

Ayukawa Formation of the Ojika Peninsula, Miyagi Prefecture, Northeast Japan

By

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Abstract

The stratigraphy of the Ayukawa Formation, Ojika Peninsula, northeast Honshu, together with the paleontological notes on the ammonites therein, is described in this paper. The Ayukawa Formation may range from Uppermost Jurassic (?) to Lower Cretaceous (Lower Neocomian) in age and moreover, is assigned to the Berriasian age at least for its middle part. This formation is much thicker than estimated before and than the equivalents of other areas in the south Kitakami Mountains.

1. Introduction

The Ojika Peninsula at the southernmost part of the Sanriku Coast is one of the Jurassic and Cretaceous fields in the southern part of the Kitakami Mountains. Concerning the geology of this area a number of reports have been published by various authors. Nevertheless, the Jurassic-Cretaceous boundary of this area and the exact age of the Ayukawa Formation have remained undetermined.

In order to solve these problems, the writer for several years engaged himself in the field work on the Jurassic and Lower Cretaceous sequences of the Ojika Peninsula. In the course of this survey 1/1,000 route maps were made along several selected routes. As a result of this investigation, the stratigraphical scheme of the Jurassic-Cretaceous sequence, especially of the Ayukawa Formation, differing fundamentally from the previous authors' schemes is established and the age of the Ayukawa Formation can be determined on the basis of several ammonoid species. Thus, this paper deals primarily with the stratigraphy of the Ayukawa Formation, adding to paleontological description of the ammonites.

Acknowledgments—The writer is much indebted to Assistant Professor Tadashi SATO of the Geological Institute, University of Tokyo for identifying ammonoid species and Dr. Itaru HAYAMI of the Department of Geology, Kyushu University for identification of pelecypod species.

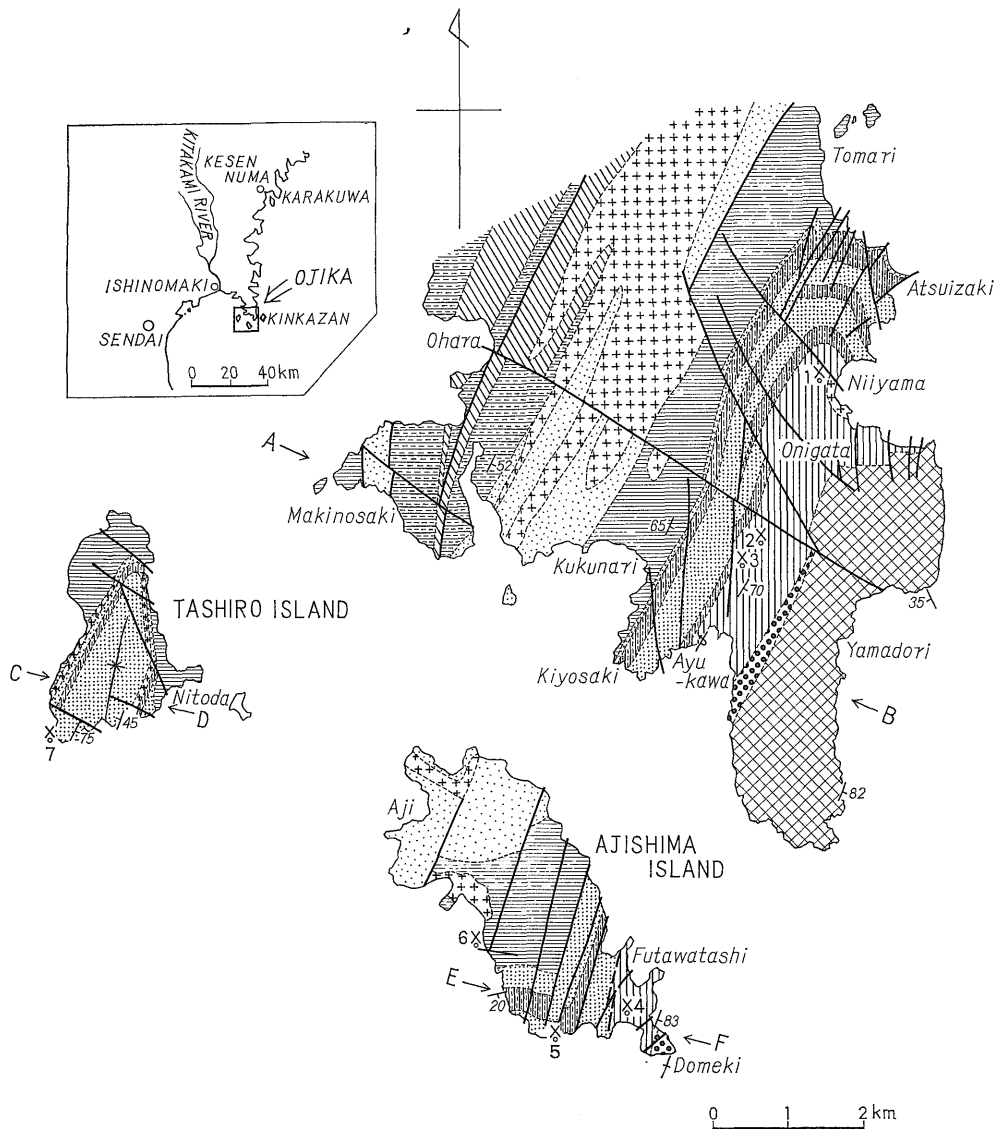
The writer also is grateful to the following staff members of the Geological Survey of Japan: to Dr. Keisaku TANAKA and Dr. Nobukazu KAMBE for much help and valuable advice in the course of the work, to Dr. Masatora KAWAI, Dr. Sachio IGI and Dr. Masato KATADA for helpful suggestions on geology and also to Mr. Yoshio MASAI for photographing specimens of ammonites.

