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# Biostratigraphic Study of the Jurassic Toyora Group

## Part I

By

Hiromichi HIRANO

## Abstract

The Jurassic Toyora Group is studied biostratigraphically with special reference to the middle and upper Liassic ammonoids. 23 genera including 42 species of ammonoids which are described in this serial study indicate successive ages from Sinemurian to Bajocian. Ammonoids indicating Upper Pliensbachian to Toarcian are especially abundant, and zoning and correlation are attempted for this part on the basis of these new data. Three zones are recognized, namely *Fontanelliceras fontanellense* Zone, *Protogrammoceras nipponicum* Zone and *Dactylioceras helianthoides* Zone in ascending order. The assemblages of ammonoids in the *Fontanelliceras fontanellense* Zone and the lower half of the *Protogrammoceras nipponicum* Zone are well characterized by Mediterranean elements. The assemblages in the upper half of the *Protogrammoceras nipponicum* Zone and the *Dactylioceras helianthoides* Zone show somewhat high similarities to European faunas. The faunal relations with various regions are discussed and analyzed by means of SIMPSON's formula. The distribution of the lower Jurassic ammonite faunas and the relation between fauna and lithofacies are discussed in connection with the Toyora fauna.

In the present part, stratigraphy is explained and 20 Domerian species of 10 ammonoid genera are described. Others are to be described in the forthcoming articles.

## I. Introduction

Lower Jurassic marine deposits are well represented by the Toyora Group in west Japan. The study of this group was first made by YOKOYAMA (1904), who described some Liassic ammonoids. The Toyora Group, named by YABE (1920), was said to be overlain by the Cretaceous Inkstone Group*. A trigonian species was found from the lower part of the Toyora Group and described by YEHARA (1921). This was revised later by KOBAYASHI & MORI (1954) under the generic name *Prosogyrotrigonia*. KOBAYASHI (1926), in his serial study of the geology of Southwest Japan, clarified the general stratigraphy of this group and divided it into four formations, that is, the Higashinagano, the Nishinakayama, the Utano and the Nanami Formation in ascending order. He described two species of *Inoceramus* at the same time. YABE & EGUCHI (1933) described a species of coral from the lower part of the Higashinagano Formation.

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* Kwanmon Group in this paper.

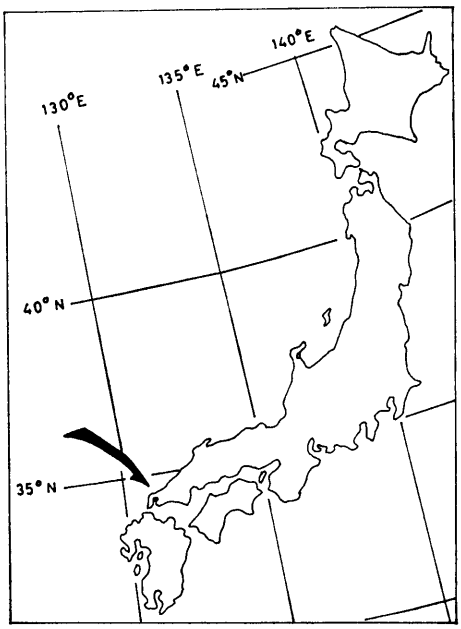



Fig. 1. Map showing the general position of the studied area.

TORIYAMA (1938) investigated this group and showed the geological map of the distributed area, dividing the group as KOBAYASHI (1926) did.

MATSUMOTO & ONO (1947), as a part of serial geological study in western Chugoku and northern Kyushu, studied the biostratigraphy of this group and described briefly many ammonoids. ARKELL (1956) cited the biostratigraphic results of MATSUMOTO & ONO (1947), revising provisionally some ammonoids without description. Since this note was published, his opinion on the biostratigraphy of the group has been followed. TAKAHASHI (1950, 1951a, b, 1954, 1965, 1966, 1968) succeeded OISHI (1935, 1940) in the study of the Toyora flora and supplemented some new knowledge to the stratigraphy. SATO (1956, 1960, 1962) studied the Jurassic stratigraphy, ammonoids and palaeogeography and concluded the biostratigraphy of the Jurassic deposits in Japan, although little revision was attempted on the taxonomy of the ammonoids from the Toyora Group. Various species of bivalves and gastropods were described and the faunal characteristics were made clear by HAYAMI (1958, 1959, 1960a, b, 1961, 1962).

The purpose of the present paper is to describe ammonties from the Toyora Group in the light of up-to-date taxonomy and to lead a revised biostratigraphic conclusion.

*Acknowledgements.*—I express my grateful gratitude to Professor Tatsuro MATSUMOTO of the Kyushu University for his pertinent leadership with excellent suggestion. Thanks are also due to Associate Professor Kametoshi KANMERA of the same university for his instructive advice, Dr. Itaru HAYAMI for his valuable criticism and warm encouragement and Mr. Tomowo OZAWA for his kind criticism.

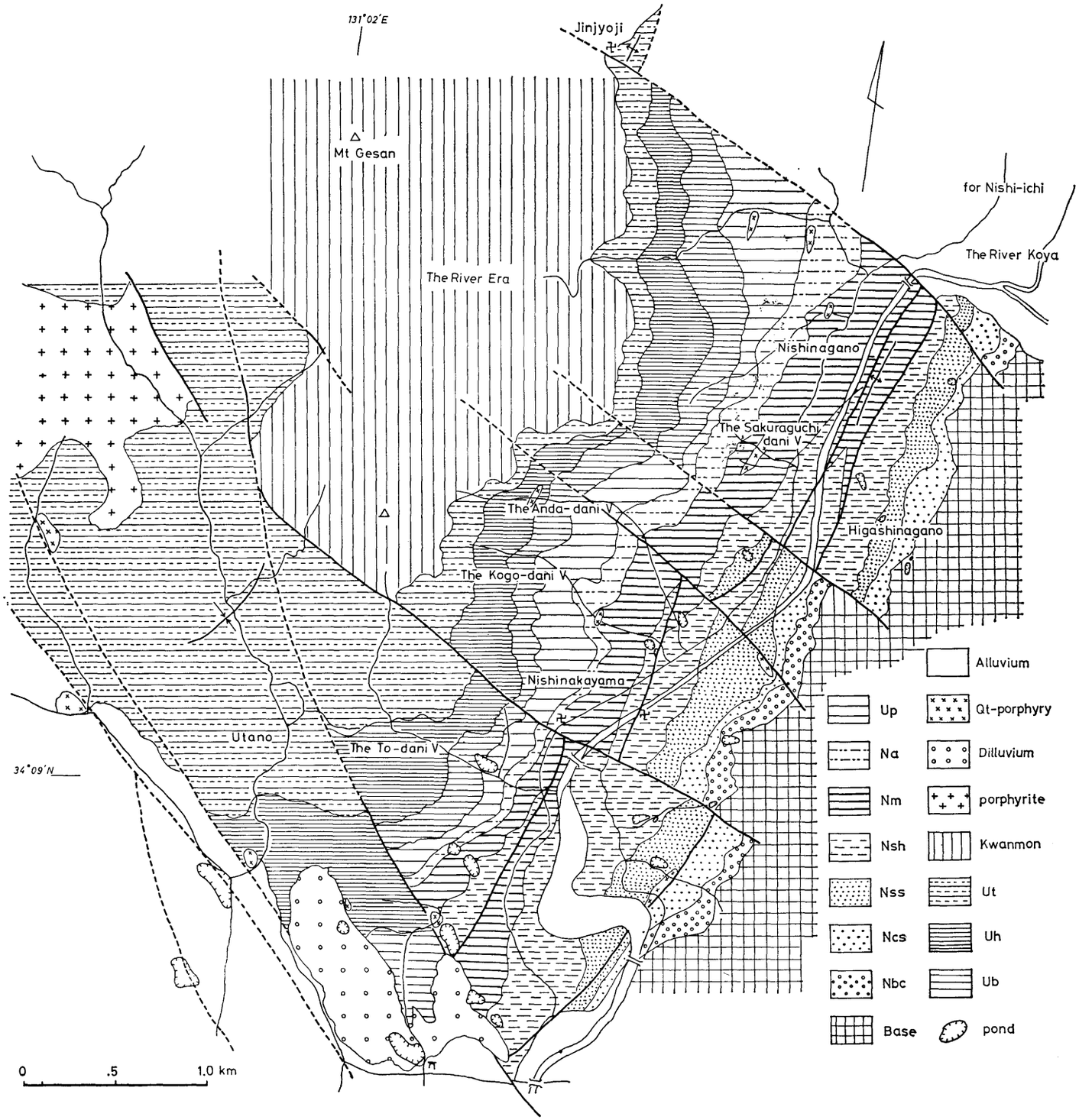



Fig. 2. Geological map of the northern part of the Toyora Group.

The basic field work was undertaken during the period from 1965 to 1968 under the supervision of Professor Tokio SHIKAMA of the Yokohama National University, whom I sincerely acknowledge. The field work has been continued since 1970, when I came to Kyushu University.

In addition to the ammonite specimens which I collected, those collected by a number of geologists, especially by the late Mr. Akira ONO and Mr. Masataka ITO, as students of the Kyushu University, are important material on which this study is based. I very much appreciate their laborious works.

I made use of type-specimens preserved in the University of Tokyo, as well as references, with the permission of the director, to whom I express my gratitude.

Thanks are extended to Mr. Hajime ENDO, the director of the civil engineering office of the Toyota district, Mrs. Koyame ENDO of Nishinakayama and the NAGAHAMAS of Ishimachi for their kindness in taking trouble for accommodation and other affairs in the field work.

Miss Yuko WADA kindly assisted me in preparing the text-figures.

## II. Notes on Stratigraphy

### A. General

The Toyora Group is distributed in an area which is about 12 km northeast to southwest and 9 km from northwest to southeast. The area is divided into two parts, northern and southern, by a long fault of NW-SE direction, called the Tabe Fault (KOBAYASHI, 1936). The alluvial deposits are developed along the fault. The southern district is relatively displaced to southeast by the fault movement. The group of the southern district is in contact with late Mesozoic granitic rocks and therefore the rock is altered to hornfels around the granite. In the southern district some fossil plants are contained in the upper part of the group, but molluscan fossils are rare in comparison with that of the northern district. In this article the Toyora Group of the northern district is treated.

The group is about 1900 m in maximum thickness. It is composed of conglomerate, coarse sandstone, medium sandstone, sandy shale, platy clay shale, alternating shale and sandstone, sandy shale, shale with frequent intercalation of sandstone and alternating shale and sandstone in ascending order. It seems to form a sedimentary cycle. From the viewpoint of this sedimentary cycle, this group is divided into three formations, namely the Higashinagano Formation of the transgressive phase, the Nishinakayama Formation of the inundative phase and the Utano Formation of the regressive phase (MATSUMOTO, 1949). I acknowledge the previously determined division. The strata mostly show NE–SW strike and NW dip and are homoclinal except in the Utano-dani, where they form a synclinal structure.

Ammonoid fossils are very abundant in the Nishinakayama Formation, less abundant in the Utano Formation and rare in the Higashinagano Formation. Zonation of the group was attempted by MATSUMOTO & ONO (1947). Only the Nishinakayama Formation is competent for reliable zoning and the Utano

Formation is difficult for precise zoning because of less abundance of fossils. The succession of ammonoid fossils in the Nishinakayama Formation is well exposed along a small stream, Sakuraguchi-dani, where the framework of zoning is established, the zonation of the Nishinakayama Formation by MATSUMOTO & ONO (1947) in the northern part is acknowledged also by me. Namely three zones are recognized, and representative species are the same as noted by MATSUMOTO & ONO (1947), although the letter nomination is replaced by the specific nomination in this paper. The age of the formation in the southern part is more or less revised, because new fossil evidence has been obtained.

## B. The Higashinagano Formation

This is the lower part of the group, consisting of conglomerate, coarse sandstone, fine sandstone and sandy shale in ascending order. Shallow-sea bivalves and corals are contained in certain layers. This formation is considered to represent a transgressive phase. It is about 400 m in average thickness. Its sequence is best observable in the Chuzankei ravine at Higashinakayama rather than at Higashinagano. This formation is divided lithostratigraphically into the following four members.

Nbc: The basal member which overlies the Sangun Metamorphic rocks with non-conformity. It is about 40 m in thickness, of which the lower part contains cobbles of phyllites and pebbles of chert and the upper part is rich in chert pebbles. Its matrix is fine sandstone. Fossils are very poor.

Ncs[=Ncs, Nbs of MATSUMOTO & ONO, 1947]: Compact, medium to coarse sandstone beds which overlie as a rule the Member Nbc. The average thickness is about 50 m. The sandstone is quartz arenite. At Higashinagano this member oversteps on to the black quartz schist of the Sangun Metamorphics.

Nss: Well bedded, medium to fine sandstone beds, with intercalated coaly seams; about 50 to 70 m thick.

Nsh: Sandy shale, bedded in the order of 30 cm or so; about 200 m thick. The boundary between this member and the Nishinakayama Formation is defined at the top of alternating siliceous fine sandstone and silty shale of about 10 m thickness. In the neighbourhood of Nishinakayama such an alternation is not discerned and a few sandstone beds, each of which is about 20 cm thick, are distributed.

## C. The Nishinakayama Formation

The middle part of the group is primarily composed of clay shale, with alternating shale and sandstone in the upper part. It is rich in ammonoids and regarded as representing an inundative phase. It is about 250 m in thickness and is best exposed along the route of Sakuraguchi-dani. Shale is everywhere black at fresh outcrop, fairly platy or paper-like in the lower part. Pyrite grains and natural gypsum are sporadically contained. On the basis of these facts the sedimentary condition of the Nishinakayama age is interpreted to have been tranquil as MATSUMOTO (1949) noted and the bottom of the bay may have been stagnant (SHIKAMA & HIRANO, 1970).

Nm[=Ne, Ng and Nd of MATSUMOTO & ONO, 1947]: The lower and middle parts of the formation, composed of black shale, are here named the Member Nm. It is 125 to 150 m in thickness with the following lithostratigraphical sequence.

The lower 25 to 50 m is well stratified in 1 cm order and paper-like platy clay shale.

The middle 50 m is well bedded in 20 cm order and fissile silty shale. Clay shale are common.

The upper 50 m also is well bedded in 30 cm order and fissile silty shale.

Na: The upper part of the formation is alternating beds of silty shale and grey medium to fine sandstone and about 100 m in average thickness. It is overlain by the Utano Formation.

## D. The Utano Formation

The upper part of the group is composed of silty shale, sandy shale and alternating beds of shale and sandstone. Ammonoids, belemnites, inocerami etc. are contained in some parts and plants in others. The formation seems to represent the regressive phase. It is about 400 m thick in the eastern area, and about 1100 m at the maximum in the Utano-dani. It is unconformably overlain by the non-marine Kwanmon Group. This formation is lithostratigraphically divided into four members as follows.

Up: The black, massive sandy shale, sometimes with thin intercalates of sandstone. This member, about 120 m thick, overlies the Nishinakayama Formation with conformity.

Ub: The black sandy shale, which is mostly massive but partly well bedded and fissile, with frequent thin sandstone beds in 10 cm order. About 90 m in average thickness.

Uh: The black and compact, massive silty shale; about 180 m in average thickness is named the Member Uh. Calcareous nodules of 10 cm or so in diameter are sporadically contained.

Ut[=Ua and Ut of MATSUMOTO & ONO, 1947]: The uppermost part of the Utano Formation is composed of black sandy shale and alternating sandstone and shale, which is named the Member Ut. The sandstone is compact, bluish grey and fine-grained. The shale is black and silty clay. Alternating beds are especially well exposed in the Utano-dani. This member is about 120 m thick in the eastern area and 650 m thick in the Utano-dani. Sandstone cobble conglomerate occurs in the upper part of this member exposed in a tributary of the River Utano. The north wing of this member in the Utano-dani is intruded by the porphyrite mass, and its western end is cut by the Tabe Fault. This member is overlain by the Kwanmon Group (Wakino Subgroup) with angular unconformity, and the basal conglomerate is characterized by cobbles of limestone, chert, black shale and sandstone.

