日本古生物学會
報告・紀事

Transactions and Proceedings
of the
Palaeontological Society of Japan

New Series No. 90

日本古生物学会

Palaeontological Society of Japan
June 20, 1973

Fossil on the cover is *Bellerophon jonesianus* DE KONINCK from the Late Permian Akasaka Series in Gifu Prefecture.

All communications relating to this journal should be addressed to the
PALAEONTOLOGICAL SOCIETY OF JAPAN
c/o Business Center for Academic Societies, Japan.
Yayoi 2-4-16, Bunkyo-ku, Tokyo 113, Japan
Sole agent: University of Tokyo Press, Hongo, Tokyo

Trans. Proc. Palaeont. Soc. Japan, N.S., No. 90, pp. 45-71, pls. 9-10, June 20, 1973

615. BIOSTRATIGRAPHIC STUDY OF THE JURASSIC TOYORA GROUP*
PART III

HIROMICHI HIRANO

Department of Geology, Faculty of Science, Kyushu University

ジュラ紀豊浦層群の化石層序学的研究—その3：豊浦層群産のアンモナイト10種を記載し，これにより，その1よりひき続いたアンモナイトの記載をすべて終了した。本層群の時代は，アンモナイトならびにイノセラムスより，Sinemurian から Bathonian に及ぶと結論される。アンモナイト化石を多産する西中山層は，下位より *Fontanelliceras fontanellense* 帯，*Protogrammoceras nipponicum* 帯，*Dactylioceras helianthoides* 帯の3帯が識別される。これらは，調査地域の北半では松本・小野（1947）の3帯に各々相当するが，南半では特にその下半部が岩相とかなり斜交することが明らかである。欧州標準地域と類縁種に基づき比較すると，*F. f.* 帯は *Margaritatus* 帯の *Stokesi* 亜帯から *Spinatum* 帯の下部に，*P. n.* 帯は *Spinatum* 帯上部から *Falcifer* 帯に，*D. h.* 帯は *Falcifer* 帯の *Exaratum* 亜帯から *Bifrons* 帯の *Fibulatum* 亜帯に対比される。本層群のアンモナイト動物群は，種数個体数ともに Hildoceratidae の優越で特徴づけられる。これを SIMPSON の公式により他域のものと比較すると，Domerian 亜階の動物群はシシリー島のものに，一般には地中海地方のものに高い類似度を示す。Whitbian では欧州各地と等しく高い類似度を示し偏りがない。Yeovilian ではコーカサス地方のものとのみ，かなり高い類似度を示す。北米西部から本層群の Domerian と Whitbian のものに比較されると報告されたものは，動物群としてみた場合さほど高い類似度を示さない。本層群および北米西部のアンモナイト動物群はともに地中海系の特徴をもつが，欧州で広くみられるような岩相と生相の一定の組合せを示さず，ボレアル系の堆積物より産する。　　　　平野弘道

Introduction

This article is Part III of the serial biostratigraphic study of the Jurassic Toyora Group. In the preceding Parts I～II lithostratigraphy and 6 genera including 31 species of Domerian, Whitbian and Yeovilian ammonites (Amaltheidae, Dactylioceratidae, Hildoceratidae, and Hammatoceratidae) were described. In the present part comparatively uncommon 4 species of Hammatoceratidae, Dactylioceratidae and Arietitidae and 6 species of Lytoceratidae, Nannolytoceratidae, Phylloceratidae and Juraphyllitidae are systematically described.

Zonation and correlation is discussed by comparing the ammonoid assemblages of the Toyora Group with European standard. The characteristics of the Toyora faunas are discussed by the investigation of assemblages, comparison with other faunas in Japan and comparison with some faunas of other region.

Palaeontology (continued from Part II)

Subfamily Hammatoceratinae
BUCKMAN, 1887

* Received July 12, 1972; read Jan. 23, 1971, at Tokyo.

Genus *Planammatoceras* BUCKMAN, 1922

Type-species:—Planammatoceras planiforme BUCKMAN, 1922

Planammatoceras sp. cf. *P. kitakamiense* (SATO)

Pl. 9, Figs. 7a-b

Cf. 1934. *Planammatoceras kitakamiense* SHIMIZU; SHIMIZU *in* SHIMIZU & OBATA, Cephalopoda, Iwanami book Co., vol. 32, no. 9, p. 119, fig. 58B (*nom. nud.*)
1947. *Hammatoceras* sp.; MATSUMOTO *in* MATSUMOTO & ONO, *Sci. Rep. Fac. Sci., Kyushu Univ., Geol.*, vol. 2, no. 1, p. 29, pl. 2, fig. 4.
Cf. 1954. *Hammatoceras kitakamiense* SHIMIZU; SATO, *Jap. Jour. Geol. Geogr.*, vol. 25, pp. 84-86, pl. 7, fig. 4, pl. 8, figs. 3 & 5, pl. 9, fig. 4.
1956 *Hammatoceras* (*Planammatoceras*) cf. *kitakamiense* (SHIMIZU); ARKELL, Jurassic Geology of the World, Oliver & Boyd Ltd., p. 421.
1962. *Planammatoceras* cf. *kitakamiense* SHIMIZU; SATO, *Mém. Soc. Géol. France*, no. 92, p. 67.
1963. *Hammatoceras* (*Planammatoceras*) cf. *kitakamiense* (SHIMIZU); TAKAI, MATSUMOTO & TORIYAMA ed., Geology of Japan, Univ. Tokyo Press, p. 83.
Cf. 1969. *Hammatoceras kitakamiense* SATO; TAKAHASHI, *Sci. Rep. Tohoku Univ.*, 2nd ser., vol. 41, no. 1, pp. 53-54, pl. 4, figs. 13-16.

Material:—A fragmentary specimen, GK. G. 2804.

Description:—The whorls enlarge slowly and consequently the umbilicus is proportionally wide. The venter has a keel. Ribs are nearly straight and radial. They spring at the umbilical seam or on the umbilical wall and run to a point one-fourth of the flank, where they bifurcate. The primary ribs are strong and swollen where the bifurcation arises. The secondary ribs are weak on the middle of the flank and become coarse toward the ventral shoulder. The intercalatory ribs occur in the middle of the flank. The secondary and intercalatory ribs are nearly equally weaker than the primary. All the ribs are not much elevated. They are weak in the last 30° of the preserved last whorl.

Measurements:—Whorl height of the preserved last stage: ca. 50 (excluding the height of keel). The maximum of the radius: ca. 86 (excluding the height of keel).

Comparison:—The present specimen is very similar to the described specimens of *Planammatoceras kitakamiense* (SATO) (SATO, 1954, pp. 84-86, pl. 7, fig. 4, pl. 8, figs. 3 and 5, pl. 9, fig. 4, 1962, p. 67; TAKAHASHI, 1969, pp. 53-54, pl. 4, figs. 13-16), from northeast Japan, in the mode of ribs, but it is too fragmentary to identify it definitely with that species. For the time being I treat it as *Planammatoceras* sp. cf. *P. kitakamiense*.

Occurrence:—Loc. 57: 1.

Family Dactylioceratidae HYATT, 1867

Genus *Dactylioceras* HYATT, 1867

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

Subgenus *Dactylioceras* HYATT, 1867

Dactylioceras (*Dactylioceras*) sp. cf. *D.* (*D.*) *helianthoides* YOKOYAMA

Pl. 9, Fig. 9

1947. *Dactylioceras* aff. *helianthoides* YOKOYAMA forma *ambiguus* MATSUMOTO; MATSUMOTO *in* MATSUMOTO & ONO, *Sci. Rep. Fac. Sci., Kyushu Univ., Geol.*, vol. 2, no. 1, p. 26.

Material:—One specimen, GK. G. 2093.

Description:—The whorls enlarge slowly and consequently the umbilicus is proportionally wide. The flank is convexly rounded. The venter is not observable, because of the ill preservation. The whorls are ornamented with primary, secondary and intercalatory ribs. The primary ribs spring at the umbilical seam and go on radially. They are fine, straight and widely interspaced. The intercalatory ribs alternate somewhat regularly with the primary ribs, and they spring on the middle or a point inner two-thirds of the flank. The secondary ribs arise on the middle of the flank. All the ribs on the outer half of the flank are nearly equally weak. The mode of ribs on the inner whorls is not well known.

Measurements:—

No.	D.	U.	U/D	Rn½
GK. G. 2093	54.0	28.0	0.52	30

Comparison:—The present specimen is closley allied to those of *Dactylioceras helianthoides* in the outline. The statistical data concerning the number of ribs per half a whorl at the same diameter is not obtained in *D. helianthoides* but the number of ribs of the present specimen may fall in the variation of *D. helianthoides*. The present specimen has secondary and intercalatory ribs on the outer half of the flank, but *D. helianthoides* has these ribs on the ventrolateral area. The mode of ribs is variable in *D. helianthoides* but no specimen of that species has such long secondary and intercalatory ribs.

As only a fragmentary specimen is at my hand and the difference between the present specimen and those of *D. helianthoides* is not so dominant as a whole, I treat the present specimen under *Dactylioceras* sp. cf. *D. helianthoides*.

Occurrence:—Loc. 13: 1.

Genus *Peronoceras* HYATT, 1867

Type-species:—*Ammonites fibulatus* SOWERBY, 1823 (subsequently designated by BUCKMAN, 1911).

Peronoceras subfibulatum (YOKOYAMA)

Pl. 9, Figs. 1-6

1904. *Coeloceras subfibulatum* YOKOYAMA; YOKOYAMA, *Jour. Coll. Sci., Imp. Univ. Tokyo*, vol. 19, art. 20, pp. 15-16, pl. 3, Figs. 3-6.

1947. *Coeloceras* (*Peronoceras*) *subfibulatum* YOKOYAMA; MATSUMOTO *in* MATSUMOTO & ONO, *Sci. Rep. Fac. Sci., Kyushu Univ.*, vol. 2, no. 1, p. 26.

1947. *Coeloceras* (*Peronoceras*) *subfibulatum* var. *intermedia* MATSUMOTO & ONO; MATSUMOTO & ONO, *ibid.*, p. 26.

1956 *Peronoceras subfibulatum* (YOKOYAMA); ARKELL, Jurassic Geology of the World, Oliver & Boyd Ltd., p. 421.

1962. *Peronoceras subfibulatum* (YOKOYAMA); SATO, *Mém. Soc. Géol. France*, no. 94, p. 59.

1962. *Peronoceras subfibulatum* var. *intermedia* MATSUMOTO; SATO, *ibid.*, p. 59, sic.

1963. *Peronoceras subfibulatum* (YOKOYAMA); TAKAI, MATSUMOTO & TORIYAMA ed., Geology of Japan, Univ. Tokyo Press, p. 83.

Types:—Here one specimen, MM. 7066, illustrated by YOKOYAMA (1904, pl. 3, fig. 6) is designated as the lectotype, which was obtained at loc. 1. Three other syntyypes, MM. 7067, 7068, 7069, which were also illustrated by YOKOYAMA (1904, pl. 3, figs. 3, 4 and 5, respectively) and were obtained at loc. 47, are referred to the paralectotypes of the present species.

Diagnosis:—A species of *Peronoceras*

which has fine, somewhat widely interspaced and irregularly arranged ribs and a comparatively small number of tubercles.

Description:—The whorls enlarge very slowly and consequently the umbilicus is proportionally wide. The lateral side is rounded and the whorl-section is assumed to be elliptical. Ribs are fine, not much elevated and widely interspaced. They spring at the umbilical seam and run radially. At the middle or outer one-third of the flank the two ribs are looped by one tubercle, where two or three secondary ribs spring and they cross the venter. Sometimes at middle or outer one-third of the flank the bifurcation arises without tubercles. Simple ribs without tubercles are not rare and in some specimens such ribs are numerous. In one specimen, GK. G. 2177, spines are preserved at the ventrolateral area.

Measurements:—

No.	D.	U.	U/D	Rn½ (primary only)
MM. 7066	ca. 39.8	22.9	/	ca. 31
MM. 7067	41.6	23.2	0.56	/
GK. G. 2171	36.2	18.2	0.50	ca. 28
GK. G. 2173	60.1	33.7	0.56	32
GK. G. 2175	32.3	14.0	0.43	32

Remarks:—MATSUMOTO & ONO (1947, p. 26) described a specimen as *Peronoceras subfibulatum* var. *intermedia*, suggesting that *Peronoceras subfibulatum* and *Dactylioceras helianthoides* are morphologically serial through the variety. In fact one specimen labelled as *Peronoceras subfibulatum* var. *intermedia* is somewhat similar to some specimens of *D. helianthoides*. In *P. subfibulatum*, however, the ribs are looped in pairs to a tubercle, which is present on the middle of the flank, and from the tubercle two or three secondary ribs arise. On the other hand in *D. helianthoides* the tubercles are usually present on the ventral shoulder and the ribs are never looped in pairs to a tubercle, though such a bifurcation sometimes occurs. At least in these characters *P. subfibulatum* is distinguishable from *D. helianthoides*.

Comparison:—The present species is similar to *Peronoceras fibulatum* (SOWERBY) (MONESTIER, 1931, pp. 43-44) in the mode of furcation. But the present species has not so many ribs and tubercles as *P. fibulatum*, though the range of the variations of those characters are not precisely examined in the two species. The mode of ribs of *P. fibulatum* seems to be more regular than that of the present species.

The present species is similar to *Peronoceras subarmatum* (YOUNG & BIRD) (HOWARTH, 1962, p. 117, MONESTIER, 1931, pp. 46-47) in the mode of ribs. In *P. subarmatum*, however, the ribs are wider and the tubercles are usually more dominant than in the present species.

Occurrence:—Loc. 47: 8, loc. 35: 5, loc. 28″: 4, loc. 3: 4, loc. 13: 2, loc. 2: 1.

Superfamily Psilocerataceae
HYATT, 1867

Family Arietitidae HYATT, 1874

Subfamily Arietitinae HYATT, 1874

Genus *Arietites* WAAGEN, 1869

Type-species: — *Ammonites bucklandi* SOWERBY, 1816 (I. C. Z. N. Opinion 305).

Arietites sp.

Pl. 9, Figs. 8a-b

Material:—A single fragmentary specimen, GK. G. 11380.

Description:—The venter is tricarinate-bisulcate. Two sulci are somewhat wide and shallow. The median keel is a little higher than other two and rounded. Six ribs are preserved and are robust. They are straight on the flank, curving forward on the ventral shoulder and reach the lateral keel. The interspace is wider than the space of a rib.

Measurements:—Whorl-breadth: 4.8 (inter costae), 5.8.

Comparison:—The present species is similar to *Coroniceras bisulcatum* BRUGUIÈRE by FREBOLD (1951, pp. 9-10) in the mode of venter and ribs. Though FREBOLD referred several specimens (1951, pl. 6, fig. 3, pl. 9, fig. 1, pl. 10, fig. 1, pl. 11, fig. 1, pl. 12, fig. 1, pl. 13, fig. 1) from British Columbia to *Coroniceras*, I think it better to refer them to *Arietites* because of the presence of two sulci on the venter.

The present species resembles *Arietites bucklandi* (SOWERBY) (DONOVAN, 1952, pp. 718-719) in the mode of venter, but in the former the ribs curve more strongly forward than in the latter.

Because the present species is represented by only a small fragmentary specimen, more detailed comparison cannot be done.

Occurrence:—Loc. 51: 1.

Suborder Lytoceratina HYATT, 1889

Superfamily Lytoceratաceae
NEUMAYR, 1875

Family Lytoceratidae NEUMAYR, 1875

Subfamily Lytoceratinae
NEUMAYR, 1875

Genus *Lytoceras* SUESS, 1865

Type-species:— *Ammonites fimbriatus* SOWERBY, 1817 (I. C. Z. N. Opinion 130).

