Ser. 9, Vol. 2 pt. 2, pp. 56–59, pl. 12, figs. 1–17; pl. 13, figs. 1–7) from the upper Putchum beds of the Peninsula of Cutch is distinguished from the present one by having thinner septa and rather prominent costae. *Cryptocoenia Bähmi* Pratz of Speyer (1913, *Paleont.* Bd. 59, p. 211, Taf. 21, Figs. 10–10a) from Kelheim can be distinguished from the present one by having wider interspaces between the corallites.

Locality: Loc. no. 2, Minaminosawa, Tomizawa, Soma City. IGPS coll. cat. no. 85531. (Holotype)
Family Thamnasteriidae Vaughan and Wells, 1943
Genus Thamnasteria Lesauvage, 1823
Thamnasteria abukumaensis Mori, n. sp.
Pl. 21, figs. 6–7.

Description: Corallum massive, surface even. Corallites circular, very large and confluent, somewhat irregular in size; 9–15 mm in diameter, without distinct wall. Septa confluent between corallites, imperforate, cyclical not regular, vary from 14 to 32, about half extending near to center of corallites. Septo-costae rather closely set, 3–5 per 5 mm, laterally united by well developed dissepiments. Interspaces usually wider than septa. Synapticulae and dissepiments abundant, well observed in longitudinal section. Columella not developed.

Remarks: The present specimen is excellently preserved and is characterized by the large corallites, which serve to distinguish.

Thamnasteria maxima Eguchi (1951, p. 47, pl. 16, figs. 2–4) is a species similar to the present one, but is distinguished from the present one by having smaller calices.

Locality: Loc. no. 4, north of Hayama, Kashima-machi, Soma-gun, Fukushima Prefecture. IGPS coll. cat. no. 85532. (Holotype)

Thamnasteria torinosuensis Eguchi
Pl. 22, fig. 3.

Thamnasteria torinosuensis Eguchi, 1951, p. 67, pl. 24, fig. 9.

Description: Corallum massive, thick. Calices shallow, superficial. Corallites numerous, subequal in size, 3–4 mm in diameter, somewhat irregular in distribution. Septa confluent, somewhat perforate except near calices, 22–32 in number; 14–20 of them extending to center of calice. Interspaces between corallites subequal. Septo-costae distinct, disposed radially, rather closely set. Columella styliform, present but in some corallites rudimentary. Synapticulae present.

Remarks: The specimen described resembles Thamnasteria naumannii Eguchi (1951, p. 67, pl. 23, fig. 4) from the Torinosu limestone of Mitoda, Kochi Prefecture, but the latter has more perforated septa.

Thamnasteria hazimotoi Eguchi (1951, p. 79, pl. 26, fig. 10) from the Torinosu limestone of Nishitokura near Itsukaichi-machi, Nisshitama-gun, Tokyo City is a close ally to the present one but the septa are more perforated.

Among foreign species, Thamnasteria smithii Wells (1943, p. 45, pl. 6, fig. 1) from the Jurassic of Ganae, Harrar Province, Ethiopia is similar to the present one, but has somewhat smaller corallites.

Locality: Loc. no. 11, Umazawa, Kashima-machi, Soma-gun, Fukushima Prefecture; Loc. no. 14, Nakayama, Fukono, Haranomachi City, Fukushima Prefecture. IGPS coll. cat. no. 85533, 85534.

Thamnasteria sp.
Pl. 22, fig. 5.

Description: Corallum probably massive. Corallites small, circular or oval, united directly by confluent septo-costae, somewhat irregularly arranged, 2.0–4.0 mm between calicular centers. Septa confluent between corallites, 28–32 in number, arranged in hexameral cycles, not regular, septa of only first cycle extending to near center. Interspaces usually broader than septa. Corallites relatively closely set in central part of corallum, but elongate and more or less perforate in marginal part. Septo-costae aterally united by synapticulae. Columella present, parietal.

Remarks: The present specimen in cross-section, though similar to Dimorphastrea in its
arrangement of corallites, the central corallite of the described one is small.

**Locality:** Loc. no. 2, Minaminosawa, Tomizawa, Soma City, Fukushima Prefecture. IGPS coll. cat. no. 85535.

Suborder Faviina Vaughan and Wells, 1943
Superfamily Faviicidae Gregory, 1900
Family Faviidae Gregory, 1900
Subfamily Montastreinae Vaughan and Wells, 1943
Genus *Goniocora* Milne Edwards and Haime, 1851

**Goniocora** ? sp.
Pl. 23, fig. 2.

**Description:** Corallum branching, laterally free. Corallites circular, subequal in size; 2.5–3.0 mm in diameter. Septa 30–36 in number, cyclical arrangement not regular, septal margin more or less dentate. Wall distinct. Columella parietal or quite rudimentary. Paliform lobes rudimentary or absent.

