

## Ammonoids from the Sakiyama Formation of the Lower Cretaceous Miyako Group, Iwate Prefecture, Northeast Japan

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**Abstract** The Sakiyama Formation of the Lower Cretaceous Miyako Group, distributed at Ebisudana, along the Rikuchu coast of Iwate Prefecture, northeast Japan, is composed by bioturbated sandy mudstone and hummocky cross-stratified sandstone. The depositional environment of the section is inferred to be the lower shoreface to inner shelf. The section yields abundant ammonoid and other fossils. Nine ammonoid species are newly identified from the Sakiyama Formation. On the basis of the ammonoid fossils, the section of the Sakiyama Formation is correlated to the uppermost part of the Hiraiga Formation to the lower part of the Aketo Formation of the Miyako Group.

**Key words:** ammonoids, depositional environments, Lower Cretaceous, Miyako Group

### Introduction

The Lower Cretaceous Miyako Group is exposed sporadically along the Rikuchu coast, which extends for approximately 35 km in Iwate Prefecture, northeast Japan (Fig. 1). It represents a shallow-marine clastic sequence, and is one of the standard strata of the Lower Cretaceous series in Japan. The lithofacies of the group changes laterally, and therefore, the stratigraphic divisions are different between the northern area (distribution in Tanohata area) and the southern area (Moshi, Taro and Miyako areas) (see Hanai *et al.*, 1968).

Since the study by Yaegashi (1900), many fossil groups: bivalves (e.g., Hayami, 1965a, b, 1966), ammonoids (e.g., Hoffmann *et al.*, 2013; Obata, 1967a, b, 1969, 1973, 1974, 1975; Obata and Matsukawa, 1980; Obata and Futakami, 1991, 1992), gastropods (Kase, 1984), crinoids (Oji, 1985), corals (Eguchi, 1951), and others have been described mainly from the northern

area. Recently, Fujino *et al.* (2006) reported tsunami deposits from the Tanohata Formation in the northern area.

On the other hand, there have been few paleontological and geological studies in the southern area in comparison with northern area. Therefore, it is desirable to obtain more geological information to enable a correlation between the northern and southern areas.

The Sakiyama Formation is dominated by silty sandstone (Shimazu *et al.*, 1970). The distribution of the Sakiyama Formation is limited in the southern area and was correlated with upper part of the Hiraiga Formation in the northern area. Shimazu *et al.* (1970) reported the occurrence of bivalves, belemnites, crinoids, echinoids, and calcareous algae from this formation.

The present paper discusses fossils and depositional environments of the Sakiyama Formation. In addition, we also compare the litho- and biostratigraphy of the north area with other Cretaceous systems.

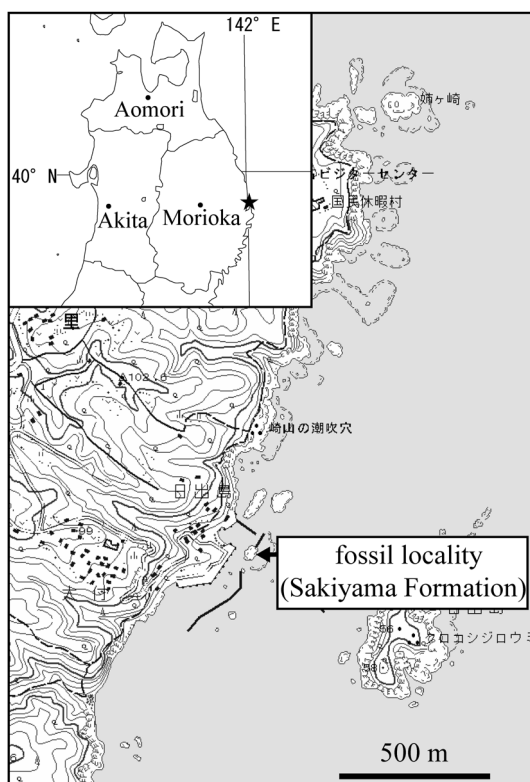


Fig. 1. Map showing the study area and the fossil locality (using the topographical map of "Taro" scale 1:25,000 published by the Geographical Survey Institute of Japan).