Lytoceras sp. A

Pl. 10, Figs. 2-3

1947. *Lytoceras* (*Thysanolytoceras* ?) sp.; MATSUMOTO *in* MATSUMOTO & ONO, *Sci. Rep. Fac. Sci., Kyushu Univ., Geol.*, vol. 2, no. 1, p. 25.
1956. *Lytoceras* sp.; ARKELL, Jurassic Geology of the World, Oliver & Boyd Ltd., p. 421.
1962. *Thysanolytoceras* sp.; SATO, *Mém. Soc. Géol. France*, no. 94, p. 58.

Material:—Eleven specimens GK. G. 2041-2044, 2049, 2051, 2061, 2064, 11331-11333.

Diagnosis:—A species of *Lytoceras* which has numerous fine ribs some of which are associated with less elevated crinkled riblets. Constrictions are indiscernible or hardly discenible. The umbilicus is usually wide proportionally to the diameter.

Description:—The whorls enlarge very rapidly or moderately but they are evolute. The whorl-section is elliptical and widest at the middle of the flank. The fine ribs spring at the umbilical seam and go on radially. They are mostly simple but sometimes bifurcation arises on the middle of the flank and intercalatory ribs are rarely present. There are some ribs in the interval of two crinkled riblets. The adoral margins of the crinkled riblets are accompanied by the ribs. Therefore the riblets are only crinkled adapically and their adoral margins are smooth. The crinkled riblets are not so elevated but as high as the ribs and wider than the ribs. In one specimen, GK. G. 11331, 6 weak spiral ribs are discernible in some part (40°).

Measurements:—

No.	D.	U.	U/D	H.	$Rn\frac{1}{2}$
GK. G. 2043	35.6	14.7	0.24	12.1	/
GK. G. 2051	32.1	14.0	0.44	10.3	ca. 63
GK. G. 2064	13.9	5.7	0.41	6.0	/

Comparison:—The present species is similar to *Lytoceras eudesianum* (D'ORBIGNY) (PUGIN, 1964, pp. 28-33) in the ornamentation, but the value of U/D is larger in the former than in the latter. The crinkled riblets of the former are more numerous than those of the latter.

I am observable only unfavourably preserved specimens, and the diagnostic characters are hot so well confirmed as comparable with that species. Therefore I treat the present specimens under *Lytoceras* sp. A.

Occurrence:—Loc. 9: 5, loc. 18E: 2, loc. 21: 1, loc. 22: 1, loc. 28″: 1, loc. 30: 1.

Lytoceras sp. B

Pl. 10, Fig. 4

Material:—One fragmentary specimen, GYU. M. 1019.

Description:—The whorls enlarge rapidly and the umbilicus is proportionally narrow, but are evolute. Three constrictions are visible in 100° of the preserved whorl and they are parallel to the ribs. The angles between the constrictions become small adorally and are 50° and 25°, though the data are poor to be generalized. Eight ribs are present in the earlier interval of 50° and four ribs in the later one of 25°. They are radial and mostly accompanied by the crinkled riblets, which are also radial. The ribs become fine adorally and the interspace become narrow adorally. Sometimes bifurcation arises on the ventral shoulder or at the umbilical periphery. Eleven crinkled riblets are present in the interval of 50° and five are in that of 25°. They are often accompanied by the ribs and therefore their adoral margins are smooth.

Measurements:—The preserved whorl: ca. 100°. The height of the last stage of the last whorl: ca. 23.

Comparison:—The present species is similar to *Lytoceras fimbriatus* (SOWERBY) (ARKELL et al., 1957, pp. L 194-196) in the mode of ribs, crinkled riblets and constrictions. The present species, however, enlarge more rapidly and has more numerous crinkled riblets than *L. fimbriatus* (SOWERBY).

The present species is distinguished from *Lytoceras* sp. A by its absence of constrictions or rarity of them. The whorls of the present species seems to enlarge more rapidly than those of *Lytoceras* sp. A.

As the present species is represented only by one fragmentary specimen, I treat it tentatively under *Lytoceras* sp. B.

Occurrence:—Loc. 18B: 1.

Family Nannolytoceratidae SPATH, 1927

Genus *Audaxlytoceras* FUCINI, 1923

Type-species:—*Lytoceras audax* MENEGHINI, 1881 (subsequently designated by ARKELL, 1957, p. L 199).

Audaxlytoceras ? sp.

Pl. 10, Fig. 9

1947. *Lytoceras* (*Thysanolytoceras* ?) sp.; MATSUMOTO *in* MATSUMOTO & ONO, *Sci. Rep. Fac. Sci., Kyushu Univ., Geol.*, vol. 2, no. 1, p. 25 (pars).

Material:—One fragmentary specimen, GK. G. 2059.

Description:—This specimen is very small. The whorls enlarge somewhat rapidly but they are little overlapping and the umbilicus is somewhat narrow. The umbilical periphery is abruptly rounded and the wall is steep. The surface of the whorl has no ribs but some constrictions, which are somewhat inclined backward on the umbilical wall, curve forward abruptly at the umbilical periphery, then go forward, and nearly at the middle of the flank moderately recurve backward. The angles between the constrictions become smaller in accordance with growth, ca. 55° at diameters from 11.9 to 12.7 mm., ca. 50° at diameters from 12.7 to ca. 14 mm. and ca. 30° at diameters from ca. 14 to ca. 15 mm. No other ornamentations are discernible on the surface of the whorls.

Measurements:—

No.	D.	U.	U/D	H.
GK. G. 2059	ca. 15	ca. 4	0.25	5.5

Comparison:—The present species is somewhat similar to *Audaxlytoceras dorcadis* MENEGHINI (MONESTIER, 1931, pp. 10-11), from south France, in the evolute and smooth shell with some constrictions. As far as the observable half a whorl is concerned, the frequency of the constrictions is nearly equal to each other. The former, however, is distinguished from the latter by the convex constrictions.

Occurrence:—Loc. 36 ?: 1.

Suborder Phylloceratina ARKELL, 1950

Superfamily Phyllocerataceae ZITTEL, 1884

Family Phylloceratidae ZITTEL, 1884

Subfamily Calliphylloceratinae SPATH, 1927

Genus *Calliphylloceras* SPATH, 1927

Type-species:—*Phylloceras disputabile* ZITTEL, 1869.

Calliphylloceras sp. A

Pl. 10, Figs. 5-6

1947. *Phylloceras* (*Calliphylloceras*) sp.; MATSUMOTO *in* MATSUMOTO & ONO, *Sci. Rep. Fac. Sci., Kyushu Univ., Geol.*, vol. 2, no. 1, p. 25.

1956. *Calliphylloceras* cf. *nilssoni* (HEBERT); ARKELL, Jurassic Geology of the World, Oliver & Boyd Ltd., p. 421.

1962. *Calliphylloceras* cf. *nilssoni* (HEBERT); SATO, *Mém. Soc. Géol. France*, no. 94. p. 58, [*sic*].

1963. *Calliphylloceras* sp.; TAKAI, MATSUMOTO & TORIYAMA ed., Geology of Japan, Univ. Tokyo Press, pp. 83-84.

Material:—Six specimens, GK. G. 2017, 2021, 2022, 2024, 2029, 2036.

Description:—The whorls enlarge rapidly and consequently the umbilicus is very narrow. They are involute. Numerous fine ribs are discernible on the whorls. They are parallel with constrictions. The constrictions are marked as furrows on the internal mould. They are nearly straight or concave adorally and somewhat prorsiradiate but the last one at the diameter of 35-56 mm. is very prorsiradiate. The angles between constrictions slightly decrease adorally. In one specimen, GK. G. 2029, the angles are 60°, 60° and 50° at the maximum diameter of 44.9 mm. In other specimen, GK. G. 2017, they are 60° and 50° of which the maximum diameter is ca. 56 mm. Often both sides of the furrows (=constrictions) are swollen as ridges. Suture is exposed at diameter 21 mm.

The first lateral lobe is narrow, deep and tripartite, and the second lateral lobe also is tripartite. The first lateral saddle seems to be triphyllic and the second lateral saddle is triphyllic.

Measurements:—

No.	D.	U.	H.	U/D
GK. G. 2021	35.8	ca. 6	ca. 19.8	ca. 0.17
GK. G. 2029	44.9	7.1	19.7	0.16

Comparison:—The present species is similar to *Calliphylloceras nilssoni* (HEBERT) (GÜRICH, 1933) in the mode of volution and constriction. The former, however, has a narrower first lateral lobe and simpler suture than the latter.

As the described specimens are too poorly preserved for exact comparison, for the time being I treat them as *Calliphylloceras* sp. A.

Occurrence:—Loc. 18: 3, loc. 53: 1, loc. 55: 1, unknown loc.: 1.

Calliphylloceras sp. B

Pl. 10, Fig. 7

Material:—Two specimens, GK. G. 11334, 11335.

Description:—The whorls enlarge rapidly and are involute. Consequently the umbilicus is very narrow. Venter is assumed to be rounded. Umbilical periphery is rounded and the wall is rather steep. Numerous fine lirae are discernible on the surface of the shell. They are fine, nearly straight and somewhat prorsiradiate. Constrictions are very weak and obscure. They are parallel with the fine ribs. In one specimen, GK. G. 11335, an angle between constrictions is ca. 40°, in the stage a half whorl younger than that with diameter of 78 mm. Suture lines are partly visible. Lateral saddle seems to be triphyllic but the details of the suture are unknown.

Measurements:—

No.	D.	U.	H.	U/D
GK. G. 11334	ca. 71	ca. 6	ca. 41	0. 09
GK. G. 11335	ca. 89	ca. 9	ca. 48	0. 10

Comparison:—The present species is similar to *Calliphylloceras* sp. A in the mode of volution, but is distinguished by the straight fine ribs and much weaker constrictions.

Calliphylloceras nilssoni (HEBERT) has nearly straight but stronger constrictions than the present species.

As the present species is represented only by two fragmentary specimen, I treat it tentatively under *Calliphylloceras* sp. B.

Occurrence:—Loc. 4: 1, loc. 27: 1.

Genus *Holcophylloceras* SPATH, 1927

Type-species:—*Phylloceras mediterraneum* NEUMAYR, 1871.

Holcophylloceras sp.

Pl. 10, Fig. 8

1947. *Phylloceras* (*Holcophylloceras*) sp.; MATSUMOTO *in* MATSUMOTO & ONO, *Sci. Rep. Fac. Sci., Kyushu Univ., Geol.*, vol. 2, no. 1, p. 25.
1956. *Holcophylloceras* sp.; ARKELL, Jurassic Geology of the World, Oliver & Boyd Ltd., p. 421.
1962. *Holcophylloceras* sp.; SATO, *Mém. Soc. Géol. France*, no. 94, p. 58.
1963. *Holcophylloceras polyolcum* (BENECKE); TAKAI, MATSUMOTO & TORIYAMA ed., Geology of Japan, Univ., Tokyo Press, p. 83.

Material:—A specimen, GK. G. 2016.

Description:—The whorls enlarge rapidly and are involute. The umbilicus is very narrow. Low ribs are present on the outer half of the whorl. They are weak and parallel with constrictions. Six constrictions are present on the preserved 150° of the last whorl, of which two are comparatively clearer and are moderately biconcave. They start from the umbilical seam and proceed adapically. At about inner one-third of the flank, they curve adorally and run straightly. They recurve adapically again at about outer one-third of the flank and furthermore they curve adorally near the venter. Two constrictions are visible as furrows and their adoral side or adapical side is swollen. Four constrictions are incompletely preserved and are manifested as ridges.

Measurements:—

Height of the whorl of the preserved last stage: 69.3 mm.

Comparison:—The present species is similar to *Holcophylloceras* aff. *polyolcum* (BENECKE) (SPATH, 1927, pp. 60-63), from Cutch, and *Holcophylloceras mediterraneum* (NEUMAYR) (SPATH, 1927, pp. 58-60), from Cutch, in the mode of volution, ribs and the abundance of constrictions, but is distinguished by its gentle curvature of constrictions.

The present species resembles *Holcophylloceras guettardi* (RASPALL) (ARKELL et al., 1957, p. L 190), from France, but the constrictions occur more frequently and curve more strongly in the former than in the latter.

Occurrence:—Loc. 59: 1.

Family Juraphyllitidae ARKELL, 1950

Genus *Harpophylloceras* SPATH, 1927

Type-species:—*Ammonites eximius* HAUER, 1854

Harpophylloceras ? sp.

Pl. 10, Fig. 1

1947. *Rhacophyllites* (*Harpophylloceras* ?) sp.; MATSUMOTO *in* MATSUMOTO & ONO, *Sci. Rep. Fac. Sci., Kyushu Univ., Geol.*, vol. 2, no. 1, p. 25.

1956. *Juraphyllites* sp.; ARKELL, Jurassic Geology of the World, Oliver & Boyd Ltd., p. 421.

1962. *Juraphyllites* sp.; SATO, *Mém, Soc. Géol. France*, no. 94, p. 58.

1963. *Juraphyllites* sp.; TAKAI, MATSUMOTO & TORIYAMA ed., Geology of Japan, Univ. Tokyo Press, p. 84.

Material:—A small specimen, GK. G. 2020.

Description:—The whorls enlarge rapidly and are involute. Consequently the umbilicus is narrow. The ventral shoulder is rounded, the flank is convex and the umbilical periphery is rounded. Therefore the whorl-section is assumed to be elliptical. The venter has a thin and low keel. A sulcus is not present. The surface of the shell seems to be ornamented with numerous and radial fine ribs. The fine ribs, however, are obscure because of the unfavourable preservation. Two constrictions are nearly straight and rectiradiate. Lateral saddle of the suture is diphyllic.

Measurements:—

No.	D.	U.	H.	U/D
GK. G. 2020	12.9	2.8	6.0	0.22

Comparison:—The present species is similar to *Harpophylloceras eximium* (HAUER) (ARKELL, 1957, p. L 191) in the mode of constrictions. The degree of involution of the former seems to resemble that of the latter, but this is compared between specimen of dissimilar size.

As only a small, unfavourably preserved specimen is at my disposal, more detailed comparison is impossible.

Occurrence:—Loc. 52: 1.

Zonation and correlation

A. *General*

Ammonoid fossils are very abundant in the Nishinakayama Formation, less abundant in the Utano Formation and rare in the Higashinagano Formation. The Higashinagano Formation is incompetent, the Utano Formation is difficult for precise zoning because of a small number of specimens and only the Nishinakayama Formation is competent for reliable zoning. 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 but that in the southern part is revised (Fig. 4). The stratigraphic and geographic distributions of ammonites and some other characteristic fossils are mentioned below in ascending order. The stratigraphic position of each fossil locality is shown in the columns (Fig. 2 in Part II).

The correlation between two regions should originally be done by the same species in strict sence but the same species is rare between the Toyora and the standard area of Europe. Therefore I use the similar species to the Toyora species and the ammonoid assemblages for the correlation in this article.

The geographic variation is only able to discuss based upon the study of variation in each population. No one has studied on the variation of ammonoids in the standpoint of population concept since the description of ammonoid species began. Therefore today no one can distinguish or identify logically a Japanese ammonite from or as a European one. Above all the variation of a local population should be clarified. I could clarify the variation of the number of ribs in some species but I could not treat other characters because of the unfavourable preservation of the material. Therefore the contents described and discussed in this article are the record of the characteristics based upon the appearance of material. At first study of ammonites in the standpoint of population concept should be done by the use of the favourably preserved material (In Japan favourably preserved material cannot be obtained).

B. *The Higashinagano Formation*

No ammonites were collected from the Member Nbc and only *Pentacrinus* sp. was collected from its upper part. Accordingly the age of the Member Nbc is not precisely determined. The sedimentary features suggest that it did not take so long time for the deposition of this member and therefore its geological age may be close to the superjacent Member Ncs.