Further thanks are due to Dr. Haruyuki TAKAYASHI of the Ibaragi University and Professor Yoshio ONUKI of the Miyagi University of Education who provided the writer with valuable information.

2. Outline of Geology

The Ojika Peninsula is occupied by folded Mesozoic strata with the general trend of NNE-SSW

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Locality of Molluscan Fossils

- | | |
|------------------|-----------------------------|
| 1. Niiyama | 2. The Quarry near Kanayama |
| 3. Minamizawa | 4. Nakashoji |
| 6. Nagatoro-hama | 7. Mitsuishi |

Fig. 1a Geologic Map of the southern part of Ojika Peninsula

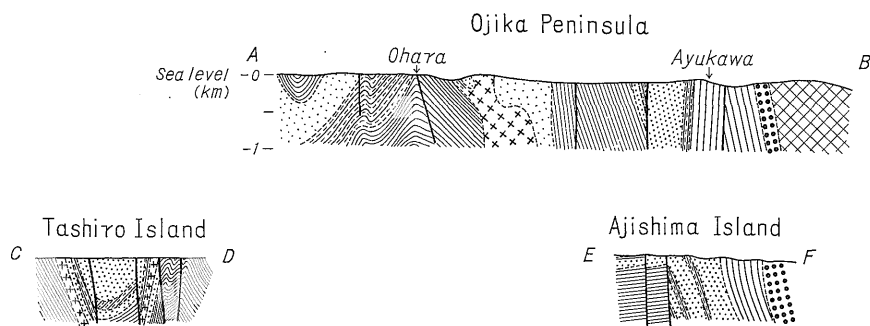
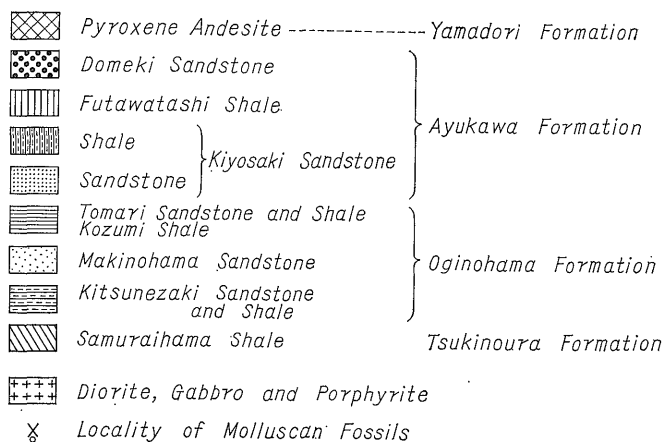


Fig. 1b Geologic Profile



which are intruded by several masses of plutonics (Fig. 1). The Jurassic to Lower Cretaceous Ojika Group overlies the Triassic Inai Group with an unconformity. The Ojika Group is stratigraphically divisible into three formations, the Tsukinoura, Oginohama and Ayukawa Formations in ascending order (Table 1). The upper half of the Ojika Group is distributed in the western Kozumi synclinorium and the eastern Niiyama synclinorium which are separated from each other by the Ohara anticlinorium and both pitch to the south on the whole. The Niiyama synclinorium is delimited on the east by the Kinkazan tectonic line (Igi and others, 1968).

