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Integrated Mega- and Micro-fossil Biostratigraphy of the Lower Cretaceous Choshi Group, Japan

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Introduction

The biostratigraphy of the Lower Cretaceous in Japan is based mainly on ammonites. These divisions have been compared with the equivalent strata in western Europe, North America and other regions.

The Upper Cretaceous sediments yield diverse micro-fossil assemblages: foraminifera, radiolaria, nannoplankton, pollen and spores that are all useful for biostratigraphy (e.g. TAKAYANAGI, 1960; MAIYA and TAKAYANAGI, 1977). On the basis of mega- and micro-fossils, TAKAYANAGI and MATSUMOTO (1982) and MATSUMOTO et al. (1982) have recently attempted a zonation and international correlation.

On the other hand, micro-fossil assemblages had not been reported in the Lower Cretaceous from any area in Japan. The Cretaceous Choshi Group in the Kwanto region is one of the important units in which a Lower Cretaceous ammonite biostatigraphy has been established in Japan. OBATA et al. (1975) have divided the Cretaceous strata into five formations and the age given by the ammonites indicates Barremian to early Late Aptian. However, several aspects of the stratigraphy and the geologic age remained to be studied. MAIYA and INOUE have since discovered the first assemblages of foraminifera from the Lower Cretaceous of Japan and have considered the geological age of the Choshi Group (MAIYA et al., 1980 MS.). OBATA and MATSUKAWA have made the field investigation, established the lithostratigraphy, confirmed the sampling localities of MAIYA et al.'s and collected many additional samples for foraminiferal analyses for this paper. We hope this work will be useful for the project of the "International Correlation of the Cretaceous System" in the research on the

international correlation of mega- and micro-fossils in the Choshi Cretaceous.

Accordingly, the purpose of this paper is to establish the lithostratigraphy and ammonite-biostratigraphy, to describe some of the foraminiferal assemblages and to show their stratigraphic position.

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All illustrated ammonites are deposited in the Department of Paleontology, National Science Museum (NSM) in Tokyo, Japan.

Stratigraphy

The stratigraphic sequence in the area can be summarized thus:

Naarai Formation ..... Miocene
——— Unconformity ———
CHOSHI GROUP
- Nagasakihana Formation ... upper Aptian
- Toriakeura Formation ..... lower Upper Aptian to uppermost Lower Aptian
- Inubouzaki Formation ..... uppermost Lower Aptian
- Kimigahama Formation .... upper Lower Barremian
- Ashikajima Formation ..... lower Barremian

——— Unconformity ———
Atagoyama Group ..... uppermost Permian

The geological map of the Choshi area is shown in Text-fig. 1.

The lithological succession in the Cretaceous Choshi Group is shown in Text-fig. 2 with the horizons that have yielded the cephalopods and foraminifera. The fossil localities are shown in Text-fig. 3.

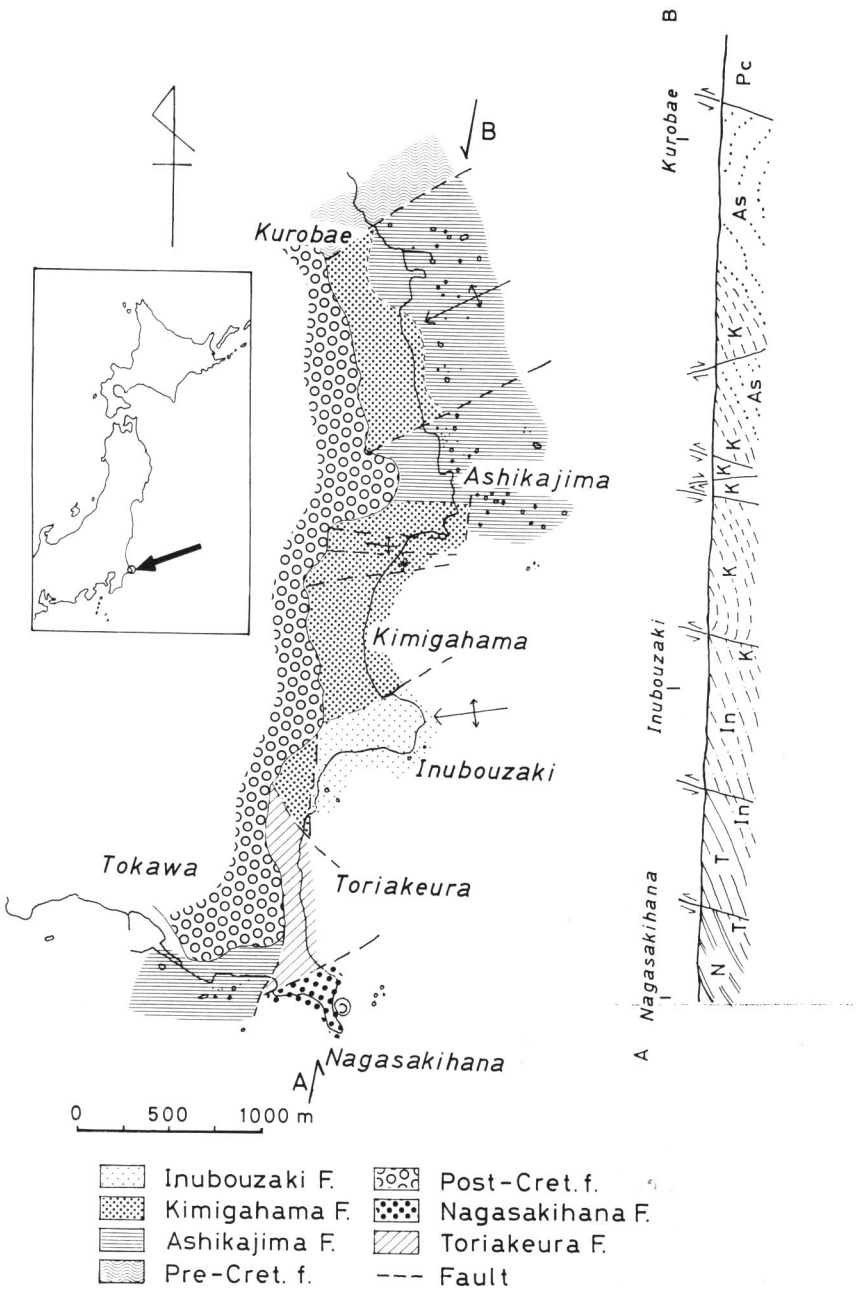
Atagoyama Group: This is mainly sandstone and conglomerate. Fusulinids such as *Lepidolina shiraiwensis* and *Yabeina columbiana* were obtained from a limestone conglomerate. These indicate that the age of the Atagoyama Group is probably latest Permian (CHISAKA, 1960).

Ashikajima Formation

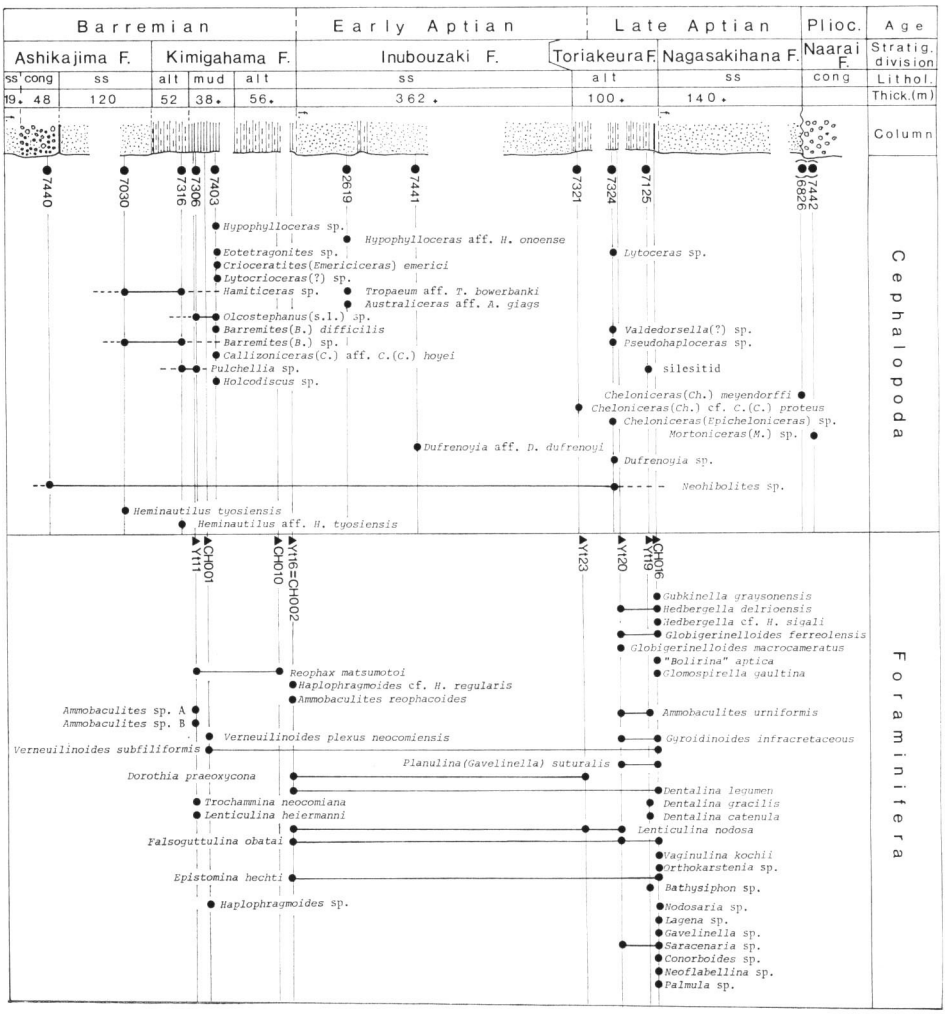
Type locality; Coast of Ashikajima, Choshi-city, Chiba Prefecture.

Thickness; 187 m+

The Ashikajima Formation is mainly conglomerate and sandstone. The basal part consists of conglomerate with sandstone, the conglomerate composed of well sorted, rounded pebbles and cobbles of chert and sandstone. The main part is



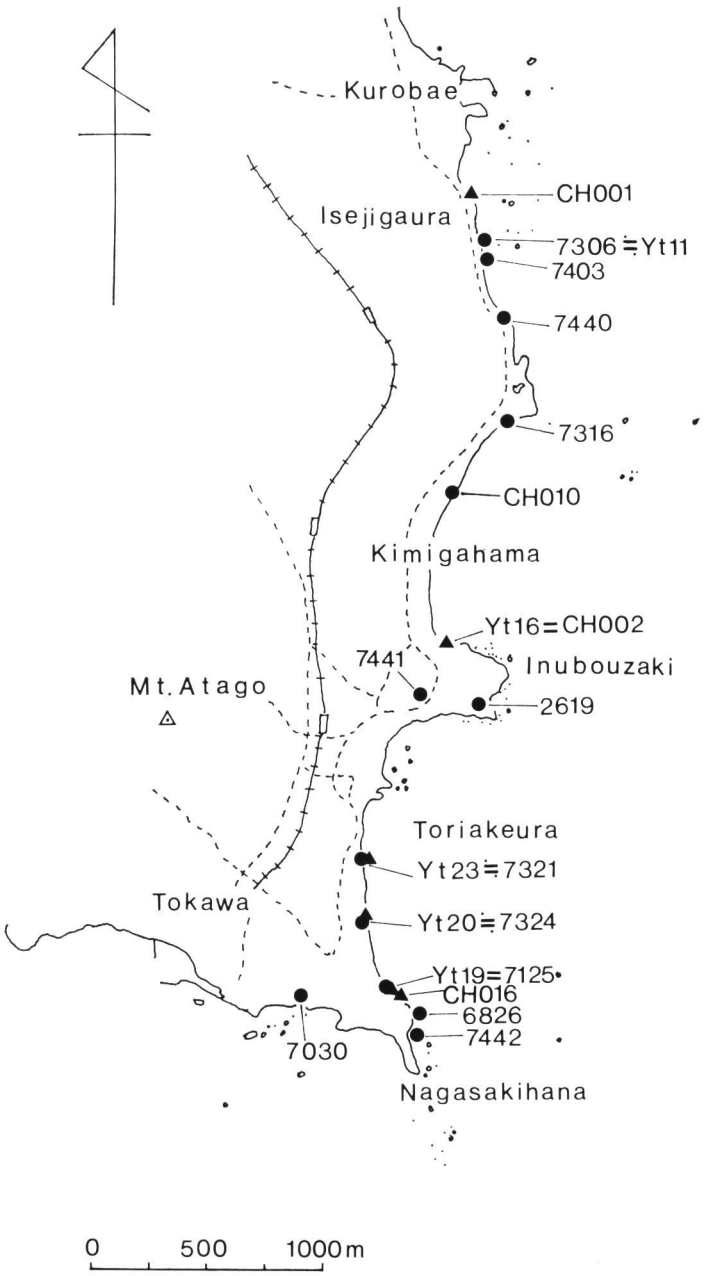
Text-fig. 1. Geological map of the Choshi area.