Various kinds of bivalves, gastropods, scaphopods, ammonoids, brachiopods, corals and crinoids have been reported. Bivalvia and gastropods from Member Ncs were described by HAYAMI, who named them as *Cardinia toriyamai* faunule (1958, 1959, 1960a, 1961, 1962). As to the ammonoids *Arietites* sp. and *Harpophylloceras*? sp. have been obtained from this member. The corals are *Chomatoseris cyclolitoides* (YABE & EGUCHI, 1933) and an isastraeid, and the crinoid is *Pentacrinus* sp. (HAYAMI, 1961). As regards the age, it is said that several pelecypods are identical with or closely related to some Liassic (properly lower Liassic) species hitherto known in Europe, northern Africa or Canada and that no Triassic (inclusive of Rhaetic) element is found in the fauna (HAYAMI, 1959, p. 37). On the basis of *Arietites* sp. I regard this member as lower Sinemurian.

The geological age of the Member Nss varies from place to place. At Higashinakayama, the age is referred to lower Domerian by the occurrence of *Amaltheus* sp. cf. *A. stokesi* and *Arieticeras* sp. aff.

A. apertum (Fig. 2d in Part II). In the northern area, *e.g.*, Higashinagano and Sakuraguchi-dani, the age of this member is considered at least in part as upper Sinemurian, because a Domerian ammonoid is known from the basal part of the Member Nm and a lower Sinemurian ammonoid is known from the lower part of the Member Ncs.

The age of the Member Nsh varies locally. In the northern area, e.g., Higashinagano and Sakuraguchi-dani, this member is assumed to be uppermost Sinemurian stage. At Nishinakayama-Higashinakayama district, not only the Nsh but also the lower part of the Nss is referred to Domerian substage. No fossil indicating an Carixian age has been obtained. The sediments of this age is regarded to have been eroded away, because there is conglomerate at the base of the Nishinakayama Formation in the southern district.

C. *The Nishinakayama Formation*

Various kinds of ammonoids have been obtained from the Member Nm and partly from Member Na and Nss at about fifty localities. Zonal frame is established in the sequence along the Sakuraguchi-dani (Fig. 2a in Part II, Fig. 1) and three zones are confirmed by the supplementary sequence along the Kogo-dani (Fig. 2c in Part II), the Anda-dani (Fig. 2b in Part II), the River Era, the River Motoyoku and the River Sakota. The three zones are discernible in the northern two-thirds of the studied area.

They are the *Fontanelliceras fontanellense* Zone, the *Protogrammoceras nipponicum* Zone and the *Dactylioceras helianthoides* Zone in ascending order as mentioned below.

Fontanelliceras fontanellense Zone: This zone is represented by *Fontanelliceras fontanellense* and about 25 to 50 m. in thickness. In addition, *Canavaria japonica*, *C.* cf. *sicula*, *Arieticeras* cf. *pseudocanavarii*, *A.* aff. *apertum*, *Paltarpites toyoranus*, *P. paltus*, *P.* aff. *platypleurus*, *Fuciniceras primordium*, *F.* cf. *normanianum*, *Dactylioceras helianthoides* *D.* (*Prodactylioceras*) aff. *italicum*, *Amaltheus* cf. *stokesi* and *Calliphylloceras* sp. A are found from this zone. The lower boundary of this zone is marked by the appearances of *Amaltheus*, *Arieticeras*, *Canavaria* and/or *D.* (*Prodactylioceras*) and is in oblique relation with lithostratigraphic unit (Fig. 4). The index, the first four genera and *Amaltheus* are known as the indices of Domerian substage. *Fuciniceras* is usually known in Domerian substage and questionably in Whitbian substage (ARKELL, 1957, p. L 258). *Dactylioceras* has so far been known in Toarcian and *Calliphylloceras* from lower Jurassic to lower Cretaceous. Accordingly, it can be said that the assemblage of this zone indicates Domerian age, and more detailed discussion is mentioned below.

Fontanelliceras fontanellense is known from MONESTIER's subzone c (=the *Gibbosus* Subzone, DEAN et al., 1961) in Aveyron (MONESTIER, 1934) and known from the equivalent of the *Spinatum* zone in Alta Brianza (VENZO, 1952). *Arieticeras pseudocanavarii* and *A. apertum* are known from MONESTIER's subzone c (=the *Gibbosus* Subzone, DEAN et al., 1961) in Aveyron (MONESTIER, 1934). A species is comparable with *Amaltheus stokesi*, which is the index of the lowest subzone of the *Margaritatus* Zone. A species is comparable with *Fuciniceras normanianum*, which is known from the *Davoei* Zone to the *Margaritatus* Zone in Haut Atlas (DRESNAY, 1963), from equivalent of the lower *Margaritatus* Zone in Huescar (DUBAR et al., 1967) and from the *Stokesi* Zone

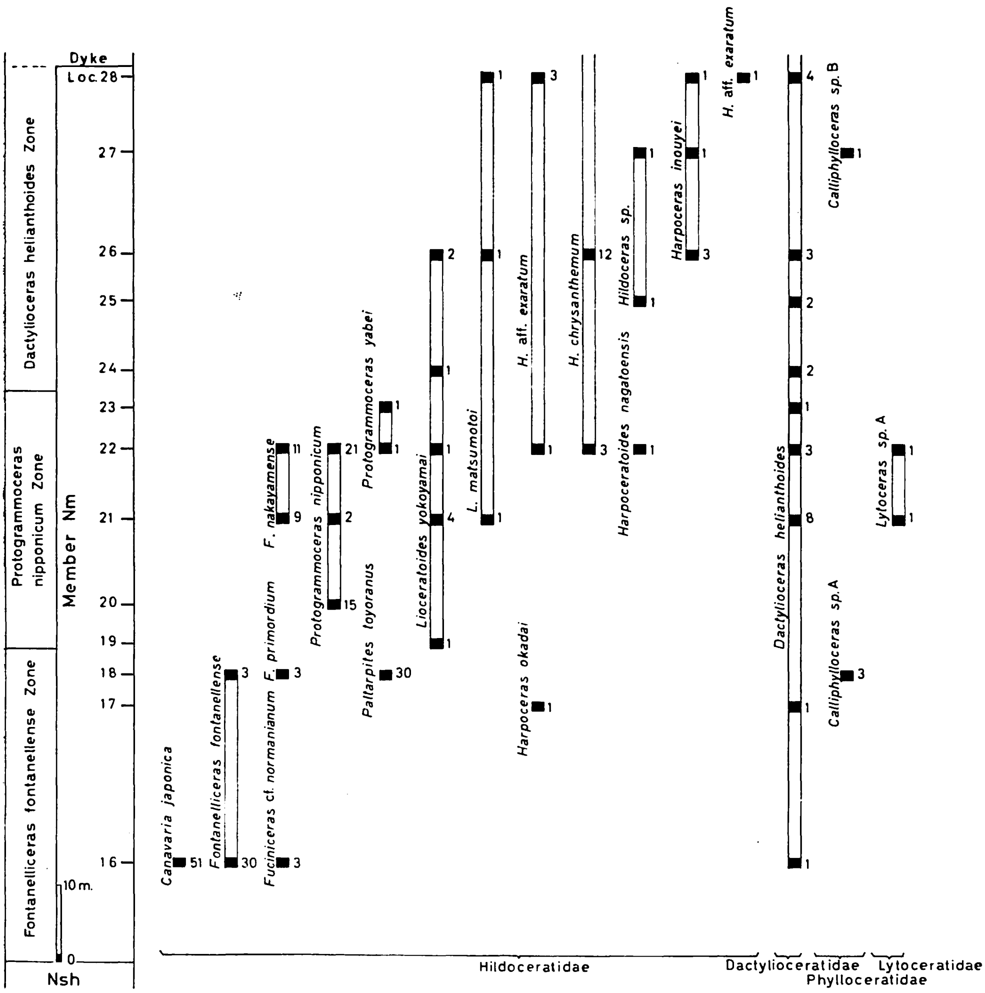


Fig. 1. The zonal framework founded on the sequence in the Sakuraguchidani. A black square corresponds to the locality number in the left side, which refers to the number in systematic description. The number beside the black square indicates the number of individuals.

(GECZI, 1970) in Hungary. A species is very similar to *Dactylioceras* (*Prodactylioceras*) *italicum*, which is known from the equivalent of the *Subnodosus* Subzone in Aveyron (MONESTIER, 1934) and from the *Davoei* Zone in Hungary (GECZI, 1970).

On the basis of these correlation, the *Fontanelliceras fontanellense* Zone is nearly correlated with the *Margaritatus* Zone and a part of the *Spinatum* Zone. The basal part may be correlated with the base of the *Stokesi* Subzone and its upper part may be correlated with the lower *Spinatum* Zone.

Protogrammoceras nipponicum Zone: This zone is represented by *Protogrammoceras nipponicum* and about 50 m. in thickness. *Protogrammoceras onoi, P. yabei, Lioceratoides yokoyamai, L. matsumotoi, Harpoceras chrysanthemum, H. okadai, H.* aff. *exaratum, H. (Harpoceratoides) nagatoensis, Fuciniceras nakayamense, Dactylioceras helianthoides, D.* cf. *helianthoides, Lytoceras* sp. A, *L.* sp. B and *Calliphylloceras* sp. B are obtained from this zone. *Protogrammoceras, Fuciniceras, Dactylioceras* and *Lioceratoides* are known in upper Pliensbachian and the first three genera are known also in lower Toarcian. *Harpoceras* and *Harpoceratoides* are known only in lower Toarcian. *Lytoceras* and *Calliphylloceras* are known not only in the lower Jurassic but also in the lower Cretaceous. It can be roughly said that this zone indicates from the upper part of Domerian to the lower part of Whitbian. The more detailed correlation is discussed below

Protogrammoceras is known from the *Stokesi* Subzone and the *Subnodosus* Subzone in Aveyron (DEAN et al., 1961). *Protogrammoceras nipponicum*, the index of this zone, is very similar to *P. celebratum, P. marianii* and *P. bonarellii* (see the description). *P. celebratum, P. marianii* and *P. bonarellii* are known from Alta Brianza with *Amaltheus margaritatus* (VENZO, 1952) and *P. celebratum* is the index of the *Margaritatus* Zone in south Europe. In Portugal, *Protogrammoceras* is mainly known from lower Domerian. *P. bonarellii* is commonly known and

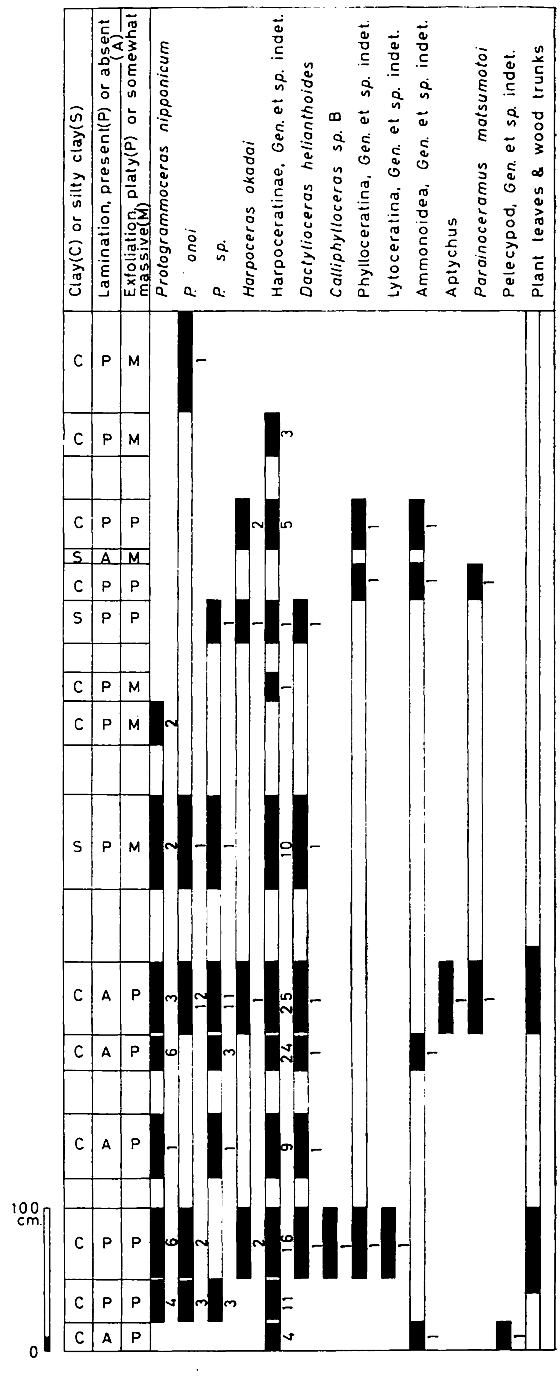


Fig. 2. The detailed mode of occurrence of fossils and lithofacies observed at the river mouth of the Motoyoku (loc. 4). The black square indicates the part which each fossil occurred. The number beside the black square indicates the number of individuals.

restricted in the *Margaritatus* Zone in Portugal (MOUTERDE, 1967). *P. celebratum* and *P. bonarellii* are known from the *Stokesi* Zone in Hungary (GECZI, 1970). *P.* cf. *nipponicum* is known with *H.* (*Harpoceratoides*) cf. *contectens*, Cf. *Canavaria excellens*, *C.* cf. *morosa*, Cf. *P. bonarellii*, *P.* cf. *marianii*, *Arieticeras* cf. *domarense*, Cf *A. algovianum*, *Liparoceras* cf. *bechei* and *Leptaleoceras dickinsoni* in Oregon (IMLAY, 1968).

Fuciniceras is known from the *Stokesi* and the *Subnodosus* Subzone in Aveyron (DEAN et al., 1961). *Fuciniceras nakayamense* is abundant only in the *P. nipponicum* Zone and is also the useful index of the zone. *F. nakayamense* is similar to *F. boscense* and *F. falciplicatum* and a little to *F. lavinianum* (see the description). *F. lavinianum* is known from the lowermost part of Domerian in Huescar, Spain (DUBAR et al., 1967). *F. falciplicatvm* is known from the *Stokesi* Subzone in Hungary (GECZI, 1970). *F. boscense* is known from the *Margaritatus* Zone in Aveyron (MONESTIER, 1934).

As mentioned above, the foreign species to which the two species, *P. nippnicum* and *F. nakayamense*, are similar are known in lower Domerian. At the same time, however, Toarcian genera such as *Harpoceras* and *Dactylioceras* are commonly known in this zone. *Harpoceras* is the characteristic genus of the *Falcifer* Zone in Europe (DEAN et al., 1961). *Dactylioceras helianthoides* is similar to *D. crassiusculosum* and *D. gracile*, which are known from the *Bifrons* Zone in Aveyron (MONESTIER, 1931).

I think the *Protogrammoceras nipponicum* Zone could be correlated with the age from upper Domerian (the *Spinatum* Zone) to lower Whitbian (the *Falcifer* Zone) on the basis of these comparison.

Dactylioceras helianthoides Zone: This zone is characterized by the abundance of *Dactylioceras helianthoides*, *Harpoceras chrysanthemum* and *H. inouyei*, and the lower boundary being drawn immediately above the disappearances of *Protogrammoceras* and *Fuciniceras*. The upper boundary is drawn just below the Member Na. *Harpoceras chrysanthemum* and *H. inouyei* appear from the uppermost part of the *P. nipponicum* Zone but the occurrences in the part are very rare and usually appear after the disppearances of *Protogrammoceras* and *Fuciniceras*. *H.* cf. *mulgravium*, *H.* cf. *exaratum*, *L. yokoyamai*, *L. matsumotoi*, *Hildoceras* sp., *Peronoceras subfibulatum* and *Calliphylloceras* sp. B are known in this zone.