The Tsukinoura Formation as a whole shows a single cycle of sedimentation and is stratigraphically divisible into two members. The lower member, Tsukinoura Sandstone is more than 120 m thick, and is littoral sediments composed of sandstone and sandy shale with basal conglomerate. The upper member, Samuraihama Shale is underlain by the Tsukinoura Sandstone with a gradual change of rock-facies, and is represented exclusively by black, bedded, silty shale. It is 500 to 600 m thick.

The Oginohama Formation is probably conformable to the underlying Samuraihama Shale. It

Formation	Member	Thickness [§] (in. m)	Lithologic character	Age		
<i>Yamadori Formation (effusive & pyroclastic rocks)</i>				?Valanginian		
Ojika Group	Ayukawa Formation	Domeki sandstone	300	coarse or very coarse-grained, arkosic sandstone	Cretaceous	
		Futawatashi shale	620	stratified or laminated black shale with fine sandstone base: coarse-grained, arkosic sandstone		Berriasian
		Kiyosaki sandstone	670	coarse or very coarse-grained, arkosic sandstone with conglomerate		?Tithonian
	Oginohama Formation	Tomari sandstone and shale	370	sandstone and shale in medium-bedded alternation	Kimmeridgian	Jurassic
		Kozumi shale	~850	black stratified shale		
		Makinohama sandstone	320	coarse or very coarse-grained, sandstone with conglomerate black shale	Oxfordian	
		Kitsunezaki sandstone and shale	360	sandstone and shale in medium-bedded alternation	Callovian	
	Tsukinoura Formation	Samuraihama shale	500 ~600	black well-stratified shale		? Bathonian
		Tsukinoura sandstone	120 ⁺	black sandy shale, coarse-grained sandstone and conglomerate	Bajocian	
<i>Inai Group</i>						

§ Thicknesses are from type sections

Table 1 Stratigraphic Classification of the Ojika Group

is stratigraphically divisible into four members. The lower Kitsunezaki Member is characterized by fine- to medium-grained sandstone and laminated shale in rhythmic alternation, exhibiting a flysch appearance. This member is about 360 m in thickness. The middle Makinohama Sandstone Member is about 320 m thick, and covers the Kitsunezaki Member conformably, but with a rapid change of lithofacies. It is composed mainly of conglomerate and sandstone with subordinate black sandy shale. Pebbles of the conglomerates are dominated by various types of granites, hornfelsic rocks of slate and sandstone, and chert. Plant fossils are abundant at several horizons. The upper member, Kozumi Shale overlies the Makinohama Sandstone with a gradual change in facies. It consists exclusively of black, bedded shale, containing some ammonites (e.g. perisphinctids). The uppermost Tomari Member is made up of medium-grained sandstone and laminated shale in flysch-like alternation. This member is thicker in the east than in the west.

The Ayukawa Formation is conformably underlain by the Tomari Member of the Oginohama Formation and unconformably overlain by the Yamadori Formation which is represented by effusive rocks. It is about 1,600 m thick and dominated by arkosic sandstone. Further details will be given in the next chapter.

The intrusive rocks in the Ojika Peninsula are composed of porphyrite, diorite and gabbro with a small amount of hypersthene basalt. All of the various kinds of intrusive rocks mentioned above may be genetically related to one another, because they grade in petrologic attributes into one another. Thus, they are generically called "the Ojika complex" (IGI and others, 1968). These intrusive bodies, roughly speaking, occur in concordance with the general trend of the Ojika Group.

3. Stratigraphy of the Ayukawa Formation

3.1 General Remarks

The Ayukawa Formation is typically exposed along the coast of Kiyosaki southwest of Ayukawa

and the southern coast of Ajishima Island. In these areas this formation shows a homoclinal structure with a general trend of NNE-SSW, dipping at an angle of 70° to 90° eastward, and is occasionally even overturned. However, the Ayukawa Formation has hitherto been erroneously regarded as being complicatedly folded and exposed only in the axial part of several synclines. Thus, the thickness of this formation was estimated at 250 m (FUKADA, 1951; MINATO, 1953, table IV; FUJI, 1956; ONUKI, 1956) or 450 m (TAKAHASHI, 1962). In actual fact, the Ayukawa Formation is found to be much thicker than estimated before, being nearly 1,600 m thick altogether.

The Ayukawa Formation, furthermore, shows a synclinal structure plunging steeply to the south near Niiyama north of Ayukawa, and a synclinal structure in Tashiro Island.

