FORAMINIFERS FROM THE "TORINOSU LIMESTONE"
EMBEDDED IN THE ISHIDO FORMATION OF THE SANCHU
CRETACEOUS SYSTEM, KANTÔ MOUNTAINS, CENTRAL JAPAN

KATSUO SASHIDA*, HISAYOSHI IGO*, SHUKO ADACHI* and SAYURI ITO**
*Institute of Geosciences, University of Tsukuba, Ibaraki, 305; **Kinkyoku Junior High School, Hiratsuka, Kanagawa, 254 Japan

ABSTRACT—A foraminiferal fauna characterized by abundant benthic species and a small amount of planktonic taxa with a few radiolarians has been recovered from the "Torinosu Limestone" embedded in the Ishido Formation of the Sanchu Cretaceous System. The benthic foraminiferal assemblage consists of several unidentified species of Haplophragmoides, Paratrochamminoides, Gyroidina, Pullenia and Gavelinella (?). The planktonic foraminiferal assemblage comprises Hedbergella planispira (Tappan), Globuligerina heterotrica (Subbotina) and Globigerinelloides aff. blowi (Bolli). The joint occurrence of H. planispira and G. heterotrica have been known only in the early Aptian. Previously, a late Haurterian to late Barremian age was assigned to the Ishido Formation based on ammonoids. This ammonoid age contradicts the age indicated by planktonic foraminifers.

Key words: Planktonic foraminifers, Torinosu Limestone, Ishido Formation, Kanto Mountain.

INTRODUCTION

The Torinosu Group has been regarded as an open shallow marine facies consisting of terrigenous clastic rocks associated with the reeval Torinosu Limestone. Many investigators contributed to the geology of the Torinosu Group and its equivalents of Southwest Japan. Recent work on the Torinosu Group in Shikoku revealed that this group of the Middle Chichibu Terrane consists predominantly of Middle Jurassic sequences, whereas that of the Southern Chichibu Terrane is the uppermost Jurassic to Lower Cretaceous strata (Ichikawa et al., 1982; Matsuoka and Yao, 1985; Aita and Okada, 1986; Suyari and Ishida, 1985; Suyari and Kuwano, 1986). Although many paleontologists have studied fossils from the Torinosu Group, we have little knowledge on the detailed age of the Torinosu Limestone except for what have been suggested by hexacorals and stromatoporoids. Recently, the following workers have clarified the age of the Torinosu Limestone by radiolarians and nannofossils. Aita and Okada (1986) reported latest Jurassic or earliest Cretaceous calcareous nannofossils from a marly limestone of the Torinosu Group exposed near the type Sakawa area of Shikoku. Ishida (1988) reported the occurrence of early Late Jurassic radiolarians from the Torinosu Limestone embedded in the shaly facies of the Northern Shimanto Terrane of eastern Shikoku. The authors (Sashida et al., 1988) briefly presented the occurrence of late Middle to Late Jurassic radiolarians from the Torinosu Limestone in the Southern Chichibu and Northern Shimanto Terranes of the Kanto Mountains.

The "Torinosu Limestone" has been known to occur in the Mesozoic strata of the western part of the Sanchu Cretaceous System. Yabe and Sugiyama (1935) reported two species of spioniomorph corals from the "Torinosu Limestone" in the Sanchu Cretaceous System. Subsequently, Eguchi (1951) described Eugyra sugiyamai. Eguchi and several other species of hexacorals from the same limestone exposed around the Ohinata area, and he presumed the age of this limestone to be Cretaceous based on the occurrence of the genus Eurya which is restricted within the Cretaceous in Europe. Fujimoto ed. (1958) set up the Jurassic Naranokidaira Formation intercalating the "Torinosu Limestone" and distinguished it from the Cretaceous formations. Matsukawa (1983) and Takei (1985) considered that this "Torinosu Limestone" is embedded in the Ishido Formation. The present authors recovered a foraminiferal fauna consisting of both benthic and planktonic foraminifers with a few radiolarians from this limestone by applying the hydrochloric acid extracting method. The present authors describe herein an early Aptian foraminiferal fauna and discuss discrepancy between the ages indicated by planktonic foraminifers and previously known ammonites.