*Locality record.*—The fossil localities are indicated by numbers and their general geographic positions are shown in Fig. 3. The fossil localities of Higashinagano and the Sakuraguchi-dani are especially shown by more detailed

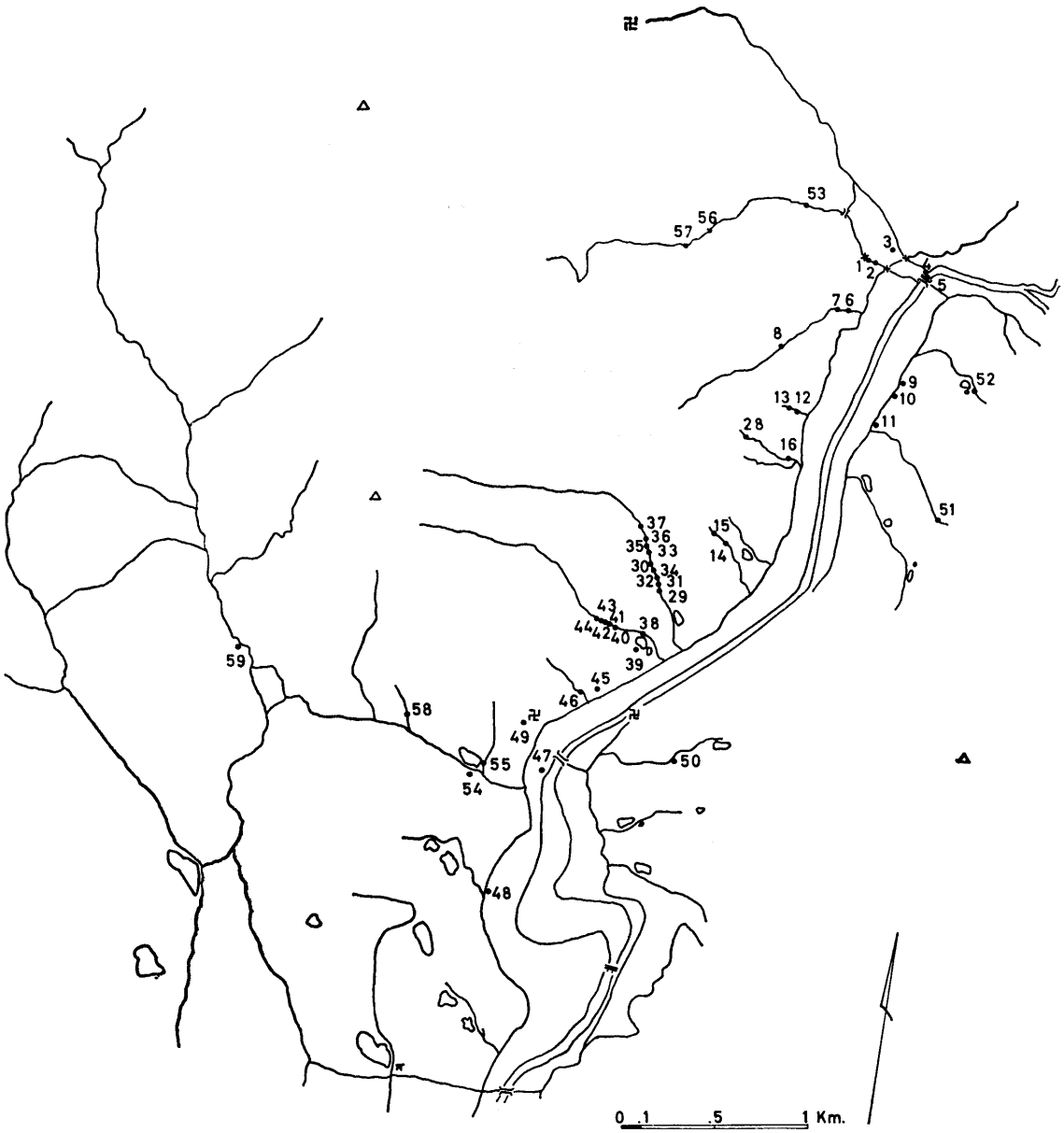



Fig. 3. Map showing the fossil localities.

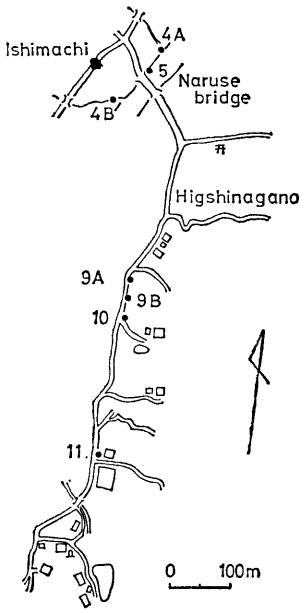



Fig. 4. Map showing the fossil localities in Higashi-nagano.

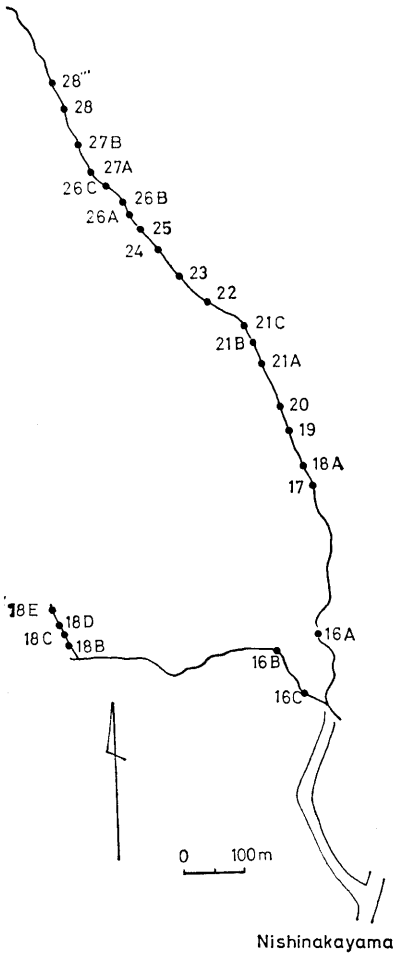



Fig. 5. Map showing the fossil localities in the Sakuraguchi-dani.

maps in Figs. 4–5. The numbers in the locality maps of Figs. 3–5 correspond to those in *Occurrence* of palaeontological descriptions. The stratigraphic guide of each fossil locality and the stratigraphic column of each formation will be shown in the last part of this serial work. As the geological map of the studied area is shown in Fig. 2 of the present article, the stratigraphic position of each locality can be understood by comparing the locality maps (Figs. 3–5) with the geological map (Fig. 2).

## III. Palaeontography

### Explanation of abbreviation

*For Measurements*:

D: The maximum diameter of the specimen, in mm.
U: The maximum diameter of the umbilicus, in mm.
H: The maximum height of the last whorl, in mm.
The standard lines of the measurements of D, U and H are the same.
B: The maximum breadth of the whorl, in mm.
Rn: The number of ribs in the last whorl.
Rn$\frac{1}{2}$: The number of ribs in half the last whorl.
Rn2: The number of ribs in the second whorl from the last.
Rn-20: The number of ribs in half a whorl at the diameter 20 mm.
Rn(20): The number of ribs in a whorl at the diameter 20 mm.

*For Statistics*:

N: Number of specimens in a sample.
$\bar{x}$: Mean value in statistical sense.
s: Standard deviation in statistical sense.
$V$: Coefficient of variation in statistical sense.
Oi: Observed value in statistical sense.
Ei: Expected value in statistical sense.
$\chi^2$: A measure to show the degree of coincidence between observed value and expected value.
$\nu$: Degrees of freedom for statistical test.
P: Probability in statistical sense.

*For Repositories*:

GK.: The head letters mean that the specimen is stored in the Type-specimens Room, Kyushu University. The numbers of 2000 level mean that the specimen was collected mainly by MATSUMOTO & ONO and partly by the students of the Department of Geology, Faculty of Science, Kyushu University. The numbers of 10000 level mean that the specimen was collected by Masataka ITO, MATSUMOTO & FUJII or me as members of Kyushu University.
GYU.: The head letters mean that the specimen was collected by me and is stored in the Type-specimens Room of the Yokohama National University.
MM.: The head letters mean that the specimen was described by YOKOYAMA (1904) and is stored in the University Museum of the University of Tokyo.

Suborder Ammonitina HYATT, 1889
Superfamily Eoderocerataceae SPATH, 1929
Family Amaltheidae HYATT, 1867
Genus *Amaltheus* DE MONTFORT, 1808
*Type-species.*—*Amaltheus margaritatus* DE MONTFORT, 1808, by monotypy.

*Amaltheus* sp. cf. *A. stokesi* (SOWERBY)
Pl. 17, Figs. 11a–b

*Material.*—Only a single fragmentary specimen, GK. G. 11293 (Coll. MATSUMOTO & FUJII).

*Description.*—The whorl enlarges rapidly and the umbilicus is narrow. It is compressed, with a fastigate venter, flat flanks and low and steep umbilical walls. The angle between the crenulation and the rib to which it is connected is up to 25° at the maximum. Each serration of the crenulated keel is as large as a grain of rice and the top is inclined adorally and the base adapically. Ribs start near the umbilical shoulder, and no ornaments exist on the umbilical wall. The ribs are somewhat strong on the inner two-thirds of the flanks, where they are approximately straight or slightly flexuous and radial. Toward the venter the ribs become weak. They are arcuate and projected on the outer one-third of the flanks and fade away at the base of the crenulated keel. Sometimes ribs are bifurcated at the point where they begin to draw arcs. The crenulations on the keel are more numerous than the ribs. The ribs are wider than their interspaces.

*Measurements.*—

Height of the whorl of the preserved last stage: 15.6 (17.1*) * inclusive of keel.

Height of the whorl of the younger stage 150° before the preserved last stage: 13.4 (15.1*)

Number of ribs within the whorl of 150°: 16

*Comparison.*—The present species is very similar to *Amaltheus stokesi* (SOWERBY) (HOWARTH, 1958, pp. 3–6; FREBOLD, 1964b, pp. 9–10; 1967, pp. 14–15) in the mode of crenulated keel and ribs. The latter, however, has commonly clearer ribs on the outer part of the flanks than the former. The rib-density of the present specimen may be included in the range of variation of the British specimens of *A. stokesi* (HOWARTH, 1958, p. 3, text-fig. 4). As concerns the ratio of the whorl height to the umbilical width, the assumed value of the present specimen does not conflict to the range of the value of *A. stokesi* indicated by HOWARTH (1958, p. 4, text-fig. 5).

The present species is somewhat similar to *Amaltheus* sp. cf. *A. margaritatus* (MONTFORT) (IMLAY, 1955, p. 87) but distinguished by its coarser ribs.

The present species is distinct from *A. margaritatus* (MONTFORT) (HOWARTH, 1958, pp. 13–17; WRIGHT, 1882, pp. 397–400), because it has no tubercles and no spiral striae.

*Amaltheus* sp. (SATO, 1955, pp. 114–117) from the Kuruma Group in Central

Japan is the only species of this genus ever known in Japan. The present species differs from the Kuruma species in the denser ribs, more clearly crenulated keel and larger angle between the crenulation and the ribs to which it is connected. Furthermore, the Kuruma species has some faint finer ribs between the primary ribs, but the present species does not show such a character.

As mentioned above the present species is more similar to *A. stokesi* than to any other species, although there are some minor differences. Unfortunately only one fragmentary specimen is at hand and therefore I treat the present species provisionally as *Amaltheus* sp. cf. *A. stokesi* (SOWERBY).

*Occurrence.*—Loc. 50: 1 specimen.

Family Dactylioceratidae HYATT, 1867

Genus *Dactylioceras* HYATT, 1867

*Type-species.*—*Ammonites communis* SOWERBY, 1815 (subsequent designation pending in I. C. Z. N.).

Subgenus *Prodactylioceras* SPATH, 1923

*Type-species.*—*Ammonites davoei* SOWERBY, 1822 (designated by SPATH, 1923, p. 10).

*Remarks.*—*Prodactylioceras* was proposed by SPATH (1923, p. 10), who divided *Coeloceras* into two genera. One is *Coeloceras* which is restricted to *Ammonites pettos*-group and the other is *Prodactylioceras* to which *Ammonites davoei* was assigned. Consequently the genus *Prodactylioceras* is of Carixian. ARKELL (1957, p. L 252) followed SPATH. Neither *Prodactylioceras* nor *Dactylioceras* was known from Domerian at that time.

Recently IMLAY (1968, pp. C 28–30) has discovered Domerian species of dactylioceratid. I also discovered a Domerian species of dactylioceratid, which shows characteristic of *Prodactylioceras* and *Dactylioceras*. As regards a taxonomic problem between *Prodactylioceras* and *Dactylioceras*, IMLAY (1968) has noted that the earliest species of *Dactylioceras* (e. g., *D.* cf. *verme*) in the Spinatum and the Tenuicostatum Zone are much more finely and densely ribbed than later species and are not very different from some species of *Prodactylioceras* (e.g., *P. rectiradiatum, P. davoei*). Furthermore he says that it seems probable that *Dactylioceras* arose from *Prodactylioceras* and that some species (e.g., *D.* cf. *tenuicostatum, D.* cf. *verme, P.* cf. *meneghinii*) show characteristics of both genera. These facts observed by IMLAY and acknowledged by me indicate that *Prodactylioceras* shows a serial change to *Dactylioceras*. Today dactylioceratid is known in various ages from Pliensbachian to Toarcian.

On the basis of these facts I think it preferable to rank *Prodactylioceras* as a subgenus of *Dactylioceras* rather than to a generic category. *Prodactylioceras* is a subgenus which includes the early group(s) (mainly Carixian and Domerian in age) of species of *Dactylioceras*. IMLAY (1968) described the difference between *Prodactylioceras* and *Dactylioceras*, which I acknowledge, though more detailed study may be necessary.

The diagnosis of the subgenus *Prodactylioceras* is defined as follow: A subgenus of *Dactylioceras* which has evolute and compressed whorls. Ribs are fine, numerous inclined forward and not so much forked.

*Dactylioceras* (*Prodactylioceras*) sp. aff. *D.* (*P.*) *italicum* (MENEGHINI)
Pl. 14, Fig. 11

Aff. 1900. *Coeloceras italicum* MENEGHINI; FUCINI, *Palaeontogr. Italica*, vol. 6, pp. 72–73, pl. 8, fig. 4.
Aff. 1905. *Coeloceras italicum* MENEGHINI; FUCINI, *ibid.*, vol. 11, pp. 115–116, pl. 6, figs. 11–14.
Aff. 1934. *Coeloceras italicum* FUCINI; MONESTIER, *Mém. Soc. Géol. France*, no. 23, p. 96, pl. 6, figs. 32–35.

*Material.*—One secondarily compressed specimen, GK. G. 11329.

*Description.*—The whorl enlarges slowly and consequently the umbilicus is proportionally wide. The venter and the umbilical periphery are rounded and the whorl section is assumed to be elliptical. The ribs spring on the umbilical seam and run radially. They are very fine and widely interspaced. An intercalatory rib occurs regularly at every longer rib on the ventrolateral part. But on one-fourth of the last whorl, the ribs are irregularly disposed, namely, the intercalatory ribs are not distributed and some ribs inclined adapically. A few secondary ribs are branched at the middle of the flank or at the ventrolateral part but are restricted only to the outer whorl. On the inner whorl the ribs are radial and straight, but the existence of the intercalatory ribs are not confirmable because of the unfavourable preservation.

*Measurements.*—

| No. | D | U | U/D | Rn-20 |
|---|---|---|---|---|
| GK. G. 11329 | 28.0 | 13.0 | 0.46 | 27 |

*Comparison.*—The present species is more or less similar to *D. helianthoides* in the mode and the number of ribs and volution. Especially, the number of ribs falls within the range of the variation of that of *D. helianthoides*. Because of the small difference between the present species and *D. helianthoides* I assume that the species is closely allied to later *D. helianthoides* in the lineage, though the former differs from the latter in the fineness and the inclination of ribs and longer secondary ribs.

The present species is similar to *Dactylioceras* (*Prodactylioceras*) *italicum* (MENEGHINI) (FUCINI, 1900, pp. 72–73; 1905, pp. 115–116; MONESTIER, 1934, p. 96) in the volution, the mode of ribs and the number of primary ribs, but is distinguished in that the latter has stronger ribs on the inner whorls and more numerous intercalatory ribs.

As regards the fineness of ribs and the volution the present species is similar to *D.* (*P.*) cf. *italicum* from eastern Oregon (IMLAY, 1968, pp. C 28–29), but is easily distinguished by its less numerous ribs and the abundance of intercalatory ribs.

The present species is somewhat similar to *Dactylioceras* (*Prodactylioceras*) *meneghinii* (FUCINI) (MONESTIER, 1934, pp. 92–93) in the widely spaced ribs,

but is distinguished by the rarity of bifurcation and the regular strength of ribs.

*Occurrence.*—Loc. 39: 1 specimen.