Text-fig. 2. Stratigraphic distribution of cephalopods and foraminifers in the Choshi section. Loose pebbles and blocks are shown in brackets. Read Miocene for Pliocene.

marked by medium to coarse sandstone which has gradually fined upwards from the lower conglomerate, intercalated with thin layers of shale. Sole marks and cross laminae are abundant. The prevalent ripple marks indicate the current direction to have been from north to south.

The following mega-fossils were obtained: Cephalopoda——*Barremites* (*B.*) sp., *Hamiticeras* sp., *Heminautilus tyoshiensis* (YABE et OZAKI) and a belemnoid.
Bivalvia (HAYAMI and OJI, 1980, p. 422)——*Nuculopsis* (*Palaeonucula*) *ishidoensis*, *Astarte* (*Astarte*) *subsenecta*, *Caestocorbula shikamai*, *Portlandia* (?) sp., *Pterotrigonia*



Text-fig. 3. Map showing the fossil localities of the cephalopods (circles) and the foraminifera (triangles).

(*Pterotrigonia*) *pocilliformis, Rasatrix suzukii, Laevicardium* (?) aff. *L.* (?) *ishidoense, Gervillia* (*Gervillia*) *forbesiana, Nipponitrigonia choshiensis.*

The Ashikajima Formation corresponds to the Kurobae Conglomerate, the Ashikajima Conglomerate and the Ashikajima Sandstone Member of SHIKAMA and SUZUKI (1972) and the Ashikajima Formation of OBATA et al. (1975).

Kimigahama Formation

Type locality; Coast of Kimigahama, Choshi-city, Chiba Prefecture.

Thickness; 146 m+

This formation overlies the Ashikajima Formation conformably and consists mainly of alternating beds of sandstone and mudstone and bedded mudstone. The sands are cross bedded. The middle mudstone contains numerous calcareous nodules. Mega-fossils were obtained from the lower and middle parts of the formation, as represented by the following species: Cephalopoda—*Barremites* (*B.*) *difficilis* (D' ORBIGNY), *Barremites* (*B.*) sp., *Callizoniceras* (*C.*) aff. *G.* (*C.*) *hoyei* (KOENEN), *Crioceratites* (*Emericiceras*) *emerici* (LÉVEILLE), *C.* (*E.*) cf. *C.* (*E.*) *hoheneggeri* (UHLIG), *Pulchellia* sp., *Eotetragonites* sp., *Lissonia* spp., *Holcodiscus* sp., *Olcostephanus* (s. l.) sp., *Hypophylloceras* sp., *Lytocricoceras* (?) sp., an olcostephanid, *Hamiticeras* sp. and *Heminautilus* aff. *H. tyosiensis.* Bivalvia and Gastropoda (HAYAMI and OJI, 1980, p. 421; KASE and MAEDA, 1980, p. 294,295)—*Solemya* sp., *Nuclupsis* (*Palaeonucla*) *ishidoensis, Portlandia sanchuensis, Mesosaccella* (?) *choshiensis, Mesosaccella* (?) sp., *Pinna* (*Pinna*) sp., *Rasatrix suzukii, Caestocorbula minima, Corbulomima* sp. cf. *C. nuiformis, Grammatodon* (*Nanonavis*) *yokoyamai, Pterotrigonia* (*Pterotrigonia*) *pocilliformis, Laevicardium* (?) sp. aff. *L.* (?) *ishidoense, Caestocorbula shikamai, Plectomya aritagawana, Amberleya* (*Eucyclus*) *japonica, Oolitica* sp., *Calliostoma* (?) *ojii, Ataphrus* (s. s.) *nipponicus, Hayamia rex, Hayamia choshiensis, Perissoptera elegans, Pietteia cretacea, Ceratosiphon densestriatus, Vanikoropsis decussata, Eriptycha japonica.*

Inubouzaki Formation

Type locality; Cape of Inubouzaki, Choshi-city, Chiba Prefecture.

Thickness; 362 m+

This formation is mainly cross-bedded coarse grained-sandstone and contains intercalated alternating beds of sandstone and shale. Ripple marks, trace fossils and plant fragments are abundant. The prevalent paleo-current was from north to south. The contact of the Inubouzaki Formation with the underlying Kimigahama Formation is abrupt. The Inubouzaki Formation is identical with the Inubou Sandstone Member named by SHIKAMA and SUZUKI (1972) and a part of the Ashikajima Formation defined by OBATA et al. (1975). Ammonites were obtained from the lower and the middle part of the Inubouzaki Formation: *Tropaeum* aff. *T. bowerbanki* (SOWERBY), *Australiceras* aff. *A. gigas* (SOWERBY), *Hypophylloceras* aff. *H. onoense* (STANTON) and *Dufrenoyia* aff. *D. dufrenoyi* (D'ORBIGNY).

Toriakeura Formation

Type locality; Coast of Toriakeura, Choshi-city, Chiba Prefecture.

Thickness; 100 m+

This formation conformably overlies the Inubouzaki Formation and consists mainly of alternating beds of mudstone and fine to medium sandstone with convolute lamination, and contains numerous nodules. Mega-fossils were obtained from three horizons, i. e. the lower, middle and upper ones:

Cephalopoda—*Cheloniceras* (*C.*) cf. *C.* (*C.*) *proteus* CASEY, *Cheloniceras* (*Epicheloniceras*) sp., *Dufrenoyia* sp., a ptychoceratid, *Valdedorsella* (?) sp., a puzosiid, *Pseudohaploceras* sp., *Lytoceras* sp., *Hamiticeras* (?) sp., a silesitid and *Neohibolites* sp.

Bivalvia and Gastropoda (HAYAMI and OJI 1980, p. 421–422), KASE and MAEDA (1980, p. 295)—*Nuculosis* (*Palaeonucula*) *ishidoensis, Cucullaea transversa, Eonavicula* (?) sp., *Neithea* (*Neithea*) sp., *Neithea* (*Neithella*) *notabilis, Plicatula* sp., *Spondylus* sp., *Acesta* (?) sp., Limidae gen. et sp. indt., *Limatula nagaoi, Rastellum* (*Arctostrea*) *carinatum, Gryphaea* (*Bilobissa* ?) sp., *Lopha* (*Actinostreon*) *nagaoi, Amphidonte* (*Ceratostreon*) *yabei, Amphidonte* (*Amphidonte*) *subhaliotoidea, Pachythaerus* sp., *Astarte* (*Yabea*) *shinanoensis, Opis* (?) sp., *Laevicardium* (?) sp. aff. *L.* (?) *ishidoense, Corbulomima* sp. cf. *C. nuciformis, Parvamussium* sp., *Metriomphalus nagasakiensis.*

Nagasakihana Formation

Type locality; Coast of Nagasakihana, Choshi-city, Chiba Prefecture.

Thickness; 140 m+

This formation is mainly massive medium sandstone, and contains numerous sandstone nodules. The lower part is marked by coarse sandstone with some chert granules. The sandstone shows cross bedding intercalated with thin layers of shale. The formation contains numerous plant fragments and much amber, but no mega-fossils.

Naarai Formation: Above the basal conglomerate this is a tuffaceous sandstone. Pelecypods, brachiopods, shark teeth and derived ammonites were obtained from the basal conglomerate. The Naarai Formation overlies the Nagasakihana Formation unconformably, and is assigned to the Miocene (MATOBA, 1967).

Biostratigraphy and Correlation based on Mega-fossils

Many mollusca have been obtained from the Choshi Group. Since ammonite indices were found in succession from the lower to the upper formations, it is possible to discuss the geological age of the Choshi Group on the international scale (Text-fig. 2).

The cephalopod faunule from the lowest division i.e., the Ashikajima Formation, has some elements in common with the Kimigahama Formation: i.e. *Barremites* (*B.*) sp., *Hamiticeras* sp., and *Heminautilus tyosiensis.* The Kimigahama Formation is characterized by *Barremites* (*Barremites*) *difficilis*, *Barremites* (*B.*) sp., *Crioceratites* (*Emericiceras*) *emerici*, *Pulchellia* sp., *Hamiticeras* sp., *Olcostephanus* (s.l.) sp., *Holcodiscus* sp., and *Heminautilus* aff. *H. tyosiensis.* This assemblage shows some affinity to the Early Barremian fauna from the European type locality. In the tethyan prov-

ince, including the stratotype, *Barremites* (*Barremites*) *difficilis* appears to be an index of the Barremian. The Lower Barremian is indicated by *Pulchellia compressissima* D'ORBIGNY, *Crioceratites* (*Emericiceras*) *emerici*, and *Holcodiscus kiliani* PAQUIER (BUSNARD, 1965).

According to HAYAMI and OJI (1980) in their study of the bivalves, the Kimigahama fauna contains several elements in common with that of the Ishido Formation in the Sanchu area of Kwanto Mountains, but has only one species in common with the fauna of the Miyako Group in the Kitakami Mountains of north Honshu. The Ashikajima bivalves also appear to be more closely related to the Sanchu fauna than the Miyako fauna. When correlated with the international ammonite-scale, the Ishido Formation is supposed to range from the upper Upper Hauterivian to the lower Upper Barremian (OBATA et al., 1976) and the Miyako Group is from the middle Upper Aptian to the upper Lower Albian (HANAI et al., 1968). Thus both the ammonites and bivalves safely suggest the Lower Barremian as the geological age of the Kimigahama and Ashikajima Formations.

The cephalopod assemblages in the Inubouzaki Formation can be separated into two horizons. The lower bed contains *Tropaeum* aff. *T. bowerbanki*, *Australiceras* aff. *A. gigas* etc., whereas the upper bed contains *Dufrenoyia* aff. *D. dufrenoyi*. As allied species of these were reported from the *Tropaeum bowerbanki* Zone of the Lower Greensand in England (CASEY, 1961), it is suggested that the Inubouzaki Formation probably corresponds to the lower *Dufrenoyia transitoria* Subzone in the *Tropaeum bowerbanki* Zone, the uppermost Lower Aptian. Thus late Barremian and early Aptian faunules cannot be confirmed on the exposed sequence along the Choshi coast because there is a fault between the Kimigahama and Inubouzaki Formations.

The Toriakeura Formation includes three horizons with cephalopods. The lower assemblage contains: *Cheloniceras* (*Cheloniceras*) cf. *C.* (*C.*) *proteus* CASEY; *Cheloniceras* (*Epicheloniceras*) sp. is found in the middle harizon and Silesitidae gen. et sp. indet. in the highest horizon. In the Lower Greensand of England, *Cheloniceras* (*Cheloniceras*) *proteus* appears in the *Tropaeum bowerbanki* Zone. The *Cheloniceras martinioides* Zone overlying the *Tropaeum bowerbanki* Zone comprises the *Cheloniceras* (*Epicheloniceras*) *debile*, *Chelociceras* (*Epicheloniceras*) *gracile* and *Cheloniceras* (*Epicheloniceras*) *buxtorfi* Subzones in ascending order (CASEY, 1961). Thus the lower Upper Aptian in the Lower Greensand is characterized by *Cheloniceras* (*Epicheloniceras*) species. The Toriakeura Formation is considered to correspond to the subzones from the uppermost Lower Aptian to the lowermost Upper Aptian. Additionally, the bivalve fauna of the Toriakeura Formation is characterized by a number of species in common with not only the Hauterivian to Barremian Sanchu fauna but also with the Aptian to Albian Miyako fauna (HAYAMI and OJI, 1890). As mentioned above, the sequence of ammonite species from the Ashikajima to the Toriakeura Formation is in harmony with the order from the *Tropaeum bowerbanki* Zone to the *Cheloniceras martinioides* Zone of the English Lower Greensand.

The Nagasakihana Formation, the uppermost formation of the Choshi Group, lacks

fossil cephalopods. An interesting fact is that two late Albian indices, i.e. *Puzosia* cf. *P. subcorbarica* MATSUMOTO and *Mortoniceras* (*Mortoniceras*) sp., have been discovered as derived fossils in the basal conglomerate of the Miocene Naarai Formation which overlies the Choshi Group unconformably. Accordingly, it is suggested that Upper Albian formerly existed in this region.

Correlation and Age from Foraminiferal Assemblages

The Choshi Group has yielded 4 genera and 6 species of planktonic foraminifera and 24 genera and 31 species of benthonic foraminifera. The Kimigahama Formation contains only benthonic foraminifera but the Toriakeura Formation yields both benthonic and planktonic assemblages.