"TORINOSU LIMESTONE" OF THE ISHIDO FORMATION

As stated earlier, the Torinosu Limestone is an important constituent of the Torinosu Group or its equivalent. This limestone is generally black bituminous and yields many reef-forming fossils, such as corals, stromatoporoid and algae. Foraminifers, mollusks, echinoids and other fossils are also locally common. Lithology of this limestone is mostly calcarenite, calcilutite and ooid grainstone with a small amount of calcirudite. From these characteristics, the Torinosu Limestone has been regarded as a reefal limestone deposited on a shelf margin. Limestone samples from the Ishido Formation have the same lithologic characteristics of the typical Torinosu Limestone (Figs. 4-10~13). However, the name Torinosu Limestone is suitable to apply only to that in the Torinosu Group or its equivalents. The present authors use the term Torinosu Limestone with quotation marks for limestones in the Ishido Formation.
GEOLOGIC SETTING

Early Aptian microfossils treated in this paper were recovered from black bituminous fossiliferous limestone exposed in the Shinzaburo Valley (Fig. 1). Sample SH-1 is a float derived from an outcrop (SH-2) on the hillside parallel to the Shinzaburo Valley. Figure 1 is a generalized geologic map of the study area mapped by the field work of Sashida. The geology of this area is very complicated. Cretaceous formations are in fault contact with the Jurassic Otchizawa Formation or “Hamadaira Group” of Hisada et al. (1987). Serpentinite intrusions occur along a fault boundary. The Cretaceous formations cropping out along the Shinzaburo Valley are subdivided into the Shiroi and Ishido Formations in ascending order (Matsukawa, 1983). The Shiroi Formation consisting mainly of conglomerates, sandstone and shale yields abundant nonmarine bivalves. The Ishido Formation conformably overlies the Shiroi and consists of muddy sandstone and an alternation of sandstone and shale. The muddy sandstone of this formation yields prolific marine molluscs including ammonites in the type section along the Mamonozawa Valley. The “Torinosu Limestone” is presumed to be intercalated in the alternation of sandstone and shale in the upper part of the Ishido Formation. However, no direct relations between the “Torinosu Limestone” and surrounding rocks can be observed due to a soil cover and vegetation.

LABORATORY PROCEDURE

To extract microfossils from the “Torinosu Limestone”, crushed rocks of a several-centimeter size were soaked in a dilute hydrochloric acid (HCl) solution (5 to 10%) for about 24 hours. Undissolved residues were washed over a 270 mesh nylon sieve and dried. Microfossils from dried residues were observed with a scanning electron microscope (SEM). Thin sections were made from the same rock samples for petrographic and further paleontologic analyses.

AGE OF MICROFOSSIL FAUNA

The authors discriminated the following planktonic and benthic foraminifers from samples SH-1 and SH-2: Hedbergella planispina (Tappan), Globigerina heterivica (Subbotina), Globigerinelloides aff. bowi (Bolli), Haplophragmoides sp. A, H. sp. B, H. sp. C, Paratrophamminoides sp., Gyroidina sp., Pulea sp., and Gavelinella? sp. Our knowledge of Cretaceous foraminiferal faunas has remarkably been accumulated in this decade based on biostratigraphical results obtained through the Deep Sea Drilling Project (DSDP). Among the above-listed foraminifers, Hedbergella planispina and Globigerina heterivica are important planktonic species for age determination. H. planispina has a rather long stratigraphic
range, well established by several works of DSDP. The first occurrence of this species is in early Aptian and the last one is in early Coniacian time. *G. hoterivica* which ranges in age from late Hauterivian to early Aptian has been known as the first diagnostic species of planktonic foraminifers in the Cretaceous. Based on the joint occurrence of these two species, an early Aptian age is assigned to this planktonic foraminifer assemblage. *G. blowi* is also an important species. According to Caron (1985), the stratigraphic range of this species is in the lower Aptian to lower upper Aptian interval. We have scarce information on the occurrence of early Cretaceous planktonic foraminifers from Japan except for the reports of a late Aptian fauna from the Choshi Group (Obata et al., 1982) and a middle Albian fauna from the Hinagu Formation (Nishi et al., 1989). The present planktonic foraminifers stand as the oldest occurrence in the Japanese Cretaceous. Figure 2 summarizes graphically the known stratigraphic range of the two planktonic foraminifer species recognized in the present “Torinosu Limestone” and *Globigerinelloides blowi*.