Harpoceras, *Hildoceras*, *Peronoceras* and *Dactylioceras* (s. str.) are known as the lower Toarcian genera (ARKELL, 1957) and *Harpoceras* is the characteristic genus of the *Falcifer* Zone (DEAN et al., 1961). *Hildoceras* is known from the *Bifrons* Zone. *Peronoceras subfibulatum* is similar to *P. fibulatum*, which is the index of the *Fibulatum* subzone. No species which indicate the age later than the *Fibulatum* subzone are known from this zone and therefore I think the uppermost part of this zone is correlated with a part of the *Fibulatum* Zone. The basal part of the *D. helianthoides* Zone is not clearly and precisely correlated with the European standard. No parts of this zone and the *P. nipponicum* Zone could be correlated with the standard *Tenuicostatum* Zone. The basal part of the zone could be correlated with a part of the *Exaratum* Subzone in consideration of the assemblage as mentioned above.

Dactylioceras helianthoides sporadically occurs in the Member Na. This member is assumed to be Whitbian considering the occurrence of *D. helianthoides* and

Table 1. Range chart of Domerian and Whitbian ammonite species in the Toyora Group and zonal correlation with the European standard zones and subzones.

Substage	Domerian					Whitbian						?
European Standard Zone	*Margaritatus*		*Spinatum*			*Tenuicostatum*	*Falcifer*		*Bifrons*			*Variabilis*
Subzone	*Stokesi*	*Subnodosus*	*Gibbosus*	*Apyrenum*	*Hawskerense*		*Exaratum*	*Falcifer*	*Commune*	*Fibulatum*	*Braunianus*	

Species	*F. fontanellense* Zone	*P. nipponicum* Zone	*D. helianthoides* Zone	Na	Up
Amaltheus cf. *stokesi*	—				
Arieticeras cf. *pseudocanavarii*	—				
A. aff. *apertum*	—				
Canavaria japonica	—				
C. cf. *sicula*	—				
Fontanelliceras fontanellense	—				
Paltarpites toyoranus	—				
P. paltus	—				
P. aff. *platypleurus*	—				
Fuciniceras primordium	—				
F. nakayamense		—			
F. cf. *normanianum*	—				
Protogrammoceras nipponicum		—			
P. yabei		—			
P. onoi		—			
Lioceratoides yokoyamai		—	—		
L. matsumotoi		—	—		
Harpoceras okadai	—	—	—		
H. cf. *exaratum*		—	—		
H. chrysanthemum		—	—		
H. inouyei		—	—		
H. cf. *mulgravium*			—		
H. (*Harpoceratoides*) *nagatoensis*		—			
Hildoceras sp.			—		
Dactylioceras (*Prodactylioceras*) aff. *italicum*	—				
D. (s. s.) *halianthoides*	—	—	—	—	
D. cf. *helianthoides*					
Peronoceras subfibulatum			—		

the ammonite assemblage of the overlaying Member Up. These discussions on correlation are concisely shown as a range chart in Table 1.

D. *The Utano Formation*

Pseudolioceras sp., *Grammoceras* aff. *obesum*, *Phymatoceras toyoranum*, *Calliphylloceras* sp. A and *Bositra* sp. are known from the Member Up. The lower limit of the *Variabilis* Zone is defined by the appearance of Phymatoceratinae in abundance and the upper limit is drawn immediately below the first occurrence of *Grammoceras* (DEAN et al., 1961). The lower limit of the *Thouarsense* Zone is defined by the sudden appearance of *Grammoceras* and the upper boundary is marked by the appearance of *Phlyseogrammoceras*. In Toyora, *Grammoceras* and *Phymatoceras* appear simultaneously. The Member Up could be roughly correlated with the *Variabilis* and the *Thouarsense* Zones considering the above mentioned ammonites assemblage.

Phymatoceras sp. is known from the Member Ub and its age is considered to be Yeovilian.

Planammatoceras cf. *kitakamiense*, *Dumortieria* ? sp. and *Calliphylloceras* sp. A are known from the Member Uh. In addition to the discrepancy of appearance and disappearance of genera between Toyora and Europe, the contents of ammonite assemblages in the Utano Formation, especially in upper part than the Member Up, is poor. Consequently the correlation in zonal level is unable to be done. The age of the Member Uh may be referred to a part of Yeovilian and a part of lower Bajocian (s. l.). The discussions on correlation of this group with European standard mentioned above are concisely shown in Fig. 3.

Harpophylloceras sp. and *Inoceramus*

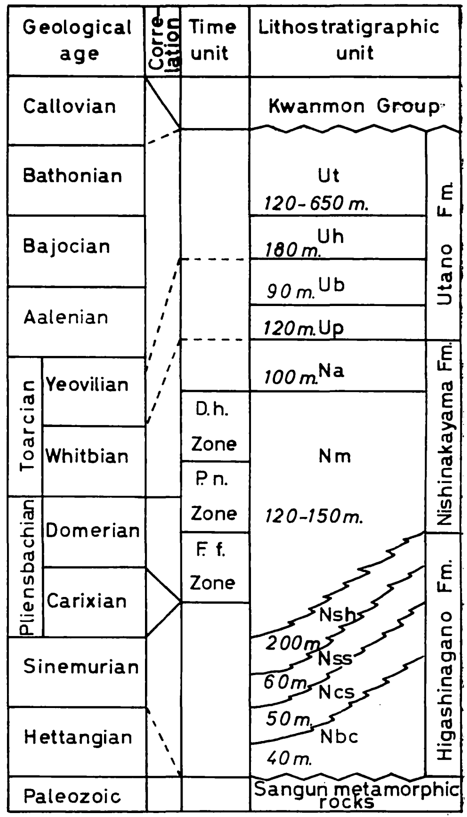


Fig. 3. Modified stratigraphic sequence of the Toyora Group and its correlation with international stage and substage.

utanoensis are known in the upper horion of the Member Ut. It is said that *I. utanoensis* is very similar to Bathonian *I. kystatymensis* KOSCHELKINA, 1960 (HAYAMI, 1962). I also think that *I. utanoensis* KOBAYASHI, 1926 is hardly distinguishable from *Retroceramus kystatymensis* from the Bathonian of east Siberia (KOSCHELKINA, 1963, pp. 150-151). This member is supposed to be Bathonian by this fact, but the accurate age of the top of this member is not determinable.

Characteristics of the Toyora faunas

A. *Assemblage*

Ammonite fossils are rich in the middleform ation and partly common in the upper formation. The middle and the upper formations are somewhat monotonous black shale without any abrupt change of lithofacies and biofacies.

Among various ammonoid species of the Toyora faunas, *Dactylioceras helianthoides* shows the longest vertical range and is accompanied by many species of Domerian and Whitbian.

Protogrammoceras nipponicum is rarely accompanied by *P. onoi* and the ratio of the numbers between them is 1:4 to 1:2 except the lowest part at the studied outcrop (Fig. 2). *P. yabei* is accompanied by *P. nipponicum*, but the number of individuals of the former is always small.

Canavaria japonica coexists with *Fontanelliceras fontanellense*, and both are large in the number of individuals (e. g., 51 of *C. japonica*, 30 of *F. fontanellense*).

Fuciniceras nakayamense coexists with *P. nipponicum* and both are large in the number of individuals (e. g., 11 of *F. nakayamense*, 21 of *P. nipponicum*).

Generally speaking, in a bed with *Canavaria*, *Fontanelliceras* and *Fuciniceras*, also *Arieticeras* occurs commonly in many parts of the world. For some reasons *Arieticeras* is poor in the Toyora Group. *Harpoceras* has hitherto been known as a lower Toarcian genus but *Harpoceras okadai* occurs with some Domerian species.

B. *Comparison with other faunas of Japan*

The Liassic ammonoids are known from the Shizukawa Group of northeast Japan and the Kuruma Group of central Japan. In the Shizukawa Group no Pliensbachian ammonoids are known and the Toarcian is indicated by *Harpoceras okadai*, *Hosoureites ikianus*, *Grammoceras* sp. and *Phymatoceras* sp. (SATO, 1956, 1962; TAKAHASHI, 1969). *Harpoceras*, *Grammoceras* and *Phymatoceras* are genera occurring in the Toyora fauna, but as regards the specific rank only *Harpoceras okadai* is common to the Toyora fauna. In the Bajocian Member Hh of the Shizukawa Group, *Planammatoceras kitakamiense* (SATO) is known and a comparable species is known in the Member Uh of the Utano Formation.

From the Kuruma Group, *Amaltheus* sp. and *Canavaria* sp. are known as Pliensbachian ammonoid. Toarcian is indicated by only *Grammoceras* sp. (KOBAYASHI et al., 1957). The Toyora ammonoid faunas are characterized and distinguished by the eminent Mediterranean elements in the Domerian substage from other fauna in Japan. The common ammonoid species are very rare between the Toyora faunas and other faunas of Japan for some reasons. Palaeogeography, palaeocurrent and faunal province were discussed in detail by SATO (1956, 1960). *Amaltheus* from the Toyora Group is newly described and therefore the palaeocurrent drawn by SATO (1960) should be partly revised, if palaeocurrent was really the principal factor to control the distribution of ammonite fauna.

C. *Comparison with some faunas of other regions*

C-1. *The Toyora fauna in Domerian substage*

From the Nishinakayama Formation the following 20 species of 11 genera are ascribed to Domerian substage. *Arieticeras* cf. *pseudocanavarii*, *A.* aff. *apertum*, *Canavaria japonica*, *C.* cf. *sicula*, *Fontanelliceras fontanellense*, *Paltarpites toyoranus*, *P. paltus*, *P.* aff. *platypleurus*, *Lioceratoides yokoyamai*, *L. matsumotoi*, *Fuciniceras primordium*, *F. nakayamense*, *F.* cf. *normanianum*, *Protogrammoceras nipponicum*, *P. yabei*, *P. onoi*, *Harpoceras okadai*, *Amaltheus* cf. *stokesi*, *Dactylioceras helianthoides*, *D.* (*Prodactylioceras*) aff. *italicum*. This assemblage is characterized by the predominance of Hildoceratidae in both number of species and that of specimens. The fauna is characterized by the Tethyan elements, namely most of the species have close affinities to the species of the Tethyan Realm as mentioned in the description. According to HALLAM (1969), the northern boundary of the Tethyan Realm is roughly corresponds to the line from the Alpine fold belt, via eastern Siberia and Japan to northern California. The cause of the separation of ammonite faunas between the Tethyan and the Boreal Realm has not been clarified, though some speculations and regional studies have been done by many students. I list up upper Pliensbachian ammonite genera from the world, paying attention to localities of the Mediterranean region and compare them with the Toyora fauna concerning the similarity by the method of SIMPSON's formula: $\frac{2C}{N1+N2}$ 100 (N1≦N2, Number of genera of each fauna; C, number of common genera in two faunas).

The computed result (Table 2) indicates that the Toyora fauna has a similarity in the highest degree to the Taormina fauna of Sicily Is. On the other hand, the Taormina fauna has similarity to the Toyora fauna in higher degree than to any other faunas. Huescar fauna in Spain is the second and S. Pedro fauna in Portugal is the third in the degree of similarity to the Toyora fauna. These are said to be representative faunas in the Tethyan faunal

Table 2. Faunal resemblance in Domerian.

$\frac{2 \cdot C}{N1+N2} \cdot 100$	Number of genera	Yorkshir Coast	Dorset Coast	Hebrides	Alta Brianza	Brescia	Mt. di Cetona	Taormina	Aveyron	Huescar	S. Pedro	Haut Atlas	E. Oregon	Br. Columbia & s. Yukon	Toyora
Yorkshire Coast	6														
Dorset Coast	9	40													
Hebrides	3	67	50												
Alta Brianza	14	30	17	0											
Brescia	12	56	29	27	56										
Monte di Cetona	7	15	13	0	40	42									
Taormina	8	43	12	0	57	50	27								
Aveyron	9	40	33	0	55	57	63	47							
Huescar	11	47	30	14	50	61	44	53	60						
S.Pedro	18	42	30	19	45	53	40	38	52	76					
Haut Atlas	7	46	25	20	30	42	43	53	50	33	48				
E. Oregon	19	24	36	0	56	45	38	52	57	53	49	46			
Br. Columbia & s. Yukon	8	43	47	36	19	20	13	25	35	42	38	53	31		
Toyora	11	47	30	14	58	52	33	74	60	64	62	56	48	53	

province of Domerian substage. On the contrary, in Yorkshire Coast, Dorset Coast and Hebrides Is. the diversities of their faunas are low, and also the degrees of similarity to the Toyora are low, though Yorkshire Coast fauna is somewhat higher than the other two.

Recently, as to the upper Pliensbachian faunas of North America, some studies have been published. Among them eastern Oregon fauna (IMLAY, 1968) shows some affinity with the Toyora fauna, and some species are actually compared with the Toyora species. In the present quantitative treatment, however, the eastern Oregon fauna does not indicate high similarity to the Toyora fauna. The eastern Oregon fauna, however, has higher similarities to the Aveyron, Alta Brianza and Huescar faunas. It is caused by the higher diversity of eastern Oregon fauna than the Toyora fauna. The British Columbia to southern Yukon fauna (FREBOLD, 1970) has some affinity with the Toyora fauna, though it has not high diversity and has some boreal elements. The British Columbia to southern Yukon fauna shows a high similarity to the Bou-Rharraf fauna in Haut Atlas at the same time.

There are various degrees of difference among the faunas of the Tethyan Realm and a certain fauna is not always similar to others. The difference is assumed to be caused by difference of local condition besides palaeogeographical circumstances. Therefore I researched the lithography of the localities in order to know a part of difference of local condition. In general survey, calcareous sediments such as limestone, marl and marly limestone are rich in the Tethyan faunal Realm as HALLAM (1969) noted. As to Toyora, eastern Oregon and British Columbia to southern Yukon, however, calcareous matter is rare or absent and clastics predominate. Some taxa which occur exclusively in non-calcareous strata in the Tethyan faunal Realm are some Liparoceratidae (e. g., *Liparoceras, Becheiceras, Metacymbites*), Harpoceratinae (*Fanninoceras, Whitbyiceras*), Arieticeratinae (*Leptaleoceras*) and Phylloceratidae (*Tragophylloceras*-with question, *Holcophylloceras*).

These data of faunas outside Japan are based on the following references.

For the Brescia fauna BETTONI (1900), the Haut Atlas oriental fauna DRESNAY (1963), Huescar fauna DUBAR et al. (1967), British Columbia to southern Yukon fauna FREBOLD (1970). Monte di Cetona fauna FUCINI (1901, 1902), Taormina fauna FUCINI (1923-28). Yorkshire fauna HOWARTH (1955), Hebrides Is. fauna HOWARTH (1957), eastern Oregon fauna IMLAY (1968), Aveyron fauna MONESTIER (1934), S. Pedro fauna MOUTERDE (1967) and for the Alta Brianza fauna VENZO (1952).

C-2. *The Toyora fauna in Whitbian substage*

In the Toyora Group the following 15 species of 7 genera are assigned to the Whitbian assemblage. *Dactylioceras helianthoides, D.* cf. *helianthoides, Peronoceras subfibulatum, Harpoceras chrysanthemum, H. inouyei, H. okadai, H.* aff. *mulgravium, H.* aff. *exaratum, Harpoceratoides nagatoensis, Hildoceras* sp., *Protogrammoceras nipponicum, P. yabei, P. onoi, Lioceratoides yokoyamai* and *L. matsumotoi*.