It should be added here that an isolated outcrop of very coarse-grained, arkosic sandstone probably belonging to the Ayukawa Formation was found by Dr. KAMBE and the present writer near Kanayama east of Ishinomaki City.

The stratigraphic sequence of the Ayukawa Formation is summarized in Fig. 2. This formation is stratigraphically divisible into three members, the Kiyosaki, Futawatashi and Domeki Members in ascending order. Of these three members, both the Futawatashi and the Domeki Members are not

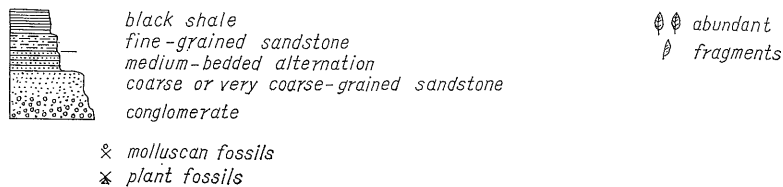
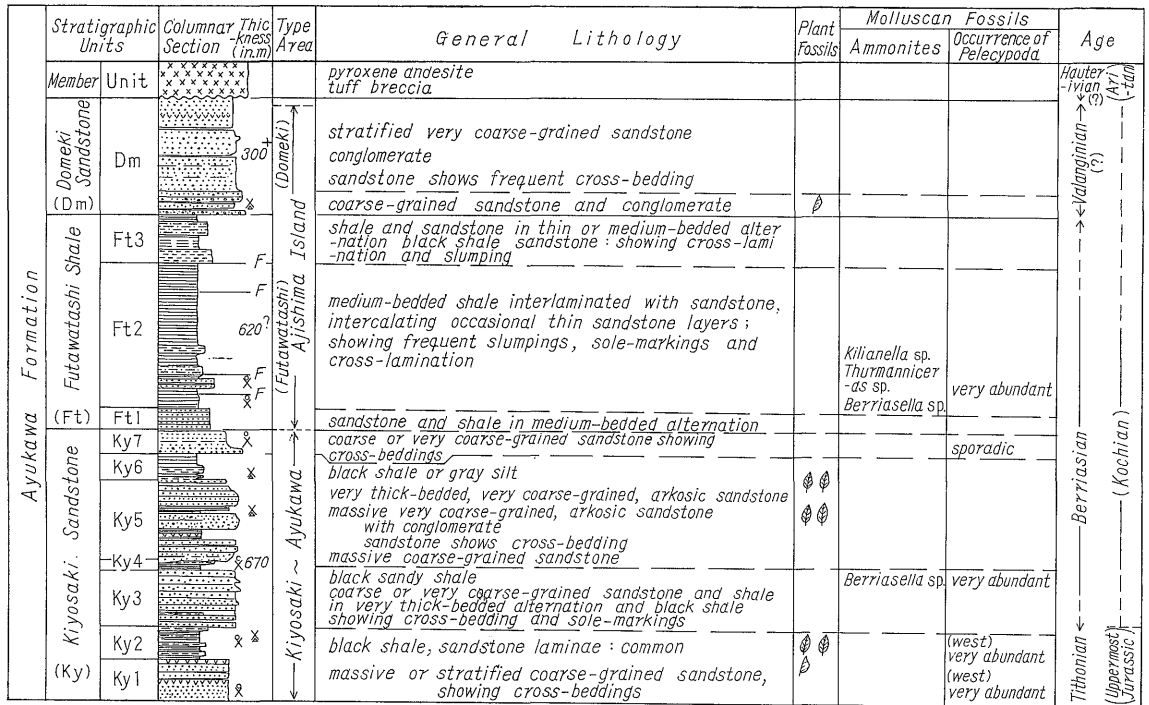


Fig. 2 Generalized stratigraphic succession of the Ayukawa Formation

exposed in Tashiro Island. The Kiyosaki Member with several plant beds and the Domeki Member are characterized by the predominance of very coarse-grained, arkosic sandstone; the middle Futawatashi Member between consists mainly of black, marine shale.

3.2 Kiyosaki Sandstone Member

This member is typically exposed along the coast of Kiyosaki southwest of Ayukawa. It consists of coarse-grained, arkosic sandstone and subordinate black shale in very thick-bedded alternation, being intercalated with some conglomerates. The Kiyosaki Member is about 670 m thick in the type area. The sandstone is composed of angular grains of quartz and feldspar and fragments of felsic volcanic rocks with a small amount of matrix. Pale-greenish dacitic to rhyolitic tuff occurs at several horizons.