### Geological setting

The Miyako Group unconformably overlies the Upper Jurassic to Lower Cretaceous Rikuchu Group and its intrusive volcanic rocks (Hanai *et al.*, 1968). The lithostratigraphy of the Miyako Group laterally changes from north to south, and different stratigraphic schemes have been applied to the northern and southern areas respectively (Fig. 2). In the northern area, the group is subdivided into the Raga, Tanohata, Hiraiga, and Aketo formations in ascending order (Hanai *et al.*, 1968). In the southern area, the group is subdivided into the Raga, Tanohata, Hiraiga, Sakiyama, and the Hideshima formations, in ascending order. The Hideshima Formation is inferred to be the uppermost of the group based on the topographical position and geological

structure (Shimazu *et al.*, 1970). The total thickness of the group excluding the Hideshima Formation is approximately 200 m, and the top is submerged in the sea. On the basis of the ammonoid biostratigraphy, the Tanohata Formation to the Aketo Formation is considered to be late Aptian to early Albian in age (Obata, 1974).

The Hiraiga Formation is distributed in both the north and south areas. However, the formation in the southern area was interpreted to represent only the lower half of sedimentary cyclothem of the Hiraiga Formation in the northern area (Shimazu *et al.*, 1970). In the present paper, follow this interpretation, and describes the "Hiraiga Formation" in the southern area by using double quotation marks. In the southern area studied, the Raga and Tanohata formations are frequently omitted due to basement topographical rises (Hanai *et al.*, 1968).

Calcareous sandstone of the Tanohata Formation unconformably covers the Rikuchu Group along the Hideshima coast in Miyako City. Alternating beds of calcareous sandstone and sandy mudstone of the "Hiraiga Formation" conformably covers the Tanohata Formation. The Sakiyama Formation, which is mainly composed of sandy mudstone, is distributed in Ebisudana, a small island located to the east of the Hideshima coast. The strata strike N 10° E, and dip 20° to 30° E in the area. According to Shimazu *et al.* (1970), the Hideshima Formation is distributed in Hideshima Island, which is located to the east of Ebisudana.

### Geologic notes and fossils

#### Geologic notes

The best section of the Sakiyama Formation of the Miyako Group is exposed at Ebisudana, which is the stereotype of the formation (Figs. 3, 4-1). The section is composed by the lower and upper part.

The lower part is characterized by dark gray, massive, and well-sorted sandy mudstone intercalated with very thin, fine-grained sandstone layers (Fig. 4-3). Distinct trace fossils are

| Stratigraphy    |       | North area<br>(Hanai <i>et al.</i> ,<br>1968) | South area<br>(Shimazu <i>et al.</i> ,<br>1970) | South area<br>(Present paper) | "Stratigraphical zonation of ammonoids" (Obata, 1974) |                       |                                       |                                                                                  |                        |
|-----------------|-------|-----------------------------------------------|-------------------------------------------------|-------------------------------|-------------------------------------------------------|-----------------------|---------------------------------------|----------------------------------------------------------------------------------|------------------------|
|                 |       |                                               |                                                 |                               | Desmocerataceae                                       |                       | Douvilleicerataceae etc.              |                                                                                  | Heteromorpha           |
|                 |       |                                               | Hideshima<br>Formation                          | Hideshima<br>Formation        |                                                       |                       |                                       |                                                                                  |                        |
| Lower<br>Albian | upper | Aketo<br>Formation                            |                                                 |                               | <i>Desmoceras</i> sp.                                 | <i>Hulinites</i> spp. | <i>Douvilleiceras<br/>mammillatum</i> | <i>Pseudoleymiella<br/>hatai</i><br>+<br><i>Pseudoleymiella<br/>hiranamensis</i> | <i>Pictetia</i><br>sp. |
|                 | lower |                                               |                                                 |                               |                                                       |                       |                                       |                                                                                  |                        |
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Fig. 2. Comparison of lithostratigraphic division and "stratigraphical zonation of ammonoids" of the Miyako Group. The obtained species from the Sakiyama Formation in the present study are shown by boldfaced type.