**Remarks:** The specimen examined is distinguishable from such genera as *Cladocora*, *Pleurocora*, etc. The generic reference of the present specimen is uncertain because of the preservation. This form bears some resemblance to *Goniocora somaensis* Eguchi, (1951, pl. 20, fig. 3) but identification with it is not adequate at present.

**Locality:** Loc. no. 12, Koike, Kashima-machi, Soma-gun, Fukushima Prefecture. IGPS coll. cat. no. 85525.

Family Montlivaltiidae Dietrich, 1926
Subfamily Montlivaltiinae Dietrich, 1926
Genus *Montlivaltiia* Lamouroux, 1821

**Montlivaltiia** ? sp.
Pl. 21, fig. 3.

**Description:** Corallum simple, oval in cross-section. Single corallite, 8.2–11.4 mm in diameter. Septa laminar, thin, numerous and crowded, 14 per 5 mm, size differing according to cycles. Epitheca very thin, partly not visible. Costae distinct, rather strongly developed. Dissepiment not present, columella absent.

**Remarks:** Although this specimen is well preserved and the septal structures can be observed in cross-section. The shape of the corallum is unknown because of there being only a single tangential section at hand.

**Locality:** Loc. no. 14, Nakayama, Haranomachi City, Fukushima Prefecture. IGPS coll. cat. no. 85529.

Genus *Thecosmilia* Milne Edwards and Haime, 1848

**Thecosmilia tosaensis** Eguchi
Pl. 23, fig. 6.

*Thecosmilia tosaensis* Eguchi, 1951, p. 63, pl. 23, fig. 3
*Thecosmilia somaensis* Eguchi, 1951, p. 74, pl. 20, fig. 5

**Description:** Corallum phaceroïd, branching; corallites laterally free, almost circular or oval, but sometimes elongate and polygonal in cross-section, irregular in size and arrangement, 2.5–8.0 mm in diameter. Interspaces between corallites variable because of irregular arrangement. Septa lamellar, thin, 40–96 in number, radially arranged in hexameral plan but not regular in some corallites. Epitheca very thin, not clearly distinguished from dissepiments. Costae present, well observable in almost corallites, subequal. Dissepiments well developed, columella indistinct.
Remarks: *Thecosmilia tosaensis* was first described by Eguchi (1951) from the Torinosu limestone, Iwasa-yama, Togano-mura, Takaoka-gun, Kochi Prefecture, and *Thecosmilia somaensis* by the same author (1951) from the Koike limestone of Koike, Kashima-machi, Soma-gun, Fukushima Prefecture. These two species are characterized by the structures of their corallite arrangement; namely *Thecosmilia tosaensis* has more regular shaped and smaller corallites than those of *Thecosmilia somaensis*. The present specimen, however, shows both characters in a single section; the arrangement of the corallites is irregular but partly regular, and the size of the corallites varies from 2.5 to 8.0 mm in diameter. Therefore, *Thecosmilia tosaensis* and *Thecosmilia somaensis* may be synonyms and the former specific name should be related from priority. In almost each specimen studied, the costae are distinct, but rarely they are rudimentary and generally the corallites show close arrangement.

Localities: Loc. no. 6, Hayama, Kashima-machi, Soma-gun, Fukushima Prefecture; Loc. no. 13, Tatenosawa, south of Koike, Kashima-machi, Soma-gun, Fukushima Prefecture. IGPS coll. cat. no. 8536, 8537.

Suborder Charyophylliina Vaughan and Wells, 1943
Superfamily Charyophylliinae Gray, 1847
Family Rhipidogyridae Koby, 1904
Genus *Aplosmilia* d’Orbigny, 1849
*Aplosmilia somaensis* Eguchi
Pl. 22, figs. 1–2

*Aplosmilia somaensis* Eguchi, 1951, pp. 73–74, pl. 20, fig. 1

Description: Corallum phacoidal, branching. Corallites circular, variable in size; 2.0–5.0 mm in diameter, scattered irregularly. Septa thin, complete hexameral plan, 48 in number, alternating in size; 6 septa of first cycle largest and broadest, extending to near center, 6 of second cycle much shorter and narrower, those of third and fourth cycles slightly developed or quite rudimentary. Interspaces usually wider than septa. Walls rather thick; almost 0.5–1.2 mm in diameter but sometimes shorter. Costae well developed, acute at edge. Columella styliform but sometimes rudimentary.