Foraminifera were obtained from the middle to upper part of the Kimigahama Formation, namely *Ammobaculites urniformis* SKOLNICK, *Ammobaculites reophacoides* BARTENSTEIN, *Ammobaculites* sp. A, *Ammobaculites* sp. B, *Verneuilinoides subfiliformis* BARTENSTEIN, *Verneuilinoides plexus neocomiensis* (MYATLIUK), *Haplophragmoides* cf. *H. regularis* SKOLNICK, *Trochammina neocomiana* MYATLIUK, *Reophax matsumotoi* n. sp., *Epistomina hechti* BARTENSTEIN, BETTENSTAEDT and BOLLI, *Lenticulina heiermanni* BATTENSTAEDT, *Falsoguttulina obatai* n. sp. etc. The Kimigahama Formation as a whole is relatively rich in agglutinated foraminifera and rarely contains calcareous foraminifera.

A Barremian age for this assemblage is indicated by the occurrence of *Epistomina hechti, Lenticulina heiermanni, Verneuilinoides subfiliformis, Verneuilinoides plexus neocomiensis, Ammobaculites reophacoides* and *Trochammina neocomiana. Epistomina hechti, Verneuilinoides subfiliformis* and *Ammobaculites reophacoides*, all of which are characteristic of the *Crioceras* ammonite Zones from along the Mittelland-Kanal near Wenden, north of Braunschweig, Niedersachsen, northern Germany (BARTENSTEIN, 1952). *Ammobaculites reophacoides* was found in DSDP Site 398 on the lower continental rise of the southern margin of Vigo Sea-mount off Portugal to which a late Hauterivian to Barremian age is assigned (SIGAL, 1979). *Lenticulina heiermanni* and *Epistomina hechti*, associated with *Hedbergella hoterivica, Hedbergella sigali* and *Globigerinelloides blowi* which are Barremian to lower Aptian planktonic foraminifera, were found in DSDP Site 397 on the uppermost rise off Cape Bojador, north west Africa, in deposits of Barremian age (BUTT, 1979).

Characteristic planktonic foraminifera in the Toriakeura Formation are *Globigerinelloides ferreolensis* (MOULLADE), *Globigerinelloides macrocameratus* LONGORIA, *Hedbergella delrioensis* (CARSEY), *Hedbergella* cf. *H. sigali* MOULLADE, but the formation mainly contains abundant calcareous foraminifera, such as: *Gubkinella graysonensis* (TAPPAN), "*Bolivina*" *aptica* TAJROV, *Gyroidinoides infracretaceous* (MOROZOVA), *Lenticulina nodosa* (REUSS), *Planulina* (*Gavelinella*) *suturalis* (MYATLIUK). Thus on the whole, calcareous foraminifera are more abundant, but they still alternate with beds yielding agglutinated foraminifera such as *Ammobaculites urni-*

formis, Glomospirella gaultina (BERTHELIN), *Bathysiphon, Rhabdammina* and *Haplophragmoides*, etc.

According to most authors, *Globigerinelloides ferreolensis* is restricted to the late Aptian (MOULLADE, 1966; SIGAL, 1966; LONGORIA, 1972). *Globigerinelloides macrocameratus* is also restricted to the late Aptian (LONGORIA, op cit). Concurrently, the presence of *Globigerinelloides ferreolensis* and *Globigerinelloides macrocameratus* in samples Yt–20 and CH–016 confirms the late Aptian age of the Toriakeura Formation. This planktonic assemblage is similar to one from the *Globigerinelloides algerianus* Zone described by LONGORIA (1974), although *Globigerinelloides algerianus*, the most prominent marker of this zone, has not been found.

Globigerinelloides ferreolensis is known from the lower Gargasian of La Drôme, France (MOULLADE, 1966) and from the upper Aptian (Algos Formation) of Spain (KUHRY, 1971). It has been found at DSDP Site 390 and 392A on Blake Nose off Florida, U.S.A. (Upper Aptian *Globigerinelloides algerianus* Zone) (GRADSTEIN, 1979). Both *Globigerinelloides ferreolensis* and *Globigerinelloides macrocameratus* were reported from the La Peña Formation of Late Aptian age in northern Mexico and from the late Aptian bed of Site 305 on Shatsky Rise in the western Pacific (LUTERBACHER, 1975). *Planulina* (*Gavelinella*) *suturalis* is known from the Aptian in the southern part of the USSR (ANTONOVA et al., 1964). Judging from the above list of species the assemblage of foraminifera from the Toriakeura Formation resembles those of the upper Aptian reported from the Tethys.

Concluding Remarks

To sum up the above description,

1) The Lower Cretaceous Choshi Group is lithostratigraphically divided into five formations which in ascending order are, the Ashikajima, Kimigahama, Inubouzaki, Toriakeura and Nagasakihana Formations.

2) The cephalopods recorded suggest that the Choshi Group is Lower Barremian to Upper Aptian.

3) Well preserved foraminiferal assemblages obtained from the Kimigahama and Toriakeura Formations are the first record from the Japanese Lower Cretaceous. The foraminiferal faunas of both these formations provide an important standard for future research on the Early Cretaceous foraminifera of Japan.

4) The foraminifera from the Kimigahama Formation suggest a Barremian age, those from the Toriakeura Formation suggest Upper Aptian. These dates agree with those given by the ammonites.

5) The succession of ammonites and foraminifera in the Choshi Group is in harmony with standard regions in Europe and other areas.

Taxonomic Notes and Descriptions

(By S. MAIYA and Y. INOUE)

The classification used for this paper follows the "Treatise on Invertebrate Paleontology", Part C, Protista 2, Volume 2 (LOEBLICH and TAPPAN, 1964). Same specimens were compared with material from Texas. Other species were identified only by descriptions and figures given by the original authors and others.

All illustrated specimens are deposited in the Central Technical Laboratory of the Japan Petroleum Exploration Co. Ltd., Tokyo, Japan.

Family Heterohelicidae CUSHMAN, 1927
Subfamily Guembelitriinae MONTANARO GALLITELLI, 1957
Genus *Gubkinella* SULEYMANOV, 1955
Gubkinella graysonensis (TAPPAN)
Pl. 4, fig. 6a–d

Globigerina graysonensis TAPPAN, 1940, Jour. Paleontology, vol. 14, no. 2, p. 120, pl. 19, figs. 15–17.
Gubkinella graysonensis (TAPPAN), MICHAEL, 1972, Jour. of Foraminiferal Research, vol. 2, no. 4, p. 207, pl. 1, figs. 1–3.
Gubkinella graysonensis (TAPPAN), LONGORIA, 1974, Revista Espanola de Micropaleontologia, Numero Extraordinario, p. 50, pl. 1, figs. 1–12.
Gubkinella graysonensis (TAPPAN), PFLAUMANN and KRASHENINNIKOV, 1978, Initial Reports of Deep Sea Drilling Project, vol. XLI, p. 546, pl. 1, figs. 9–11.

This very minute species (maximum size of the specimens is 0.18 mm in diameter) has a subspherical, high trochospiral test with four globular chambers on the last whorl. Early portion of the test is acute. Aperture is hard to see, but is probably interiomarginal in the middle part of the last chamber.

This species has been reported from the upper part of the Grayson Formation and the Duck Creek Formation (Upper Albian) of Texas; from the Cuche Formation, *Lenticulina* (*Lenticulina*) *ouachensis ouachensis* Zone of Trinidad; from the La Peña Formation of Mexico; from the Argos Formation of Spain and from DSDP cores in the Atlantic (Leg 41, off western coast of Africa; Leg 47B, off the coast of Portugal) and western Pacific (Leg 32; on Shatsky Rise). LONGORIA (1974) recorded the species from the *Leupoldina cabri* Zone (Upper Aptian) to the *Rotalipora evoluta* Subzone (Cenomanian).

Occurrence: This species is rather commonly found in the Toriakeura Formation. This is the first record of *Gubkinella graysonensis* from the Japanese Cretaceous.

Family Rotaliporidae SIGAL, 1958
Subfamily Hedbergellinae LOEBLICH and TAPPAN, 1961
Genus *Hedbergella* BRÖNNIMANN and BROWN, 1958
Hedbergella delrioensis (CARSEY)
Pl. 4, fig. 1a–c

Globigerina cretacea D'ORBIGNY var. *delrioensis* CARSEY, 1926, Univ. Texas Bull., no. 2612, p. 43.
Hedbergella delrioensis (CARSEY), TAKAYANAGI and IWAMOTO, 1962, Palaeont. Soc. Japan, Trans. Proc., N. S., no. 45, p. 190, pl. 28, figs. 10a–12c.
Hedbergella delrioensis (CARSEY), TAKAYANAGI, 1965, Sci. Rept. Tohoku Univ., 2nd ser. (Geol.), vol. 36, no. 2, pl. 21, figs. 4a-c.
Hedbergella delrioensis (CARSEY), MICHAEL, 1972, Jour. of Foraminiferal Research, vol. 2, no. 4, p. 120, pl. 2, figs. 1–3.
Hedbergella delrioensis (CARSEY), LONGORIA, 1974, Revista Espanola de Micropaleontologia, Numero Extraordinario, p. 54, pl. 10, figs. 1–12, pl. 13, figs. 3–5, 15–17, 18, pl. 26, figs. 10–11.
Hedbergella delrioensis (CARSEY), PFLAUMANN and KRASHENINNIKOV, 1978, Initial Reports of Deep Sea Drilling Project, vol. XLI, p. 546, pl. 2, fig. 7a–c.

Two morphologic variations have been observed amongst the hypotypes. One form has a convex test on the spiral side and has a strongly protruded last chamber to the umbilicus; the other has a nearly flat spiral side.

The present specimen is low trochospiral with three whorls, six to six and half chambers are visible in the last whorl, and the last chamber protrudes towards the umbilicus; the sutures are radial, straight, constricted on both spiral and umbilical sides; the aperture is a low arch, extraumbilical with a flap. Diameter of the test is 0.4 mm, thickness 0.2 mm.

This species has been recorded from the Albian Duck Creek Formation of the Gulf Coastal region of the U.S.A., Trinidad, Italy, Switzerland, Rumania, Spain, Australia, Hokkaido of Japan, etc. LONGORIA (1974) gave a range for this form from late Aptian to Cenomanian (*Leupoldina cabri* Zone to *Rotalipora evoluta* Subzone). According to MAIYA and TAKAYANAGI (1977), this species is very common in the Albian to Cenomanian formations of Hokkaido.
Occurrence: Rare in the Toriakeura Formation.

Hedbergella cf. *H. sigali* MOULLADE

Pl. 4, fig. 2a–c

Hedbergella (*Hedbergella*) *sigali* MOULLADE, 1966, Lyon Univ., Fac. Sci., Lab. Geol., Doc., Lyon, no. 15, fasc. 1–2, pp. 87, 88, pl. 7, figs. 20–25.
Hedbergella sigali MOULLADE, LONGORIA, 1974, Revista Espanola de Micropaleontologia, Numero Extraordinario, p. 68, pl. 21, figs. 6–8, pl. 22, figs. 1–13.
Hedbergella sigali MOULLADE, PFLAUMANN and KRASHENINNIKOV, 1978, Initial Reports of Deep Sea Drilling Project, vol. XLI, p. 547, pl. 1, figs. 1–2.

Test is composed of two to three whorls, periphery rounded, four chambers in the last whorl, size increasing gradually; sutures radial, straight on both spiral and umbilical sides, aperture a low arch, extraumbilical; wall coarsely perforated, sometimes slightly reticulated as in the wall of *Favusella*. Diameter of the specimen reaches 0.22 mm, thickness is up to 0.18 mm.

The present specimen has a distinctly thicker test than the original specimen (the holotype of MOULLADE) and other types. Therefore, it is not strictly identical with that species, which was originally described from Saint-Cyrice (Hautes Alpes), France. It also occurs in northern Mexico and in the DSDP cores off the western coast of

Africa. According to LONGORIA (1974), this species has a rather short range from the base of *Globigerinelloides gottisi* Zone (Lower Aptian) to the lower *Leupoldina cabri* Zone (Upper Aptian).

Occurrence: This species is commonly found in the Toriakeura Formation.

Family Planomalinidae BOLLI, LOEBLICH and TAPPAN, 1957

Genus *Globigerinelloides* CUSHMAN and TEN DAM, 1948

Globigerinelloides ferreolensis (MOULLADE)

Pl. 4, fig. 4a–b

Biticinella ferreolensis MOULLADE, 1961, Rev. Micropaleontol., vol. 3, no. 4, p. 214, pl. 1, figs. 1–5.

Globigerinelloides ferreolensis (MOULLADE), RISCH, 1969, Inaugral-Dissertation, Ludwing-Maximilian—Universitat, Munchen, 180, pl. 13, figs. 3–4.