Subgenus *Dactylioceras* HYATT, 1867

*Dactylioceras* (*Dactylioceras*) *helianthoides* YOKOYAMA

Pl. 14 Figs. 1–10

1904. *Dactylioceras helianthoides* YOKOYAMA; YOKOYAMA, *Jour. Coll. Sci., Imp. Univ. Tokyo*, vol. 19, art. 20, pp. 16–17, pl. 4, figs. 4–6.
1947. *Dactylioceras helianthoides* YOKOYAMA normal forms MATSUMOTO; MATSUMOTO *in* MATSUMOTO & ONO, *Sci. Rep. Fac. Sci., Kyushu Univ., Geol.*, vol. 2, no. 1, p. 25.
1947. *Dactylioceras helianthoides* YOKOYAMA var. *tenuicostatus* MATSUMOTO; MATSUMOTO *in* MATSUMOTO & ONO, *loc. cit.*
1947. *Dactylioceras helianthoides* YOKOYAMA var. *paucicostatus* MATSUMOTO; MATSUMOTO *in* MATSUMOTO & ONO, *op. cit.*, p. 26.
1947. *Dactylioceras helianthoides* YOKOYAMA var. *tuberculatus* MATSUMOTO; MATSUMOTO *in* MATSUMOTO & ONO, *op. cit.*, p. 26, pl. 2, fig. 10.
1956. *Dactylioceras helianthoides* YOKOYAMA; ARKELL, Jurassic Geology of the World, Oliver & Boyd Ltd., pp. 421–422.
1962. *Dactylioceras helianthoides* YOKOYAMA; SATO, *Mém. Soc. Géol. France*, no. 94, p. 58.
1962. *Dactylioceras helianthoides* YOKOYAMA var. *tenuicostata* MATSUMOTO; SATO, *loc. cit.*
1962. *Dactylioceras helianthoides* YOKOYAMA var. *paucicostata* MATSUMOTO; SATO, *loc. cit.*
1962. *Dactylioceras helianthoides* YOKOYAMA var. *tuberculata* MATSUMOTO; SATO, *loc. cit.*
1963. *Dactylioceras helianthoides* YOKOYAMA; TAKAI, MATSUMOTO and TORIYAMA ed., Geology of Japan, Univ. Tokyo Press, p. 83.
1964. *Dactylioceras* sp.; FREBOLD, *Geol. Surv. Canada, Bull.* 116, p. 11, pl. 5, figs. 7–8.

*Types.*—Here one of the illustrated specimens of YOKOYAMA (1904, pl. 4, fig. 6) is designated as the lectotype, MM. 7073, and the other illustrated ones (1904, pl. 4, figs. 4–5) as the paralectotypes, MM. 7074, 7075. The lectotype and a paralectotype, MM. 7075, were collected from Nishinakayama (perhaps loc. 47) and the other, MM. 7074, was from either Nishinakayama or Ishimachi according to the original description.

*Material.*—Sixtyeight specimens (in addition to the types, GYU. M. 1069–70, GK. G. 2010, 2091, 2093, 2096, 2108, 2114, 2115, 2117, 2120, 2130–2132, 2135–2138, 2145–2148, 2150–2151, 2153–2154, 2156, 2158, 2165, 2167–2168, 2194, 11328, 11330, 11381–11411).

*Diagnosis.*—A species of *Dactylioceras* (s. str.) which has fine, radial and numerous ribs. It has commonly intercalatory and secondary ribs and also sometimes tubercles. There is a wide extent of variation in the ornamentation, as described below.

*Description.*—The whorls enlarge slowly, consequently the umbilicus is proportionally wide. The flank is convexly rounded, and the venter and the umbilical periphery are not angular. Therefore the whorl section is assumed to be elliptical. Ribs are nearly radial, straight and fine. The primary ribs

spring on the umbilical seam and run to the venter. The details of the ribs on the venter is hardly observable on account of the unfavourable preservation.

About half of the examined specimens have a row of tubercles usually at the ventrolateral shoulder, where secondary ribs spring, or at a point of outer one-third of the primary ribs. The intercalatory ribs are observed in more than 80 per cent of the examined specimens. They usually occur on the venter or the ventrolateral part of the shell. No more than two intercalatory ribs are present between two adjacent primary ribs. In more than 65 per cent of the examined specimens secondary ribs are perceptible. Usually the secondary ribs spring on the ventrolateral part of the shell and in a few specimens the secondary ribs spring on the outer one third of the primary ribs. As far as the examinable specimens are concerned no eminent ontogenetic change of these ornaments is perceptible.

*Measurements.*—

| No. | D | U | U/D | Rn-20 | Rn-30 | Rn-40 | Rn½ |
|---|---|---|---|---|---|---|---|
| MM. 7073 | 70.8 | / | / | / | / | / | 44+ |
| MM. 7074 | 62.9 | 30.4 | 0.48 | 24 | 29 | 35 | 50 |
| MM. 7075 | 48.5+ | 27.0 | 0.56− | 21 | 26 | 26 | 35 |
| GK. G. 2010 | 45.4 | 21.2 | 0.47 | 41 | 42 | 43 | 46 |
| GK. G. 11330 | 34.3 | 16.4 | 0.48 | / | 24 | / | 28 |
| GK. G. 2114 | 26.9 | 13.4 | 0.50 | 30 | / | / | 45 |
| GK. G. 2136 | 21.2 | 10.2 | 0.48 | 25 | / | / | 28 |
| GK. G. 2115 | 19.2 | 10.3 | 0.54 | 42 | / | / | 42 |

*Statistics.*—Concerning the number of primary ribs, twelve specimens are available from the *Protogrammoceras nipponicum* Zone for counting the ribs per half a whorl at the diameter of 20 mm. Similarly from the *Dactylioceras helianthoides* Zone thirtythree specimens are available. Here the assumption is made that both two samples are collected by random sampling from each fossil population with normal distributions of the characters.

The results of the chi-square test are as follows; The histogram of the number of ribs per half a whorl at the diameter of 20 mm.
Sample from the *Protogrammoceras nipponicum* Zone (Table 2, Fig. 6).
$N=12$, $\bar{x}=26.58$, $s=6.19$, $V=23.30$, $\chi^2=0.496$, $\chi^2_{0.05(\nu=1)}=3.841$, $P\gg0.05$
Not significant.
Sample from the *Dactylioceras helianthoides* Zone (Table 1, Fig. 6)
$N=33$, $\bar{x}=26.03$, $s=5.15$, $V=19.80$, $\chi^2=1.95$, $\chi^2_{0.05(\nu=2)}=5.99$, $P\gg0.05$
Not significant

Both two histograms seem to be unimodal. On the basis of these examination it can be statistically said that two samples are collected respectively from a simple population.

*Remarks.*—Previously MATSUMOTO (in MATSUMOTO & ONO, 1947) described a typical form and three varieties under the specific name of *Dactylioceras helianthoides*, and the variation was manifested in the ornamentation of the shell. At the same time he described some intermediate specimens among the typical form and three varieties and regarded them as one and the same species. The mode and

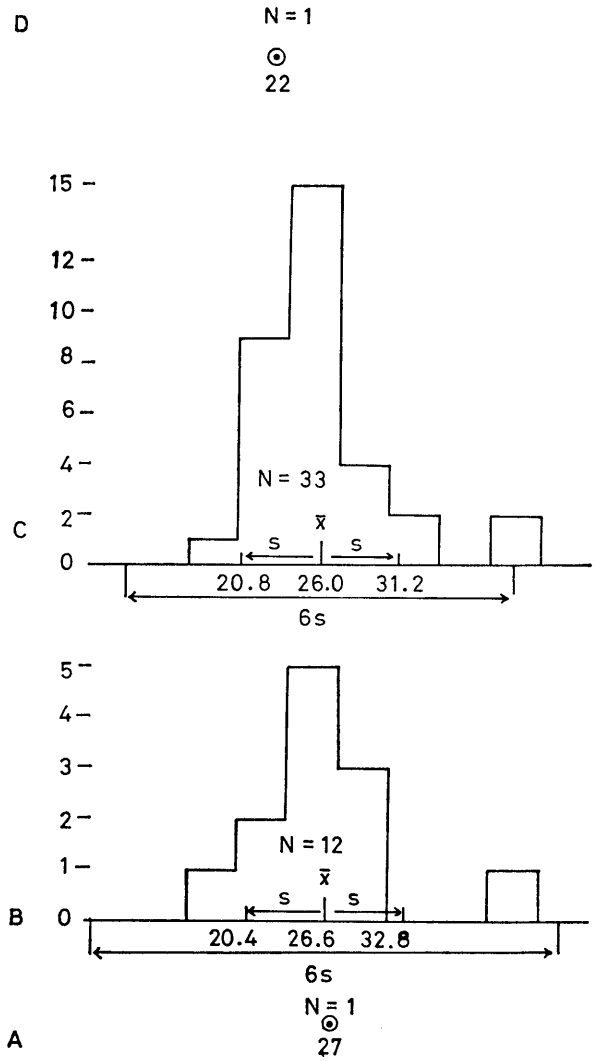



Fig. 6. The histograms of the number of ribs per half a whorl at the diameter of 20 mm. A: Sample of *D.* (*P.*) aff. *italicum* (MENEGHINI) from the *Fontanelliceras fontanellense* Zone (Ne). B: Sample from the *Protogrammoceras nipponicum* Zone (Ng). C: Sample from the *Dactylioceras helanthoides* Zone (Nd). D: Sample from Member Na. The vertical change of the number of ribs is not statistically discerned, though the mean seems to decrease slightly with time. B-D are samples of *D.* (*D.*) *helianthoides*.

the number of tubercles, intercalatory and secondary ribs are serial. Therefore it is concluded that there is no ground to divide the examined specimens into more than two species by the number and the mode of ribs, tubercles, intercalatory and secondary ribs.

*Comparison.*—The present species is allied to *Dactylioceras crassiusculosum* (SIMPSON) (MONESTIER, 1931, pp. 63–64), from south France, in the mode

Table 1. The number of ribs per half a whorl at the diameter of 20 mm. Data classified for chi-square test.
Sample from *Dactylioceras helianthoides* Zone.

| Class | Oi | Ei |
|---|---|---|
| 16.5~20.5 | 2 | 3.63 |
| 20.5~24.5 | 10 | 7.91 |
| 24.5~28.5 | 13 | 9.98 |
| 28.5~32.5 | 4 | 6.99 |
| 32.5~36.5 | 2 | 2.73 |
| 36.5~40.5 | 1 } 4 | 0.62 } 3.43 |
| 40.5~44.5 | 1 | 0.08 |
| Total | 33 | 31.93 |

Table 2. The number of ribs per half a whorl at the diameter of 20 mm. Data classified for chi-square test.
Sample from *Protogammoceras nipponicum* Zone.

| Class | Oi | Ei |
|---|---|---|
| 15.5~21.5 | 2 | 2.03 |
| 21.5~27.5 | 6 | 4.24 |
| 27.5~33.5 | 3 | 3.71 |
| 33.5~39.5 | 0 } 1 | 1.36 } 1.57 |
| 39.5~45.5 | 1 | 0.21 |
| Total | 12 | 11.55 |

of volution, primary and secondary ribs. The former, however, differs from the latter in more numerous intercalatory ribs, higher and sharper ribs. It also seems that the ribs and the tubercles are numerous in the former than the latter, though the detailed variation of the latter is not clarified.

The present species is more or less similar to *Dactylioceras gracile* (SIMPSON) (MONESTIER, 1931, pp. 56–57), from south France, in the mode of ribs. The former, however, even in sparsely ribbed specimen, has much denser ribs than the latter. The intercalatory ribs are a little longer and the tubercles are more eminent in *D. helianthoides* than in *D. gracile*.

The present species is somewhat similar to *D.* cf. *acanthus* (BUCKMAN) (IMLAY, 1968, p. C 30), from eastern Oregon, but is distinguished by the less elevated and finer radial ribs. The ontogenetic change of the ribbing is less conspicuous in the present species than in *D.* cf. *acanthus*.

The present species is more or less similar to *D.* aff. *semicelatum* (SIMPSON) (FREBOLD, MOUNTJOY and TEMPELMAN-KLUIT, 1967, p. 17), from the Yukon territory, in the mode of ribs, but the former has finer and more strictly radial ribs and obvious tubercles.

Judging from the above comparison, the present species seems to be more closely allied to the Mediterranean and northwest American species than to the west European ones.

*Occurrence.*—The Sakuraguchi-dani: loc. 16: 1, loc. 17: 1, loc. 18E: 6, loc. 21: 8, loc. 22: 3, loc. 23: 1, loc. 24: 2, loc. 25: 2, loc. 26: 3, loc. 28: 4, loc. 28″: 3, loc. 28‴: 9, unknown: 8.

The Anda-dani: loc. 29: 1, loc. 30: 1, loc. 34: 8, loc. 35: 26, loc. 36: 6.

The Kogo-dani: loc. 40: 1, loc. 43: 6, loc. 44: 2, unknown: 2.

Other area: loc. 4: 9, loc. 5: 4, loc. 1: 2, loc. 2: 3, loc. 47: 7, loc. 49: 2, loc. 3: 15, loc. 8: 2, unknown loc. of Ishimachi: 3, loc. 13: 3, unknown loc. of Nishinakayama: 5.

Superfamily Hildocerataceae HYATT, 1867
Family Hildoceratidae HYATT, 1867
Subfamily Arieticeratinae HOWARTH, 1955
Genus *Arieticeras* SEGUENZA, 1885

*Type-species.*—*Ammonites algovianus* OPPEL, 1862.

*Arieticeras* sp. cf. *A. pseudocanavarii* MONESTIER
Pl. 19, Fig. 9

Cf. 1934. *Arieticeras pseudocanavarii* MONESTIER; MONESTIER, *Mém. Soc. Géol. France,* vol. 10, no. 23, pp. 65–66, pl. 10, figs. 18–26.

*Material.*—A single fragmentary specimen, GK. G. 11291.

*Description.*—The whorls enlarge moderately and consequently the umbilicus is moderate. The venter is unicarinate but the sulcus is not confirmed. The umbilical wall is low and steep. The ribs are slightly falcoidal, moderately wide and more or less widely interspaced. Sometimes two ribs are slightly in contact with each other at the umbilical shoulder. They spring at the umbilical wall and go on forward. At about inner one-third of the flank, they curve slightly backward and go on nearly straight. On or near the ventral shoulder, they curve forward and go on for a short distance, fading away before they reach the keel. On the ventral shoulder they are thick and on the inner one-third of the flank they are weak.

*Measurements.*—

| No. | D | U | H | $Rn\frac{1}{4}$ |
|---|---|---|---|---|
| GK. G. 11291 | / | 9.9 | 7.4 | 11 |

*Comparison.*—The present species is closely similar to and probably identical with *Arieticeras pseudocanavarii* MONESTIER (1934, pp. 65–66). In the mode of volution, ribs and slight fasciculation, the two species are indistinguishable. The described specimen, however, shows stronger curvature of the ribs at inner one-third of the flank than the specimens from Europe.

*Arieticeras disputabile* FUCINI (MONESTIER, 1934, p. 67) may be an allied species, but no fascicular ribs are visible on the whorl. In other characters the present species is hardly distinguishable from *A. disputabile* FUCINI.

Because only one fragmentary specimen is available at this time, the present species is named provisionally as *Arieticeras* sp. cf. *A. pseudocanavarii* MONESTIER.

*Occurrence.*—Loc. 39: 1 specimen.

### *Arieticeras* sp. aff. *A. apertum* MONESTIER
Pl. 17, Figs. 10a–b

Aff. 1934. *Arieticeras apertum* MONESTIER; MONESTIER, *Mém. Soc. Géol. France*, vol. 10, no. 23, pp. 50–51, pl. 10, figs. 21–23, 28–29, pl. 11, fig. 6.

*Material.*—Only a single fragmentary specimen, GK. G. 11292.

*Description.*—The whorls enlarge very slowly and consequently the umbilicus is wide. The whorl section is subquadrate to somewhat elliptical and the venter is unicarinate-bisulcate. The keel is thin and low, and the sulci are narrow and shallow. The flanks are moderately convex. The umbilical wall is low, steep and nearly vertical. The ribs are fine but somewhat elevated, slightly sigmoidal and moderately rursiradiate. They are simple and widely interspaced. They start on the umbilical seam and go on somewhat backward. On the middle of the flank they curve still more backward. Near the ventral shoulder they recurve moderately forward and go on for a short distance, fading away before they reach the sulcus. They keep the same strength from the umbilical wall to the ventral shoulder. On the inner whorls the ribs are clear, keeping the same characters as on the outer whorl.

*Measurements.*—Whorl height of the preserved last stage: 4.6* (* inter costae)

Whorl breadth of the preserved last stage: 3.4*

Approximate length of the radius at the last stage: 9.2

Whorl height of the younger stage, 170° before the preserved last stage: 3.8*

Number of ribs on the preserved last whorl (170°): 14

*Comparison.*—The present species is very similar to *Arieticeras apertum* MONESTIER (1934, pp. 50–51) in the mode of volution, whorl section and ribs. According to the original description, however, the shell surface of the latter is smooth before the diameter of 10 mm. On the other hand the former has clear ribs on the whorl before that diameter. By this difference the present species may be distinguished from *A. apertum*.

The present species is also similar to *Arieticeras macrum* MONESTIER (1934, pp. 52–53), especially in the mode of ribbing. According to the description (MONESTIER, *loc. cit.*), however, the whorl of *A. macrum* is smooth before the diameter of 9–12 mm. The whorl section in the present species is wider than in that species. The present species is distinguished from *A. macrum* by these differences.