This fauna shows remarkably high similarities to the Alta Brianza fauna, the Pyrenees fauna and the eastern part of the Paris Basin fauna (Table 3). The Alta Brianza fauna shows the highest similarity to the Valdorbia fauna, the Pyrenees fauna and the eastern part of the Paris Basin fauna. Alta Brianza and Valdorbia are in the Mediterranean region but the other two are not. The Alta Brianza fauna, however, shows a considerably high similarity with the eastern part of the Paris Basin fauna. The Toyora fauna shows somewhat high similarities to the Dorset-Somerset fauna, the Tage fauna, the eastern Caucasus fauna and the northern Alaska

Table 3. Faunal resemblance in Whitbian. *Harpoceratoides* is treated being independent of *Harpoceras* (Tables 3-4).

$\frac{2 \cdot C}{N_1+N_2} \cdot 100$	Number of genera	Dorset-Somerset	Northants	Alta Brianza	Valdorbia(Umbria)	E. Paris Basin	Tage	Pyrenees	Jura Mts.	E. Caucasus	E. Oregon	Br. Columbia, Alberta& s. Yukon	N. Alaska	C. Arabia	Madagascar	Toyora
Dorset-Somerset	3															
Northants	7	60														
Alta Brianza	8	55	67													
Valdorbia(Umbria)	8	55	53	75												
E. Paris Basin	5	75	67	62	77											
Tage	12	40	53	60	50	59										
Pyrenees	5	75	50	62	77	80	47									
Jura Mts.	3	67	40	36	55	75	40	75								
E. Caucasus	3	67	60	55	55	75	40	50	33							
E. Oregon	10	31	24	33	22	27	55	27	15	15						
Br. Columbia, Alberta& s. Yukon	2	40	44	40	40	57	29	29	0	80	17					
N. Alaska	3	100	60	55	55	75	40	75	67	67	31	40				
C. Arabia	4	0	0	0	0	0	25	0	0	0	14	0	0			
Madagascar	4	29	18	17	17	22	25	22	0	29	29	33	29	75		
Toyora	7	60	57	67	53	67	63	67	40	60	59	44	60	18	36	

fauna. The Dorset-Somerset fauna shows the highest similarity to the northern Alaska fauna and a somewhat high similarity to the eastern Caucasus fauna but a low similarity to the Tage fauna. The eastern Caucasus fauna shows a high similarity to the British Columbia fauna, but the British Columbia fauna shows a low similarity to the northern Alaska fauna. The Jebel Tuwaiq and the Madagascar faunas are peculiar and do not seem to have similarities to the Toyora fauna, as far as the available evidence is concerned. Hammatoceratidae and Bouleiceratidae are regarded as the Tethyan elements by HALLAM (1969), but *Bouleiceras* is restricted to Jebel Tuwaiq, Madagascar, related areas and is unknown from the western Mediterranean region. On the contrary genera of Hammatoceratidae are known as north as the Paris Basin and Britain, and their distribution is wide. A few ammonites of Hammatoceratidae occur in the Toyora fauna but it is difficult to say that they are of the Tethyan Realm. In Europe, high similarity is shown between two adjacent faunas and the longer the distance, the lower the similarity (e.g., Dorset-E. Paris Basin-Jura Mts., Dorset-E. Paris Basin-Pyrenees-Alta Brianza-Valdorbia-Tage). In comparison with the Domerian ones the Whitbian faunas show higher similarity between the provinces.

The above data of the faunas outside Japan are based on the following references.

For the Dorset-Somerset fauna ARKELL (1933), Jebel Tuwaiq fauna ARKELL et al. (1952), Northants fauna ARKELL (1933), eastern Caucasus, east of the Paris Basin, Jura Mts., Madagascar and Pyrenees faunas ARKELL (1956), Valdorbia fauna DONOVAN (1958), British Columbia, Alberta and southern Yukon fauna FREBOLD (1970), northern Alaska fauna IMLAY (1955), eastern Oregon and California IMLAY (1968) and for the Alta Brianza fauna VENZO (1952).

C-3. *The Toyora fauna in Yeovilian substage*

The Toyora fauna shows the highest similarity to the eastern Caucasus fauna and low similarities to other faunas (Table 4). In this substage, the European faunas show very high similarities between the subprovinces and the longer the distance the lower the similarity (e.g., Dorset-E. Paris Basin-Pyrenees-Tage-Valdorbia) and they generally show low similarities to faunas of other regions. As regards North America, it is noted that British Columbia, eastern Oregon and northern Alaska show very low similarity mutually throughout Domerian, Whitbian and Yeovilian.

The data of the faunas outside Japan are based on the following references.

For the Dorset-Somerset fauna ARKELL (1933), Jebel Tuwaiq fauna ARKELL et al. (1952), eastern Caucasus fauna, east

Table 4. Faunal resemblance in Yeovilian.

$\frac{2 \cdot C}{N_1+N_2} \cdot 100$	Number of genera	Dorset-Somerset	Alta Brianza	Valdorbia	E. Paris Basin	Tage	Pyrenees	Jura Mts.	E. Caucasus	E. Oregon	Br. Columbia, Alberta & s. Yukon	N. Alaska	C. Arabia	Madagascar	Toyora
Dorset-Somerset	6														
Alta Brianza	5	36													
Valdorbia	9	53	71												
E. Paris Basin	7	92	50	63											
Tage	12	67	47	67	74										
Pyrenees	7	77	67	75	86	74									
Jura Mts.	8	86	46	59	93	80	80								
E. Caucasus	3	44	25	33	40	40	40	36							
E. Oregon	7	46	33	38	43	53	57	53	40						
Br. Columbia, Alberta & s.Yukon	4	40	44	31	55	50	36	67	29	36					
N. Alaska	1	0	0	0	0	15	0	0	50	0	0				
C. Arabia	1	0	0	0	0	0	0	0	0	0	0	0			
Madagascar	3	44	0	17	40	27	40	36	33	40	0	0	50		
Toyora	4	40	44	46	55	50	55	50	86	36	50	40	0	29	

of the Paris Basin fauna, Jura Mts. fauna, Madagascar fauna and Pyrenees fauna ARKELL (1956), Valdorbia fauna DONOVAN (1958), British Columbia fauna FREBOLD (1970), northern Alaska fauna IMLAY (1955), eastern Oregon and California fauna IMLAY (1968) and for the Alta Brianza fauna VENZO (1952).

Conclusion

The Toyora Group is composed of conglomerate, sandstone, shale and alternation of sandstone and shale and shale and 1200 to 1900 m. in thickness.

The group represents a sedimentary cycle and it 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.

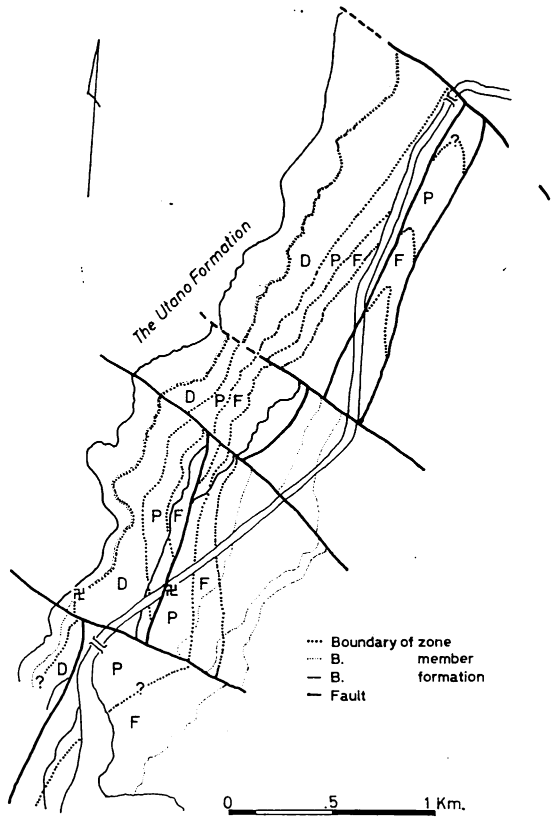
23 genera including 42 species of ammonoids are identified and described. The age of the Toyora Group ranges from Sinemurian to Bathonian as evidenced by these ammonoids and some other fossils.

A diachronous situation of the lithostratigraphic unit is suggested from the data in the Higashinakayama area.

Three zones are recognized in the middle part of the Toyora Group on the basis of ammonid assemblage. They are correlated from the *Stokesi* Subzone of the *Margaritatus* Zone to the *Fibulatum* Subzone of the *Bifrons* Zone. The Member Up of the Utano Formation is roughly correlated with the *Variabilis* and the *Thouarsense* Zones.

The Toyora fauna in Domerian substage is characterized by elements of the Mediterranean or Tethyan faunas.

It is restricted only to Whitbian that the Toyora fanua shows a somewhat high similarity to that of western



Text-fig. 4. Map showing the zonation. F: *Fontanelliceras fontanellense* Zone, P: *Protogrammoceras nipponicum* Zone, D: *Dactylioceras helianthoides* Zone.

Europe. The Toyora fauna shows a somewhat low similarity to the faunas of western and southern Europe in Yeovilian substage.

There are some comparable species between the Toyora fauna and the eastern Oregon fauna, but high similarity is not recognized in the generic assemblage.

Stratigraphic guide of localities
(loc. 1-59)

Member Ncs: Loc. 51, 52.
Member Nss: Loc. 50.
Fontanelliceras fontanellense Zone: Loc. 11,

12, 12B, 14, 16, 17, 18, 19, 29, 38, 39, 48, 50.
Protogrammoceras nipponicum Zone: Loc. 4, 9, 10, 13, 15, 18B, 18D, 18E, 20, 21, 22, 23, 24, 30,31, 32.
Dactylioceras helianthoides Zone: Loc. 1, 2, 3, 5, 6, 7, 25, 26, 27, 28, 28′-28″″, 33, 34, 35, 36, 40, 41, 42, 43, 44, 45, 46, 47.
Member Na: Loc. 8, 37, 49.
Member Up: Loc. 53, 54, 55.
Member Ub: Loc. 56.
Member Uh: Loc. 57, 58.
Member Ut: Loc. 59.

References

ARKELL, W. J. (1933): The Jurassic System in Great Britain, Oxford Press, 681p.

—— (1956): Jurassic geology of the World, Oliver & Boyd Ltd., 806p.

—— et al. (1957): Treatise on invertebrate paleontology, Mollusca, pt. L4, Geol. Soc. America & Univ. Kansas Press, 490p.

—— BRAMKAMP, R. A. and STEINEKE, M. (1952): Jurassic ammonites from Jebel Tuwaiq, central Arabia, *Phil. Trans. Roy. Soc. London*, ser. B, vol. 633, pp. 241-313, pls. 15-31.

BETTONI, A. (1900): Fossil Domeriani della Provincia di Brescia, *Mém. Soc. Paléont. Suisse* (*Abh. schweiz. paläont. Gesell.*), vol. 27, pp. 1-88, pls. 1-9.

BUCKMAN, S. S. (1899): A monograph on the Inferior Oolite ammonites of the British Islands, *Palaeontogr. Soc.*, pt. 11, supple., pp. 33-64, pls. 5-14.

—— (1904): Ditto, *Ibid.*, pt. 12, supple., pp. 65-168, pls. 15-19.

—— (1905): Ditto, *Ibid.*, pt. 13, supple., pp. 169-208, pls. 20-24.

—— (1909): Yorkshire Type Ammonites, vol. 1, pts. 1-8, 80 pls.

—— (1921-1923): Type Ammonites, vol. 4, pts. 25-42, 180 pls.

—— (1925-1927): Ditto, vol. 6, 192 pls.

DEAN, W. T., DONOVAN, D. T. and HOWARTH, M. K. (1961): The Liassic ammonite zones and subzones of the North-west European province, *Bull. Brit. Mus.* (*Nat. Hist.*), *Geol.*, vol. 4, no. 10, pp. 437-505.

DONOVAN, D. T. (1952): The ammonites of the Blue Lias of the British district, pt. 2, Arietitidae, *Ann. Mag. Nat. Hist.*, ser. 12, vol. 5, pp. 717-752, pls. 27-29.

—— (1958): The Lower Liassic ammonite fauna from the fossil bed at Langeneckgrat, near Thun (Median Prealps), *Schweiz. Palaeont. Abh.*, vol. 74, pp. 1-58, pls. 1-7.

DRESNAY, R. (1963): Quelques ammonites de la partie inférieure du Pliensbachien (Carixien et Domérien pro parte) du jbel Bou-Rharraf (Haut Atlas oriental), *Note Serv. Géol. Maroc*, vol. 23, no. 172, pp. 141-164, pls. 1-2.

DUBAR, G., FOUCAULT, A. and MOUTERDE, R. (1967): Le Lias moyen des environs de Huescar (province de Grenade, Espagne), *Bull. Soc. Géol. France*, vol. 7, no. 9, pp. 830-834.

DUMORTIER, E. (1867): Etudes paléontologiques sur les dépôts jurassiques du Basin du Rhône, pt. 2, 252 p., 50 pls.

FREBOLD, H. (1951): Contributions of the palaeontology and stratigraphy of the Jurassic System in Canada, *Geol. Surv. Canada, Bull.* 18, pp. 1-54, pls. 1-17.

—— (1957): The Jurassic Fernie Group in the Canadian Rocky Mountains and foothills, *Geol. Surv. Canada, Mem.* 287, no. 2531, pp. 1-197, pls. 1-44.

—— (1964a): Illustration of Canadian fossils, Jurassic of western and Arctic Canada, *Geol. Surv. Canada, Paper* 63-4, pp. 1-106, pls. 1-51.

—— (1964b): Lower Jurassic and Bajocian ammonoid faunas of northwestern British Columbia and southern Yukon, *Geol. Surv. Canada, Bull.* 116, pp. 1-31, pls. 1-8.

—— (1970): Pliensbachian ammonoids from British Columbia and Southern Yukon, *Can. Jour. E. Sci.*, vol. 7, no. 2, pp. 435-456, pls. 1-4.

—— and LITTLE, H. W. (1962): Palaeontology, stratigraphy and structure of the Jurassic rocks in Salmo map-area, British Columbia, *Geol. Surv. Canada, Bull.* 81, pp. 1-31, pls. 1-5.

——, MOUNTJOY, E. W. and TEMPELMAN-KLUIT, D. J. (1967): New occurrences of Jurassic rocks and fossils in central and northern Yukon Territory, *Geol. Surv. Canada, Paper* 67-12, pp. 1-35, pls. 1-3.

FUCINI, A. (1900) : Ammoniti del Lias medio dell'Appennino centrale esistenti nel Museo di Pisa, *Palaeontogr. Italica*, vol. 6, pp. 17-78, pls. 7-13.

—— (1901) : Cefalopodi liassici del Monte di Cetona, pt. 1, *Ibid.*, vol. 7, pp. 1-89, pls. 1-14.

—— (1902) : Ditto, pt. 2, *Ibid.*, vol. 8, pp. 131-217, pls. 12-26.

—— (1904) : Ditto, pt. 4, *Ibid.*, vol. 10, pp. 275-298, pls. 18-21.

—— (1905) : Ditto, pt. 5, *Ibid.*, vol. 11, pp. 93-146, pls. 3-11.

—— (1923-1928) : Fossili domeriani dei Dintorni di Taormina, *Ibid.*, vols. 29-30, pp. 41-77, pls. 4-15.

—— (1931) : Ditto, pt. 4, *Ibid.*, vol. 31, pp. 93-149, pls. 5-21.

GECZI, B. (1970) : Pliensbachi ammonites zonak a Bakonyhegy-segben, *Bull. Hung. Geol. Soc.*, vol. 100, pp. 248-258.

GEMMELLARO, G. G. (1885) : Sopra taluni Harpoceratidi del Lias superiori dei Taormina, *Giorn. Sci. Nat. Econ. Palermo.*, vol. 17, pp. 1-109, pls. 1-2.

GÜRICH, G. (1933) : Leitfossilien, *Gebruder Borntreger*, 272 p., 24 pls.