Globigerinelloides ferreolensis (MOULLADE), LONGORIA, 1974, Revista Espanola de Micropaleontologia, Numero Extraordinario, p. 84, pl. 5, figs. 7–8, pl. 8, figs. 1–3, 8–15, pl. 14, figs. 7–8, pl. 27, fig. 3.

Globigerinelloides ferreolensis (MOULLADE), GRADSTEIN, 1978, Initial Reports of Deep Sea Drilling Project, vol. XLIV, p. 672, pl. 9, figs. 1–4, pl. 10, figs. 14–17.

Globigerinelloides ferreolensis (MOULLADE), PFLAUMANN and KRASHENINNIKOV, 1978, Ibid, vol. XLI, p. 548, pl. 3, fig. 1a-c.

The present specimens have a semi-evolute test and generally contain seven chambers in the last whorl with a large final chamber. The primary aperture is indistinctly visible on the base of the last chamber; relict apertures are not visible. Maximum dimensions of the specimen are: diameter 0.28 mm, thickness 0.12 mm.

This species has been reported from lower Gargasian in France, uppermost Aptian to lower Albian of Germany, late Aptian of Spain and Mexico. It also occurs in the DSDP cores off western coast of Africa and off Florida, U.S.A. LONGORIA (1974) recorded the species from the upperpart of the *Leupoldina cabri* Zone to the *Hedbergella gorbachikae* Zone (Upper Aptian).

Occurrence: This species is fairly common in the Toriakeura Formation. This is the first record of this species from the Japanese Cretaceous.

Globigerinelloides macrocameratus LONGORIA

Pl. 4, fig. 5a–b

Globigerinelloides macrocameratus LONGORIA, 1974, Revista Espanola de Micropaleontologia, Numero Extraordinario, p. 85, pl. 5, figs. 1–6.

The specimens have an involute test of eight chambers in the last whorl; the bipartite primary aperture is not distinct, but long relict apertural flaps are well preserved. Diameter of the hypotype is 0.29 mm, thickness 0.1 mm.

This species was originally described from the La Peña Formation of Mexico and La Drôme section of France. The range is limited to the *Globigerinelloides algerianus* Zone (Upper Aptian).

Occurrence: Found rarely in the Toriakeura Formation. This is the first record of the species from the Cretaceous of Japan.

Family Ammodiscidae REUSS, 1862
Genus *Glomospirella* PLUMMER, 1945
Glomospirella gaultina (BERTHELIN)
Pl. 5, fig. 13a–b

Ammodiscus gaultinus BERTHELIN, 1880, Soc. Geol. France, Mem., ser. 3, vol. 1, no. 5, p. 19, pl. 1, fig. 3.
Involutina gaultina (BERTHELIN), TAKAYANAGI, 1960, Sci. Rep. Tohoku Univ., 2nd ser. (Geol.), 32 (1), p. 67, pl. 1, figs. 13a–14b.
Ammodiscus gaultinus BERTHELIN, MAYNC, 1973, Initial Reports of Deep Sea Drilling Project, vol. XIII, Part 2, p. 1081, pl. 1, figs. 4, 5.
Glomospirella gaultina (BERTHELIN), KRASHENINNIKOV and PFLAUMANN, 1978, Ibid., vol. XLI, p. 568, pl. 2, fig. 5.

The test is discoidal. Early whorls show a low trochoidal coil of a tubular chamber like *Glomospira*. The later one to two whorls coil planispirally in one plane as in *Ammodiscus*. The periphery is rounded; spiral suture depressed; wall very fine, homogeneously arenaceous, so that practically no grains are visible.

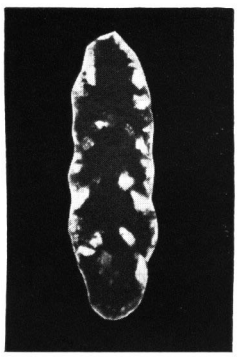
This species was originally described from the Albian of Montcley, France and has been recorded from various areas; the Gulf Coastal region of U.S.A., Germany, Austria, Switzerland, Egypt, Western Australia, Canada, northern Alaska, Hokkaido in Japan etc. According to TAKAYANAGI (1960), this species appears to have a range from the Callovian in the Jurassic to the Campanian. It is known from the Upper Miyakoan to the Upper Gyliakian of Hokkaido.

Occurrence: This species occurs rarely in the Kimigahama and Toriakeura formations.

Family Hormosinidae HAECKEL, 1894
Genus *Reophax* MONTFORT, 1808
Reophax matsumotoi n. sp.
Pl. 5, figs. 5a–b, 6a–b; Text–fig. 4

Description: Test free, composed of three to five somewhat inflated chambers increasing gradually in size as added; axis of test usually straight or rarely slightly curved; initial chamber large and spherical, sometimes two thirds obliquely covered by the succeding chamber; the last chamber sub-ellipsoidal, produced into a short cylindrical neck, all chambers connected by an entosolenian tube in vertical section; wall rough, composed of coarse sand grains cemented firmly together; sutures depressed, usually somewhat obscured by large fragments of wall material; aperture simple, nearly circular at the end of a short tubular neck; length of holotype, 0.87 mm, maximum diameter 0.25 mm; length of paratype, 1.075 mm, maximum diameter 0.33 mm.

Remarks: This species somewhat resembles *Reophax suevica* FRANKE from the Jurassic of Germany, but the wall of the test is more rough and the chambers do not increase so rapidly in size as added. This species also resembles *Reophax texana* CUSHMAN and WATERS from the Upper Cretaceous of Texas, but the present species differs from the latter in being slightly smaller in size and in having a short tubular neck.



Text-fig. 4. *Reophax matsumotoi* n. sp. ×38. CH-010, Kimigahama Formation.

Text-fig. 5. *Lenticulina heiermanni* BETTENSTAEDT. ×37. Yt-11, Kimigahama Formation.

Occurrence: This species is abundant in the Kimigahama Formation, but has not been found in the Toriakeura Formation.

Family Lituolidae DE BLAINVILLE, 1825
Subfamily Haplophragmoidinae MAYNC, 1952
Genus *Haplophragmoides* CUSHMAN, 1910
Haplophragmoides cf. *H. regularis* SKOLNICK
Pl. 5, fig. 12a–b

Haplophragmoides regularis SKOLNICK, 1958, Jour. Pal., vol. 32, no. 2, p. 284, pl. 38, fig. 1a–c.

According to the original descriptions, *Haplophragmoides regularis* shows six to seven visible chambers in the final whorl at a diameter of the test of 0.35 to 0.48 mm. The present specimens are more or less deformed and are not strictly identified with SKOLNICK's species. The test is larger than the original figure from the Graneros Formation of South Dakota (diameter 0.75 mm). There are eight chambers in the last-formed whorl, umbilical area on each side somewhat opened. Sutures are distinct, very slightly curved. Wall is finely arenaceous.
Occurrence: This species is rare in the Kimigahama Formation.

Subfamily Lituolinae DE BLAINVILLE, 1825
Genus *Ammobaculites* CUSHMAN, 1910
Ammobaculites reophacoides BARTENSTEIN
Pl. 5, fig. 8a–b

Ammobaculites reophacoides BARTENSTEIN, 1952, Taxonomische Revision und Nomenklator zu Franz E. HECHT "Standard-Gleiderung der Nordwestdeutschen Unterkreide nach Foraminiferen" (1938); Teil 2, vol. 33, no. 416, p. 307, p. 309, tf. 1.

Test in the early stage is coiled and composed of three to four chambers; later portion of three to four cylindrical inflated chambers in a linear series. Last chamber large and usually occupying more than one third of the test. Wall coarsely arenaceous.

This species has been recorded from the lower Barremian to the lower Aptian of Germany and from the Neocomian to middle Albian of the Yukon in Canada. A similar form was also recorded from the DSDP core at Site 398 (Leg. 47B), off the coast of Portugal.

Occurrence: This species is common in the Kimigahama Formation.

Ammobaculites urniformis SKOLNICK

Pl. 5, fig. 4a–b

Ammobaculites urniformis SKOLNICK, 1958, Jour. Pal., vol. 32, no. 2, p. 282, pl. 37, fig. 3a–e.

The early portion is involutely coiled with about five chambers. The uniserial portion consists of four chambers, which gradually increase in height but with almost no change in width; chamber elliptical on the apertural side. The length of the test is 0.71 mm and the greatest diameter of the coiling portion is 0.28 mm, short diameter is 0.24 mm, uniserial part 0.51 mm in length, coiling portion is 0.18 mm in thickness. Wall is coarsely arenaceous with much cement.

Occurrence: This species is common in both the Kimigahama and Toriakeura formations.

Ammobaculites sp. A

Pl. 5, fig. 1a–b

The test median, early portion is somewhat evolutely coiled with five to six chambers, uniserial part enlarges rapidly in relative height and width, composed of three to four chambers. Sutures are obscure in the coiled part, and somewhat indistinct in the uniserial part. The terminal chamber is large and inflated. The aperture is terminal and round at the top of the last chamber. Wall coarsely arenaceous with much cement. The length of the specimen is 0.48 mm, and maximum diameter of last chamber is 0.23 mm and minimum is 0.16 mm. Thickness of coiled portion is 0.07 mm.

Occurrence: This species is common in the Kimigahama Formation.

Ammobaculites sp. B

Pl. 5, fig. 2a–b

The early portion is involutely coiled and centrally umbilicate of four chambers with rounded periphery. The later portion of the test is uniserial with two chambers. The sutures are indistinct. The wall is coarsely arenaceous with much cement. The length of the specimen is 0.38 mm, maximum diameter is 0.23 mm, minimum diameter is 0.11 mm. This specimen resembles *Ammobaculites urniformis* but differs from this in its shorter uniserial stage. This specimen may be a juvenile form.

Occurrence: This species is rare in the Kimigahama Formation.

Family Ataxophragmiidae SCHWAGER, 1877

Subfamily Verneuilininae CUSHMAN, 1911

Genus *Verneuilinoides* LOEBLICH and TAPPAN, 1949

Verneuilinoides plexus neocomiensis (MYATLIUK)
Pl. 5, fig. 10a–b

Verneuilina neocomiensis MYATLIUK, 1939, Neftiangi geologorazvedochnyi Institut, Trudy, Leningrad, ser. A, fasc. 120, pp. 50, 71, pl. 1, figs. 12, 13a–b.

Verneuilinoides plexus neocomiensis (MYATLIUK), 1973, MAYNC. Initial Reports of Deep Sea Drilling Project, vol. XIII, Part 2, p. 1085, pl. 1, figs. 29–30.

Test elongate, tapering toward the initial end composed of six to seven volutions of triserial chambers, rounded in cross section. All chambers are markedly inflated, gradually increasing in size with growth; sutures depressed and distinct; wall finely arenaceous, usually found as a pyrite replacement. Aperture a low arch at the base of the final chamber. The length of the specimen is 0.38 mm–0.42 mm and maximum diameter is 0.11 mm–0.18 mm.

This species was originally described from the Saratov District of U.S.S.R. According to MAYNC (1973), transitional or highly variable morphotypes are usually observed between *Verneuilinoides neocomiensis* and *Verneuilinoides subfiliformis* (described below). He recorded a wide geographical distribution for this from which appears in the Valanginian and ranges up to the Barremian-Aptian.

Occurrence: This species is rare in the Kimigahama Formation.

Verneuilinoides subfiliformis BARTENSTEIN
Pl. 5, fig. 9a–b

Verneuilinoides subfiliformis BARTENSTEIN, 1952, Taxonomische Revision und Nomenklator zu Franz E. HECHT "Standard-Gliederung der Nordwestdeutschen Unterkreide nach Foraminiferen" (1938), Teil 2, vol. 33, no. 4/6, p. 308, p. 309, tis. 2–3.

The test is narrow, elongate, tapering towards the initial end, but is usually crushed. Sutures are depressed and indistinct, wall finely arenaceous, aperture not visible due to the compression of the test. Length of the adult tests is 0.50 mm–0.32 mm, maximum diameter 0.18 mm–0.15 mm.

This species has been recorded from northwest Germany. A similar form is also reported from DSDP Site 398.

Occurrence: This species is rare in the Toriakeura Formation and common in the Kimigahama Formation.

Subfamily Globotextulariinae CUSHMAN, 1927
Genus *Dorothia* PLUMMER, 1931
Dorothia praeoxycona MOULLADE
Pl. 5, fig. 3a–b

Dorothia praeoxycona MOULLADE, 1966, Lyon Univ., Fac. Sci., Lab. Geol., Doc., Lyon, no. 15, fasc. 1–2, pp. 30, 31, pl. 3, figs. 8–11, pl. 10, figs. 7–9.

Dorothia praeoxycona MOULLADE, LUTERBACHER, 1975, Initial Reports of Deep Sea Drilling Project, vol. XXXII, pl. 4, figs. 10–14.