*Occurrence.*—Loc. 50: 1 specimen.

### Genus *Canavaria* GEMMELLARO, 1886

*Type-species.*—*Harpoceras* (*Dumortieria*) *haugi* GEMMELLARO, 1885 (designated by HOWARTH, 1955, p. 167).

*Canavaria japonica* (MATSUMOTO)
Pl. 15, Figs. 1–6

1947. *Arieticeras* (?) *japonicum* MATSUMOTO; MATSUMOTO in MATSUMOTO & ONO, *Sci. Rep. Fac. Sci., Kyushu Univ., Geol.*, vol. 2, no. 1, p. 26, pl. 2, fig. 2.
1956. *Seguentia* sp. cf. *S. parodii* FUCINI; ARKELL, Jurassic Geology of the World, Oliver & Boyd Ltd., p. 421.
1962. *Seguentia* sp. cf. *S. parodii* FUCINI; SATO, *Mém. Soc. Géol. France*, no. 94, p. 59.
1963. *Seguentia* sp.; TAKAI, MATSUMOTO and TORIYAMA ed., Geology of Japan, Univ. Tokyo Press, p. 84.

*Types.*—Here one of the syntypes, GK. G. 2002 illustrated by MATSUMOTO (in MATSUMOTO & ONO, 1947, pl. 1, fig. 2) is designated as the lectotype, which was obtained at loc. 29.

*Material.*—Sixtythree specimens (GK. G. 2002, 2236–2240, 2242, 11041–11096) are examined.

*Diagnosis.*—A species of *Canavaria* with slightly falcoidal ribs, which are not twinned at the umbilical margin, unituberculated on the ventral shoulder and elevated on the umbilical shoulder, forming sometimes umbilical tubercles.

*Description.*—The whorls are evolute and do not enlarge so rapidly. The venter is carinate, but the keel is low and not stout. The umbilical wall is low and not steep. The ribs spring on the umbilical seam, run forward for one-fourth of the flank, curve backward on the remainder of the flank, and then recurve forward for a short distance, fading away as they approach the keel. They are fine and more or less widely interspaced. A small turbercle is situated at the bending point of every rib on the ventral shoulder. In some specimens there is sometimes another tubercle on the umbilical shoulder on some ribs. No specimen has striae. Almost all the specimens at hand are nearly equal in size, being about 25 to 30 mm in diameter, although it is not determined whether the size indicates the maturity or not.

*Measurements.*—

| No. | D | U | U/D | Rn |
|---|---|---|---|---|
| GK. G. 11061 | 28.0 | 12.7 | 0.45 | 39 |
| GK. G. 11041 | 30.5 | 15.4 | 0.51 | 39 |
| GK. G. 11043 | 27.4 | 12.7 | 0.46 | 43+ |
| GK. G. 11042 | 24.8 | 11.8 | 0.48 | 40+ |

*Comparison.*—The present species was listed by ARKELL (1956) as *Seguentia* sp. cf. *S. parodii* FUCINI, but it differs from *Canavaria parodii* in that its ribs are more flexuous, much finer and somewhat more widely interspaced than in *C. parodii* and distinct even on the umbilical wall and that the latter has no tubercles at the umbilical periphery.

The present species resembles *Canavaria scuderii* (FUCINI) (1931, p. 138) and *Canavaria gentile* (FUCINI) (1931, p. 141) but differs in its more flexuous ribs.

*Canavaria* sp. from the Kuruma Group, Central Japan (SATO, 1955, pp. 111–118), has little affinity with the present species except in the fineness of the ribs.

*Occurrence.*—Loc. 16A: 51, loc. 16B: 4, loc. 29: 8.

### *Canavaria* sp. cf. *C. sicula* FUCINI
Pl. 15, Fig. 7

Cf. 1931. *Canavaria sicula* FUCINI; FUCINI, *Palaeontogr. Italica,* vol. 31, pp. 133–134, pl.16, figs.4–8.

*Material.*—An internal mould of left side, GYU. M. 1005.

*Description.*—The whorls are evolute but rather rapidly enlarged. The venter has a keel which is not stout but probably no furrows. Simple ribs, springing from the umbilical wall, run on the flank with nearly constant strength up to the vicinity of the keel. They are nearly rectiradiate, only slightly flexuous, moderately strong and moderately interspaced on the outer whorl (more than 22 mm diameter), but more or less rursiradiate, slightly sinuous, and somewhat crowded on the inner whorls (less than 22 mm diameter). The ribs are weakly bituberculated, a row on the ventral shoulder and the other on the umbilical shoulder, but sometimes the latter may be undeveloped on some ribs.

*Measurements.*—

| No. | D | U | Rnl | Rn2 | U/D |
|---|---|---|---|---|---|
| GYU. M. 1005 | 33.6 | 13.9 | 36 | 31 | 0.41 |

*Comparison.*—The present species is comparable with *Canavaria sicula* FUCINI (*loc. cit.*) in the mode of volution and ribbing. In the latter the ribs are described as rursiradiate but seem to be nearly rectiradiate in the illustration. The ribs are slightly more flexuous and numerous in the present species than in that species, but these differences are slight.

The present species is somewhat similar to *Canavaria silvestri* FUCINI (1931, p. 133) but differs from the latter in the wider umbilicus.

*Occurrence.*—Loc. 48: 1 specimen.

## Genus *Fontanelliceras* FUCINI, 1931

*Type-species.*—*Harpoceras fontanellense* GEMMELLARO, 1885 (designated by VECCHIA, 1949).

### *Fontanelliceras fontanellense* (GEMMELLARO)
Pl. 16, Figs. 1–4

1885. *Harpoceras fontanellense* GEMMELLARO; GEMMELLARO, *Giorn. Sci. Nat. Econ. Palermo,* vol. 17, p. 12, pl. 2, figs. 1–2.
1900. *Harpoceras (Arieticeras) fontanellense* GEMMELLARO; BETTONI, *Schweiz. Palaeont. Gesel. Abh.*, vol. 27, pp. 58–59, pl. 5, figs. 10–12.
1913. *Arieticeras (Vermiceras) fontanellense* GEMMELLARO; HAAS, *Beitr. Palaeont. Öster. Ung. Orients,* vol. 26, p. 42, pl. 3, figs. 1–2.
1931. *Fontanelliceras fontanellense* GEMMELLARO; FUCINI, *Palaeontogr. Italica,* vol. 31, p. 110, pl. 8, figs. 21–26.
1934. *Arieticeras fontanellense* GEMMELLARO; MONESTIER, *Mém. Soc. Géol. France,* vol. 10, fasc. 3, no. 23, pp. 68–69, pl. 10, figs. 48–52, pl. 11, fig. 9.

1947. *Echioceras* sp. $\alpha$; MATSUMOTO *in* MATSUMOTO & ONO, *Sci. Rep. Fac. Sci., Kyushu Univ., Geol.*, vol. 2, no. 1, p. 26, pl. 1, fig. 1.
1947. *Echioceras* sp. $\beta$; MATSUMOTO *in* MATSUMOTO & ONO, ibid., vol. 2, no. 1, p. 26.
1956. *Fontanelliceras* sp. cf. *F. fontanellense* (GEMMELLARO); ARKELL, Jurassic Geology of the World, Oliver & Boyd Ltd., p. 421.
1962. *Fontanelliceras* sp. cf. *F. fontanellense* (GEMMELLARO); SATO, *Mém. Soc. Géol. France*, no. 94, p. 59.
1962. *Fontanelliceras* sp. $\beta$; SATO, *ibid.*, no. 94, p. 59.
1963. *Fontanelliceras* sp. cf. *F. fontanellense* (GEMMELLARO); TAKAI, MATSUMOTO and TORIYAMA ed., Geology of Japan, Univ. Tokyo Press, p. 84.

*Types.*—GEMMELLARO (1885) established this species on two illustrated syntypes from Taormina of Sicily. As I have no access to the original specimens, I refrain from designating the lectotype.

*Material.*—Sixtysix specimens (GYU. M. 1004 & 1006, GK. G. 2001, 2202–2218, 2220–2223, 2225, 2227–2230, 11001–11037).

*Diagnosis.*—Though I have had no opportunity of examining the types and other European specimens, the descriptions in principal papers may allow me to define the specific diagnosis as follows: A species of *Fontanelliceras* with nearly quadrate whorl section and rectiradiate, sometimes very slightly arcuate, distant, simple and rather robust ribs. The density of ribs in the various ontogenetic stages has not been clearly described. I show below the data in the two defined stages based on the Toyora collection.

*Description.*—The whorls are evolute, enlarging very slowly. The venter is tricarinate-bisulcate. The umbilical wall is not steep. All the ribs are simple, rather robust, straight, radial and widely interspaced. They spring from the umbilical seam and abruptly fade away on the ventral shoulder. Sometimes the ribs are accompanied by striae on the last whorl. The number of ribs per whorl increases very slowly as shown below.

*Measurements.*—

| No. | D | U | H | Rnl | Rn2 | U/D | H/D |
|---|---|---|---|---|---|---|---|
| GK. G. 11002 | 14.5 | 7.9 | 4.2 | 27 | 25 | 0.55 | 0.29 |
| GK. G. 2001 | 21.1 | 11.0 | 5.1 | 24 | 22 | 0.52 | 0.24 |
| GK. G. 11001 | 21.9 | 12.2 | 5.8 | 26 | 24 | 0.56 | 0.27 |
| GYU. M. 1004 | 25.4 | 13.5 | 6.9 | 23 | 22 | 0.53 | 0.29 |

*Statistics.*—In this study twentytwo specimens are available for counting the ribs per whorl at the diameter of 10 mm and/or 20 mm. Here the assumption is made that the sample is collected by random sampling from one fossil population with the normal distribution of the character.

The results of the chi-square test are as follows: The histogram of the number of ribs per whorl at the diameter of 10 mm (Fig. 3-A).
$N=22$, $\bar{x}=25.7$, $s=3.5$, $\chi^2=3.45$, $\chi^2_{0.05(\nu=2)}=5.99$, $P \gg 0.05$
The histogram of the number of ribs per whorl at the diameter of 20 mm (Fig. 3-B).
$N=11$, $\bar{x}=26.1$, $s=2.3$, $\chi^2=1.27$, $\chi^2_{0.05(\nu=1)}=3.84$, $P \gg 0.05$

By the test as mentioned above no significant difference is found from

the normal distribution, and the histograms seem to be uni-modal.

*Remarks.*—Two forms were distinguished by MATSUMOTO (1947) as *Echioceras* sp. $\alpha$ and sp. $\beta$. The former was said to have more stout and more crowded ribs not only on the outer whorl but also on the inner whorls. The latter was said to have more or less fine and delicate ribs and on the inner whorls the ribs are more fragile than in the former. As a result of biometrical examination and observation, I confirm that this sample represents one and the same species.

The following minor differences discernible between the present and the previously described extra-Japanese specimens are regarded as variation within one and the same species.

The illustrated specimens from Taormina of Sicily (FUCINI, 1931, pp. 110–111, pl. 8, figs. 21–26) have somewhat more numerous and more robust ribs and have an apparently less stout keel than the present specimens.

According to HAAS (1913, p. 42, pl. 3, figs. 1–2), who referred the present species to *Arieticeras*, the ribs are slightly flexuous, but in the present specimens they are almost straight, although slightly flexuous ones are occasionally found

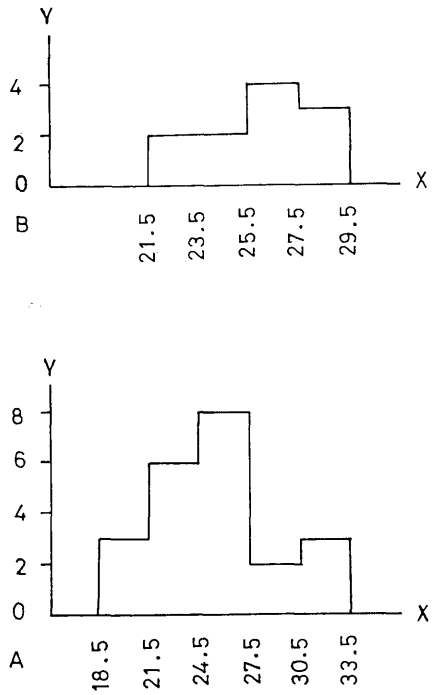



Fig. 7. Histogram of the number of ribs per whorl at defined diameter of *Fontanelliceras fontanellense* (GEMMELLARO). A: X-axis is the number of ribs per whorl of 10 mm diameter. Y-axis is the number of individuals. N=22, $\bar{x}$=25.70, $V$=13.54, s=3.48, $\chi^2$=3.45, $\chi^2_{0.05(\nu=2)}$=5.99, P$\gg$0.05, Not significant. B: X-axis is the number of ribs per whorl of 20 mm diameter. Y-axis is the number of individuals. N=11, $\bar{x}$=26.10, $V$=8.65, s=2.26, $\chi^2$=1.27, $\chi^2_{0.05(\nu=1)}$=3.84, P$\gg$0.05, Not significant.

in some specimens. In the general features HAAS's specimens from Ballino of South Tyrol most closely resemble those from Japan.

The specimens from Aveyron, South France, (MONESTIER, 1934, p. 68, pl. 10, figs. 48–52) have more rapidly enlarging whorls and consequently a narrower umbilicus than those from Toyora.

*Comparison.*—*Fontanelliceras retrorsicosta* (FUCINI, 1913, p. 60) shows rather rapid enlargement of whorls and rather narrowly spaced ribs than *F. fontanellense*.

*Fontanelliceras juliae* (FUCINI, 1931, p. 111) differs from the present species in its stouter and coarser ribs.

*Occurrence.*—Loc. 16A: 30, loc. 16B: 9, loc. 18: 3, loc. 29: 20, loc. 12: 3, loc. 13: 1 specimen.

Subfamily Harpoceratinae NEUMAYR, 1875

Genus *Paltarpites* BUCKMAN, 1922

*Type-species.*—*Paltarpites paltus* BUCKMAN, 1922.

*Paltarpites toyoranus* (MATSUMOTO)

Pl. 19, Figs. 1–5

1947. *Harpoceras* (s. l.) (*Nagatoceras*) *toyoranum* MATSUMOTO; MATSUMOTO *in* MATSUMOTO & ONO, *Sci. Rep. Fac. Sci., Kyushu Univ., Geol.*, vol. 2, no. 1, p. 28, pl. 1, fig. 6.

1947. *Harpoceras* (s. l.) (*Nagatoceras*) *toyoranum* MATSUMOTO var. *costata* MATSUMOTO; MATSUMOTO *in* MATSUMOTO & ONO, *op. cit.*, p. 28.

1956. *Paltarpites toyoranus* (MATSUMOTO); ARKELL, Jurassic Geology of the World, Oliver & Boyd Ltd., p. 421.

1962. *Paltarpites toyoranus* (MATSUMOTO); SATO, *Mém. Soc. Géol. France*, no. 94, p. 59.

1963. *Paltarpites toyoranus* (MATSUMOTO); TAKAI, MATSUMOTO and TORIYAMA ed., Geology of Japan, Univ. Tokyo Press, p. 84.

*Types.*—One of the thirtyeight syntypes, GK. G. 2006, is designated as the lectotype, which was obtained at loc. 12 and the remaining thirtyseven specimens (GK. G. 2234, 2252–2259, 2261–2264, 2266, 2268–2282, 2284–2287, 2290–2293) as the paralectotypes (see also p. 116).

*Material.*—The above mentioned thirtyeight specimens.

*Diagnosis.*—A species of *Paltarpites* which has somewhat strongly curved, wide and crowded ribs.

*Description.*—The whorls enlarge rapidly and somewhat involute. The venter seems to be unicarinate-tabulate. The umbilical wall is low and perpendicular or steep. In the small stage less than 22 mm diameter the ribs are not crowded and gently falcoidal, and their tops are not flattened. In this stage the umbilicus is very narrow and involute. In the comparatively larger stage more than 30 mm diameter the ribs are moderately or somewhat strongly falcoidal. The top of the rib is flattened or rounded. The interspace between the ribs is much narrower than the space of the ribs. All the ribs spring from the umbilical seam and go on forward. In the interval from inner one-third to a half of the flank, the

ribs curve backward, drawing an arc, and approach the ventral shoulder, where they project adorally. Generally the ribs become broader toward the ventral shoulder and fade away on the venter. On a fragment of a large specimen with whorl-height of 43 mm, the ribs are comparatively fine, numerous and strongly falcoidal.