HAAS, O. (1913) : Die Fauna des mittleren Lias von Ballino in Südtirol, *Beitr. Paläont. Geol. Oster. Orient.*, Bd. 26, pp. 1-161, pls. 1-7.

HALLAM, A. (1969) : Faunal realms and facies in the Jurassic, *Palaeontology*, vol. 12, pt. 1, pp. 1-18.

HAUG, E. (1885) : Beiträe zu einer Monographie der Ammoniten Gattung *Harpoceras*, *N. Jb. Min.*, B.-Bd. 3, pp. 585-722, pls. 11-12.

HAYAMI, I. (1958) : Taxonomic notes on *Cardinia* with description of a new species from the Lias of western Japan, *Jour. Fac. Sci., Univ. Tokyo*, sec. 2, vol. 11, pt. 2, pp. 115-130, pl. 11.

—— (1959) : Lower Liassic Lamellibranch fauna of the Higashinagano Formation in West Japan, *Ibid.*, vol. 12, pt. 1, pp. 31-84, pls. 5-8.

—— (1960a) : Lower Liassic gastropods from the Higashinagano Formation in West Japan, *Jap. Jour. Geol. Geogr.*, vol. 31, nos. 2-4, pp. 99-106, pl. 9.

—— (1960b) : Jurassic inoceramids in Japan, *Jour. Fac. Sci., Univ. Tokyo*, sec. 2, vol. 12, pt. 2, pp. 277-328, pls. 15-18.

—— (1961) : On the Jurassic pelecypod faunas in Japan, *Ibid.*, vol. 13, pt. 2, pp. 243-343, pl. 14.

—— (1962) : Jurassic pelecypod faunas in Japan with special reference to their stratigraphical distribution and biogeographical provinces, *Jour. Geol. Soc. Japan*, vol. 68, no. 797, pp. 96-108. [in Japanese with English abstract].

HIRANO, H. (1971) : Biostratigraphic study of the Jurassic Toyora Group. Pt. 1, *Mem. Fac. Sci., Kyushu Univ.*, ser. D, vol. 21, no. 1, pp. 93-128, pls. 14-20.

—— (1973) : Ditto, pt. 2, *Trans. Proc. Palaeont. Soc. Japan*, N. S., no. 89, pp. 1-14, pls. 1-4.

HOWARTH, M. K. (1955) : Domerian of the Yorkshire Coast, *Proc. Yorkshire Geol. Soc.*, vol. 30, pt. 2, no. 10, pp. 147-175, pls. 10-12.

—— (1956) : The Scalpa Sandstone of the Isle of Raasy, Inner Hebrides, *Ibid.*, vol. 30, pt. 4, no. 19, pp. 353-370, pl. 27.

—— (1957) : The middle Lias of the Dorset Coast, *Q. J. G. S. London*, vol. 113, pp. 185-203, pl. 17.

—— (1958) : A Monograph of the ammonites of the Liassic family Amatheidae in Britain, pt. 1, *Palaeontogr. Soc.*, pp. 1-26, pls. 1-4.

—— (1962) : The Yorkshire type ammonites and nautiloids of YOUNG and BIRD, PHILLIPS, and Martin SIMPSON, *Palaeontology*, vol. 5, pt. 1, pp. 93-136, pls. 13-19.

IMLAY, R. W. (1955) : Characteristic Jurassic Mollusks from northern Alaska, *Geol. Surv. U. S. A., Prof. Paper* 274-D, pp. 69-96, pls. 8-13.

—— (1968) : Lower Jurassic (Pliensbachian and Toarcian) ammonites from eastern Oregon and California, *Ibid.*, 593-C, pp. C1-C51, pls. 1-9.

KOBAYASHI, T. (1926) : Note on the Mesozoic Formation in Province Nagato, Chugoku, Japan, *Jour. Geol. Soc. Japan*, vol. 33, pp. 1-9, pl. 11.

—— (1935) : Contributions to the Jurassic Torinosu Series of Japan, *Jap. Jour. Geol. Geogr.*, vol. 12, nos. 3-4, pp. 69-92, pl. 12.

—— (1936) : The geological structure of Southwest Japan and its Mesozoic palaeogeography, pt. 4, *Jour. Geol. Soc. Japan*, vol. 43, pp. 531-541 [in Japanese].

——, KONISHI, K., SATO, T., HAYAMI, I. and TOKUYAMA, A. (1957) : On the Lower Jurassic Kuruma Group, *Ibid.*, vol. 63, no. 738, pp. 182-194 [in Japanese].

—— and MORI, K. (1954) : Studies on the Jurassic trigonians in Japan, pt. 2, *Prosogyrotrigonia* and the Trigoniinae, *Jap. Jour. Geol. Geogr.*, vol. 25, nos. 3-4, pp. 155-175, pls. 15-16.

KOSCHELKINA, Z. V. (1953) : Stratigraphy and bivalve mollusks of the Jurassic deposits of Viluysk syncline and near-Verkhojansk foredeep, *Trans. East. Siberia Kom. Inst.*, vol. 5, pp. 1-219, pls. 1-25.

MATSUMOTO, T. (1949) : The Late Mesozoic geological history in the Nagato Province, Southwest Japan, *Jap. Jour. Geol. Geogr.*, vol. 21, pp. 235-243.

—— ed. (1963) : A survey of the fossils from Japan illustrated in classical monographs (Primarily a nomenclatorial revision), *Palaeont. Soc. Japan, 55th Anniversary Vol.*, 57 p., 68 pls.

—— et al. (1967) : Historical geology, pt. 2, Asakura Book Co., 683 p. [in Japanese].

—— in MAKIYAMA, J. et al. (1953) : Historical geology, pt. 2, Asakura Book Co., 546 p. [in Japanese].

—— and ONO, A. (1947) : A biostratigraphic study of the Jurassic Toyora Group, with special reference to ammonites, *Sci. Rep. Fac. Sci., Kyushu Univ., Geol.*, vol. 2, no. 1, pp. 20-31, pls. 1-2 [in Japanese].

MERLA, G. (1933) : Ammoniti giuresi dell'-Appennino centrale, I. Hildoceratidae, *Palaeontogr. Italica*, vol. 33, n. ser. 3, pp. 1-54, pls. 1-7.

MONESTIER, J. (1931) : Ammonites rares ou peu connues et ammonites nouvelles du Toarcian moyen de la région de l'Aveyron, *Soc. Géol. France Mém., n. ser.*, vol. 7, pt. 1, pp. 1-79, pls. 1-9.

—— (1934) : Ammonites du Domérien de la région sud-est de l'Aveyron et de quelques régions de las Lozère a l'exclusion des Amalthéides, *Ibid.*, vol. 10, pt. 3, pp. 1-102, pls. 1-11.

MOUTERDE, R. (1967) : Le Lias moyen de Sao Pedro de Muel (Portugal) (Première partie), *Comun. Serv. Géol. Portugal*, vol. 52, pp. 185-208.

NAUMANN, E. and NEUMAYR, M. (1890) : Zur Geologie und Paläontologie von Japan, *Denk. Mathem. Natur. Klasse Konig.*

Explanation of Plate 9

(All in natural size)

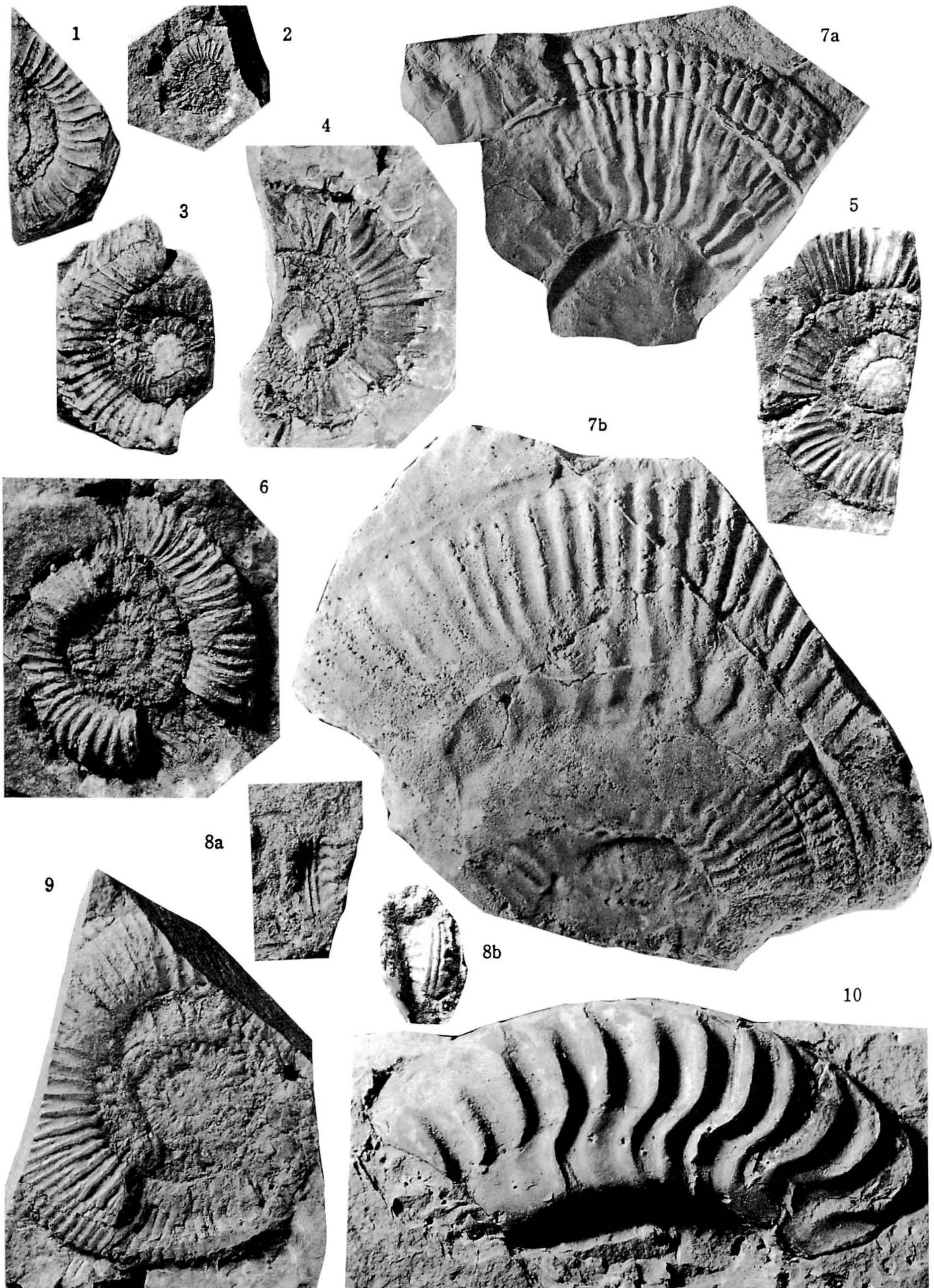
Figs. 1-6. *Peronoceras subfibulatum* (YOKOYAMA)
1. MM. 7068, Paralectotype, loc. 47; 2. GK. G. 2182, loc. 28″; 3. MM. 7069, Paralectotype, loc. 47; 4. GK. G. 2177, loc. 35; 5. MM. 7067, Paralectotype, loc. 47; 6. MM. 7066, Lectotype, loc. 1.

Figs. 7a-b. *Planammatoceras* sp. cf. *P. kitakamiense* (SATO)
7a. Gypsum cast of GK. G. 2014, loc. 57; 7b. Rubber cast of a part of GK. G. 2014

Figs. 8a-b. *Arietites* sp.
8a. GK. G. 11380, external mould, loc. 51; 8b. Rubber cast of GK. G. 11380

Fig. 9. *Dactylioceras* (s. str.) sp. cf. *D. helianthoides* YOKOYAMA
GK. G. 2093, loc. 13

Fig. 10. *Hidoceras* sp.
GK. G. 11352, loc. 44


1
2
7a
4
3
5
7b
6
8a
9
8b
10

Akad. Wissen., Bd. 57, p. 35, figs. 1-3.

NUTSCHUBIDZJ, K. S. (1966): Lower Jurassic fauna of Caucasus, 212 p., 41 pls.

OISHI, S. (1935): A new species of *Zamites* from the Nishi-Nakayama Bed, Yamaguchi Prefecture, *Jour. Fac. Sci., Hokkaido Imp. Univ., ser.* 4, vol. 3, no. 1, pp. 97-100.

—— (1940): The Mesozoic floras of Japan, *Ibid.*, vol. 5, nos. 2-4, pp. 123-480, pls. 1-48.

PUGIN, L. (1964): Ammonites prealpines. Étude critique des *Lytoceratina* du Dogger, *Schweiz. Palaeont. Abh.*, vol. 80, pp. 1-67, pls. 1-4.

SATO, T. (1954): *Hammatoceras* de Kitakami, Japon, *Jap. Jour. Geol. Geogr.*, vol. 25. nos. 1-2, pp. 81-100, pls. 7-9.

—— (1955): Les ammonites recueillies dans le groupe de Kuruma, nord du Japon central, *Trans. Proc. Palaeont. Soc. Japan*, N. S., no. 20, pp. 111-118, pl. 18.

—— (1956): Corrélation du Jurassique inférieur japonais en basant sur les ammonites fossils, *Jour. Geol. Soc. Japan*, vol. 62, no. 732, pp. 490-503 [in Japanese with French abstract].

—— (1957): Biostratigraphie de la série de Shizukawa (Jurassique inférieur) du Japon septentrional, *Jour. Fac. Sc., Univ. Tokyo*, sec. 2, vol. 10, pt. 3, pp. 131-350, pls. 1-2.

—— (1960): A propos des courants océaniques froids provés par l'existence des ammonites d'origine arctique dans le Jurassique japonais, *Internat. Geol. Congr. Norden, Rep. 21st.*, pt. 12, pp. 165-169.

—— (1962): Études biostratigraphiques des ammonites du Jurassique du Japon, *Mém. Soc. Géol. France*, no. 94, pp. 1-122, pls. 1-10.

—— in ASANO, K. et al. (1967): Historical geology, revised ed., pt. 2, 683 p., Asakura Book Co. [in Japanese].

SHIKAMA, T. and HIRANO, H. (1970): On the mode of occurrence of ammonites in the Nishinakayama Formation, Toyora Group, *Sci. Rep. Yokohama Natl. Univ.*, sec. 2, no. 16, pp. 61-71, pls. 9-11.

SHIMIZU, S. (1928): Remarks on two ammonites *Harpoceras japonicum* NEUMAYR and *Arapadites sakawanus* MOJSISOVICS from the Sakawa basin in Shikoku, *Jap. Jour. Geol. Geogr.*, vol. 5, no. 4, pp. 219-222.

—— and OBATA, T. (1934): Cephalopoda, Geol. Palaeont., vol.. 32, no. 9, pp. 1-137, Iwanami Book Co. [in Japanese].

SPATH, L. F. (1919): Notes on ammonites, *Geol. Mag.*, ser. 6, vol. 6, pp. 170-177.

—— (1923): Correlation of the *Ibex* and *Jamesoni* Zones of the Lower Lias, *Ibid.*, vol. 60, pp. 6-11.

—— (1927): Revision of the Jurassic cephalopod fauna of Kachh (Cutch), pt. 1, *Palaeontogr. Indica*, n. ser. vol. 9, no. 2, pp. 1-72, pls. 1-7.

TAKAHASHI, E. (1951a): Descriptive notes on some Mesozoic plants from Province Nagato (Yamaguchi Pref.), *Jour. Geol. Soc. Japan*, vol. 57, no. 664, pp. 29-33.

—— (1951b): Some Cycadophyta from the Jurassic Toyora Series, Province Nagato (Yamaguchi Pref.), Japan, *Ibid.*, vol. 57, no. 668, pp. 191-193.