Test median, horn shaped, biserial portion usually comprising two thirds of the test; rounded in cross section, tapering towards the initial end; sutures slightly de-

pressed, obscure in the early stage, but at a later stage gradually becomes distinct; aperture a high round opening at the base of the apertural face; wall finely arenaceous. Length of the adult test 0.81 mm–0.63 mm; breadth 0.50 mm–0.42 mm.

This species was first described from the Barremian of southeast France and has also been recorded from DSDP sites from the western Pacific.

Occurrence: This species is common in the Kimigahama Formation and occurs rarely in the Toriakeura Formation.

Family Trochamminidae SCHWAGER, 1877

Genus *Trochammina* PARKER and JONES, 1859

Trochammina neocomiana MYATLIUK

Pl. 5, fig. 14a–c

Trochammina neocomiana MYATLIUK, 1939, Neftianyi geologo-razvedochnyi Institut, Trudy, Leningrad, ser. A, fasc. 120, pp. 51, 71, pl. 1, fig. 10.

The specimens are slightly deformed, so that it is imposible to observe a true view of the test. Early chambers not visible due to the compression of the test, but on the dorsal side two whorls are visible, composed of four to six chambers in the last whorl; on the ventral side there are five to six chambers. Aperture not visible. Wall finely arenaceous.

This species was originally described from the Upper Neocomian to Barremian of the Kuibyshev District, U.S.S.R.

Occurrence: This species is dominantly found in the Kimigahama Formation.

Family Nodosariidae EHRENBERG, 1838

Subfamily Nodosariinae EHRENBERG, 1838

Genus *Dentalina* RISSO, 1826

Dentalina catenula REUSS

Pl. 6, fig. 1a–b

Dentalina catenula REUSS, 1860, K. Akad. Wiss. Wien, Math.-Naturw. cl., Sitzber., Wien, Bd. 40, p. 185, pl. 3, fig. 6.

Dentalina catenula REUSS, TAKAYANAGI, 1960, Sci. Rep. Tohoku Univ., 2nd ser. (Geol.), 32 (1), p. 94, pl. 5, fig. 7.

The test is composed of a gently curved row of three inflated chambers. The initial chamber is large, spherical and as large as the final chamber, but the second chamber is smaller than initial and final chambers in both length and width. Length of the specimen is 0.80 mm, diameter of apertural chamber 0.25 mm.

This species has been recorded from various areas, most of which are Upper Cretaceous, and has been reported from the Lower Gyliakian to Lower Hetonaian of the Otoinep-Saku, Haboro and Obira areas of Hokkaido.

Occurrence: This species is rare in the Toriakeura Formation.

Dentalina gracilis D'ORBIGNY

Pl. 6, fig. 8

Nodosaria (*Dentalina*) *gracilis* D'ORBIGNY, 1840, Mém. Soc. Geol. France, vol. 4, Mém. no. 1, p. 14, pl. 1, fig. 5.

Dentalina gracilis D'ORBIGNY, TAKAYANAGI, 1960, Sci. Rep. Tohoku Univ., 2nd ser. (Geol.), 32 (1), p. 95, pl. 5, figs. 9, 10.

Dentalina gracilis D'ORBIGNY, YOSHIDA, 1963, Jour. Hokkaido Gakugei Univ. vol. 13, no. 2, pl. 7, figs. 1–2.

Dentalina gracilis D'ORBIGNY, MAYNC, 1973, Initial Reports of Deep Sea Drilling Project, vol. XIII, Part 2, p. 1094, pl. 3, figs. 8, 9.

The test of the present species is composed of two elongate-ovate chambers of almost the same size. Axis of the test very slightly curved. Suture obscure, somewhat depressed. Length is 0.58 mm, diameter 0.20 mm.

This species is widespread in Upper Cretaceous formations and has been reported from the Otoinep-Saku, Haboro, Obira, Oyubari and Mombetsu areas of Hokkaido (uppermost Miyakoan to Lower Hetonaian). This species has also been reported from the Kappei and the Kawaruppu formations of Hombetsu district, Hokkaido (uppermost Cretaceous).

Occurrence: This species occurs rarely in the Toriakeura Formation.

Dentalina legumen REUSS

Pl. 6, fig. 10a–b

Nodosaria (*Dentalina*) *legumen* REUSS, 1845, Die Verstein-erungen der böhmischen Kreide-formation, p. 28, pl. 13, figs. 23–24.

Dentalina legumen REUSS, MAYNC, 1973, Initial Reports of Deep Sea Drilling Project, vol. XIII, Part 2, p. 1094, pl. 3, fig. 10.

The test of the present specimens have four to five non-inflated chambers, is slightly curved, tapering towards the initial end. Sutures are straight, somewhat obscure. Length is 0.75 mm–0.59 mm, diameter 0.16 mm–0.10 mm.

According to MAYNC (1973), this species is known from the entire European Cretaceous and from the American Upper Cretaceous.

Occurrence: This species is common in the Toriakeura Formation and is rare in the upper part of the Kimigahama Formation.

Genus *Lenticulina* LAMARCK, 1804

Lenticulina heiermanni BETTENSTAEDT

Text-fig. 5

Lenticulina (*Lenticulina*) *heiermanni* BETTENSTAEDT, 1952, Senckenbergiana, Frankfurt on Main, vol. 33, no. 4–6, p. 270, pl. 1, figs. 9–11.

Lenticulina heiermanni BETTENSTAEDT, BUTT, 1979, Initial Reports of Deep Sea Drilling Project, vol. XLVII, part 1, pl. 1, fig. 15.

The present specimen is smaller than the original types from Germany. Test is closely coiled, thirteen chambers in the last whorl with an acute periphery and umbonate; sutures raised, limbate, curved. Diameter of the test is 1 mm, thickness 0.47 mm. The holotype has twelve chambers in its last whorl, while our specimen has thirteen, but this may be ordinary morphologic variation.

This species was first described from the Upper Neocomian to Middle Barremian of northwest Germany. It was also reported from the DSDP Site 397.
Occurrence: This species is rare in the Kimigahama Formation.

Lenticulina nodosa (REUSS)
Pl. 6, fig. 3a–b

Cristellaria (*Robulina*) *nodosa* REUSS, 1863, A. Akad. Wiss. Wien, Math.-Naturw. cl., Sitzber., Wien, Bd. 46, Abth. 1 (1862), p. 78, pl. 9, fig. 6.
Lenticulina nodosa (Reuss), BASOV et al., 1976, Initial Reports of Deep Sea Drilling Project, vol. XLVII, Part 2, pl. 5, fig. 15.
Lenticulina nodosa (REUSS), KUZNETSOVA and SEIBOLD, 1978, Ibid, vol. XLI, pl. 5, fig. 6.
Lenticulina nodosa (REUSS), BUTT, 1979, Ibid, vol. XLVII, Part 1, pl. 1, fig. 16.
Lenticulina nodosa (REUSS), SIGAL, 1979, Ibid, vol. XLVII, Part 2, pl. 1, fig. 24.

Test having eight chambers in the last whorl; sutures raised, limbate, curved, meeting the periphery obliquely; umbilical area is occupied by a large callus not elevated above the surface of the test. Diameter is 0.70 mm; thickness 0.35 mm.

This species was originally described from the lower Cretaceous of north Germany and has been recorded from many DSDP Sites (e.g. Sites 367 and 370, off the west coast of Africa; Site 397, offshore from Cape Bojador; Site 398, off the coast of Portugal).
Occurrence: This species is rare in the Toriakeura Formation.

Genus *Vaginulina* D'ORBIGNY, 1826
Vaginulina kochii ROEMER
Pl. 6, fig. 5

Vaginulina kochii ROEMER, 1841, Hannover, Deutschland, Hahnschen Hofbuchhandlung, p. 96, pl. 15, fig. 10.

The specimens have a large test (length 1.6 mm, width 0.17 mm); ten chambers are visible in side view; periphery quadangular, slightly raised on both edges, rectangular in both apertural and edge views; sutures flush, slightly curved, no ornamentation seen on the test.
Occurrence: This species is rare in the Toriakeura Formation.

Family Polymorphinidae D'ORBIGNY, 1839
Genus *Falsoguttulina* BARTENSTEIN and BRAND, 1949
Falsoguttulina obatai n. sp.
Pl. 6, figs. 14a–b, 15a–b

Description: Test free, subrhomboid or subdeltoid in side view; maximum width slightly below the middle; initial end rounded, apertural end subacute, triangular in apertural view; early chambers are somewhat inflated, have a rounded periphery, later ones are elongate, have a subacute periphery. Usually five to seven chambers are visible, arranged in low quinqueloculine series with each succeeding chamber removed further from the basal end of the test; sutures thin and indistinct in the early

portion, distinct and depressed in the later portion; wall calcareous, finely perforate, smooth; aperture terminal, large, a slightly curved slit at the apex of the last-formed chamber. Length of holotype 0.33 mm; paratype 0.23 mm; maximum diameter of holotype 0.17 mm, paratype 0.15 mm.

Remarks: This species resembles *Falsoguttulina diversa* DAILEY from the Chickabally Member of California, but differs from that species in having a more slender test and larger aperture. It is also similar to *Falsoguttulina wolburgi* BARTENSTEIN and BRAND from the Lower Cretaceous of Germany, but differs from the latter in having less inflated chambers and subacute periphery.

Occurrence: This species is the main constituent of the calcareous fauna in the Kimigahama Formation, occuring abundantly in the upper part; rare in the Toriakeura Formation.

Family Bolivinitidae CUSHMAN, 1927
Genus *Bolivina* D'ORBIGNY, 1839
"Bolivina" aptica TAJROV
Pl. 4, fig. 3a–b

"*Bolivina*" *aptica* TAJROV, SIGAL, 1979, Initial Reports of Deep Sea Drilling Project, vol. XLVII, part 2, pl. 3, fig. 1.

Family Uvigerinidae HAECKEL, 1894
Genus *Orthokarstenia* DIETRICH, 1935
Orthokarstenia sp.
Pl. 6, fig. 9a–b

Test free, elongate, tapering towards the initial end; initial chambers arranged triserially, later becoming uniserial, but it is difficult to see the preservation of the wall in the triserial stage; uniserial stage consists of three to four slightly inflated chambers which increase very gradually in size as added, broader than high; sutures distinct, thin, depressed; wall calcareous, perforate, finely papillate, sometimes found as a pyrite replacement; aperture simple, terminal, an elliptical to circular opening at the end of a thick neck in the last chamber. Length of the tests is 0.55 mm–0.38 mm; breadth 0.17 mm–0.12 mm.

This species resembles *Orthokarstenia shastaensis* DAILEY described from California, but differs from that species in being more slender and having a smaller test. The present form is possibly a new species, but more well preserved specimens are needed to evaluate it.

Occurrence: This species is common in the Toriakeura Formation.

Family Osangulariidae LOEBLICH and TAPPAN, 1964
Genus *Gyroidinoides* BROTZEN, 1942
Gyroidinoides infracretaceous (MOROZOVA)
Pl. 6, figs. 12a–c, 13a–c

Gyroidina nitida REUSS var. *infracretacea* MOROZOVA, 1948, Moskovsk. Obshch. Ispyt. Prirody, Byull.,

n. ser., vol. 53, Otdel. Geol., vol. 23, no. 3, p. 40, pl. 2, figs. 12–14.

Gyroidinoides infracretaceous (MOROZOVA), BASOV et al., 1976, Initial Reports of Deep Sea Drilling Project, vol. XLVII, Part. 2, pl. 6, figs. 3, 5, 9, 10.

The present specimens have a subconical test in side view and circular in spiral view; dorsal side flattened or very slightly convex, ventral side strongly convex, periphery broadly rounded; three whorls on the spiral side. Chambers gradually increase in size, with about twelve to fourteen chambers visible on the spiral side, five to six chambers on the umbilical side; sutures distinct, depressed, usually straight, sometimes slightly curved on both the dorsal and ventral sides; aperture is a long slit at the base of the last-formed chamber, extending from the periphery to the umbilicus. Diameter of the specimens is 0.31 mm–0.23 mm; thickness 0.22 mm–0.18 mm. The present specimens have more straight sutures than the original specimens, but may be within the same morphologic variation. This species was first described from the lower Albian of the southwestern Caucasus, U.S.S.R. and has also been recorded from the DSDP, Site 398.

Occurrence: This species is abundantly in the Toriakeura Formation.

Family Cibicididae CUSHMAN, 1927
Subfamily Planulininae BERMUDEZ, 1952
Genus *Planulina* D'ORBIGNY, 1826
Planulina (*Gavelinella*) *suturalis* (MYATLIUK)
Pl. 7, figs. 2a–d, 3a–c

Anomalina suturalis MYATLIUK, 1949, Vses. Neft. Nauchno-Issled. Geol.-Razved. Inst. Trudy, n. s., vypusk 34, p. 218, pl. 4, fig. 1a–c.