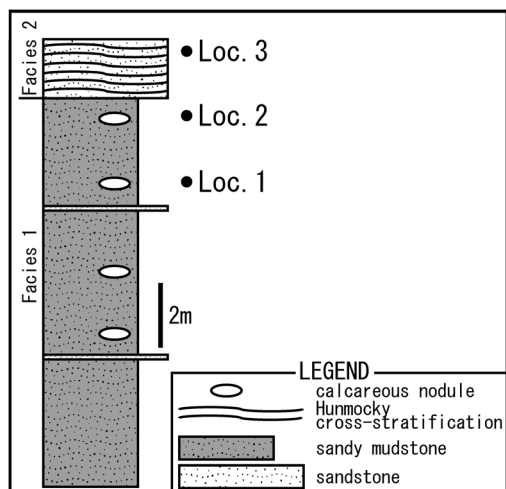


Fig. 3. Columnar section of the Sakiyama Formation of Ebisudana.

scarcely found in the lower part, but bioturbation is predominant. Fossiliferous spherical calcareous nodules, approximately 30 cm in diameter, are commonly embedded within the sandy mudstone. The lower part is 9 m thick. According to

Tanaka (1978), the lower part indicates a gradual transition from that of the "Hiraiga Formation."

The upper part is characterized by moderately sorted fine sandstone with hummocky cross-stratification and granules or pebbles (Fig. 4-2). Large remains of tree trunks are found in the middle part of the facies. The upper part also bears no trace fossils. The upper part is 1.5 m thick, but the upper limit is uncertain in the sea.

### Fossils

Fossils are obtained from Loc. 1 and 2 of the lower part and Loc. 3 of the upper part.

Fossils from the lower part are composed by bivalves, normally coiled ammonoids such as *Aconeceras* sp., *Pseudoleymiella hatai*, *Valdedorsella getulina*, *Pseudohaploceras* sp., *Eotetragonites* sp. and *Pictetia* sp., gastropods, plant remains such as *Cladophlebis* sp. and echinoids, such as *Heteraster hiranamensis* and asteroid fragments (Table 1, Figs. 4-4, 5).

Fossils from the upper part are composed by bivalves such as, gastropods, crinoids, poly-





Fig. 4. 1, Ebisudana from the coast of Hideshima. 2, Hummocky cross-stratified sandstone in the upper part. 3, Sandy mudstone (the upper part) and covering hummocky cross-stratified sandstone (the lower part). 4, Mode of occurrence of fossils (the lower part). 5, Mode of occurrence of fossils (the upper part). Scale = hammer in 1 and 2 (length = 30 cm), bar in 4 (1 cm), chisel in 5 (diameter = 1 cm).

chaete tubes, shark teeth, and ammonoids (Table 1, Figs. 4-5, 5).

## Discussion

### Sedimentary environment

The section is comprised by hummocky cross-stratified sandstone and sandy mudstone. Walker



Table 1. Occurrence of ammonoids from the Sakiyama Formation in Ebisudana.

| Species                               | Loc. 1 | Loc. 2 | Loc. 3 |
|---------------------------------------|--------|--------|--------|
| <i>Eotetragonites</i> sp.             |        | X      |        |
| <i>Aconeceras</i> sp.                 | X      | X      |        |
| Desmoceratidae gen. et sp. indet.     |        | X      | X      |
| <i>Valdedorsella getulina</i>         |        | X      |        |
| <i>Pseudohaploceras</i> sp.           | X      | X      |        |
| <i>Pictetia</i> sp.                   |        | X      |        |
| <i>Ptychoceras</i> sp.                |        | X      |        |
| Douvilleiceratidae gen. et sp. indet. |        | X      |        |
| <i>Pseudoleymeriella hataii</i>       |        | X      |        |

and Plint (1992) interpreted this structure as storm deposits. Saito (1989) defined that the mean fairweather wave base is between upper and lower shoreface and the mean storm wave base is between inner and outer shelf. Accordingly, the section is interpreted to have been deposited in a lower shoreface to inner shelf environment.