—— (1954): Stratigraphy of the fossil plants of the Toyora Group, *Ibid.*, vol. 60, no. 703, p. 169 [in Japanese].

—— et al. (1965): Palaeozoic and Mesozoic formations of the eastern and the southern parts of the Tabe Basin, Yamaguchi Prefecture, *Sci. Rep. Yamaguchi Univ.*,v ol. 15, pp. 33-49, pls. 1-3 [in Japanese with English abstract].

—— et al. (1966): Mesozoic formations of the northern and the eastern parts of the Tabe Basin, Yamaguchi Prefecture, *Ibid.*, vol. 16, pp. 53-65, pls. 1-2 [in Japanese with English abstract].

—— et al. (1968): Geology and structure of the Toyogadake-Nishiichi district of the Nagato tectonic zone, *Ibid.*, vol. 18, pp. 9-25, pls. 1-2 [in Japanese with English abstract].

—— and NAITO, G. (1950): *Dictyozamites* from the Jurassic Toyonishi Series of Prov. Nagato (Yamaguchi Pref.), *Jour. Geol. Soc. Japan*, vol. 56, no. 655, p. 188. [in Japanese].

TAKAHASHI, H. (1969): Stratigraphy and

ammonite fauna of the Jurassic system of the southern Kitakami Massif, Northeast Honshu, Japan, *Sci. Rep. Tohoku Univ., 2nd ser. Geol.*, vol. 41, no. 1, pp. 1-93, pls. 1-19.

TAKAI, F., MATSUMOTO, T. and TORIYAMA, R. ed. (1963) : Geology of Japan, 279 p., Univ. Tokyo Press.

THEVENIN, A. (1908) : Paléontologie de Madagascar-5. Fossiles Liasiques, *Ann. Paléont.*, vol. 3, pp. 105-143, pls. 8-12.

TORIYAMA, R. (1938) : Geology of the Toyora Group in Toyora county, Yamaguchi Prefecture, *Jour. Geol. Soc. Japan*, vol. 45, no. 533, pp. 247-258 [in Japanese].

VENZO, S. (1952) : Nuove faune ad ammoniti del Domeriano-Aleniano dell'Alpe turati e dintorni (Alta Brianza), *Atti Soc. Ital. Sci. Nat.*, no. 91, pp. 95-123, pls. A-B.

WRIGHT, T. (1882) : Monograph on the Lias ammonites of the British Islands, *Palaeontogr. Soc.*, vol. 5, pp. 329-400, pls. 49-69.

—— (1883) : Ditto, *Ibid.*, vol., 6. pp. 401-440, pls. 70-77.

—— (1884) : Ditto, *Ibid.*, vol. 7, pp. 441-480, pls. 78-87.

YABE, H. (1920) : On the so-called Mesozoic formation of the Kiku Peninsula, Province Bizen, *Jour. Geogr.*, vol. 32, no. 389, pp. 1-8 [in Japanese].

—— and EGUCHI, M. (1933) : *Anabachia cyclolitoides* sp. nov. from Japan, with remarks of the genus *Anabachia*, *Jap. Jour. Geol. Geogr.*, vol. 10, nos. 3-4, pp. 119-124.

YEHARA, S. (1921) : On some new species of *Trigonia* from the Lias of Prov. of Nagato and the Cretaceous of Prov. Awa, *Jour. Geol. Soc. Tokyo*, vol. 28, pp. 7-11, pl. 5.

—— (1927) : Faunal and stratigraphical study of the Sakawa Basin, Shikoku, *Jap. Jour. Geol. Geogr.*, vol. 5, nos. 1-2, pp. 1-40, pls. 1-5.

YOKOYAMA, M. (1904) : Jurassic ammonites from Echizen and Nagato, *Jour. Coll. Sci. Imp. Univ. Takyo*, vol. 19, art. 20, pp. 1-17, pls. 1-4.

ZEISS, A. (1956) : *Hecticoceras* and *Reineckeia* im Mittel- und Ober-Callovien von Blumberg (Sudbaden), *Bayer. Akad. Wiss. München*, pp. 1-101, pls. 1-4.

ZITTEL, K. A. (1885) : Handbuch der Paläontologie, Bd. 2, 893 p, *R. Oldenbourg*.

Explanation of Plate 10

(All in natural size)

Fig. 1. *Harpophylloceras* ? sp.
GK. G. 2020, loc. 52

Figs. 2-3. *Lytoceras* sp. A
2. GK. G. 2049, loc. 9; 3. GK. G. 2043, loc. 9

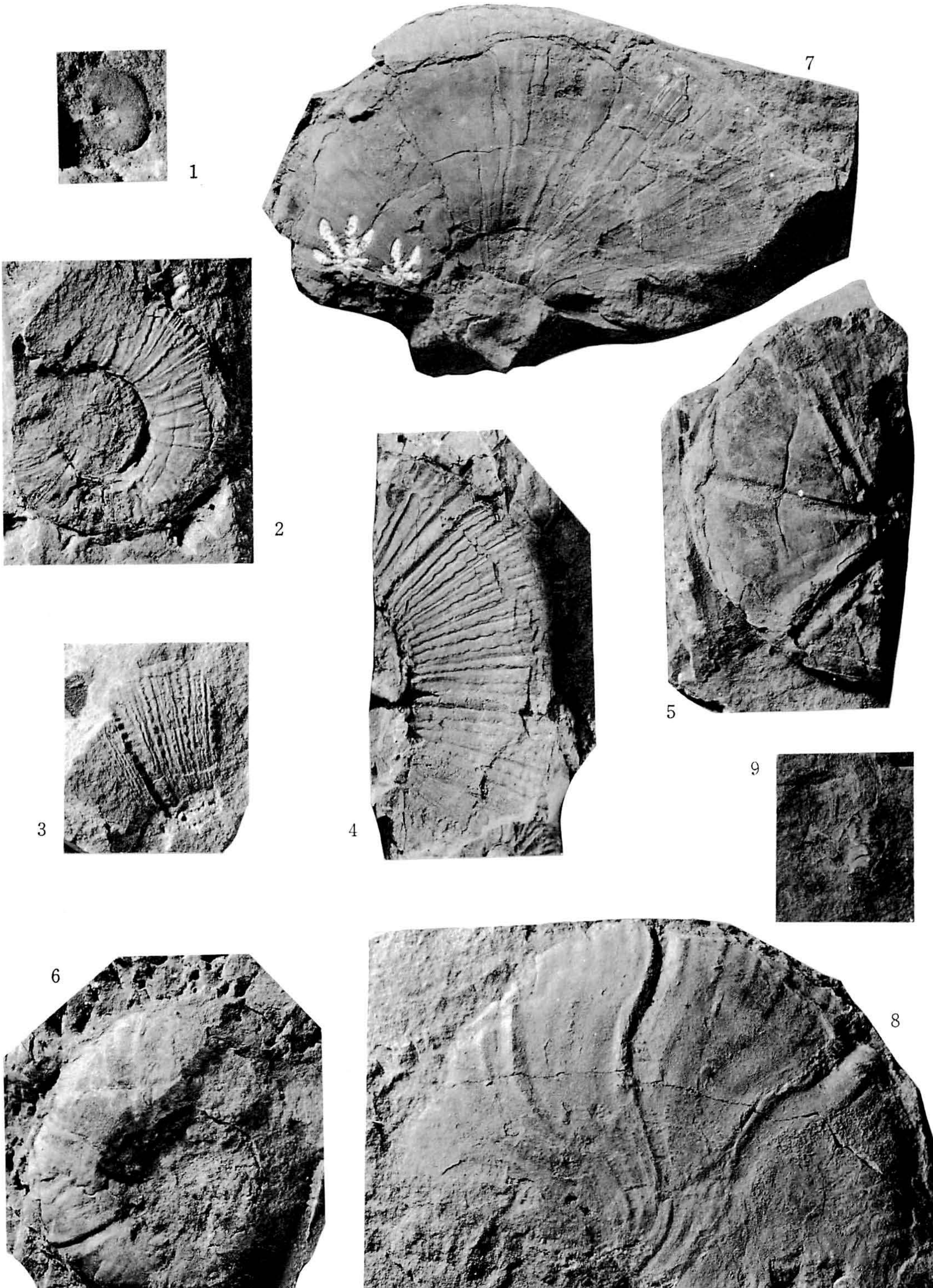
Fig. 4. *Lytoceras* sp. B
GYU. M. 1019, loc. 18B

Figs. 5-6. *Calliphylloceras* sp. A
5. GK. G. 2017, loc. 53; 6. GK. G. 2029, the Anda-dani

Fig. 7. *Calliphylloceras* sp. B
GK. G. 11335, loc. 23

Fig. 8. *Holcophylloceras* sp.
GK. G. 2016, loc. 59

Fig. 9. *Audaxlytoceras* ? sp.
Rubber cast of GK. G. 2059, loc. 36 ?


1
2
3
4
5
6
7
8
9

Higashinagano	東長野	Higashinakayama	東中山
Nishinakayama	西中山	the River Era	江良川
Utano	歌野	the River Motoyoku	本浴川
Sakuraguchi-dani	桜口谷	tne River Sakota	迫田川
Anda-dani	安田谷		

Trans. Proc. Palaeont. Soc. Japan, N.S., No. 90, pp. 72-80, pls. 11-13, June 30, 1972

616. EARLY PERMIAN *PARAFUSULINA* AND *PSEUDOFUSULINELLA* FROM THE CHILLIWACK GROUP, SOUTHWESTERN BRITISH COLUMBIA, CANADA*

KIMIYOSHI SADA

Department of Geology, Faculty of General Education, Hiroshima University, Hiroshima 730

and

WILBERT R. DANNER

Department of Geological Sciences, the University of British Columbia, Vancouver, Canada

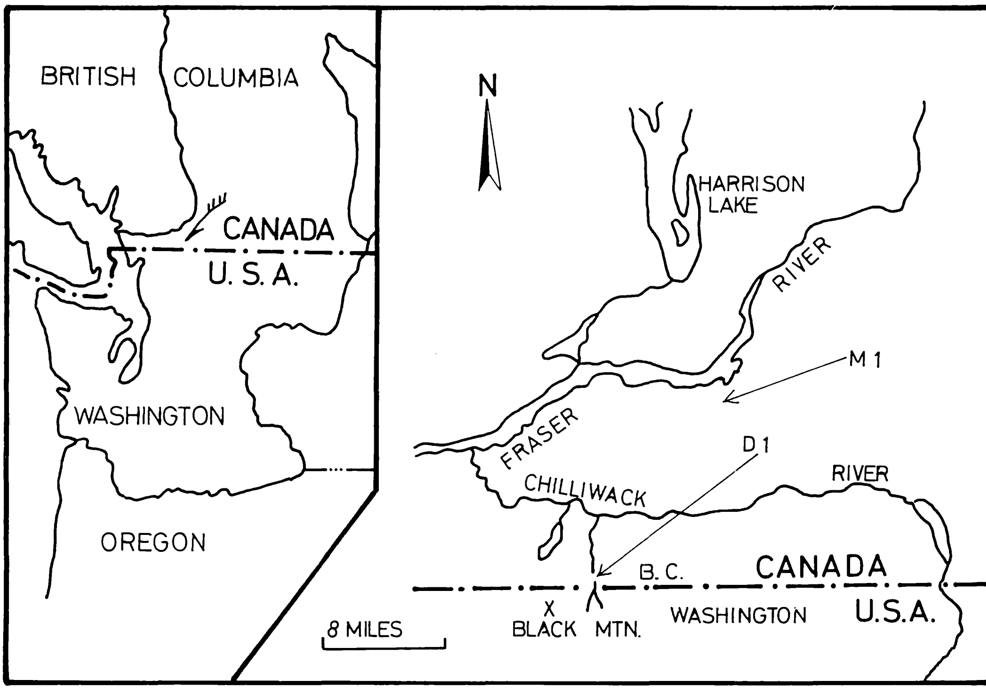
カナダ British Columbia 南西部の Chilliwack 層群の *Parafusulina* と *Pseudofusulinella*: British Columbia 南西部 Chilliwack valley 地域の Chilliwack 層群中の石灰岩レンズから時代決定に重要な役割を果たす *Parafusulina* と *Pseudofusulinella* を識別したので報告する。ここに記載された種は *Pseudofusulinella danneri* SKINNER & WILDE, *Parafusulina mongeri* SADA & DANNER, sp. nov., *P. laudoni* SKINNER & WILDE の3種である。これらの種によって構成される Chilliwack 紡錘虫化石動物群は SKINNER & WILDE (1966) によって報告された Washington 州の Black Mountain 紡錘虫化石動物群よりもやゝ後期のもののように思われ, California 州の McCloud 石灰岩のH帯 (SKINNER & WILDE, 1965) の化石動物群に対比される。これらのことから, この化石動物群は Leonardian 初期のものと考えられる。 佐田公好 • W.R. DANNER

Introduction

The Chilliwack Group is a thick sequence of upper Paleozoic clastic, carbonate and volcanic rocks cropping out on both sides of the International Border in southwestern British Columbia, Canada and northwestern Washington, U. S. A. South of the border it includes rocks as old as Devonian but north of the border only rocks of Pennsylvanian and Permian age have been recognized.

DALY (1912) gave the name Chilliwack *Series* to the Paleozoic rocks of the Chilliwack valley but the term *Group* was substituted for *Series* on the 1944 Geologic Map of the Hope Sheet by CAIRNES (Geological Survey of Canada map 737A) to bring the nomenclature in line with modern usage of stratigraphic terminology. DALY (1912) found limestone containing bryozoa, brachiopods and the fusulinid *Fusulina elongata* south of the border in Washington and GIRTY (in DALY, 1912, p. 515) suggested that this fauna probably correlated with

* Received Jan. 13, 1973; read Oct. 28, 1972 at Matsuyama.



Text-fig. 1. Map showing Chilliwack fossil localities in southwestern British Columbia.

that of the Nosoni Formation of northern California. THOMPSON, WHEELER & HAZZAR (1946) regarded *F. elongata* SHUMARD as probably belonging to the genus *Parafusulina.* COOGAN (1960) and SKINNER & WILDE (1965) described the Nosoni Formation fusulinids and found them to be advanced species of *Parafusulina* which are younger than forms found in the Chilliwack Group.

HILLHOUSE (1965) noted fusulinid-bearing limestone on the British Columbia side of the border but they were too poorly preserved for specific identification. Their large size, however, indicated a Permian age. In 1956 DANNER started reconnaissance studies of the Chilliwack area to continue field work started several years earlier on the Washington side of the border. DANNER (1957) listed an abundant fusulinid fauna from the Black Mountain area in Washington State which SKINNER (personal communication) considered to be of Wolfcampian age. Later the discovery of a *Parafusulina* in these collections (SKINNER & WILDE, 1966) suggested a probable early Leonardian age for this same fauna which contains one species of *Pseudofusulinella,* two species of *Schwagerina* and one species of *Parafusulina.*

MONGER (1966) started field work in the area in 1962 on his Ph. D. thesis and made many fossil collections including fusulinids. Specimens from one of his localities are included in the descriptions in this paper. He made the most accurate geologic map that has yet been produced of the Chilliwack Group on the Canadian side of the border and he recognized the probable diachronous nature of the Permian limestone bodies.

Field work in the Chilliwack area by W. R. DANNER and laboratory work carried on at the University of British Columbia by K. SADA as a post-doctoral fellow was financed by grants from the National Research Council of Canada. Further work on this project was carried out while DANNER was visiting Professor at Hiroshima University under the auspices of the Japan Society for the Promotion of Science.

Geology

The Chilliwack Group is composed of a sequence of argillites, fine- to coarse-grained volcanic arenites, rare conglomerates, large and small limestone bodies and near the top a volcanic unit of altered basic to intermediate flows, tuffs and silicified tuffs and chert. The base is not exposed. The top is overlain disconformably or is infault contact with fine- to medium-grained volcanic arenites and argillites of the late Triassic-early Jurassic Cultus Formation.