Gavelinella suturalis (MYATLIUK), BASOV et al., 1976, Initial Reports of Deep Sea Drilling Project, vol. XLVII, Part 2, pl. 5, figs. 14, 18.

Test is planoconvex (spiral side flat) to almost lenticular; early stage trochoid, later somewhat evolute; periphery angular to slightly rounded, ten to twelve chambers in the last whorl; sutures raised, limbate, strongly oblique; aperture a low interiomarginal slit extending from the peripheral margin onto the umbilical side beneath the umbilical chamber flaps. Diameter is 0.53 mm–0.35 mm; thickness 0.15 mm–0.10 mm.

This species was originally described from the lower Aptian of Kazakh, ASSR. and was also recorded from DSDP, Site 398.

Occurrence: This species is fairly common in the Toriakeura Formation.

Family Ceratobuliminidae CUSHMAN, 1927
Subfamily Epistomininae WEDEKIND, 1937
Genus *Epistomina* TERQUEM, 1883
Epistomina hechti BARTENSTEIN, BETTENSTAEDT and BOLLI
Pl. 7, fig. 1a–c

Epistomina hechti BARTENSTEIN, BETTENSTAEDT and BOLLI, 1957, Ecologae Geol. Helv., Basel, vol. 50, no. 1, p. 46.

Epistomina hechti BARTENSTEIN, BETTENSTAEDT and BOLLI, BUTT, 1979, Initial Reports of Deep Sea Drilling Project, vol. XLVII, Part 1, pl. 2, fig. 4.

Test biconvex, periphery acute, but the chambers are indistinctly seen, probably about six to seven in the adult whorl. The wall surfaces of most of the present specimens are poorly preserved during fossilization, because of the aragonitic test of the species. As a result the actual form of the species is rather difficult to observe in one specimen. Diameter of the test is 0.28 mm–0.23 mm: thickness 0.15–0.10 mm.

This species was originally described from the upper Neocomian to middle Barremian (*Crioceras denckmanni* ammonite Zone) of northwest Germany, and has also been recorded from DSDP, Site 397.

Occurrence: This species is rare to common in the Toriakeura Formation and rare in the Kimigahama Formation.

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Explanation of Plates

Plate 1

Fig. 1. *Pulchellia* sp.
NSM-PM 9497 from loc. 7306. Lateral (b. d), front (a) and ventral (c) views, ×1.5.
Fig. 2. *Olcostephanus* (s. l.) sp.
NSM-PM 6909 from loc. 7306. Lateral view, ×1.5.
Fig. 3. *Olcostephanus* (s. l.) sp.
NSM-PM 9498 from loc. 7306. Lateral (b), front (a) and ventral (c) views, ×1.5.
Fig. 4. *Crioceratites* (*Emericiceras*) *emerici* (LÉVEILLE)
NSM-PM 9499 from loc. 7306. Lateral (b.d), front (a) and ventral (c) views, ×1.5.
Fig. 5. *Barremites* (*B.*) sp.
NSM-PM 6825 from loc. 7403. Lateral (a) and ventral (b) views, ×1.5.
Fig. 6. *Crioceratites* (*Emericiceras*) *emerici* (LÉVEILLE)
NSM-PM 6785 from loc. 7309. Ventral (a) and lateral (b) views, ×1.5.
Fig. 7. *Barremites* (*Barremites*) *difficilis* (D'ORBIGNY)
NSM-PM 9500 from loc. 7404. Lateral (b.d), front (a) and ventral (d) views, ×1.0.

Plate 2

Fig. 1. *Tropaeum* aff. *T. bowerbanki* (SOWERBY)
NSM-PM 7441 from loc. 2619. Lateral view ×0.5.
Fig. 2. *Tropaeum* aff. *T. bowerbanki* (SOWERBY)
NSM-PM 9503 from loc. 2619. Lateral (a. c) and ventral (b) views ×0.5.
Fig. 3. *Australiceras* aff. *A. gigas* (SOWERBY)
NSM-PM 9502 from loc. 2619. Lateral view ×0.5.
Fig. 4. *Dufrenoyia* sp.
NSM-PM 6877 from loc. 7324. Lateral view ×1.0.

Plate 3

Fig. 1. *Dufrenoyia* aff. *D. dufrenoyi* (D'ORBIGNY)
NSM-PM 9501 from loc. 7441. Lateral views, (b); plaster cast, ×1.0.
Fig. 2. *Cheloniceras* (*Epicheloniceras*) sp.
NSM-PM 6875 from loc. 7324. Lateral view, ×1.5.
Fig. 3. *Cheloniceras* (*Epicheloniceras*) sp.
NSM-PM 6873 from loc. 7324. Ventral view, ×1.0.
Fig. 4. *Australiceras* aff. *A. gigas* (SOWERBY)
NSM-PM 7448 from loc. 2619. Lateral (a) and ventral (b) views, ×0.5.

Plate 4

Fig. 1a–c. *Hedbergella delrioensis* (CARSEY)
a, dorsal view; b, ventral view; c, edge view; ×175, CH-016, Toriakeura Formation
Fig. 2a–c. *Hedbergella* cf. *H. sigali* MOULLADE
a, dorsal view; b, ventral view; c, edge view; ×175, CH-016, Toriakeura Formation
Fig. 3a–b. "*Bolivina*" *aptica* TAJROV
a, apertural view; b, side view; ×175, CH-016, Toriakeura Formation.
Fig. 4a–b. *Globigerinelloides ferreolensis* (MOULLADE)
a, apertural view; b, side view; ×175, Yt-20, Toriakeura Formation
Fig. 5a–b. *Globigerinelloides macrocameratus* LONGORIA
a, side view; b, apertural view; ×175, Yt-20, Toriakeura Formation

Fig. 6a–d. *Gubkinella graysonensis* (TAPPAN)
a, dorsal view; b, ventral view; c, edge view; d, oblique ventral view; ×250, CH-016, Toriakeura Formation.

Plate 5

Fig. 1. *Ammobaculites* sp. A
a, side view; b, apertural view; ×100, Yt–11, Kimigahama Formation.
Fig. 2. *Ammobaculites* sp. B
a, side view; b, apertural view; ×100, Yt–11 Kimigahama Formation.
Fig. 3. *Dorothia praeoxygona* MOULLADE
a, side view; b, apertural view; ×75, Yt–16, Kimigahama Formation.
Fig. 4. *Ammobaculites urniformis* SKOLNICK
a, side view; b, apertural view; ×50, Yt–19, Toriakeura Formation.
Fig. 5. *Reophax matsumotoi* n. sp.
a, side view; b, apertural view; holotype; ×50, Yt–11, Kimigahama Formation.
Fig. 6. *Reophax matsumotoi* n. sp.
a, side view; b, apertural view; paratype; ×50, Yt–11, Kimigahama Formation.
Fig. 7. *Haplophragmoides* sp.
a, side view; b, apertural view; ×75, CH–001, Kimigahama Formation.
Fig. 8. *Ammobaculites reophacoides* BARTENSTEIN
a, side view; b, apertural view; ×50, Yt–16, Kimigahama Formation.
Fig. 9. *Verneuilinoides subfiliformis* BARTENSTEIN
a, side view; b, apertural view; ×75, CH–001, Kimigahama Formation.
Fig. 10. *Verneuilinoides plexus neocomiensis* (MYATLIUK)
a, side view; b, apertural view; ×75, CH–001, Kimigahama Formation.
Fig. 11. *Bathysiphon* sp.
×50, Yt–19, Toriakeura Formation
Fig. 12. *Haplophragmoides* cf. *H. regularis* SKOLNICK
a, side view; b, apertural view; ×75, Yt–16, Kimigahama Formation.
Fig. 13. *Glomospirella gaultina* (BERTHELIN)
a, side view; b, apertural view; ×75, CH–016, Toriakeura Formation.
Fig. 14. *Trochammina neocomiana* MYATLIUK
a, ventral view; b, edge view; c, dorsal view; ×75, Yt-11, Kimigahama Formation.

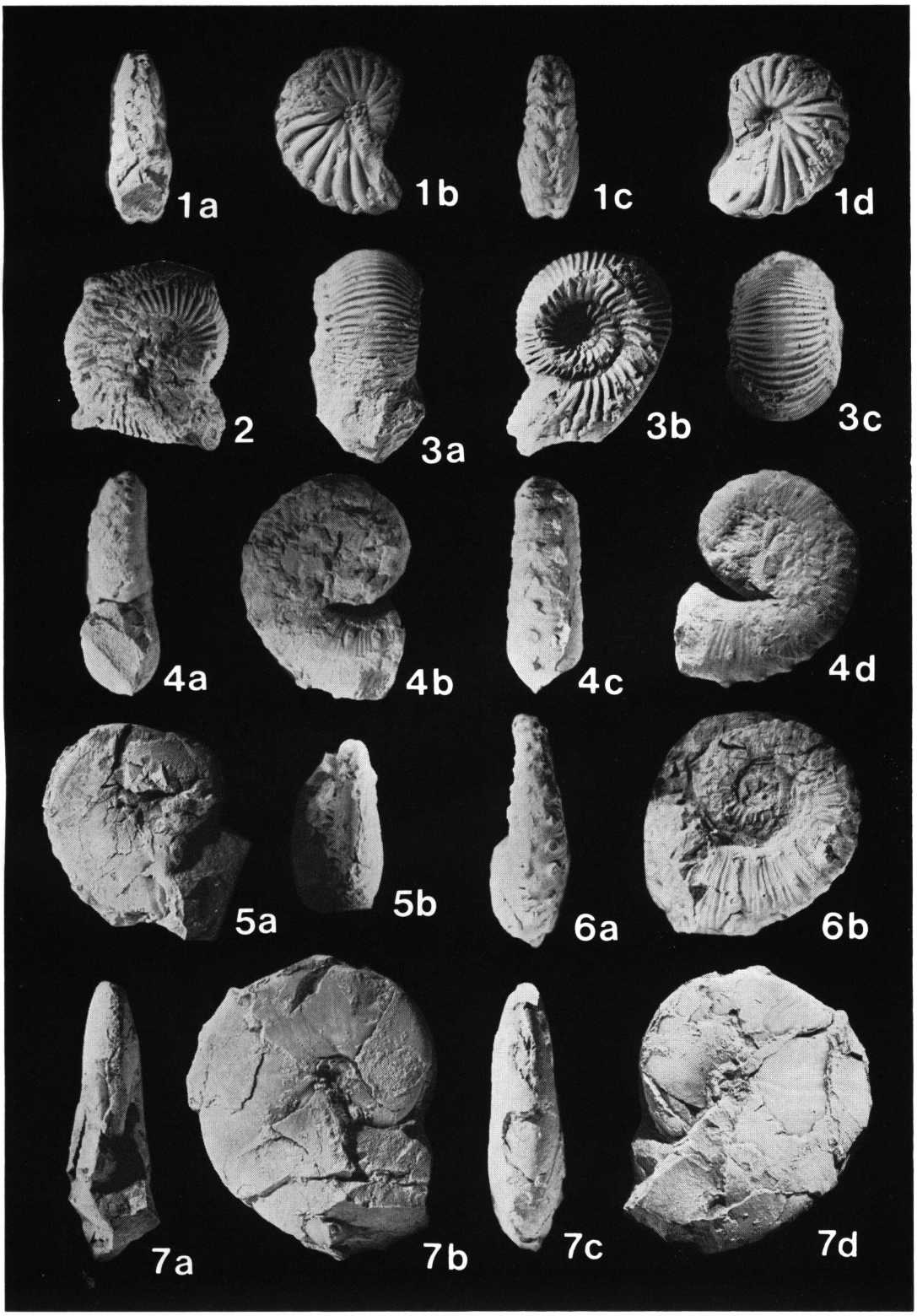
Plate 6

Fig. 1. *Dentalina catenula* REUSS
a, side view; b, apertural view; ×50, Yt–19, Toriakeura Formation.
Fig. 2. *Nodosaria* sp.
a, side view; b, apertural view; ×50, CH–016, Toriakeura Formation.
Fig. 3. *Lenticulina nodosa* (REUSS)
a, side view; b, apertural view; ×75, Yt–23, Toriakeura Formation.
Fig. 4. *Lagena* sp.
a, side view; b, apertural view; ×75, CH–016, Toriakeura Formation.
Fig. 5. *Vaginulina kochii* ROEMER
×37, CH–016, Toriakeura Formation.
Fig. 6. *Lagena* sp.
a, side view; b, apertural view; ×75, CH–016, Toriakeura Formation.
Fig. 7. *Lagena* sp.
a, side view; b, apertural view; ×50, CH–016, Toriakeura Formation.