The present member is very variable in lithofacies from base to top, thus being divisible into seven units (Fig. 2). Some units are rich in sandstone, but others are dominated by shale. A depositional break as represented by a diastem or partial disconformity is observed between unit Ky 4 and unit Ky 5. The characteristics of each stratigraphical unit are as follows.

Unit Ky 1.— This unit is made up of coarse-grained, arkosic sandstone accompanied by siltstone and acid tuff. At Atsuizaki there occurs black bituminous shale bearing coaly fragments. The sandstone of this unit is thickly bedded in the eastern part of the studied area, while massive in the western

Table 2 List of the molluscan fossils from the Ayukawa Formation

Species	Locality	1	2	3	4	5	7
Ammonoid							
<i>Thurmanniceras</i> sp. cf. <i>T. isokusensis</i> (KOBAYASHI et FUKADA)			R				
<i>Kilianella</i> sp.					R		
<i>Berriasella</i> sp.						C	
Pelecypoda							
<i>Parallelodon kesenumensis</i> HAYAMI						S	
<i>Syncyclonema</i> (?) sp.						R	
<i>Grammatodon</i> sp.				S			
<i>Neithea</i> n. sp.						C	
<i>Trinosucatella</i> sp. cf. <i>T. Kobayashii</i> (TAMURA)						R	
<i>Somapecten</i> sp. cf. <i>S. Kamimanensis</i> KIMURA						R	
<i>Mantellum akiyamae</i> (HAYAMI)						A	
<i>Mantellum</i> sp.				S			
<i>Amphidonte</i> sp. cf. " <i>Exogyra</i> " <i>Kumensis</i> KIMURA				S			V. A
<i>Ctenostreon</i> sp. cf. <i>C. probossidenm</i> (SOWERBY)	R						
<i>Myophorella</i> (<i>Promyophorella</i>) <i>orientalis</i> KOBAYASHI and TAMURA				C			
<i>M.</i> (<i>P.</i>) sp.				C			V. A
<i>M.</i> (<i>Haidaia</i>) <i>crenulata</i> KOBAYASHI and TAMURA						R	
<i>Astarte higoensis</i> TAMURA						S	
<i>A.</i> sp. cf. <i>spitiensis</i> STOLICZKA						R	
<i>A.</i> sp.						C	
<i>Opis</i> (<i>Trigonopsis</i>) sp. cf. <i>O. torinosuensis</i> KIMURA				R			
<i>Plectomya</i> (?) sp.						R	
Gastropoda		R		S		S	
Brachiopoda						S	

Locality (See Fig. 1)

V. A : very abundant A : abundant C : common S : sporadic R : rare

1. Niiyama. 2. The Quarry near Kanayama, north of Ayukawa 3. Minamizawa, about 1 km north of Ayukawa
4. Nakashoji, Ajishima Island. 5. Yokone, southern coast of Ajishima Island. 7. Mitsuishi, Tashiro Island.

part (Tashiro Island). Bivalves are very abundant in sandstone in Tashiro Island.

Unit Ky 2.— The unit consists of shale interlaminated with sandstone, carrying occasional interbeds of fine-grained sandstone. The shale is dark gray in color and rich in plant fossils in the eastern part of the area, whereas in the western part of the area (Tashiro Island) it is black in color and intercalated with some marine shell beds. Unit Ky 2 was formerly regarded as being equivalent to unit Ky 6 which is similarly represented by shale. In reality, the shale of unit Ky 2 is rich in sandstone lamina, whereas that of unit Ky 6 is monotonous without including sandy material.

Unit Ky 3.— This unit consists of a thick-bedded alternation of very coarse-grained sandstone and black shale, each of them is generally several meters thick. Some sandstone beds begin with conglomerate. Sole markings and graded bedding are commonly developed in sandstones.

Unit Ky 4.— The unit is represented by black sandy shale of marine deposition and contains pelecypod fossils very abundantly. Some ammonites (e.g. *Berriasella*) also are found in this unit. The unit is much thicker in Ajishima Island than in the northern part of the peninsula.

Unit Ky 5.— This unit is made up mainly of very coarse-grained sandstone with frequent intercalation of conglomerates. The sediments of this unit as a whole are coarser grained than those of the other units. Graded bedding is almost imperceptible, but cross-bedding is common.

Unit Ky 6.— This unit consists largely of black shale accompanied by siltstone containing plant fossils.