Unfortunately, benthic foraminifers recovered from the “Torinosu Limestone” cannot be identified to the species level. Among the authors’ specimens of benthic foraminifers, haplophragmoid foraminifers, such as *Haplophragmoides* sp. A, H. sp. B, and *H. sp. C*, are predominant. These foraminifers exceed more than two thirds of the total number of both planktonic and benthic foraminifers from the “Torinosu Limestone”. The morphological characters of these unidentified species of *Haplophragmoides* are similar to those of the Late Cretaceous reported from the western part of the Pacific Ocean (Krasheninnikov, 1973) and the northwestern part of the Indian Ocean (Krasheninnikov, 1974).

Two unidentified radiolarian species belonging to the genera *Hemicyrtocapsa* and *Holocryptocanium* were only discriminated from sample SH-1. The former genus was described from the Hauterivian and lower Cenomanian formations of Rumania by Dumitrica (1970) and it is a common constituent of the Japanese Lower Cretaceous radiolarian assemblages. The latter genus, *Holo-

**AGE SUGGESTED BY AMMONITE FAUNA**

Matsukawa (1983) stated that ammonites were found in three horizons of the Ishido Formation exposed in the Mamonozawa and Myokezawa, about 16 km east of the Shinzaburo Valley. According to his study, the characteristic species are as follows: *Barremites (B.) difficilis* (d’Orbigny), *Pulchellina ishidoensis* Yabe and Shimizu and *Simbirsikites* (Milanowska) sp. from the lower horizon; *Shasticrioceras* aff. *patrickii* Murphy from the middle horizon; and *Barremites (B.) aff. streitostoma* (Uhlig), *Pseudohaploceras japonicum* Obata and Matsukawa and *Heteroceras (H.) aff. astieri* d’Orbigny from the upper horizon. These ammonites are identical with or similar to those of the late Hauterivian to Barremian faunas of the Tethys, Boreal and circum-Pacific provinces.

**DISCUSSION**

Several species of ammonites reported from three horizons of the Ishido Formation in the Mamonozawa and Myokezawa valleys indicate a late Hauterivian to Barremian age. However, planktonic foraminifiers recovered from the “Torinosu Limestone” suggest an early Aptian age. Thus, there is contradiction in age assignments suggested by ammonites and planktonic foraminifiers.

Very recently, Kamikawa et al. (1988) reported the occurrence of late Albian radiolarians from the shale of the Ishido Formation of Matsukawa (1983), exposed near Shiroi, Ueno village, Tano county, Gumma Prefecture. As stated earlier, the age of the Ishido Formation

<table>
<thead>
<tr>
<th>Stage</th>
<th>Hauterivian</th>
<th>Barr.</th>
<th>Early</th>
<th>Aptian</th>
<th>Late</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planktonic foraminiferal zones</td>
<td><em>Globigerina hoterivica</em></td>
<td><em>Hedbergella sigill</em></td>
<td><em>Globigerinelloides blowi</em></td>
<td><em>Schizolina cabrill</em></td>
<td><em>Globigerinelloides algirica</em></td>
</tr>
</tbody>
</table>

![Fig. 2](image.png) Known stratigraphic ranges of three taxa relating to the “Torinosu Limestone” plotted to planktonic foraminiferal zones of Caron (1985). Correlation of the zonation with the standard Cretaceous stages also adopted from her work.
was confirmed in the Mamonozawa and Myokezawa valleys and the “Torinosu Limestone” cropping out in the Shinzaburo Valley is placed in the upper stratigraphic horizon of the Ishido Formation based on lithofacies. Ammonites and other important fossils have never been reported from this formation in the Shinzaburo Valley. Therefore, the Ishido Formation exposed in the Shinzaburo Valley further ranges up to at least an early Aptian age. Micropaleontological study of this formation is necessary not only in the type sections but also in other areas.