### Comparison with north area

The stratigraphical position of the Sakiyama Formation in the Miyako Group is discussed by Shimazu *et al.* (1970) and Tanaka (1978). On the basis of sedimentological cyclothem arrangement, these authors inferred that the formation is correlated to the upper Hiraiga Formation in the northern area.

In the present investigation, many ammonoids, which are common with the northern Hiraiga area, were newly obtained from the Sakiyama Formation. According to Obata (1974), *Valdedorsella getulina* occurs from the Tanohata Formation to the lower part of the Aketo Formation, *Pseudoleymeriella hataii* from the uppermost of the Hiraiga Formation to the Aketo Formation and *Ptychoceras* sp. from the Tanohata Formation to the Aketo Formation. Hoffmann *et al.* (2013) reported *Pictetia* from the Aketo Formation. These fossils occur from the uppermost part of the Hiraiga Formation to the lower part of the Aketo Formation. This result indicates that the section of the Sakiyama Formation stratigraphically covers much higher level than expectation by Shimazu *et al.* (1970).

### Comparison ammonioids

In the present investigation, many ammonoids were newly obtained from the Sakiyama Formation at Ebisudana. The ammonoids of Locs. 1 and 2 are from calcareous nodules in the sandy mudstone of the lower part. The ammonoids of Loc. 3 are from the hummocky cross-stratified sandstone of the upper part.

*Aconeceras* sp. resembles *A. nusus* (Orbigny), the type species of the genus, from the Upper Aptian of France, in the compressed shell, sides more or less flat, keel low and ribs appearing late in ontogeny. All Miyako specimens are juveniles, and keels with finely denticulation and fairly strong ribs are not observed. *Aconeceras* which is reported from the Miyako Group for the first time in the present paper, has been reported from Europe, Greenland, Algeria, South Africa, Madagascar, Australia (Queensland and Western Australia), Argentina, and Nepal (Wright *et al.*, 1996).

*Valdedorsella getulina* occurs from Loc. 2. Obata (1967a) suggested wide geographic distribution of *V. getulina* from North Africa, Majorca, Madagascar and Japan.

*Pseudohaploceras* sp. occurs from Loc. 1. Recently, Bogdanova and Hoedemaeker (2004) described eight species of *Pseudohaploceras* from the Lower Cretaceous of Colombia. Obata and Matsukawa (2007) reported *Pseudohaploceras* sp. from the Choshi Group, Japan. The present specimen is discriminated from these species by fine ribs and no constrictions.

*Eotetragonites*, *Ptychoceras* and *Pseudoleymeriella* which occur from Loc. 2, have