Fig. 8. *Dentalina gracilis* D'ORBIGNY
×50, Yt–19, Toriakeura Formation.
Fig. 9. *Orthokarstenia* sp.
a, side view; b, apertural view; ×75, CH–016, Toriakeura Formation.
Fig. 10. *Dentalina legumen* REUSS
a, side view; b, apertural view; ×50, CH–016, Toriakeura Formation.
Fig. 11. *Gyroidinoides infracretaceous* (MOROZOVA)
a, dorsal view; b, ventral view; c, edge view; ×100, Yt–20, Toriakeura Formation.
Fig. 12. *Gyroidinoides infracretaceous* (MOROZOVA)
a, dorsal view; b, ventral view; c, edge view; ×100, Yt–20, Toriakeura Formation.
Fig. 13. *Lagena* sp.
a, side view; b, apertural view; ×75, Yt–20, Toriakeura Formation.
Fig. 14. *Falsoguttulina obatai* n. sp.
a, side view; b, apertural view; paratype, ×100, CH–002, Kimigahama Formation.
Fig. 15. *Falsoguttulina obatai* n. sp.
a, apertural view; b, side view; holotype, ×100, CH–002, Kimigahama Formation.
Fig. 16. *Gavelinella* sp.
a, dorsal view; b, ventral view; c, edge view; ×100, CH–016, Toriakeura Formation.