Remarks: Although the Genus *Aplosmilia* has not been recorded from the so-called Torinosu limestone of southwestern Japan to date, it is interesting that it occurs abundantly in the Koike limestone. In the type specimen, the number of septa was given as 12, but the material at hand show the septa of 4 cycles. In the examined specimen, there are costae lacking corallites, but the costae may have been worn secondarily.

Localities: Loc. no. 2, Minaminosawa; Loc. no. 3, southwest of Loc. no. 2, both of Soma City, Fukushima Prefecture; Loc. no. 4, north of Hayama; Loc. no. 12, Koike, both of Kashima-machi, Soma-gun, Fukushima Prefecture. IGPS coll. cat. no. 8517, 8518, 8519, 8520.

*Aplosmilia ? tochikuboensis* Mori, n. sp.
Pl. 21, fig. 2; Pl. 23, fig. 1

Description: Corallum branching, corallites circular, subequal in size; 3.0–3.5 mm in diameter. Septa 20 in number, distinct decameral plan, but exceptionally 18 in number, alternating in size; 10 of first cycle longest and sometimes reach to columella, 10 of second cycle shorter and thinner than those of first cycle, and rarely septa of third cycle slightly developed near wall in mature form or rudimentary. Walls usually distinct, 0.3–0.7 mm in thickness. Costae observed in well preserved corallites, acute at edge, subequal. Columella styliform, somewhat lamellar.

Remarks: The only specimen of this species at hand is a fragment from the Koike
limestone distributed in the north of Tochikubo. The details of the corallum are unknown and the generic reference is only tentative.

*Aplosmilia somaensis* Eguchi (1951, pp. 73–74, pl. 20, fig. 1) is a species allied to the present one but the former can be distinguished by having distinct hexameral septa.

*Aplosmilia semisulcata* Koby (1904–1905, *Polyp. jur. sup. Portugal.*, pp. 17–18, pl. 1, figs. 13–14a) from Portugal and *Apl. cf. semisulcata* Mich. of Speyer (1913, *Paleont.*, Vol. 59, pp. 204–205, pl. 21, figs. 3–3a) from Kelhelm are similar to the present one, but they have hexameral septa and larger corallites.

**Locality:** Loc. no. 5, north of Tochikubo, Kashima-machi, Soma-gun, Fukushima Prefecture. IGPS coll. cat. no. 85521.

**Genus Acanthogyra** Ogilvie, 1897

*Acanthogyra* sp.

Pl. 22, fig. 4.

**Description:** Corallum small and massive. Corallites prismatic or polygonal, somewhat different in size and shape; 2X4 mm–9X10 mm broad. Septa 24 in number, alternating in size, first and second cycles of septa subequal and extending to near center; third cycle shorter and narrower than first and second, wedge-shaped in section. Interspaces between corallites broad. Columella in corallites rudimentary, but sometimes developed, lamellar. **Remarks:** Only a cross-section of the present specimen was examined. The corallum is fragmental and the structure between each corallite is ill preserved. Therefore there remains doubt as to its generic identification. The present specimen is included in *Acanthogyra* because each corallite is not so elongate as in *Placogyra*. The described specimen resembles *Acanthogyra tosaensis* Eguchi (1951, p. 57, pl. 24, fig. 1; pl. 16, fig. 12) from the Torinosu limestone of Konpira-yama, Kochi Prefecture, but is distinguished therefrom by the latter having more closely set septa and very distinct collines. Although this is undoubtedly a new species, it is not named because of the state of preservation. **Locality:** Loc. no. 1, Nakanosawa, Tomizawa, Soma City, Fukushima Prefecture. IGPS coll. cat. no. 85516.

**Superfamily Agaricicace Gray, 1847**

**Family Calamorphylliidae Vaughan and Wells, 1943**

**Genus Latomeandra** Milne Edwards and Haime, 1849

*Latomeandra † eguchi* Mori, n. sp.

Pl. 23, figs. 4–5

**Description:** Corallum massive, formed of very long, parallel, but sometimes meandroid and dichotomous series of corallites; few isolated corallites seen in short meandroid part. Centers of corallites usually distinct. Septa thin, usually thinner than interspaces, sub-parallel at wall, but often irregularly arranged, some extend to wall in sections, subequal in size; 8–9 septa per 5 mm. Wall between each series rather thick, 2.0 mm in maximum diameter, usually distinct. Columella absent. **Remarks:** This specimen is well preserved in the thin sections. This species is characterized by forming long series of corallites. By its features described above, it is distinguished from the ones mentioned below.

*Latomeandra somaensis* Eguchi (1951, p. 78, pl. 20, fig. 6) from the Koike limestone of Tomizawa differs from the present species by having more crowded septa (14–15 per 5 mm).