During Jurassic to Early Cretaceous time, the convergent complex of the Southern Chichibu and a part of the Shimanto Terranes was formed in connection with the subduction of oceanic plate. On the other hand, on the inner side of this complex, the Sanchu Cretaceous formations accumulated. Thus they are regarded as sediments on a fore arc shelf (Matsukawa, 1983). Matsukawa (1983) mentioned, based on the sedimentological and paleontological analyses, that there was a paleogeographically deeper basin to the south of the western part of the Ishido Formation. As already stated, the “Torinosu Limestone” has the same petrographic and organic characteristics as the typical Torinosu Limestone which is thought to be a reefal limestone deposited on the shelf or shelf margin. Reefs on the shelf margin were destroyed by prevailing physical agents, such as waves, tides, storm and others. Talus deposits originated from the reef complex were derived from reef to slope or basin by debris flow or turbidity current. Planktonic organisms, such as foraminifers and radiolarians, were contained in some constituent rocks of the “Torinosu Limestone” while it was situated in the neritic to bathyal environments as talus deposits. The “Torinosu Limestone” is thought to have been deposited as reef breccia within muddy sand or mud-rich alternations of sand and mud on the slope or basin.

SYSTEMATIC DESCRIPTION

All the species of planktonic foraminifers and some benthic species are paleontologically studied by the senior author (K. S.). Synonymies are limited to the original description and some references provided with illustrations of good quality.

All the figured specimens are deposited in the collections of the Institute of Geosciences, the University of Tsukuba (IGUT).

Order Foraminiferida Eichwald, 1803
Suborder Globigerinina Delage and Hérouard, 1896
Superfamily Rotaliporaceae Sigal, 1958
Family Hedbergellidae Loeblich and Tappan, 1961
Subfamily Hedbergellinae Loeblich and Tappan, 1961
Genus Hedbergella Brönnimann and Brown, 1958
Hedbergella planispira (Tappan)

Figs. 3-1a—2c
Globigerina planispira Tappan, 1940, p. 122, pl. 19, fig. 12.
Hedbergella planispira (Tappan). Loeblich and Tappan, 1961, p. 276, pl. 5, figs. 4–11; Piauma and Kraheninnikov, 1977, p. 547, pl. 2, figs. 1–5, pl. 3, fig. 3; Gradstein, 1978, p. 673, pl. 11, figs. 14–16; Caron, 1978, p. 658, pl. 1, figs. 1; 2, pl. 7, figs. 7, 8; Leckie, 1984, p. 599, pl. 9, figs. 6–7; Nishi et al., 1989, p. 6, 7, figs. 3a–4c.

Remarks.—Although the present specimens are very poorly preserved, they have the characteristic feature of this species in size and number of chambers in the last whorl.

Occurrence.—Common in the present planktonic assemblage.

Family Favusellidae Longoria, 1974
Genus Globuligerina Bignot and Geyader, 1971
Globuligerina heterovica (Subbotina)
Figs. 3-3a–4
Globuligerina heterovica Subbotina, 1953, p. 50, pl. 1, figs. 1a–c.
Globuligerina kugleri Bolli, 1959, p. 270, pl. 23, figs. 3a–c.
Hedbergella heterovica (Subbotina). Butt, 1979, p. 3, figs. 1–7, pl. 4, figs. 1–4.
Globuligerina heterovica (Subbotina). Caron, 1985, p. 57, figs. 25–1–3.