*Measurements.*—

| No. | D | U | U/D | H | Rn½ |
|---|---|---|---|---|---|
| GK. G. 2006 | 60+ | ca. 23 | / | 17+ | 33 |
| GK. G. 2273 | 43.8 | 12.2 | 0.28 | 19.6 | 29 |
| GK. G. 2277 | 33.0 | 11.3 | 0.34 | 12.3 | 28 |

*Comparison.*—In comparison with *Paltarpites paltus* BUCKMAN, the present species has more strongly curved ribs, especially their bending is much stronger on the middle of the flank. The ribs project more strongly in *Paltarpites paltus* than in the present species.

In comparison with *Paltarpites argutus* (BUCKMAN) and *Paltarpites platypleurus* (BUCKMAN), the present species is likewise distinguishable by the more strongly curved ribs.

The variations in the mode of ribbing of *Paltarpites paltus* BUCKMAN, *P. argutus* (BUCKMAN) and *P. platypleurus* (BUCKMAN) have not yet been made clear, and only the illustration of the type specimens and brief reports of the occurrences were published. More detailed study of *Paltarpites* from Europe is desired for more precise comparison with the Japanese species.

*Occurrence.*—Loc. 18: 30, loc. 12: 7, loc. 12B: 1.

### *Paltarpites paltus* BUCKMAN

Pl. 19, Figs. 7–8

1922. *Paltarpites paltus* BUCKMAN; BUCKMAN, Type Ammonites, pls. 362a–b.
1934. *Polyplectus Kurrianus* OPPEL; MONESTIER, *Mém. Soc. Géol. France*, vol. 10, no. 23, pp. 90–92, pl. 5, fig. 23.
1957. *Paltarpites paltus* BUCKMAN; HOWARTH, *Q. J. G. S.*, London, vol. 113, p. 199.
1964. *Harpoceras* sp. cf. *H. exaratum* (YOUNG & BIRD); FREBOLD, *Geol. Surv. Canada, Bull.* 116, p. 16, pl. 6, figs. 1–5.
1970. *Paltarpites paltus* BUCKMAN; FREBOLD, *Can. Jour. E. Sci.*, vol. 7, no. 2, pp. 443–444.

*Type.*—*Paltarpites paltus* BUCKMAN, 1922, pl. 362a, is the holotype.

*Material.*—Two specimens, GYU. M. 1020 and 1021.

*Diagnosis.*—Although I have had no opportunities to observe foreign specimens, the description in the previously published papers may allow me to give the specific diagnosis of the present species as follows: A species of *Paltarpites* which has deep or moderate involution and wide and flat-topped ribs with variable space and interspace of ribs. The ribs are falcoidal but weakly biconcave, for the inner one-third of rib is weakly concave.

*Description.*—The whorls enlarge rapidly and the umbilicus is narrow. The

ventral margin is not preserved. The umbilical wall is low and steep. The ribs start on the umbilical seam and go on backward on the umbilical wall. At the umbilical periphery the ribs curve forward. At the middle of the flank they recurve backward, and then draw an arc, running forward near or on the ventral shoulder. They seem to project forward on the venter, although the ventral part is too poorly preserved to see the details. The ribs are wide and their tops are somewhat flat. The interspace of the ribs is very narrow. There are some lirae at the apertural end.

*Measurements.*—

| No. | D | U | H | U/D | H/D | Rn½ |
|---|---|---|---|---|---|---|
| GYU. M. 1020 | 31+ | 7.8 | 13.4 | 0.25+ | 0.43+ | 30 |

*Comparison.*—The present species is somewhat similar to *Paltarpites argutus* (BUCKMAN) in the weakly biconcave ribs. The ribs of the former are, however, more strongly projected on the venter than those of the latter. The former has in general a more strongly involute shell than the latter.

In comparison with *Paltarpites toyoranus* (MATSUMOTO) the present species has more weakly curved ribs.

*Occurrences.*—Loc. 16B: 2 specimens.

*Paltarpites* sp. aff. *P. platypleurus* (BUCKMAN)
Pl. 19, Fig. 6

Aff. 1927. *Platyharpites platypleurus* BUCKMAN; BUCKMAN, Type Ammonites, pl. 698.

1947. *Harpoceras* (s. l.) (*Nagatoceras*) *toyoranum* MATSUMOTO (pars); MATSUMOTO *in* MATSUMOTO & ONO, *Sci. Rep. Fac. Sci., Kyushu Univ., Geol.*, vol. 2, no. 1, p. 28.

1956. *Paltarpites* sp. cf. *P. paltus* BUCKMAN; ARKELL, Jurassic Geology of the World, Oliver & Boyd Ltd., p. 421.

1962. *Paltarpites* sp. cf. *P. paltus* BUCKMAN; SATO, *Mém. Soc. Géol. France*, no. 94, p. 59.

*Material.*—A single fragmentary specimen, GK. G. 2252.

*Description.*—The whorls enlarge rapidly, involute and the umbilicus is narrow. The venter is carinate-tabulate, and the keel is high. The umbilical wall is low and somewhat steep. The ribs start on the umbilical wall and go on forward. At about one-third of the flank the ribs curve backward moderately and near the ventral shoulder they recurve forward. They are projected on the venter. They are thus moderately curved. They are very wide, being the widest at the outer one-third of the flank, and their interspaces are very narrow.

*Measurements.*—Specimen No.: GK. G. 2252

The preserved outer whorl: 150°

Height of the whorl (highest value of the preserved whorl): 27.4

Number of ribs: 25

*Comparison.*—The present species is very similar to *Paltarpites playtpleurus* (BUCKMAN) in the density of ribs and the involute shell, but the curve of its rib is weaker. Likewise it is distinguished from *Paltarpites toyoranus* (MATSU-

MOTO) and *Paltarpites argutus* (BUCKMAN) by its weaker curve of the ribs.

At this time I can examine only one fragmentary specimen, which is provisionally referred to *Paltarpites* sp. aff. *P. platypleurus* (BUCKMAN). The present specimen should be re-examined, when more specimens are collected and more detailed study on the taxonomy of *Paltarpites* from Europe is published.

*Occurrence.*—Loc. 12: 1 specimen.

Genus *Lioceratoides* SPATH, 1919

*Type-species.*—*Lioceras*? *grecoi* FUCINI, 1900, p. 65 (designated by SPATH, 1919, p. 174).

*Lioceratoides yokoyamai* (MATSUMOTO)
Pl. 15, Figs. 9–10

1947. *Hildoceras* (*Brodeia*) *yokoyamai* MATSUMOTO; MATSUMOTO *in* MATSUMOTO & ONO, *Sci. Rep. Fac. Sci., Kyushu Univ., Geol.*, vol. 2, no. 1, p. 28, pl. 1, fig. 9.
1956. *Lioceratoides yokoyamai* (MATSUMOTO); ARKELL, Jurassic Geology of the World, Oliver & Boyd Ltd., p. 421.
1962. *Lioceratoides yokoyamai* (MATSUMOTO); SATO, *Mém. Soc. Géol. France*, no. 94, p. 59.
1963. *Lioceratoides yokoyamai* (MATSUMOTO); TAKAI, MATSUMOTO and TORIYAMA ed., Geology of Japan, Univ. Tokyo Press p. 83.

*Types.*—One of the syntypes, GK. G. 2009 (MATSUMOTO in MATSUMOTO & ONO, 1947, pl. 1, fig. 9) is designated here as the lectotype. It was obtained at loc. 13.

*Material.*—Twelve specimens (GK. G. 2009, 2691, 11271–11272, 11274–11280, GYU. M. 1007).

*Etymology.*—In commemoration of the late Professor Matajiro YOKOYAMA, the pioneer of palaeontology in Japan.

*Diagnosis.*—A species of *Lioceratoides* with alternating insertion of the ribs on the outer part of the flank and fasciculation of the ribs on the inner part of the flank.

*Description.*—The whorls enlarge moderately, embracing a fairly narrow umbilicus. The venter bears a more or less eminent keel and two sulci. The ribs are slightly prorsiradiate and falcoidal. The ribs are fasciculate or bifurcated at inner one-third of the flanks. Commonly insertion occurs between two sets of fasciculation or bifurcation. The inserted ribs fade out at the middle of the flank. The relief of the ribs is weak near the apertural part, perhaps indicating the anterior part of a living chamber.

*Measurements.*—

| No. | D | U | H | U/D |
|---|---|---|---|---|
| GK. G. 2009 | 14.1 | 37.0 | 14.5 | 0.38 |
| GK. G. 2691 | 8.6 | 32.0 | 13.4 | 0.27 |
| GYU. M. 1007 | 15.4 | 48.9 | 19.6 | 0.32 |

*Comparison.*—The present species is similar to *Lioceratoides aradasi*

(FUCINI) (1923, pp. 71–72) in the mode of insertion and bifurcation, but is distinguished by its wider umbilicus and prorsiradiate ribs.

The present species is similar to *Lioceratoides diodoroi* (FUCINI) (HAAS, 1913, p. 168; FUCINI, 1929–30, pp. 95–96) in having many insertion on the outer lateral part, but the former is easily distinguishable from the latter by its smooth falcoidal ribs instead of rather angular ones of the latter and its wider interspaces of the ribs. Moreover, the bifurcation arises at inner one-third of the flank in the former but at the middle of the flank in the latter.

*Occurrence.*—Loc. 21: 4, loc. 26: 2, loc. 4: 1, loc. 5: 1, loc. 13: 1, loc. 19: 1, loc. 22: 1, loc. 24: 1, unknown loc. of the Sakuraguchi-dani: 1.

*Lioceratoides matsumotoi* sp. nov.
Pl. 15, Figs. 8, 11–13

1947. *Hildoceras* (*Brodeia*) *yokoyamai* MATSUMOTO (pars); MATSUMOTO *in* MATSUMOTO & ONO, *Sci. Rep. Fac. Sci., Kyushu Univ., Geol.*, vol. 2, no. 1, p. 28.

*Types.*—A left internal mould, GK. G. 2692, is designated here as a holotype which was obtained at loc. 13, and four specimens, GK. G. 11273, 11281, 11282 and 11283, are designated as paratypes.

*Material.*—The above mentioned five specimens.

*Etymology.*—Dedicated to Professor Tatsuro MATSUMOTO, an excellent investigator of cephalopods and in historical geology.

*Diagnosis.*—A species of *Lioceratoides* with a high and dominant keel, very narrow umbilicus and more or less weak but regular ribs that is accompanied by bifurcation and insertion.

*Description.*—The whorls enlarge very rapidly and are much involute. The venter bears a high and dominant keel, and probably it is bisulcate. The ribs spring on the umbilical wall and go on forward. At inner two-fifths or a half of the flank, the ribs curve backward and recurve forward near the ventral shoulder drawing arcs on the outer half of the flanks. The ribs fade away near the sulcus. The larger whorl which has weakly falcoidal and blunt ribs is regarded as a living chamber. The ribs are stronger on the outer half of the flank than those on the inner half. Sometimes bandles of the striae are there instead of the ribs on the apertural part. Bifurcation, insertion and striation are visible, but bifurcation arises at a point one-third or a half of the flanks, mostly insertion is restricted on the outer half of the flanks and striation is there on the apertural end.

*Measurements.*—

| No. | D | U | H | U/D | H/D |
|---|---|---|---|---|---|
| GK. G. 2692 | / | 8.0 | 22.2 | / | / |
| GK. G. 11281 | 57.3 | 9.2 | 16.7 | 0.25 | 0.45 |
| GK. G. 11283 | / | 10.7 | 23.7 | / | / |

*Comparison.*—The present species is similar to *Lioceratoides serotinum* (BETTONI) (FUCINI, 1900, p. 92; 1923, p. 71; HAAS, 1913, pp. 106–107) in the general mode of ribbing and volution. In the former the ribs are stronger on the outer half of the flanks than on the inner half of the flanks in contrast to those of constant intensity in the latter and they curve moderately in the former but they curve more sharply backward in the latter.

The present species is also similar to *Lioceratoides aradasi* (FUCINI) (FUCINI, 1923, p. 71; 1929, p. 71) in the mode of bifurcation but is distinguished in its weaker curve of ribs and narrower umbilicus.

The present species is somewhat similar to *Lioceratoides lamacoi* (FUCINI) (1929, p. 99) in the mode of ribs, but is distinguished by its more involute shell and stronger keel.

The present species is distinguished from *Lioceratoides yokoyamai* (MATSUMOTO) in the preceding section by its more involute shell and more blunt ribs.

*Occurrence.*—Loc. 13: 1, loc. 21: 1, loc. 26: 1, loc. 28: 1.

## Genus *Fuciniceras* HAAS, 1913

*Type-species.*—*Harpoceras lavinianum* MENEGHINI *in* FUCINI, 1900 (designated by HAAS, 1913, p. 77).

### *Fuciniceras primordium* (MATSUMOTO)

Pl. 17, Figs. 1–3

1947. *Grammoceras* (s. l.) *primordium* MATSUMOTO; MATSUMOTO *in* MATSUMOTO & ONO, *Sci. Rep. Fac. Sci., Kyushu Univ., Geol.*, vol. 2, no. 1, p. 27, pl. 1, fig. 3.
1956. *Fuciniceras primordium* (MATSUMOTO); ARKELL, Jurassic Geology of the World, Oliver & Boyd Ltd., p. 421.
1962. *Fuciniceras primordium* (MATSUMOTO); SATO, *Mém. Soc. Géol. France*, no. 94, p. 59.
1963. *Fuciniceras primordium* (MATSUMOTO); TAKAI, MATSUMOTO and TORIYAMA ed., Geology of Japan, Univ. Tokyo Press, p. 85.

*Types.*—I designate here the illustrated specimen of MATSUMOTO (1947, pl. 1, fig. 3), GK. G. 2003, as the lectotype, and other syntypes (GK. G. 2232, 2233) as the paralectotypes. They were obtained at loc. 18.

*Material.*—The above mentioned three specimens.

*Diagnosis.*—A species of *Fuciniceras* with coarse and stout ribs. Sulci are robust and more or less deep.

*Description.*—The whorls are evolute, and the venter is carinate-bisulcate. The keel is fairly robust, and the sulci are somewhat deep. The ribs are stout, widely interspaced and usually simple. The ribs spring from the umbilical wall and go on forward to a point one-fourth of the flank, where they recurve backward and go on the remainder of the flank. They curve forward near the ventral shoulder. The ribs curve gently and they become stout toward the ventral shoulder. The ribs are accompanied by some striae in the last stage of the lectotype. The septal suture is less complex than in *F. lavinianum*. The lateral lobe

is narrow and deep, and the first lateral saddle is narrow and bifid at the younger growth stage with the whorl of the diameter of ca. 31 mm.

*Measurements.*—

| No. | D | U | Rn |
|---|---|---|---|
| GK. G. 2003 | ca. 55 | ca. 23 | 28± |

*Comparison.*—*Fuciniceras intumescens* (FUCINI) (1900, pp. 63–65) closely resembles the present species in many characters, but the former has denser ribs and a narrower umbilicus than the latter.

The present species resembles *Fuciniceras* sp. cf. *F. intumescens* by IMLAY (1968, pp. C42–43) but is distinguished by its more flexuous and somewhat finer ribs as IMLAY mentioned.

The present species is distinguished from *Fuciniceras nakayamense* of higher horizon by its coarser and more gently curved ribs, stouter keel and deeper and clearer sulci.

*Occurrence.*—Loc. 18: 3 specimens.

### *Fuciniceras nakayamense* (MATSUMOTO)
Pl. 17, Figs. 4–9

1947. *Grammoceras* (*Pseudogrammoceras*) *nakayamense* MATSUMTO; MATSUMOTO *in* MATSUMOTO & ONO, *Sci. Rep. Fac. Sci., Kyushu Univ., Geol.*, vol. 2, no. 1, p. 27, pl. 1, figs. 4–5.
1956. *Fuciniceras* sp. cf. *F. lavinianum* (MENEGHINI); ARKELL, Jurassic Geology of the World, Oliver & Boyd Ltd., pp. 421–422.
1962. *Fuciniceras* sp. cf. *F. lavinianum* (MENEGHINI); SATO, *Mém. Soc. Géol. France*, no. 94, p. 59.
1963. *Fuciniceras* sp. cf. *F. lavinianum* (MENEGHINI); TAKAI, MATSUMOTO and TORIYAMA ed., Geology of Japan, Univ. Tokyo Press, p. 84.

*Types.*—One of the ten syntypes is designated as the lectotype, GK. G. 2004, which was illustrated by MATSUMOTO (MATSUMOTO & ONO, 1947, pl. 1, fig. 4). It was obtained at loc. 9. Other syntypes are designated as the paralectotypes, GK. G. 2005, 2401, 2403–5, 2407, 2411, 2415 and 2421.

*Material.*—Fifty specimens (above indicated types, GK. G. 11101–11130 and GYU. M. 1048–1057).

*Diagnosis.*—A species of *Fuciniceras* with carinate-bisulcate venter, moderately tight volution and more or less strongly curved, falcoidal and moderately dense ribs.