Unit Ky 7.— This unit begins with a thin layer of conglomerate which, in turn, is followed by a 40 m sequence of coarse- or very coarse-grained arkosic sandstone.

3.3 Middle Shale Member

This member is typically exposed near Futawatashi, Ajishima Island. The main part of the member consists chiefly of muddy flysch-like sediments which are represented by black, laminated to medium-bedded shale frequently interlaminated and interbedded with sandstone. The thickness of the member in the type area measures about 620 m, although its exact value can not be obtained owing to frequently steeply dipping overthrusts.

Some ammonoids such as *Kilianella*, *Thurmanniceras* and *Berriasella*, and pelecypods are found in the shale. It should be noticed that the Futawatashi Member is essentially different in sedimentary facies from the other members of the Ojika Group. That is to say, the member is characterized by the common occurrence of disturbed beds and penecontemporaneous deformational structures such as slump overfold ball-and-pillow structure. Thin interbeds of fine-grained sandstone display a variety of current sole markings, load structures, convolute lamination, cross-lamination and current ripple marks.

3.4 Domeki Sandstone Member

This member is typically exposed near Domeki at the eastern extremity of Ajishima Island. It consists mostly of very coarse-grained, arkosic sandstone and is lithologically very similar to the Kiyosaki Sandstone. Black shale is intercalated only in the lower part of the member. At several horizons there occurs conglomerate, pebbles mainly rhyolite, granite and chert.

The thickness of the member increases to the south on the whole, measuring more than 330 m at Domeki. The stratigraphic relation between this member and the underlying strata, in spite of the rapid change of lithofacies, is probably conformable. On the other hand, the Domeki Member is unconformable to the overlying Yamadori Formation.

4. Geologic Age of the Ayukawa Formation

The Ayukawa Formation has hitherto been referred to the earliest Cretaceous or the Kochian Series of the Japanese time-scale on the basis of insufficient paleontological evidence. However, the ammonites from the Ayukawa Formation are very similar to those from the Berriasian Isokusa and Nagasaki Formations (SATO, 1959) of the Karakuwa district north of the Ojika Peninsula. This fact makes it possible to determine the age of the Ayukawa Formation.

Among the identified ammonoid species, *Thurmanniceras cf. isokusensis* and *Kilianella sp.* surely indicate a Lower Cretaceous Berriasian age. Accordingly, the lower part of the Futawatashi Member, the middle part of the Ayukawa Formation can be safely correlated with the Berriasian Isokusa and Nagasaki Formations. Furthermore, the relatively upper part of the Ayukawa Formation may be referred to the Valanginian.

In the Karakuwa area the stratigraphic relation between the Isokusa-Nagasaki Formation and the Upper Jurassic Kogoshio Formation is unknown because of poor exposure. Judging from the writer's preliminary field survey, however, it may well be said that the Isokusa and Nagasaki Formations are referred to the upper part of the Kogoshio Formation. In actual fact, the lower part of the Ayukawa Formation (i.e. the Kiyosaki Member) and the Kogoshio Formation are extremely similar to each other in lithofacies, mode of cyclic sedimentation, thickness and kind of pebbles. Therefore, it is reasonable that the Ayukawa Formation as a whole is correlated to the Kogoshio Formation inclusive of the Isokusa-Nagasaki Formation.

The Ayukawa Formation is covered with the Yamadori Formation which is correlated to the Kanaegaura Formation in Oshima Island of the Karakuwa district. It is established that the Oshima Formation overlying the Kanaegaura Formation is Hauterivio-Barremian in age. From these facts it is concluded that the age of the Ayukawa Formation ranges from Uppermost Jurassic Tithonian (?) to Lower Neocomian (Valanginian?).

Appendix

On Some Berriasian Ammonites from the Ayukawa Formation, Ojika Peninsula

By

Tadashi SATO* & Fuminori TAKIZAWA

One of the writers (TAKIZAWA) discovered a number of ammonites from the Ayukawa Formation, the upper part of the Jurassic-Cretaceous Ojika Group, of the Ojika Peninsula, and then SATO identified them. As a result, among the ammonites there are discriminated three species which are quite similar to the ammonites reported by SATO from the Berriasian Isokusa and Nagasaki Formations of Oshima Island in the Karakuwa district. Therefore, these characteristic ammonites indicate a Berriasian age at least for the middle part of the Ayukawa Formation and then supports the aforementioned stratigraphical scheme of the same formation established by the junior author.

Of the ammonites from the Ayukawa Formation *Berriasella* occurs in abundance at Yokone and Bando-no-hama of Ajishima Island.