*Latomeandra mitodaensis* Eguchi (1951, p. 66, pl. 24, fig. 6) from the Torinosu limestone of Mitoda, Kochi Prefecture is a similar species but it is distinguished from the described one by having thinner wall and shorter series of corallites.
Latomeandra tosaensis Eguchi (1951, p. 66, pl. 24, fig. 7) from the Torinosu limestone of Mitoda, Kochi Prefecture is a Meandraracea-type species. This is also similar to the present one, but the latter can be distinguished from the former by forming long series of corallites and less crowded septa.

Locality: Loc. no. 3, Minaminosawa, Tomizawa, Soma City; Loc. no. 4, north of Hayama, Kashima-machi, Soma-gun, both of Fukushima Prefecture. IGPS coll. cat. no. 85527. (Holotype)

REFERENCES


Moore, R.C. (1956): Treatise on Invertebrate Paleontology, Pt. F. Coelenterata.


——— (1960): A note on Neoburmesia, a peculiar Jurassic pelecypods, with description of Mytilids.


and ——— (1939): Discovery of a Mesozoic hexacoral in a “green schistose rock of the Kamuikotan system” of Hokkaido. Imp. Ac. Tokyo, Pr., 15, pp. 86–89.


Fig. 1. *Myriophyllia* sp. Tangential section, X4. IGPS coll. cat. no. 85530. Loc.: Minaminosawa, Tomizawa, Soma City, Fukushima Prefecture.

Fig. 2. *Apolosmia* ? *tochikuboensis* Mori, n. sp. Tangential section, X4. IGPS coll. cat. no. 85521. Loc.: North of Tochikubo, Kashima-machi, Soma-gun, Fukushima Prefecture.

Fig. 3. *Montlivaltia* ? sp. Tangential section, X 4. IGPS coll. cat. no. 85529. Loc.: Nakayama, Fukono, Haranomachi City, Fukushima Prefecture.


Figs. 6–7. *Thamnasteria abukumaensis* Mori, n. sp. Fig. 6: Tangential section, X 4. Fig. 7: Longitudinal section, X4. IGPS coll. cat. no. 85532. Loc. North of Hayama, Kashima-machi, Soma-gun, Fukushima Prefecture.

Fig. 8. *Astrocoenia* sp. Weathered surface, X2. IGPS coll. cat. no. 85522. Loc.: Koike, Kashimamachi, Soma-gun, Fukushima Prefecture.
Kumagai photo
PLATE 22

Fig. 1. *Aplasmilia somaensis* Eguchi, Tangential section, X4. IGPS coll. cat. no. 85517. Loc.: Koike, Kashima-machi, Soma-gun, Fukushima Prefecture.

Fig. 2. *Aplasmilia somaensis* Eguchi, Tangential section and Longitudinal section. X4. IGPS coll. cat. no. 85518. Loc.: Koike, Kashima-machi, Soma-gun, Fukushima Prefecture.

Fig. 3. *Thamnasteria torinoshimensis* Eguchi, Tangential section, X4. IGPS coll. cat. no. 85533. Loc.: Umazawa, southwest of Koyamada, Kashima-machi, Soma-gun, Fukushima Prefecture.

Fig. 4. *Acanthogyra* sp., Tangential section, X4. IGPS coll. cat. no. 85516. Loc.: Nakanosawa, west of Tomizawa, Soma City, Fukushima Prefecture.

Fig. 5. *Thamnasteria* sp., Tangential section, X4. IGPS coll. cat. no. 85535. Loc.: Minaminosawa, Tomizawa, Soma City, Fukushima Prefecture.
Fig. 1. *Aplosmilia tochikuboensis* Mori, n. sp. Tangential section, X4. IGPS coll. cat. no. 85521. Loc.: North of Tochikubo, Kashima-machi, Soma-gun, Fukushima Prefecture.

Fig. 2. *Goniocora* ? sp., Tangential section, X4. IGPS coll. cat. no. 85525. Loc.: Koike, Kashima-machi, Soma-gun, Fukushima Prefecture.

Fig. 3. *Enallhelia nipponica somaensis* Eguchi, Tangential section, X4. IGPS coll. cat. no. 85523. Loc.: Kitakuchi, Koyamada, Kashima-machi, Soma-gun, Fukushima Prefecture.

Figs. 4–5. *Latomeandra eguchii* Mori, n. sp., Fig. 4.: Tangential section, X2. Fig. 5: Longitudinal section, X2. IGPS coll. cat. no. 85527. Loc.: Minaminosawa, Tomizawa, Soma City, Fukushima Prefecture.

Fig. 6. *Thecosmilia tosaensis* Eguchi, Tangential section, X4. IGPS coll. cat. no. 85536. Loc.: Tatenosawa, south of Koike, Kashima-machi, Soma-gun, Fukushima Prefecture.