*Description.*—The whorls are somewhat evolute, and the venter is unicarinate-bisulcate. The keel is generally sharp and eminent. The umbilicus is moderate, and the wall is somewhat steep. The ribs are moderate in strength and usually gently but sometimes fairly strongly falcoidal. They start on the umbilical wall and go on forward. Usually at one-third or one-fourth of the flanks they curve backward and recurve gently forward on the ventral shoulder. The points of

the first curve of the ribs are occasionally situated on the middle of the flank. The ribs are fine on the inner part of the flank and become coarser toward the ventral shoulder. Most of the ribs are simple, but bifurcation arises in some specimens. Generally the curvature of ribs in the larger stage is stronger than in the younger stage, although the change is not considerable. On some specimens, e.g., GK. G. 2401, 2403 and 11101, the ribs are accompanied by some lirae which are weak and not numerous, and therefore under unfavourable preservation hardly discerned.

*Measurements.*—

| No. | D | U | H | Rn | U/D | H/D |
|---|---|---|---|---|---|---|
| GK. G. 2403 | 22.1 | 10.5 | 7.0 | 33± | 0.48 | 0.32 |
| GK. G. 11101 | 23.3 | 9.1 | 9.1 | 32 | 0.39 | 0.39 |
| GYU. M. 1002 | 38.5 | 12.2 | 13.1 | / | 0.31 | 0.34 |
| GYU. M. 1001 | 46.5 | 15.2 | 17.2 | 50± | 0.33 | 0.37 |
| GK. G. 11105 | 47.3 | 18.1 | 16.4 | 31± | 0.38 | 0.35 |
| GK. G. 2004 | 51.5 | 20.9 | 16.8 | 49 | 0.41 | 0.33 |
| GK. G. 2401 | 54.0 | 19.4 | 18.9 | 39 | 0.31 | 0.35 |
| GK. G. 11102 | 68.8 | 32.2 | 20.0 | 38± | 0.47 | 0.30 |

*Remarks.*—The ribs of some specimens are accompanied by lirae as mentioned above, and usually the lirae are present on the adoral half of the outer whorl. The lectotype is larger than most of other specimens but it has no lirae. If the lectotype is regarded as mature, it is concluded that the existence of lirae is not always concerned with the size or growth stage.

*Comparison.*—The present species was listed as *Fuciniceras* sp. cf. *F. lavinianum* (MENEGHINI) by ARKELL (*op. cit.*) but is distinct from that species in its coarser and more strongly curved ribs and a somewhat wider umbilicus.

The present species is most closely allied to ***Fuciniceras boscense*** (REYNES) (FUCINI, 1900, pp. 17–20; 1905, pp. 107–108; MONESTIER, 1934, pp. 85–86; NUTSCHUBIDZJ, 1966, pp. 89–90) in general features, but is distinguished by the stronger keel(s), wider umbilicus and less numerous ribs.

The present species is fairly similar to *Fuciniceras falciplicatum* (FUCINI) (1904, p. 297) in the general mode of ribs, but is distinguished by its more weakly curved ribs and more evolute whorls.

*Occurrence.*—Loc. 22: 11, loc. 21: 9, loc. 4: 4, loc. 5: 4, loc. 13: 4, loc. 9: 3, loc. 18E: 3, loc. 47: 2, loc. 1: 1, loc. 31: 1, unknown loc.: 8 specimens.

### *Fuciniceras* sp. cf. *F. normanianum* (FUCINI)

Pl. 17, Figs. 12–13

Cf. 1900. *Grammoceras normanianum* D'ORBIGNY; FUCINI, *Palaeontogr. Italica*, vol. 6, pp. 28–29, pl. 7, figs. 9a–b.

Cf. 1905. *Hildoceras normannianum* D'ORBIGNY; FUCINI, *Palaeontogr. Italica*, vol. 11, pp. 108–109, pl. 5, figs. 1–5, [*sic*].

1947. *Protogrammoceras* sp. cf. *P. normannianum* (D'ORBIGNY); MATSUMOTO *in* MATSUMOTO & ONO, *Sci. Rep. Fac. Sci., Kyushu Univ., Geol.*, vol. 2, no. 1, p. 27, [*sic*].

1956. *Protogrammoceras* sp. cf. *P. normanianum* (D'ORBIGNY); ARKELL, Jurassic Geology of the World, Oliver & Boyd Ltd., p. 421.
1962. *Protogrammoceras* sp. cf. *P. normanianum* (D'ORBIGNY); SATO, *Mém. Soc. Géol. France*, no. 94, p. 59.
1963. *Protogrammoceras* sp.; TAKAI, MATSUMOTO and TORIYAMA ed., Geology of Japan, Univ. Tokyo Press, p. 84.
Cf. 1963. *Fuciniceras normanianum* (FUCINI); DRESNAY, *Notes Serv. Géol. Maroc*, vol. 23, p. 154, pl. 1, fig. 7, text-fig. 6b.

*Material.*—Four specimens, GK. G. 2231, 11313–5.

*Description.*—The whorls enlarge moderately or somewhat rapidly. Accordingly the umbilicus is moderate or rather narrow. Its periphery is rounded, and its wall is very low. The venter has a weak keel but the detailed nature is invisible. The ribs are fine, weak. and very gently curved. They spring on the umbilical wall (GK. G. 2231 and 11315) or on the inner part of the flank near the umbilical shoulder (GK. G. 11313–4) and go nearly radially. Near the middle of the flank thev curve weakly backward and go on near the ventral shoulder, where they recurve forward very weakly. Their mode is fairly regular. The interspace is twice or three times as wide as the width of the rib.

*Measurements.*—

| No. | D | U | H | U/D | Rn½ |
|---|---|---|---|---|---|
| GK. G. 2231 | 24+ | 10.8 | 9+ | 0.45− | 35 |
| GK. G. 11315 | 21.9 | 9.0 | 7.8 | 0.41 | 31 |

*Comparison.*—The present specimens are closely allied to the European ones of *Fuciniceras normanianum* (FUCINI) described by FUCINI (1900, pp. 28–29; 1905, pp. 108–109) and DRESNAY (1963, p. 154) in the mode of volution and ribs. It is said that the umbilical periphery is smooth in *F. normanianum* but the present specimens do not always show this nature.

The present species is also similar to *Fuciniceras lavinianum* (FUCINI) (1900. pp. 52–54; 1905, pp. 94–96) in the general mode of ribs, but is distinguished by its still stronger curvature of ribs.

The Toyora specimens are too poorly preserved for the precise identification. Therefore I deal it tentatively as *Fuciniceras* sp. cf. *F. normanianum* (FUCINI).

*Occurrence.*—Loc. 16: 3, loc. 29: 1 specimen.

## Genus *Protogrammoceras* SPATH, 1913

*Type-species.*—*Grammoceras bassanii* FUCINI, 1900 (designated by SPATH, 1919, p. 174).

### *Protogrammoceras nipponicum* (MATSUMOTO)

Pl. 18, Figs. 1–5

1947. *Grammoceras* (s. s.) *nipponicum* MATSUMOTO; MATSUMOTO *in* MATSUMOTO & ONO, *Sci. Rep. Fac. Sci., Kyushu Univ., Geol.*, vol. 2, no. 1, p. 27, pl. 2, fig. 3.
1947. *Grammoceras* (s. s.) *nipponicum* MATSUMOTO var. *tenuicostata* MATSU-

MOTO; MATSUMOTO *in* MATSUMOTO & ONO, *loc. cit.*

1947. *Grammoceras* (s. s.) *nipponicum* MATSUMOTO var. *paucicostata* MATSUMOTO; MATSUMOTO *in* MATSUMOTO & ONO, *loc. cit.*

1956. *Protogrammoceras nipponicum* (MATSUMOTO); ARKELL, Jurassic Geology of the World, Oliver & Boyd Ltd., pp. 421–422.

1962. *Protogrammoceras nipponicum* (MATSUMOTO); SATO, *Mém. Soc. Géol. France*, no. 94, p. 59.

1963. *Protogrammoceras nipponicum* (MATSUMOTO); TAKAI, MATSUMOTO and TORIYAMA ed., Geology of Japan, Univ. Tokyo Press, p. 83.

*Types.*—One of sixty syntypes is designated here as the lectotype, GK. G. 2013, and others are as the paralectotypes. GK. G. 2321A. B, 2322–2329A. B, 2331, 2332A, B, 2333A. B. 2334A. B. 2335A. B. 2336A. B. 2337A. B. C. 2338A. B. 2339A, B, 2340–2344A. B. 2346. 2350–2358A, B. 2359–2378. The lectotype was obtained at loc. 22 and illustrated by MATSUMOTO (1947. pl. 2. fig. 3).

*Material.*—One hundred and twentynine specimens (in addition to type specimens, GK. G. 11221–11249 and GK. G. 11151–11180).

*Diagnosis.*—A species of *Protogrammoceras* with a moderately elevated keel. umbilicus of moderate width, moderately falcoidal and variable number of ribs and striae.

*Description.*—The whorls are mostly moderately involute. All the specimens bear one keel on the venter, but the sulci are imperceptible because of the unfavourable preservation. The ribs are normally simple and fine or moderate in width. In a few specimens a few ribs are fasciculated on the inner part of the flank. Specimens more than twenty mm in diameter often bear striae between the ribs on the apertural part of the outer whorl. The ribs are slightly rursiradiate and moderately falcoidal. They start on the umbilical wall, curve backward at a point inner one-third of the flank. projected at the ventral shoulder and fade away near the keel. The number of ribs varies in a wide extent as shown in *Statistics*. On some large specimens (e.g.. a specimen of 81.6 mm diameter), ribs become weak and many lirae are there on the apertural part of the outer whorl. Sometimes *Cornaptychus* occurs with the specimens.

*Measurements.*—

| No. | D | U | U/D | Rn-20 |
|---|---|---|---|---|
| GK. G. 2358 | 18.5 | 6.3 | 0.34 | 35 |
| GK. G. 2349 | ca. 22 | ca. 8 | ca. 0.36 | 29 |
| GK. G. 2370 | 34.7 | 14.7 | 0.42 | 33 |
| GK. G. 2336 | 46.3 | 19.4 | 0.42 | 23 |
| GK. G. 2013 | 47.5 | 23.0 | 0.49 | 32 |

*Statistics.*—The assumption is made that the sample is collected at random from one fossil population with normal distribution of the characters. The histogram of the number of ribs at each diameter seems to be unimodal. According to chi-square test on these histograms, no significant difference is found from the normal distribution (Tables 3 and 4). No other characters relate with the number of ribs.

*Remarks.*—*Protogrammoceras nipponicum* (MATSUMOTO) was said to be composed of normal form, var. *tenuicostata* and var. *paucicostata* by MATSUMOTO

Table 3. Frequency table concerning the number of ribs per half a whorl at 15 mm diameter.

| Class | Oi | Ei |
|---|---|---|
| 16.5~19.5 | 3 | 2.37 |
| 19.5~22.5 | 9 | 7.58 |
| 22.5~25.5 | 11 | 13.13 |
| 25.5~28.5 | 13 | 12.83 |
| 28.5~31.5 | 7 | 7.04 |
| 31.5~34.5 | 2 | 2.17 |
| Total | N=46 | 45.12 |

$\bar{x}=25.39$, $s=3.83$, $V=15.09$, $\chi^2=0.79$, $\chi^2_{0.05(\nu=3)}=7.81$, $P \gg 0.05$, Not significant.

Table 4. Frequency table concerning the number of ribs per half a whorl at 20 mm diameter.

| Class | Oi | Ei |
|---|---|---|
| 17.5~21.5 | 3 | 2.73 |
| 21.5~25.5 | 8 | 7.05 |
| 25.5~29.5 | 7 | 10.52 |
| 29.5~33.5 | 12 | 8.66 |
| 33.5~37.5 | 4 | 4.13 |
| 37.5~41.5 | 0 | 1.08 |
| 41.5~45.5 | 1 | 0.16 |
| Total | N=35 | 34.33 |

The classes between 33.5 and 45.5 are calculated and therefore the classes total up to 5.
$\bar{x}=28.23$, $s=5.16$, $V=18.27$, $\chi^2=2.65$, $\chi^2_{0.05(\nu=2)}=5.99$, $P \gg 0.05$, Not significant.

(1947). The division was based on the number of ribs. As mentioned in the preceding lines, the character in fact shows a wide extent of variation. On the basis of the results of statistics, it is regarded that the present sample indicates only one species in spite of the wide extent in the number of ribs.

*Comparison.*—Some specimens described by MATSUMOTO as varieties of the present species were said to be indistinguishable from *Protogrammoceras isseli* (FUCINI) and *P. inseparabilis* (FUCINI) by ARKELL (1956, p. 422). Indeed the present species is very similar to them, but is distinguished in that it has often more strongly falcoidal ribs than *P. isseli* (FUCINI) (1900, pp. 37–39). The present species has a narrower umbilicus and somewhat stronger falcoidal ribs than *Protogrammoceras inseparabilis* (FUCINI) (1900, p. 29).

The present species is also similar to *Protogrammoceras celebratum* (FUCINI) (1900, pp. 41–43), but it is distinguished by its somewhat stronger keel and the existence of striae.

*Protogrammoceras bonarellii* (FUCINI) (1900, pp. 45–46) differs from the present species in the less numerous and more widely separated ribs.

*Protogrammoceras marianii* (FUCINI) (1904, pp. 283–285) and *P. curioni* (MENEGHINI) (BETTONI, 1900, p. 67) differ from the present species in their irregular, coarser and more strongly backward curved ribs and more involute whorls.

*Protogrammoceras* sp. cf. *P. nipponicum* (MATSUMOTO) (IMLAY, 1968, p. C 38) differs in its involute whorls from the present species as IMLAY mentioned.

*Occurrence.*—Loc. 9: 44, loc. 4: 35, loc. 22: 21, loc. 20: 15, loc. 18E: 4, loc. 4B: 2, loc. 13: 2, loc. 21: 2, unknown loc. of the Kogo-dani: 1, unknown loc. of the Sakuraguchi-dani: 1, unknown loc.: 1 specimen.

### *Protogrammoceras yabei* sp. nov.
**Pl. 18, Figs. 6–9**

1947. *Grammoceras* sp. aff. *Gr. nipponicum* MATSUMOTO; MATSUMOTO *in* MATSUMOTO & ONO, *Sci. Rep. Fac. Sci., Kyushu Univ., Geol.*, vol. 2, no. 1, p. 27.
1956. *Protogrammoceras* sp. cf. *P. nipponicum* (MATSUMOTO); ARKELL, Jurassic Geology of the World, Oliver & Boyd Ltd., p. 421.
1963. *Protogrammoceras* sp.; TAKAI, MATSUMOTO and TORIYAMA ed., Geology of Japan, Univ. Tokyo Press, p. 83.

*Types.*—A specimen, GK. G. 2352, is designated here as the holotype, which was obtained at loc. 22, and five specimens, GK. G. 11211, GYU. M. 1008, 1009, 1010 and 1011, as paratypes.

*Material.*—Above mentioned six specimens.

*Etymology.*—To dedicate to late Prof. Emeritus Hisakatsu YABE, who gave outstanding contributions in palaeontology and named the Toyora Group.

*Diagnosis.*—A species of *Protogrammoceras* with evolute whorls and somewhat coarse, narrowly interspaced and moderately curved ribs.

*Description.*—The whorls enlarge slowly and are consequently evolute. The venter bears a rather clear and high keel and sulci, although some specimens are too poorly preserved to see the details of the venter. The umbilical wall is low and more or less steep. So far as the septate whorls are concerned, ribs are simple, numerous, coarse and wide on the flank but weak and fine at the umbilical periphery and on the ventral shoulder. They are moderately flexuous, showing a backward curve at one-third of the flank and a rather weak projection at the ventrolateral shoulder. Their interspaces are somewhat narrower than the ribs. This mode does not show a remarkable change with growth. Their total course is slightly rursiradiate, unless modified by secondary deformation.

*Measurements.*—

| No. | D | U | H | U/D |
|---|---|---|---|---|
| GK. G. 2352 | 47.8 | 18.6 | 15.8 | 0.39 |
| GYU. M. 1008 | 54.4 | 26.0 | 16.4 | 0.48 |

*Comparison.*—As MATSUMOTO (MATSUMOTO & ONO, 1947) mentioned, the present species has some affinity with *Protogrammoceras nipponicum*. It is dis-

tinguished, however, by its more evolute whorls and wider and stronger ribs.

The present species is similar to *Protogrammoceras marianii* (FUCINI) (1904, pp. 283–285), but is distinguished by its more evolute shell with slower enlarging whorls and somewhat stronger and denser ribs.

The present species is similar to *Protogrammoceras bonarellii* (FUCINI) (1900, pp. 45–46; 1905, p. 102) in the mode of ribs, but is distinguished by its wider umbilicus. Likewise it has wider ribs and more evolute whorls than *Protogrammoceras* sp. cf. *P. bonarellii* (FUCINI) (IMLAY, 1968, p. C 38).