Brief paleontological remarks are given on four identified ammonoid species including one species from the underlying Kozumi Member of the Oginohama Formation.

Family Berriasellidae SPATH, 1922

Subfamily Berriasellinae SPATH, 1922

Genus *Berriasella* UHLIG, 1905

Berriasella sp. Pl. 1, Fig. 1.

Material—Several specimens, all fragmental.

Description—A large adult or rather senile specimen, though highly corroded, presents Berriasellid characters such as irregular, somewhat flexuous, generally bifurcated ribbing. The ribbing becomes obsolete at the senile stage. No ventral aspect is known. But a specimen from Yokone, well-preserved outer mold of the ventral portion, exhibits clear and smooth siphonal band, bounded by the swelled terminals of the ribs. There is no guarantee, however, that all the specimens belong to one and the same species.

Remarks—Despite the impossibility of specific determination, the general aspect of the shell ornamentation suggests some of the more or less advanced forms of *Berriasella*. Such forms can coexist with the *Thurmanniceras* as in the case of the Nagasaki and Isokusa Formations of Oshima Island.

Occurrence—Black sandy shale at Yokone of Ajishima Island. Probably Berriasian.

Subfamily Neocomitinae SPATH, 1924

Genus *Thurmanniceras* COSSMANN, 1901

Thurmanniceras sp. cf. *T. isokusensis* (KOBAYASHI and FUKADA) Pl. 1, Fig. 2.

Compare—1947. *Perisphinctes* (*Discosphinctes*) *isokusensis* KOBAYASHI and FUKADA,

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p. 55, pl. XIII, figs. 2-4.

1958. *Thurmanniceras isokusensis*, SATO, p. 592, pl. XXVIII, figs. 9-12.

Material—A single immature specimen. GSJ 5513*.

Description—Whorl rather rapidly growing, with somewhat convex side and slightly flattened ventral region. Ribbing fine and dense, somewhat sinuous and prorsiradiate, but irregularly bifurcated at various heights of the side, and sometimes even bidichotomous, terminated by small swellings at the border of the smooth siphonal band. Faint constriction present.

Remarks—Since the specimen is small and immature, the comparison with the described species of *Thurmanniceras* is difficult. The attribution to the genus is, however, justified by the characteristic ribbing which definitely differs from that of *Olcostephanus* forms known from the corresponding horizons of Oshima Island.

Occurrence—Black bedded shale at a quarry near Kanayama north of Ayukawa. Berriasian.

Genus *Kilianella* UHLIG, 1905

Kilianella sp. Pl. 1, Fig. 3

Compare—1958. *Kilianella* sp. SATO, p. 595, pl. XXXVIII, fig. 8.

Material—A single specimen. GSJ 5514.

Description—Widely spaced, stout ribs are characteristic. Strong and probably prorsiradiate constriction present, accompanied by triplicate rib behind. Ribs are mostly simple, but there are some bifurcated ones at the ventral shoulder.

Remarks—The specimen at hand, though fragmental and deformed, closely resembles the described *Kilianella* from Oshima Island (SATO, 1958, pl. XXVIII, fig. 8) on the general aspect of the shell.

Occurrence—Derived from a rolled block at Nakashoji of Ajishima Island. Probably Berriasian.

Family Perisphinctidae STEINMANN, 1890

Subfamily Perisphinctinae STEINMANN, 1890

Perisphinctinid gen. et sp. indet. Pl. 1, Fig. 4.

Material—A single large specimen.

Description—The specimen is poorly preserved except small part of the body chamber, and is difficult to be determined even generically. The rounded ventral region, regular, biplicate and uninterrupted ribbing and presence of faint constrictions accompanied by peculiar ribs are all indicative of some Perisphinctid genera instead of some similar Berriasellids.

Occurrence—Black shale of probable Kozumi Shale Member along the western coast of Ajishima Island (Nagatoro-hama). Probably uppermost Jurassic.

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* The prefix GSJ for numbers of catalogue is an abbreviation for the Geological Survey of Japan.