Plate 7

Fig. 1. *Epistomina hechti* BARTENSTEIN, BETTENSTAEDT and BOLLI
a, ventral view; b, dorsal view; c, edge view; ×175, CH–002, Kimigahama Formation.
Fig. 2. *Planulina* (*Gavelinella*) *suturalis* (MYATLIUK)
a, ventral view; b, dorsal view; c, edge view; d, dorsal view (optical microscope). ×100, Yt–20, Toriakeura Formation.
Fig. 3. *Planulina* (*Gavelinella*) *suturalis* (MYATLIUK)
a, dorsal view; b, ventral view; c, edge view; ×100, Yt-20, Toriakeura Formation.
Fig. 4. *Saracenaria* sp.
a, side view; b, apertural view; ×75, CH–016, Toriakeura Formation.
Fig. 5. *Conorboides* sp.
a, dorsal view; b, edge view; ×100, CH–016, Toriakeura Formation.
Fig. 6. *Saracenaria* sp.
a, side view; b, apertural view; ×50, Yt–20, Toriakeura Formation.
Fig. 7. *Neoflabellina* sp.
a, side view; b, oblique apertural view; ×75, CH–016, Toriakeura Formation.
Fig. 8. *Palmula* sp.
a, side view; b, oblique apertural view; ×75, CH–016, Toriakeura Formation.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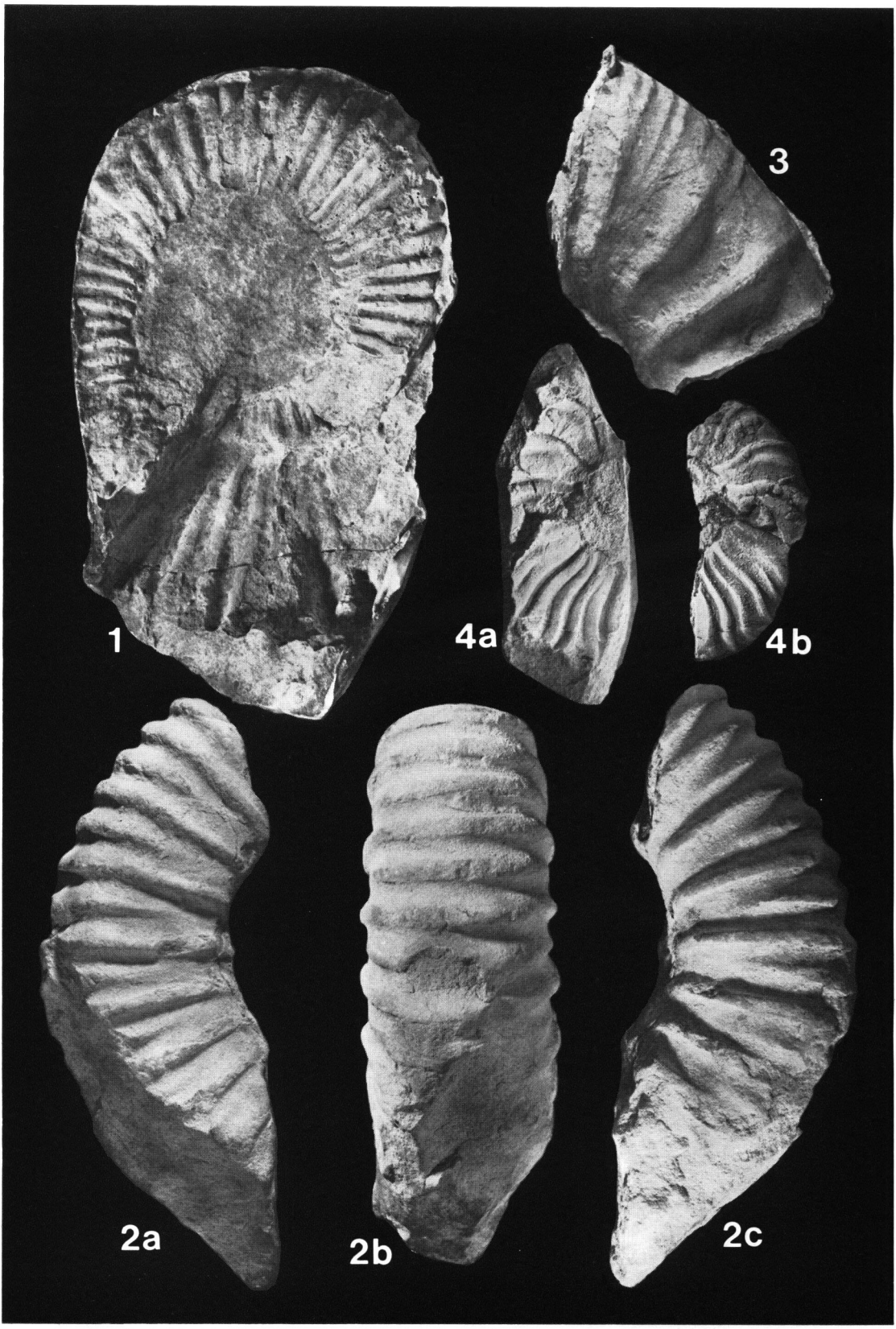
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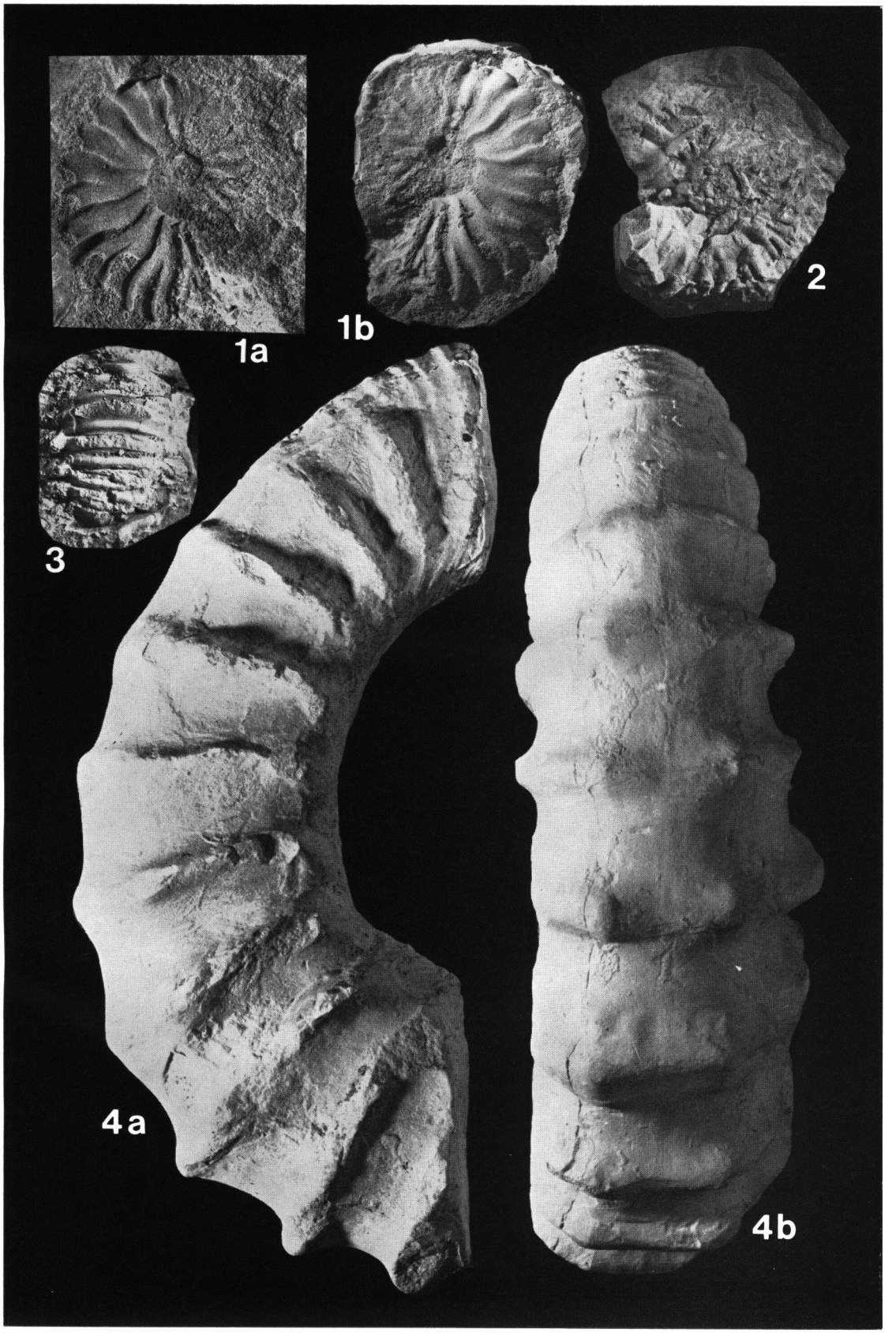
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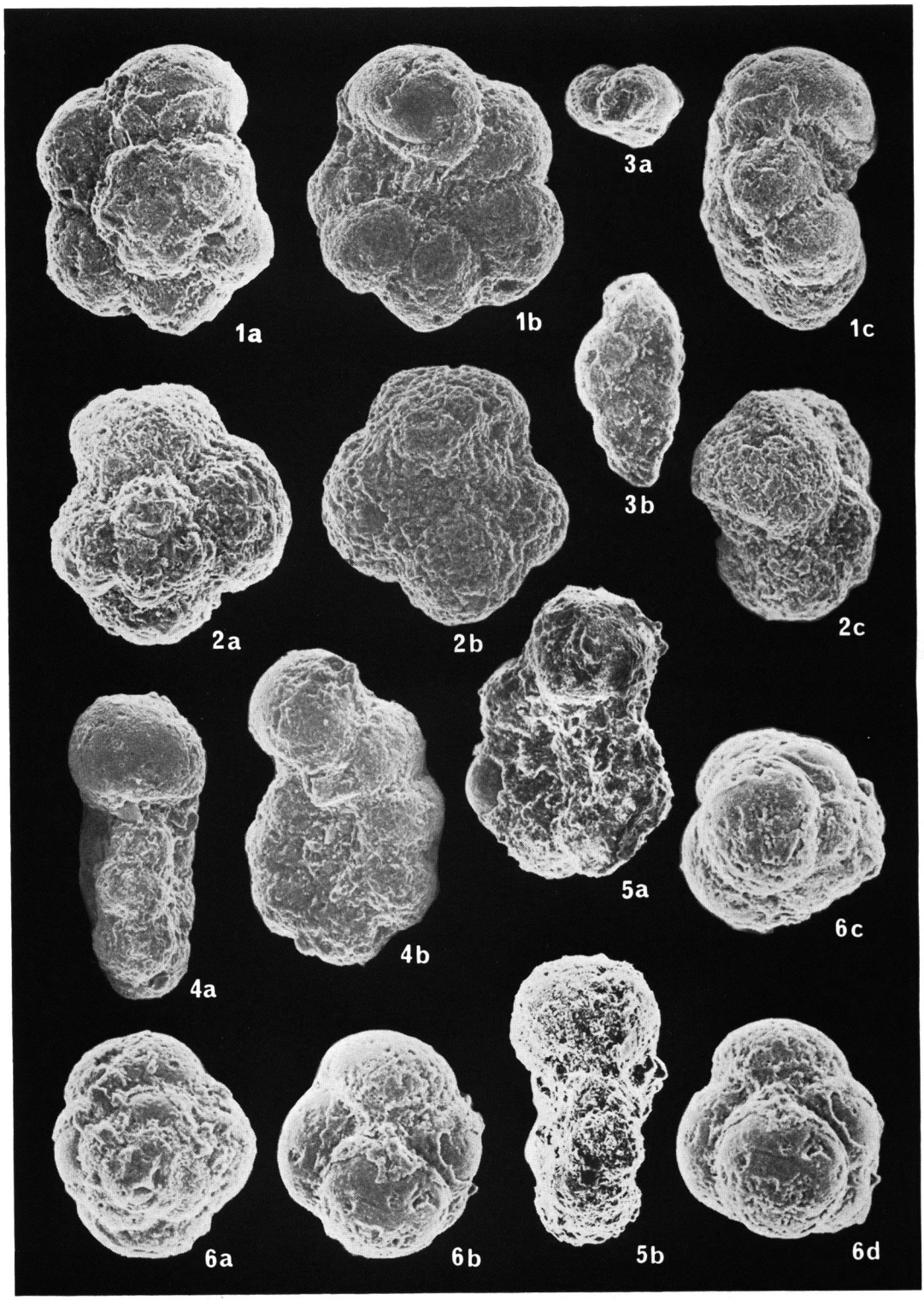
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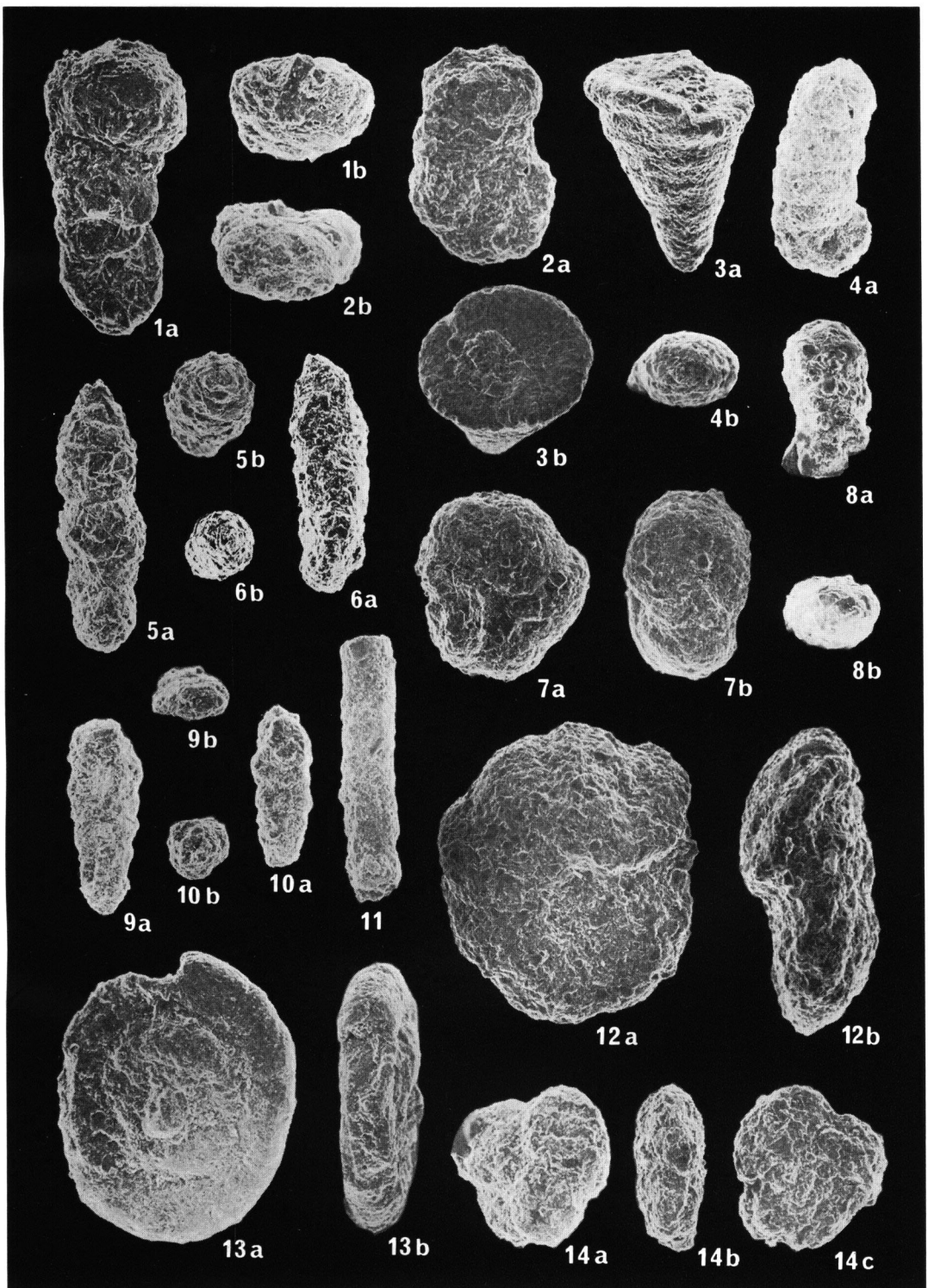
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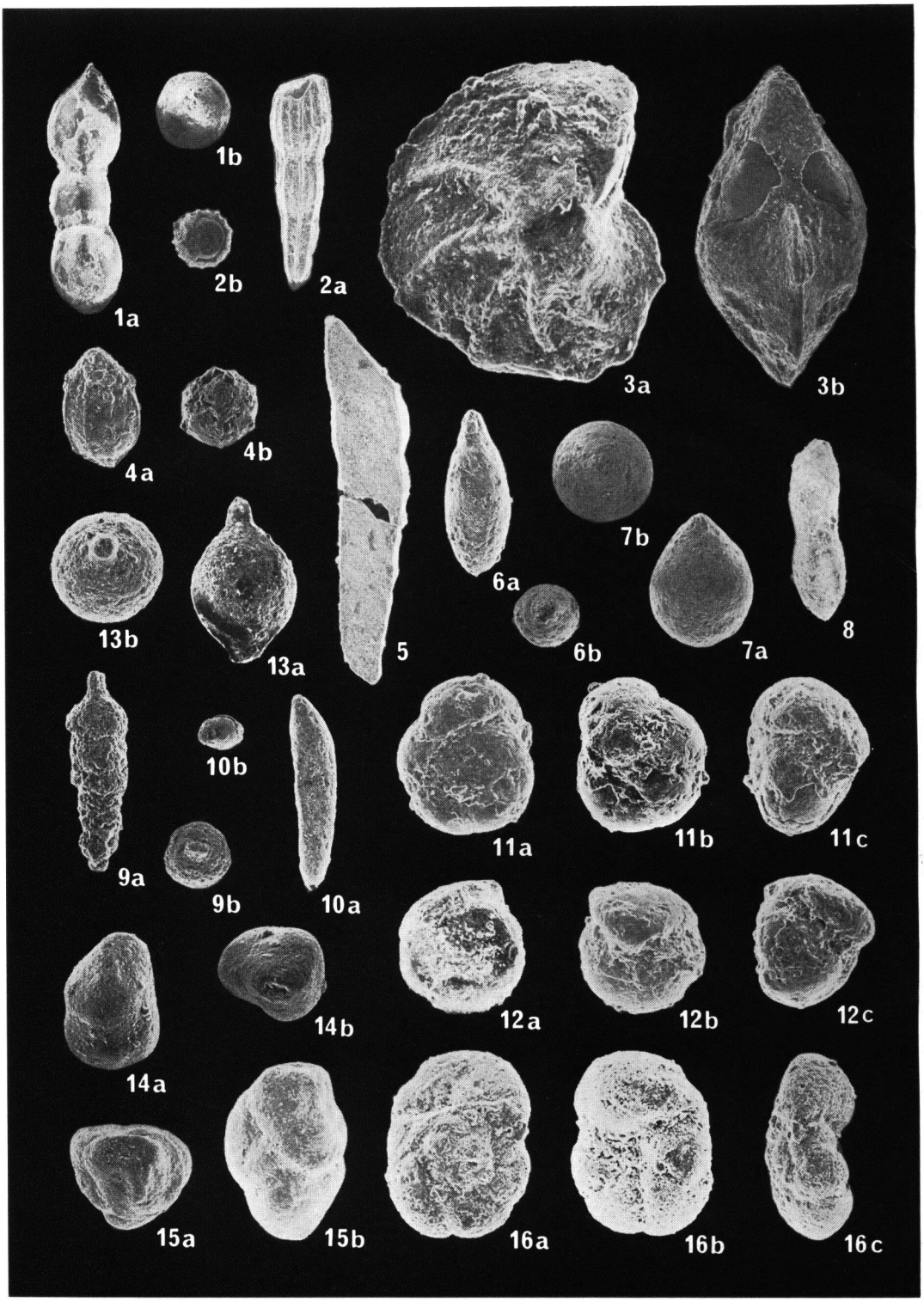
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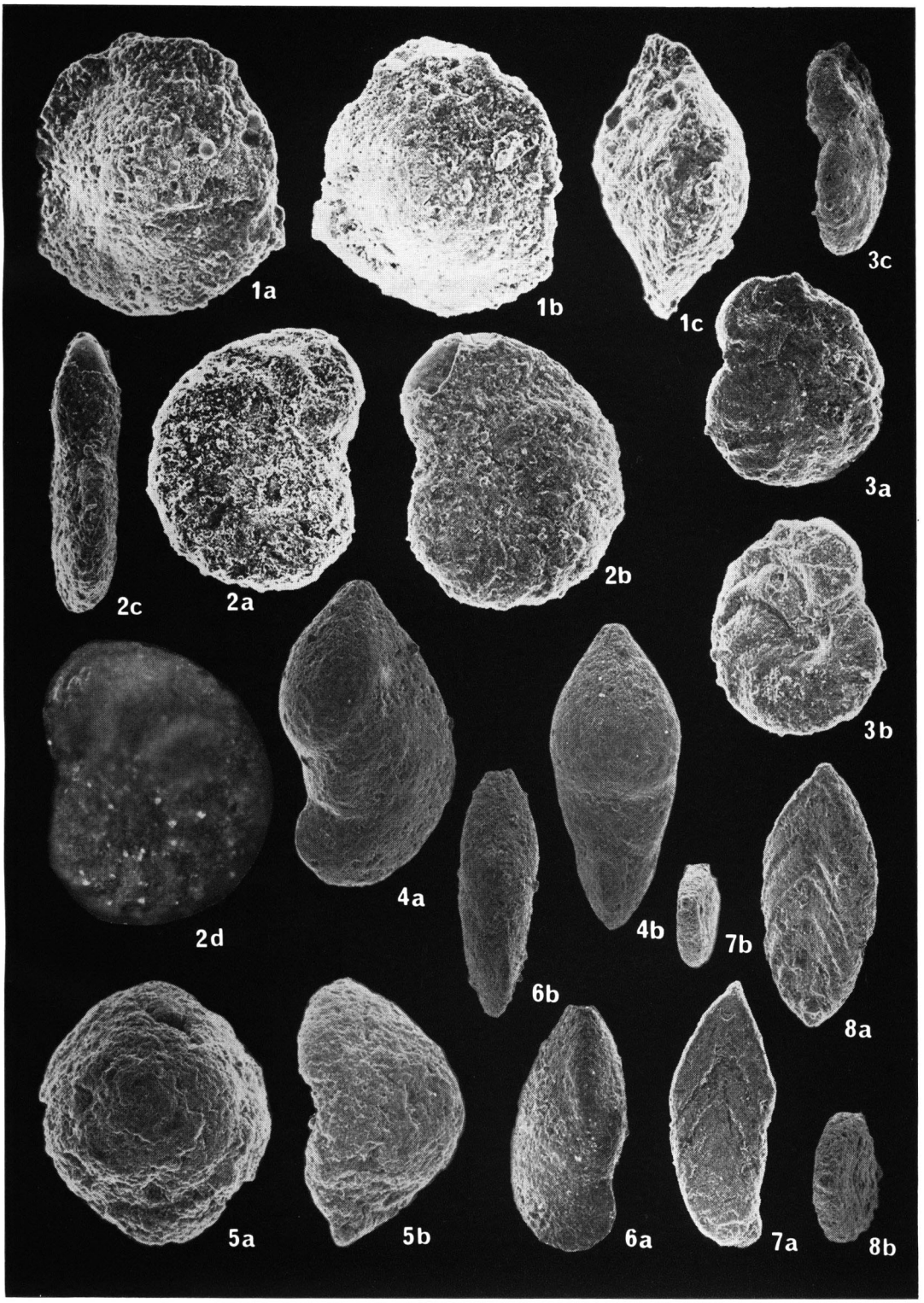
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