*Occurrence.*—Loc. 9: 4, loc. 22: 1, loc. 23: 1 specimen.

### *Protogrammoceras onoi* sp. nov.
Pl. 16, Figs. 5–11

*Types.*—Holotype is GK. G. 11181, obtained at loc. 4, and twentynine specimens. GK. G. 11182–11210, are paratypes.

*Material.*—Above mentioned thirty specimens.

*Etymology.*—To dedicate to the late Mr. Akira ONO who intensively investigated the Toyora Group.

*Diagnosis.*—A species of *Protogrammoceras* with a clear keel and strongly falciform ribs which are moderately but not densely arranged.

*Description.*—The whorls enlarge rather rapidly and the umbilicus is moderate. The umbilical wall is low and steep. The venter bears a strong and clear keel and sulci, although its detailed nature is unknown. The ribs are clear, simple and strongly falciform. They show a somewhat sharply backward curve at inner one-third of the flank and strong projection at the ventral shoulder. Near the apertural end of a large specimen (e.g., 47 mm diameter) the ribs become weak and striae are developed. In the small stage, the umbilicus is narrow, the shell is involute and the ribs are strongly falciform and rather crowded.

*Measurements.*—

| No. | D | U | H | U/D | Rn(20) | Rn |
|---|---|---|---|---|---|---|
| GK. G. 11181 | 43.0 | 15.2 | 15.7 | 0.35 | 24 | 25 |
| GK. G. 11182 | 40.4 | 13.7 | 13.0 | 0.34 | 18 | 25 |
| GK. G. 11183 | 37.6 | 12.0 | 14.8 | 0.32 | 23 | 23 |

*Comparison.*—The present species is closest to *Protogrammoceras celebratum* (FUCINI) (1900, pp. 41–43; 1904, pp. 275–276) in the strong falciform ribs and moderate volution, but is distinguished by its less crowded ribbing.

The present species is somewhat similar to but distinguished from *Protogrammoceras bonarellii* (FUCINI) (1900, pp. 45–46; 1905, p. 102; HAAS, 1913, p. 49). In the former the ribs sharply curve backward at inner one-third of the flank but in the latter moderately so.

The present species is similar to *Protogrammoceras madagascariense* (THEVENIN) (1908, pp. 111–113; ARKELL, 1952, pp. 264–265) in the mode of ribs, but is distinguished by its more evolute shell.

The present species differs from *Protogrammoceras nipponicum* (MATSU-

MOTO) in the strongly falciform ribs and the clear keel.

*Occurrence.*—Loc. 4: 30 specimens.

Genus *Harpoceras* WAAGEN, 1869

*Type-species.*—*Ammonites falcifer* SOWERBY, 1820 (designated by ARKELL, 1951, I. C. Z. N. Opinion 363, 1954).

Subgenus *Harpoceras* WAAGEN, 1869

*Harpoceras* (*Harpoceras*) *okadai* (YOKOYAMA)

**Pl. 20, Figs. 1–9**

1904. *Grammoceras* (?) *okadai* YOKOYAMA; YOKOYAMA, *Jour. Coll. Sci., Imp. Univ. Tokyo,* vol. 19, art. 20, p. 14, pl. 4, fig. 3.
1947. *Pseudolioceras okadai* (YOKOYAMA); MATSUMOTO *in* MATSUMOTO & ONO, *Sci. Rep. Fac. Sci., Kyushu Univ., Geol.,* vol. 2, no. 1, p. 29, pl. 1, fig. 8.
1955. *Harpoceras* sp. cf. *H. exaratum* (YOUNG & BIRD); IMLAY, *U. S. Geol. Surv. Prof. Pap.,* 274-D, p. 84, pl. 11, figs. 12 and 15.
1957. *Harpoceras* s. str. *okadai* (YOKOYAMA); SATO, *Jour. Fac. Sci., Univ. Tokyo,* sec. 2, vol. 10, pt. 3, pp. 345–346, pl. 2, figs. 9–10.
1967. *Harpoceras* sp. aff. *H. exaratum* (YOUNG & BIRD); FREBOLD, *Geol. Surv. Can., Pap.* 67–12, p. 16, pl. 1, fig. 8.
1969. *Harpoceras* (*Harpoceras*) *okadai* (YOKOYAMA); TAKAHASHI, *Sci. Rep. Tohoku Univ.,* 2nd ser., (Geol.), vol. 41, no. 1, p. 48, pl. 2, figs. 5–6.

*Types.*—A left internal mould obtained at loc. 47, which was illustrated by YOKOYAMA (1904, p. 14, pl. 4, fig. 3) is the holotype, MM. 7072, of the present species. Because the original illustration of this specimen is by drawing, the photographic reillustration is shown in this paper (Pl. 20, Fig. 1).

*Material.*—Twentyfour specimens (MM. 7072, GYU. M. 1013–1016, GK. G. 2008, 2721–2726, 11301–11312).

*Etymology.*—Probably, in commemoration of the late Dr. H. OKADA who surveyed the geology of the Toyora area in the beginning of this century.

*Diagnosis.*—A species of *Harpoceras* (s. str.) with very involute shell and nearly straight and long hafts of the falcoidal ribs.

*Description.*—The whorls enlarge very rapidly and very involute. The venter is presumably unicarinate-bisulcate. The whorl is tightly involute through the observable growth stages. The ribs are falcoidal, fine and numerous but seem to change their characters with growth. For instance, on the shell of the early growth stage before ca. 35 mm in the height of the whorl, the ribs have flat top, and are separated by narrower interspaces. In the holotype, however, the space of the ribs is moderate to fine and the interspace is moderate. The ribs become finer toward aperture, though the holotype is small and its later stage is unknown. After this stage the ribs become fine, and the interspace of the ribs is nearly as fine as the rib or slightly wider than the rib on the external half of the flank. Finally the ribs become dense lirae, which may indicate the adult stage. The ribs start on the umbilical seam and are slightly prorsiradiate on the inner half of the flank. At the middle of the flank they begin to curve moderately backward and near the ventral shoulder they strongly

project adorally. This mode of bending of the rib seems constant through the growth.

On the specimens from Shizukawa (SATO, 1955, pp. 345–346, pl. 2, figs. 9–10) the ribs are fine until larger stage, ca. 72 mm in whorl height. In the stage later than 72 mm in whorl height a specimen has somewhat wider ribs separated by narrower interspaces. The curvature of the rib is the same as that of the Toyora specimens.

*Measurements.*—

| No. | D | U | U/D | H | Rn½ |
|---|---|---|---|---|---|
| GYU. M. 1013 | 80+ | 11.0 | 0.14− | 36+ | 81 |
| GK. G. 2008 | 58.9 | 7.2 | 0.12 | 32.8 | 61 |
| GK. G. 11301 | 49.6 | 6.2 | 0.12 | 26.9 | 40 |
| MM. 7092 | 35.4 | 10.4− | 0.29− | 13.7 | 39 |
| GK. G. 11304 | 25.8 | 2.1 | 0.08 | 14.6 | 40± |
| GYU. M. 1016 | 22.4 | 3.0 | 0.13 | 12.8 | 36 |
| GK. G. 11303 | 20.2 | 2.9 | 0.14 | 11.0 | 27+ |

*Comparison.*—*Harpoceras subplanatum* (OPPEL) (DUMORTIER, 1867, pp. 51–53) is very similar to the present species, but is distinguished by its stronger curve of the ribs on the middle of the flank.

YOKOYAMA (1904) said that *Harpoceras acutum* (TATE) (WRIGHT, 1884, pp. 469–470) is similar to the present species. Indeed the young specimens of the present species is somewhat similar to *Harpoceras acutum* (TATE), but the latter has much shorter hafts and weaker curvature of ribs.

The present species is also very similar to *Harpoceras exaratum* (YOUNG & BIRD) (BUCKMAN, 1909, pp. 5 b–c, pl. 5) but seems to be distinguished by its longer and straight hafts. Detailed study of *Harpoceras exaratum* (YOUNG & BIRD) in Europe may be necessary for precise comparison with the present species.

Some of the specimens, from northwest Canada, illustrated under *Harpoceras* sp. cf *H. exaratum* (YOUNG & BIRD) (e.g., 1962, pp. 17–18, pl. 2, figs. 1–6; 1964a, pl. 9, fig. 1) and *Harpoceras* sp. aff. *H. exaratum* (YOUNG & BIRD) (1967, p. 16, pl. 1, fig. 8) by FREBOLD closely resemble the specimens of the present species in the mode of ribs and volution and could be identified with the present species.

Likewise, *Harpoceras* sp. cf. *H. exaratum* (YOUNG & BIRD), from Prince Patric Island, described by IMLAY (1955, p. 88) can possibly be identified with the present species.

*Occurrence.*—Loc. 4: 9, loc. 5: 2, loc. 9: 1, loc. 10: 3, loc. 17: 1, loc. 31: 1, loc. 28′: 2, loc. 28″: 1, loc. 47: 1, unknown loc.: 3 specimens.

**(to be continued)**

Hiromichi HIRANO

# Biostratigraphic Study of the Jurassic Toyora Group
# Part I

Plate 14～20

Plate 14

## Explanation of Plate 14

Figs. 1–10. *Dactylioceras helianthoides* YOKOYAMA ..... Page 104

1. GK. G. 2187, loc. 28″
2. GK. G. 2136, the Sakuraguchi-dani (detailed loc. unknown)
3. GK. G. 2153, loc. 36
4. Rubber cast of GK. G. 2114, the Sakuraguchi-dani (detailed loc. unknown)
5. Rubber cast of GK. G. 2010, loc. 35
6. Rubber cast of GK. G. 11330, loc. 23
7. Rubber cast of GK. G. 11382, loc. 22

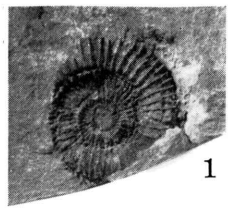
8a. Clay cast of MM. 7074, 8b. MM. 7074, Paralectotype, loc. 47 or loc. 1

9. MM. 7073, Lectotype, loc. 47
10. Rubber cast of MM. 7075, Paralectotype, loc. 47

Fig. 11. *Dactylioceras* (*Prodactylioceras*) sp. aff. *D.* (*P.*) *italicum* (MENEGHINI) ..... Page 103

11. GK. G. 11329, loc.. 39

All in natural size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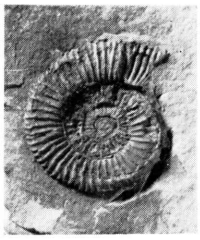
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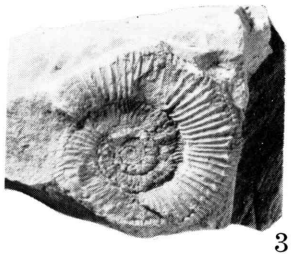
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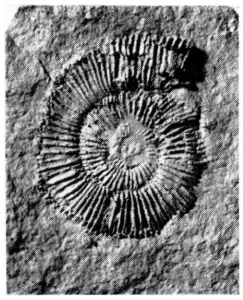
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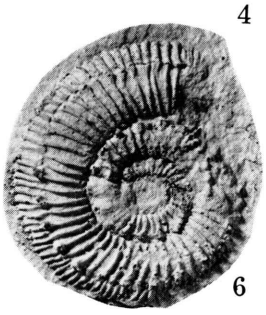
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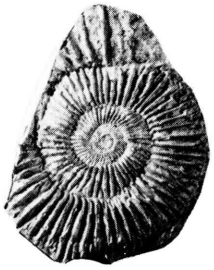
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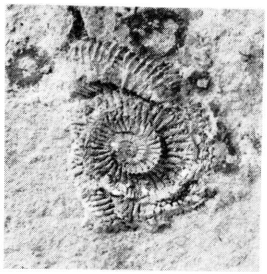

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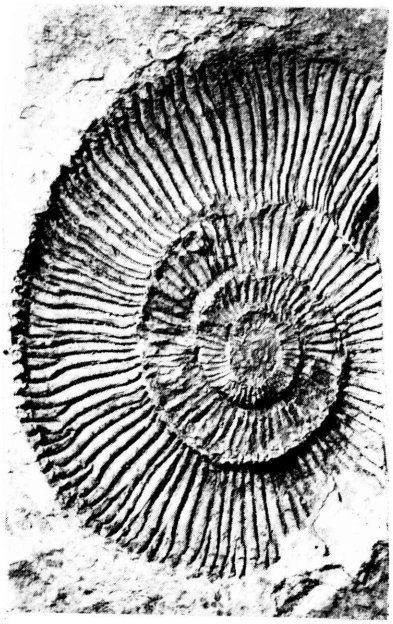


H. HIRANO: Jurassic Toyora Group

Plate 15

## Explanation of Plate 15

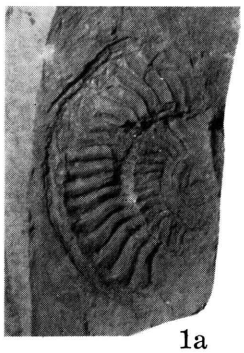
Figs. 1a–6. *Canavaria japonica* (MATSUMOTO) ..... Page 110
1ab. GK. G. 11062, loc. 16, a. internal mould, b. external mould
2. GK. G. 11042, loc. 16
3. GK. G. 11060, loc. 16
4. GK. G. 11061, loc. 16, ×1.5
5. GK. G. 2002, Lectotype, loc. 29
6. GK. G. 11049, loc. 16

Fig. 7. *Canavaria* sp. cf. *C. sicula* FUCINI ..... Page 111
7. GYU. M. 1005, loc. 48

Figs. 9–10. *Lioceratoides yokoyamai* (MATSUMOTO) ..... Page 117
9. Rubber cast of GK. G. 2691, loc. 22
10. GK. G. 2009, Lectotype, loc. 13

Figs. 8, 11–13. *Lioceratoides matsumotoi* n. sp. ..... Page 118
8. GK. G. 11273, loc. 24
11. GK. G. 2692, Holotype, loc. 13
12. GK. G. 11281, Paratype, loc. 26
13. GK. G. 11283, Paratype, loc. 21

All in natural size unless otherwise indicated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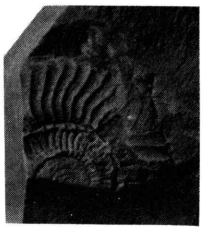
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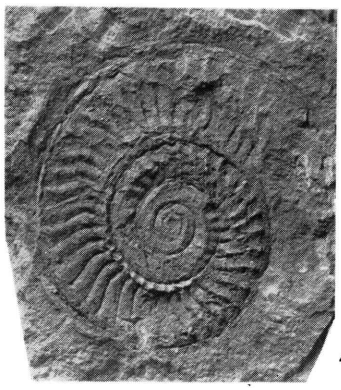
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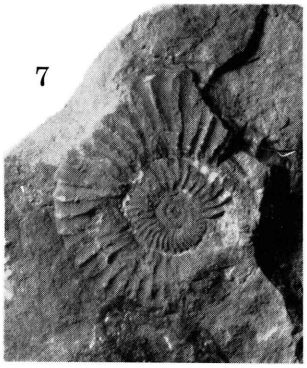
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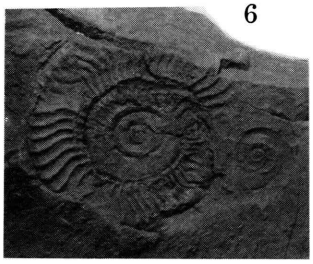
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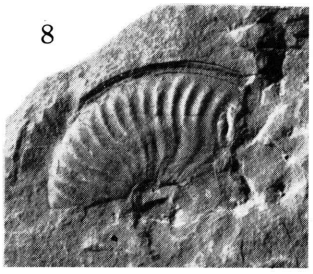
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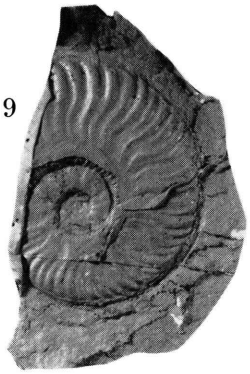
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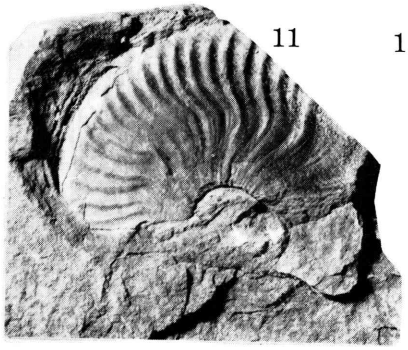
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H. HIRANO: Jurassic Toyora Group