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宮城県牡鹿半島の鮎川層について

滝沢文教

要 旨

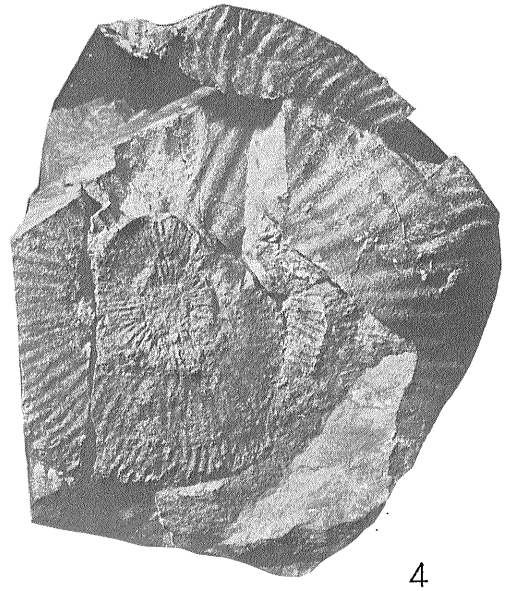
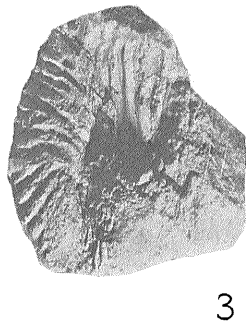
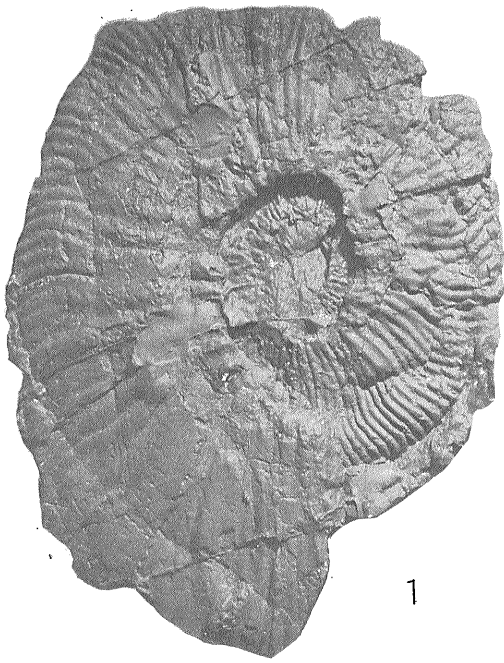
牡鹿層群 (中部ジュラ系～下部白亜系) の最上部層である鮎川層の層序と構造について新知見を述べた。本層については、従来等斜褶曲構造を示し、層厚 250m あるいは 450m とされていた。筆者の調査では、本層は主分布域において基本的に同斜構造を呈し、厚さ約 1,600m に達することがわかった。本稿では新しい層序区分を示し、対比に関連してアンモナイトの記載を付記した。鮎川層は岩相的に下位から次の 3 部層に区分される。

(下部) 清崎砂岩: 浅海～陸成 (?) の粗粒アルコーズ砂岩を主とする。厚さ 670m

(中部) 長渡頁岩: 泥質フレッシュ型の海成黒色頁岩, 厚さ 620m

(上部) ドウメキ砂岩: 粗粒アルコーズ砂岩厚さ約 300m

本層の粗粒砂岩は酸性火山岩の礫および岩石片を多量に含有することで特徴づけられ、田代島の砂岩が層相から清崎砂岩と同層準であることは確実である。アンモナイトおよび海棲二枚介は下部層～中部層下半より産出し、それらは下部白亜紀 Berriasian を示している。しかも唐桑地域の磯草・長崎層産のものに酷似する。



Explanation of PLATE I (*Plate 44*)

Fig. 1. *Berriasella* sp.

A gypsum cast from external mold, GSJ 5512 from loc. 5, Yokone, Ajishima Island, Unit Ky. 4, Kiyosaki Sandstone Member, Ayukawa Formation (Coll. TAKIZAWA). Lateral view $\times 0.7$.

Fig. 2. *Thurmanniceras* sp. cf. *T. isokusensis* (KOBAYASHI and FUKADA)

GSJ 5513, from loc. 2, near Kanayama north of Ayukawa, Unit F3, Futawatashi Shale Member, Ayukawa Formation (Coll. TAKIZAWA). Lateral view $\times 2.8$.

Fig. 3. *Kilianella* sp.

GSJ 5514, from loc. 4, Nakashoji, Ajishima Island, probably derived from Unit F3, Futawatashi Shale Member, Ayukawa Formation (Coll. TAKIZAWA). Lateral view $\times 1.1$.

Fig. 4. *Perisphinctinid* gen. et sp. indet.

GSJ 5515, from loc. 6, Nagatoro-hama, western coast of Ajishima, Kozumi Shale Member, Oginohama Formation underlain by the Ayukawa Formation (Coll. TAKIZAWA). Lateral view $\times 0.7$.