Remarks.—Caron (1985) renamed this species under the genus Globuligerina. High trochospiral gloar lobular forms with four chambers in the last whorl have been identified with this species by various authors. This species does not have any pronounced variation from the Hauterivian to early Aptian. Some well-preserved specimens of this species obtained from the DSDP cores possess a coarse reticulate honeycomb sculpture with pores in each polygonal structure. This character is similar to that of the genus Favusella which first appeared during the Barremian. Although it is impossible to confirm the above-mentioned characteristic shell wall due to ill preservation, the authors’ specimens are safely identifiable to the original and above-listed examples of this species.

Occurrence.—Rare in the present planktonic assemblage.

Superfamily Planomalinae Bolli, Loeblich and Tappan, 1957
Family Globigerinelloides Longoria, 1974
Subfamily Globigerinelloidae Longoria, 1974
Genus Globigerinelloides Cushman and Ten Dam, 1984
Globigerinelloides aff. blowi (Bolli)
Figs. 3-5a—6c

Compared with:
Planomalina blowi Bolli, 1959, p. 260, pl. 20, figs. 2, 3.
Globigerinelloides blowi (Bolli). Gradstein, 1978, p. 672, pl. 9, figs. 5–8; Caron, 1978, p. 658, pl. 6, figs. 11, 12; Butt, 1979, pl. 3, figs. 14–17.
Globigerinelloides blowi s.l. (Bolli). Leckie, 1984, p. 593, pl. 1, figs. 4–8.

Remarks.—This well-known and short ranging (early to late Aptian) species is characterized by having spheroidal to subospherical chambers which increase fairly rapidly.
in size. The present specimens are similar to the previously reported figures of Globigerinelloides blowi in general appearance. However, the authors' specimens have trapezoidal to subspherical chambers in the final whorl. The present authors tentatively refer these specimens to G. blowi, because a very limited number of poorly-preserved specimens are available for the present study.

**Occurrence.**—Rare in the present planktonic assemblage.

Superfamily Lituolacea de Blainville, 1827  
Family Haplophragmoididae Maync, 1952  
Genus Haplophragmoides Cushman, 1910  
**Haplophragmoides** sp. A  
Figs. 3-1a, b  

**Descriptive remarks.**—Lens-like test is large, planispiral and entirely involute. Maximum diameter and thickness of test attain 0.40 to 0.55 mm and 0.28 to 0.31 mm, respectively. Peripheral view is regularly oval with slightly convex lateral sides and subrounded peripheral margin. Chambers are high, rapidly increasing in size. The last whorl consists of 4 to 5 chambers, which are triangular in shape. The apertural face is a low and curved arch. A low and long slit-like aperture exists at its base.

This unidentified species somewhat resembles the Upper Cretaceous species of Haplophragmoides mentitens Krasheninnikov in general appearance. However, the latter has a smaller test and a fewer number of chambers in the last whorl than those of the former.

**Occurrence.**—Common in the present benthic assemblage.

**Haplophragmoides** sp. B  
Figs. 3-8a—9c  

**Descriptive remarks.**—Planispiral test is large (diameter 0.35 to 0.50 mm, thickness 0.18 to 0.20 mm), with wide and shallow umbilicus. Peripheral margin of test is rounded and has a lobulate outline. Chambers are high and rapidly increasing in size. The last whorl consists of 5 chambers, which are high trapeziform, moderately convex and rather broad. Septal sutures are slightly concave. The apertural surface is convex, low and broadly oval with an arch-shaped aperture at its base.

This unidentified species is characterized by its trapezoidal chambers in the last whorl. It is easily distinguished from H. sp. A in the present assemblage by its trapezoidal chamber and inner evolute volution. This unidentified species is similar to H. constrictus Krasheninnikov reported from the northwestern part of the Pacific Ocean (Krasheninnikov, 1973) and the northeastern part of the Indian Ocean (Krasheninnikov, 1974). However, the former is distinguishable from the latter by having a larger test and a smaller number of chambers in the last whorl.