Plate 16

## Explanation of Plate 16

Figs. 1–4. *Fontanelliceras fontanellense* (GEMMELLARO) ..... Page 111

1. GK. G. 2001, loc. 29
2. Rubber cast of GYU. M. 1004, loc. 16B

3a, b. GK. G. 11002, loc. 16, a. internal mould, b. external mould

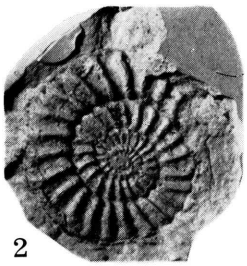
4a, b. GK. G. 11001, loc. 16, a. internal mould, b. external mould

Figs. 5–11. *Protogrammoceras onoi* n. sp. ..... Page 126

5. GK. G. 11181, Holotype, loc. 4
6. GK. G. 11185, Paratype, loc. 4
7. GK. G. 11190, Paratype, loc. 4
8. GK. G. 11183, Paratype, loc. 4
9. GK. G. 11186, Paratype, loc. 4
10. GK. G. 11188, Paratype, loc. 4, a. internal mould, b. external mould
11. GK. G. 11182, Paratype, loc. 4

All in natural size

1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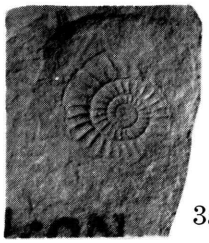
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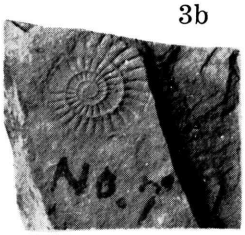
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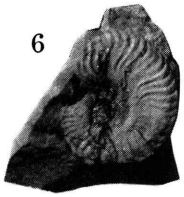
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4a

4b

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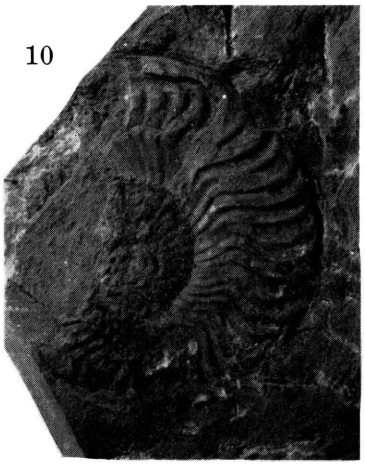
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Plate 17

## Explanation of Plate 17

Figs. 1–3. *Fuciniceras primordium* (MATSUMOTO) ..... Page 119
1. GK. G. 2003, Lectotype, loc. 18
2. GK. G. 2232, Paralectotype, loc. 18
3. GK. G. 2233, Paralectotype, loc. 18

Figs. 4–9. *Fuciniceras nakayamense* (MATSUMOTO)..... Page 120
4. GK. G. 2004, Lectotype, loc. 9
5. GK. G. 2421, Paralectotype, loc. 9
6. GK. G. 2401, Paralectotype, loc. 22
7. GK. G. 2005, Paralectotype, loc. 9
8. GK. G. 2403, Paralectotype, loc. 13
9. GK. G. 11101, loc. 18E

Figs. 10a, b. *Arieticeras* sp. aff. *A. apertum* MONESTIER ..... Page 109
10a, b. GK. G. 11292, loc. 50, a. lateral view, b. ventral view

Figs. 11a, b. *Amaltheus* sp. cf. *A. stokesi* (SOWERBY) ..... Page 101
11a, b. GK. G. 11293, loc. 50, a. right lateral view, b. left lateral view

Figs. 12–13. *Fuciniceras* sp. cf. *F. normanianum* (FUCINI)..... Page 121
12. GK. G. 2231, loc. 29
13. GK. G. 11313, loc. 16

All in natural size

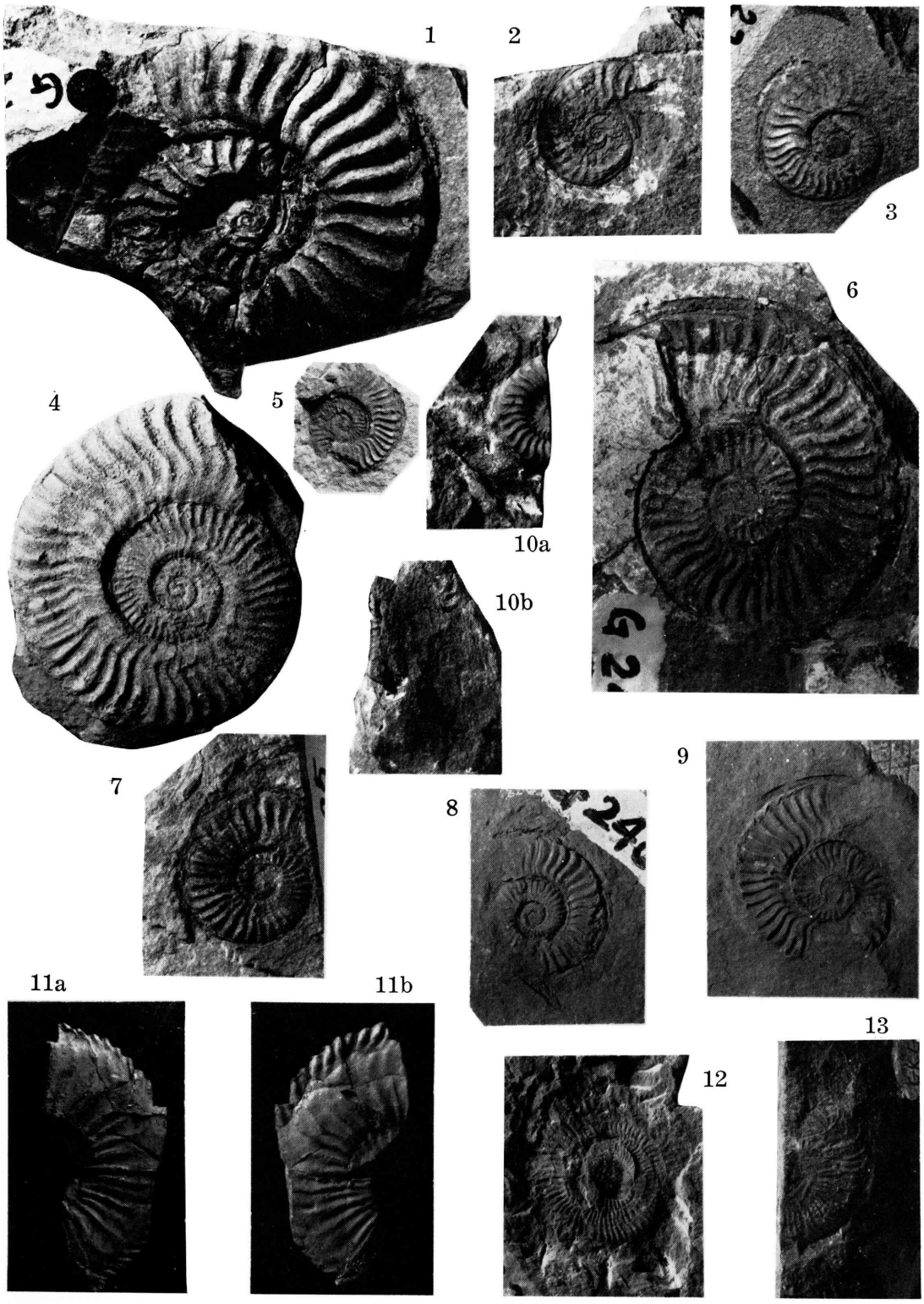


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Plate 18

## Explanation of Plate 18

Figs. 1–5. *Protogrammoceras nipponicum* (MATSUMOTO) ..... Page 122

1. GK. G. 2013, Lectotype, loc. 22
2. GK. G. 2354, Paralectotype, loc. 9

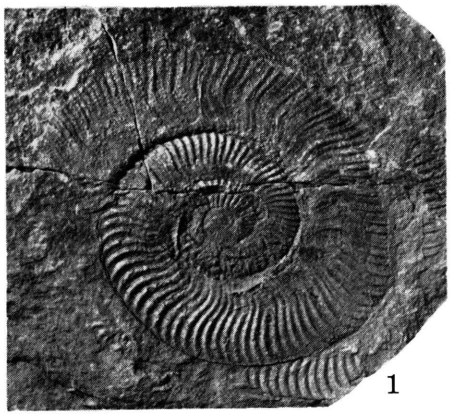
3a, b. GK. G. 2351, Paralectotype, the Sakuraguchi-dani (detailed loc. unknown), a. internal mould, b. external mould

4. GK. G. 2358, Paralectotype, loc. 9
5. GK. G. 2332, Paralectotype, loc. unknown

Figs. 6–9. *Protogrammoceras yabei* n. sp. ..... Page 125

6. Gypsum cast of GK. G. 2352, Holotype, loc. 22
7. GK. G. 11211, loc. 23
8. GYU. M. 1010, Paratype, loc. 9
9. Rubber cast of GYU. M. 1008, Paratype, loc. 9

All in natural size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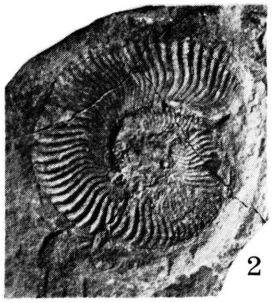
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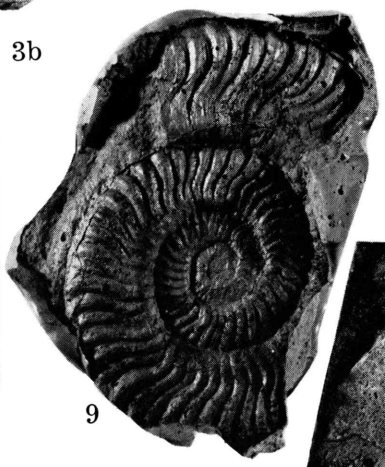
3a

3b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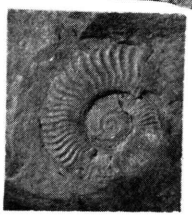
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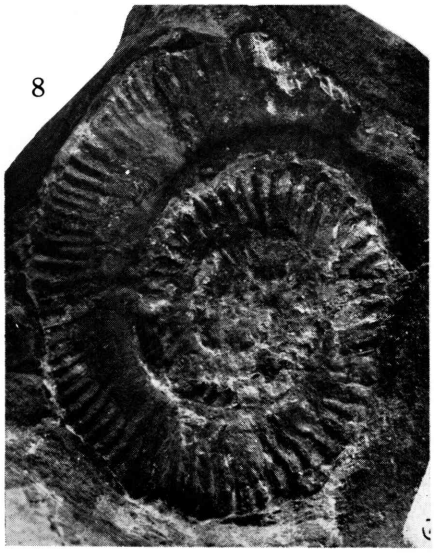
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Plate 19

## Explanation of Plate 19

Figs. 1–5. *Paltarpites toyoranus* (MATSUMOTO) ..... Page 114

1. Rubber cast of GK. G. 2276, Paralectotype, loc. 12
2. Rubber cast of GK. G. 2277, Paralectotype, loc. 18
3. Rubber cast of GK. G. 2273, Paralectotype, loc. 18
4. GK. G. 2275, Paralectotype, loc. 18
5. GK. G. 2006, Lectotype, loc. 12

Fig. 6. *Paltarpites* sp. aff. *P. platypleurus* (BUCKMAN) ..... Page 116

6. GK. G. 2252, loc. 12

Figs. 7–8. *Paltarpites paltus* (BUCKMAN) ..... Page 115

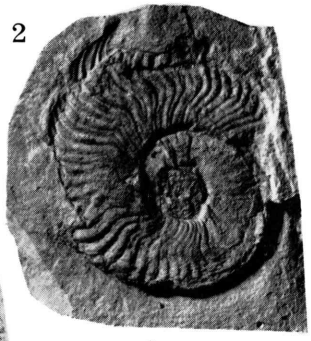
7. GYU. M. 1021, loc. 16B
8. Rubber cast of GYU. M. 1020, loc. 16B

Fig. 9. *Arieticeras* sp. cf. *A. pseudocanavarii* MONESTIER ..... Page 108

9. GK. G. 11291, loc. 39

All in natural size

1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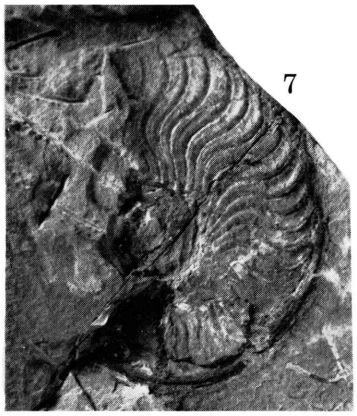
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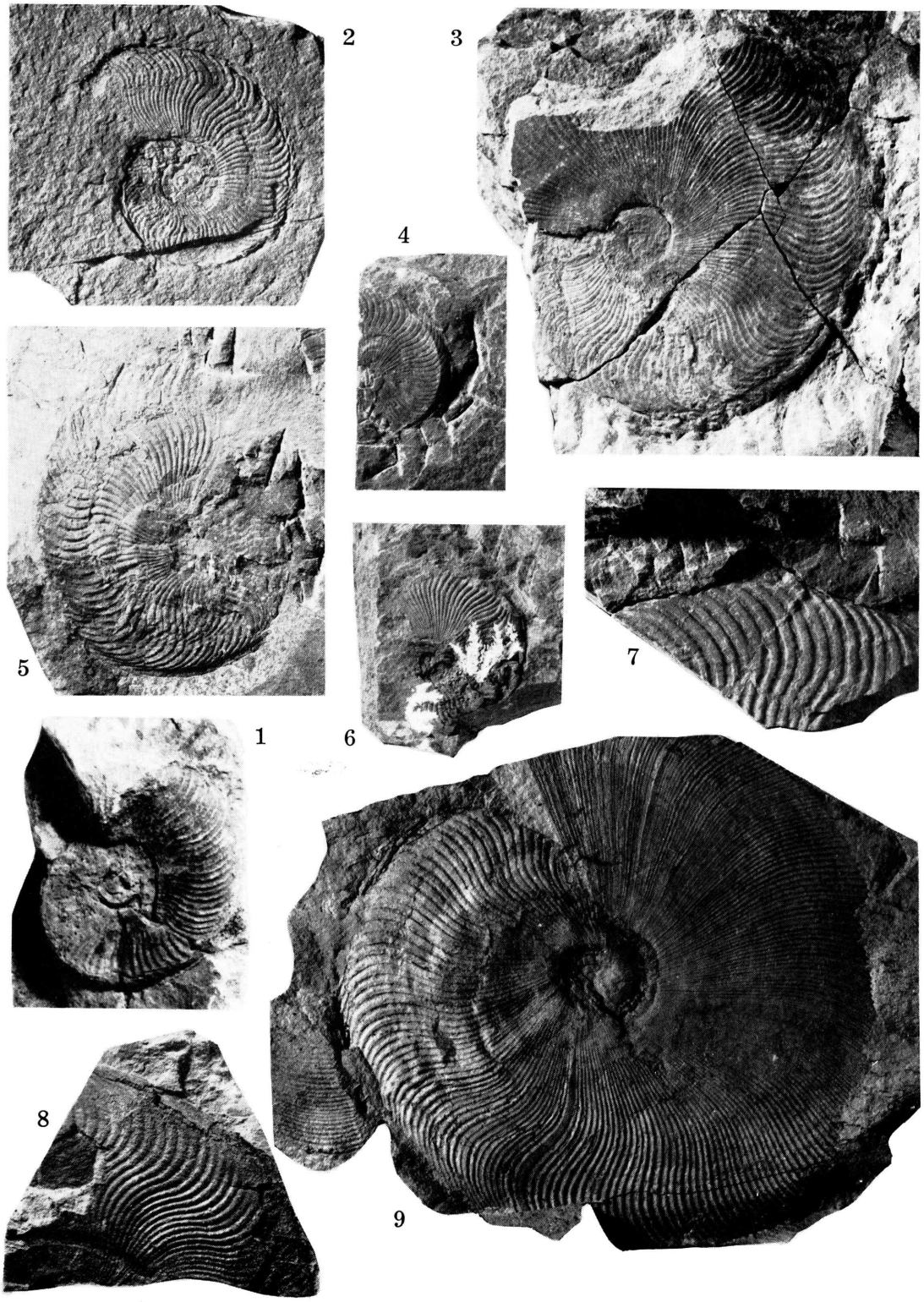
Plate 20

## Explanation of Plate 20

Figs. 1–9. *Harpoceras okadai* (YOKOYAMA)..... Page 127

1. MM. 7072, Holotype, loc. 47
2. GK. G. 11302, loc. 4
3. GK. G. 2008, loc. 9
4. GYU. M. 1016, loc. 5
5. GK. G. 11301, loc. 21
6. GK. G. 11312, the Sakuraguchi-dani (detailed loc. unknown)
7. GK. G. 11306, loc. 4
8. GK. G. 11311, the Anda-dani (detailed loc. unknown)
9. Rubber cast of GYU. M. 1013, loc. 31, ×0.8

All in natural size unless otherwise indicated

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