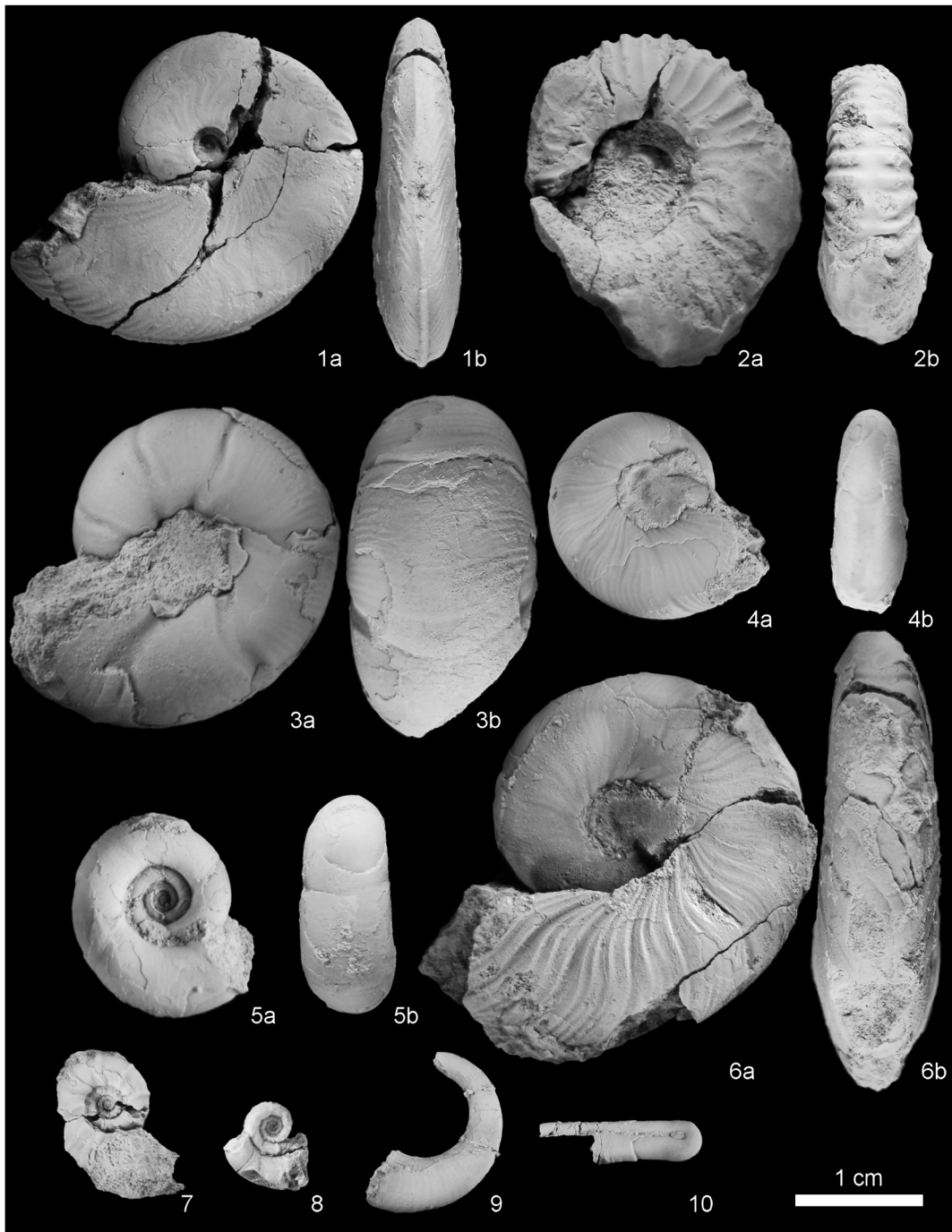


Fig. 5. Ammonoids from the Sakiyama Formation. 1, *Aconeceras* sp., NMNS PM23790. 2, *Pseudoleymeriella hatai* Obata, NMNS PM23791. 3, *Valdedorsella getulina* (Coquand), NMNS PM23792. 4, Desmocerataceae gen. sp. indet., NMNS PM23793. 5, *Eotetragonites* sp., NMNS PM23794. 6, *Pseudohaploceras* sp., NMNS PM23795. 7, Douvilleicerataceae gen. sp. indet., NMNS PM23796. 8, Douvilleicerataceae gen. sp. indet., NMNS PM23797. 9, *Pictetia* sp., NMNS PM23798. 10, *Ptychoceras* sp., NMNS PM23799. 1 and 6 from Loc. 1. The others from Loc. 2. A scale bar is applied to all specimens.

been reported from Tethys and Pacific areas.

### Conclusions

1. The Sakiyama Formation of the Miyako Group at Ebisudana is inferred to be inner shelf to lower shelf deposits.
2. Many ammonoids including *Eotetragonites* sp., *Aconeceras* sp., *Valdedorsella getulina*, *Pseudohaploceras* sp., Desmocerataceae gen. sp. indet., *Ptychoceras* sp., *Pseudoleymeriella hataii*, Douvilleicerataceae gen. sp. indet. and *Pictetia* sp. were newly collected from the Sakiyama Formation.
3. These ammonoids and inferred depositional environments of the lower shoreface to inner shelf suggest that the section of the Sakiyama Formation is correlated with the uppermost part of the Hiraiga Formation to the lower part of the Aketo Formation.

### Acknowledgments

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