**Occurrence.**—Abundant in the present benthic assemblage.

**Haplophragmoides** sp. C  
Figs. 3-7a-c, 10a-c  

**Descriptive remarks.**—Planispiral test is large (diameter 0.36 to 0.49 mm, thickness 0.15 to 0.18 mm), with a narrow and rather deep umbilicus. When viewed laterally, test is more or less oval, with a slightly lobulate outline. In edge view, it is oval, with a rounded peripheral margin and flattened lateral sides. Chambers are high and rapidly increase in size. The last whorl consists of 4.5 to 5 broad subtriangular or trapeziform chambers. Septal sutures are slightly incised, distinct and slightly concave. The apertural face is oval, and a slit-like aperture is situated at its base.

This unidentified species slightly resembles H. molestus described by Krasheninnikov from the northwestern part of the Pacific Ocean. However, the latter has a test smaller than the former.

**Occurrence.**—Common in the present benthic assemblage.

Family Litulidae de Blainville, 1825  
Genus Paratrochamniondois Soliman, 1972  
**Paratrochamniondois** sp.  
Fig. 4-2  

**Remarks.**—Soliman (1972) introduced the genus Paratrochamniondois for representatives of Trochamniondois with irregular coiling at all stages of shell growth. The authors' specimens have an irregularly shaped test with a low and irregularly trochoidal initial part. However, the precise coiling pattern of the whorls can not be determined because of the lack of well-preserved specimens.

**Occurrence.**—Rare in the present benthic assemblage.

Superfamily Chistostellacea Brady, 1881  
Family Alabaminidae Hofker, 1951  
Subfamily Gyroidinae Saidova, 1981  
Genus Gyroidina d'Orbigny, 1826  
**Gyroidina** sp.  
Figs. 4-4a, b  

**Remarks.**—The authors have only a limited number of ill-preserved specimens. This species is characterized by its compressed test and a higher and rather wider apertural face. This species slightly resembles G. heisseli White originally described from the Tampico Embayment area of Mexico. However, the former has a more depressed test than the latter.

**Occurrence.**—Rare in the present benthic assemblage.

---

Fig. 4. Foraminifers, radiolarians, corals and algae? from the "Torinou Limestone" of the Ishido Formation. All from sample SH-1 except for 5, 7 and 8 from sample SH-2. Scale bars, A to C equal 100 μm; A applies to 5, 7, B to 3, 4, 8, 9, C to 1 and 2. Scale bars, 10 to 13 equal 5 mm. 1. *Pallinopsis* sp., 1, IGUS-KS3811, 5, IGUS-KS3845; 2. *Paratrochamniondois* sp., IGUS-KS3849; 3. *Gavelinella* sp., IGUS-KS3918; 4. *Gyroidina* sp., IGUS-KS3831; 6 to 7. *Holotrypa* sp., IGUS-3807; 7. *Holocryptocapsa* sp., IGUS-KS3809, 9. IGUS-KS3806; 10, 12. thin-sectioned specimens of algae?; 11. hexacoral, *Goniocora* sp. in a lime-mud matrix; 13. hexacoral gen. et sp. indet. in a lime-mud matrix.
Remarks.—Usually, all whorls are visible on the spiral side in the species of *Gavelinella*. Because of ill-preservation, chambers of the final whorl are observed on the spiral side in the authors’ specimens. Although the present specimens have the characters of *Gavelinella*, they are only tentatively referred to this genus.

Occurrence.—Rare in the present benthic assemblage.

Superfamily Cassidulinaeae d’Orbigny, 1839
Family Nonionidae Schultze, 1854
Genus *Pularella* Parker and Jones, 1862
*Pularella* sp.

Figs. 4-3a-c

Remarks.—This unidentified species is characterized by a subspherical test and a non-lobated equatorial periphery. The present species is similar to *Pularella cretacea* Cushman reported from DSDP Leg 78 in the western Central Atlantic Ocean (Hemleben and Troester, 1983). However, the latter has a more inflated oval test in axial profile than that of the former.

Occurrence.—Common in the present benthic assemblage.

REFERENCES