In the Chilliwack area the maximum total thickness of the Chilliwack Group is estimated to be about 5700 feet (MONGER, 1966). The sequence is complexly folded and faulted and in some instances is inverted. Most of the Chilliwack rocks, except for the limestones, are not distinctive enough that they can be easily defined as formations and used for correlation. However, the limestones are diachronous and their bases and tops are not stratigraphic horizons, a phenomena noted in other western Cordilleran North American limestones of similar environment (SKINNER & WILDE, 1965). Mostly it is only fossils in the limestones that offer reliable indications. It is also very difficult to identify whether the argillites and fine- to medium-grained volcanic arenites belong to the Chilliwack Group or to a similar lithology of the younger late Triassic-early Jurassic Cultus Formation.

Throughout the area of the Chilliwack Group lower Permian and lower Pennsylvanian limestones form the two most prominent marker units. Between them is a clastic sequence ranging from fine- to coarse-grained volcanic arenites and coarse conglomerates. At several localities this clastic sequence contains plant fragments. It is between 450 and 800 feet thick in the Chilliwack area but may be 300 feet or less in parts of northwestern Washington.

Lower Permian fusulinid-bearing limestone is found as large and small beds and lenses. It is dark grey to light grey and buff in color. Locally it is dolomitized and contains a considerable amount of black to grey secondary chert. It is commonly cliff-forming and where internally folded has thicknesses of more than 2000 feet. The maximum normal thickness found by MONGER is 300 feet. To the south in Washington State it is generally thinner and may be represented by two or more limestone members separated by shales.

MONGER (1966), noted fusulinids to be the commonest fauna in the Permian limestone and found them to be most abundant at the top of the limestone bodies underlying the Chilliwack volcanic unit. Associated with the fusulinids are bryozoans, crinoid columnals and rare gastropod and brachiopod fragments. Large corals (*Dibunophyllum* ?) are often present. Many of the limestone bodies in the Chilliwack Group are recrystallized and only outlines of the fossils are preserved. Recrystallization is most common in the eastern part of the area nearer the contact with the Cenozoic Chilliwack Batholith.

Discussion of the Fauna

The Chilliwack Group early Permian fusulinid collections from the Chilliwack area of British Columbia contain *Pseudofusulinella danneri* SKINNER & WILDE, *Parafusulina laudoni* SKINNER & WILDE, and *Parafusulina mongeri*, sp. nov. at the top of the lower Permian limestone unit or in numerous small limestone pods underlying and interbedded with the volcanic unit. A few schwagerinids occur in the larger limestone bodies but our specimens are generally not well enough preserved for description. *Parafusulina* is very abundant and in some localities may be the only fusulinid present. In contrast, to the south in Washington at Black Mountain *Parafusulina* is rare at most localities and schwagerinids are abundant and well preserved. *Pseudofusulinella danneri* SKINNER & WILDE, is relatively abundant at both of our localities and at Black Mountain.

It seems apparent, as suggested by MONGER (1966) that the Washington fusulinid fauna described by SKINNER & WILDE (1966) represents a slightly older fauna than the fusulinids described here from the Chilliwack area. However, we do not have enough well preserved schwagerinid material to describe and to see if they correlate with the Black Mountain fauna of SKINNER & WILDE. The Chilliwack area early Permian *Parafusulina* zone seems to correlate most closely with zone H in the McCloud Limestone of California (SKINNER & WILDE, 1965) and is of early Leonardian age. The Chilliwack fusulinid fauna appears to be younger than most of the eastern facies of the Cache Creek Group to the north in the Kamloops area of British Columbia.

Chilliwack Fossil Localities

Locality M1: (James MONGER thesis locality No. 5) Limestone on side of logging road, just north of saddle, 2½ miles south of Bridal Falls, altitude 4,000 feet. South side of Fraser River valley.

Locality D1: Talus blocks from hillside above lower forks of Liumchen Creek. Along logging road and in creek bed. Altitude about 2,000 feet. Many of the fusulinids are silicified.

Systematic Paleontology

Subfamily Fusulininae von MÖLLER, 1878

Genus *Pseudofusulinella* THOMPSON, 1951

Type-species:—Neofusulinella occidentalis THOMPSON & WHEELER, 1946

Pseudofusulinella danneri
SKINNER & WILDE

Pl. 11, figs. 1–13

1966. *Pseudofusulinella danneri* SKINNER & WILDE. *Pal. Contrib. Univ. Kansas, Paper* 4, pp. 42–43, pl. 34, figs. 1–5.

Description:—The shell of *Pseudofusulinella danneri* SKINNER & WILDE is small and thickly fusiform, having a straight axis of coiling and moderately pointed poles. The lateral slopes are straight to slightly concave. The mature shells of seven to nine volutions of eight specimens are 5.25 to 7.00 mm. in length and 2.75 to 3.67 mm. in width. The form ratio ranges from 1.81 to 2.32.

The outside diameter of the proloculus varies from 75 to 207 microns, commonly 113 to 188 microns. The shell is tightly coiled in the inner three volutions and expands rapidly and uniformly in the outer volutions. The radius vectors of the 1st to the 9th volution of eight specimens are 94-132, 118-226, 245-321, 358-491, 491-673, 675-887, 849-1170, 1435-1095 and 1748-1824 microns, respectively. The heights of the chambers are about the same throughout the length of the shell excepting in the extreme polar regions. There the chambers slightly increase in height.

The spirotheca is thin and composed of the upper and lower dense layers, a tectum and a thin porous layer. The thickness of the spirotheca of the 1st to the 8th volution of eight specimens is 16-50, 23-50, 29-69, 29-96, 34-98, 36-92, 59-105 and 46-121 microns, respectively. The proloculus wall is thin and its average thickness measures 37 microns.

The septa are almost plane in the region of the tunnel and closely fluted in the extreme polar regions. The septal counts of the 1st to the 7th volution of a specimen illustrated as Fig. 11 on Pl. 11 are 11, 15, 20, 22, 23, 32 and 32, respectively.

The chomata are well developed throughout the growth of the shell, reaching nearly to the tops of the chambers. The tunnel angles are 18 to 23 degrees in the 8th volution.

Remarks and comparison:—The present specimens resemble *Pseudofusulinella danneri* SKINNER & WILDE more closely than any other known species of the genus in the shell-shape, the internal characters and the statistic data. *P. danneri* was originally described by SKINNER & WILDE (1966) from the Permian Chilliwack Group in the Black Mountain area, northwestern Washington. This species was mainly characterized by the thick fusiform shells, the large proloculus for a member of this genus, the well developed chomata and the straight to slightly concave lateral slopes of the shells. The last one plays an important role in the specific variation of this species. As shown by the figures of the holotype and the paratypes, this reveals considerable variation in the shell shape. The holotype (SKINNER & WILDE, 1966, pl. 34, fig. 1) is thick fusiform with concave lateral slopes but the paratypes (SKINNER & WILDE, 1966, figs. 2 and 3) are thick fusiform with straight lateral slopes. We here designate the holotype as α-form and the paratypes as β-form.

The specimens we described are also as variable in their shell-shape as the original specimens of the species described by SKINNER & WILDE (1966). The specimens illustrated here as Figs. 1, 2, and 4 on Pl. 11 coincide with α-form and the other specimens illustrated as Figs. 5 to 10 on the same plate are referable to β-form in the shell-shape. The lateral slopes of the former are concave and the ones of the latter are straight.

Of these specimens the forms illustrated as Figs. 8 to 10 on Pl. 11, all belonging to β-form, are somewhat larger

---

Explanation of Plate 11

All ×10 except fig. 13

Figs. 1-13. *Pseudofusulinella danneri* SKINNER & WILDE

1-10. Axial sections; Rg. No. M44, M42, M34, M43, M49, M48, M41, M45, D1 and M46, respectively. 11-12. Sagittal sections: M50 and D7, respectively. 13. Enlarged figure of fig. 10 showing wall structure. ×123.

Photos by K. SADA

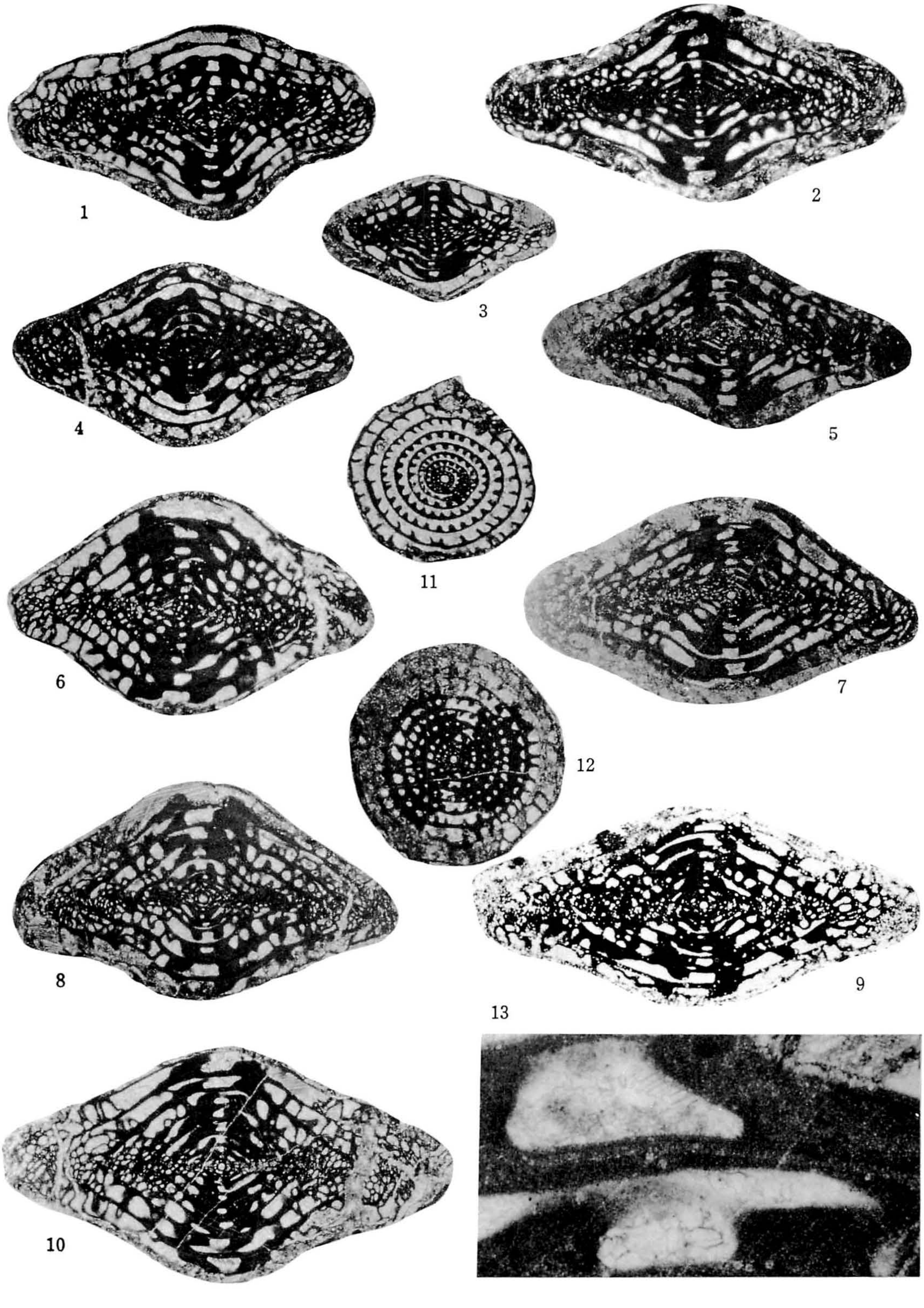

1
2
3
4
5
11
6
7
12
8
9
13
10

Table 1. Measurements of *Pseudofusulinella danneri* SKINNER & WILDE.

Speci-men	Rg. No.	Pl.	fig.	L.	W.	R.	Prol.	Radius vector 1	2	3	4	5	6	7	8	9	Thickness of spirotheca 0	1	2	3	4	5	6	7	8	9
1	M46	11	10	6. 65	3. 67	1. 81	. 150	. 132	. 118	. 321	. 491	. 637	. 675	1. 170	1. 397	1. 824	. 046	. 050	. 044	. 069	. 071	. 098	. 073	. 080	. 098	
2	M45	11	8	6. 35	3. 40	1. 86	. 075	. 132	. 207	. 283	. 358	. 584	. 811	1. 076	1. 359	1. 748	. 036	. 027	. 048	. 046	. 052	. 078	. 080	. 105	. 087	. 061
3	M43	11	4	5. 45	2. 85	1. 91	. 113	. 113	. 170	. 283	. 396	. 566	. 793	1. 038	1. 246		. 029	. 029	. 039	. 048	. 069	. 075	. 052	. 059		
4	M44	11	1	6. 00	2. 90	2. 06	. 188	. 132	. 226	. 321	. 453	. 604	. 717	1. 001	1. 246		. 046	. 016	. 029	. 052	. 029	. 050	. 085	. 089	. 059	
5	M42	11	2	6. 75	2. 90	2. 32	. 150	. 094	. 207	. 321	. 472	. 661	. 887	1. 133	1. 435		. 039	. 032	. 050	. 043	. 096	. 069	. 078	. 059	. 121	
6	M49	11	5	5. 25	2. 75	1. 90	. 132	. 113	. 118	. 245	. 377	. 491	. 679	. 887	1. 095		. 034	. 029	. 034	. 034	. 044	. 034	. 036	. 057	. 085	
7	M41	11	7	6. 00	3. 00	2. 00	. 207	. 132	. 207	. 321	. 434	. 566	. 830	1. 095			. 041	. 039	. 023	. 057	. 034	. 064	. 092	. 073	. 046	
8	D1	11	9	7. 00	3. 10	2. 25	. 188	. 113	. 170	. 264	. 358	. 510	. 738	. 849	1. 133		. 026	. 039	. 041	. 029	. 041	. 059	. 072	. 092	. 059	
		Min.		5. 25	2. 75	1. 81	. 075	. 094	. 118	. 245	. 358	. 491	. 675	. 849	1. 435	1. 748	. 026	. 016	. 023	. 029	. 029	. 034	. 036	. 059	. 046	. 061
		Max.		7. 00	3. 67	2. 32	. 207	. 132	. 226	. 321	. 491	. 673	. 887	1. 170	1. 095	1. 824	. 046	. 050	. 050	. 069	. 096	. 098	. 092	. 105	. 121	

than the holotype and paratypes of *P. danneri* in size, having 6.35 to 7.00 mm. in length and 3.10 to 3.67 mm. in width of the shells. However, these specimens quite resemble the paratypes of the species in the shell-shape and the other internal characters of the shells. Therefore we can hardly avoid the conclusion that these should be the fully grown specimens of *Pseudofusulinella danneri.*

The present specimens are somewhat similar to *Pseudofusulinella pinguis* SKINNER & WILDE (1965, p. 38, pl. 53, figs. 6-10) from the upper part of the McCloud Limestone of northern California and (1966, p. 12, pl. 9, figs. 2-5) from Coyote Butte Limestone in Suplee area, east-central Oregon. However, they can be easily distinguished by the smaller form ratios, the smaller tunnel angles, the convex lateral slopes of the shells and the weaker septal fluting of the latter species.

Occurrence:—Abundant at Loc. "M1" and Loc. "D1" in Chilliwack area, southwestern British Columbia. The specimens illustrated as Figs. 1-8, 10-11 on Pl. 11 came from Loc. "M1" and figs. 9 and 12 from Loc. "D1".

Subfamily Schwagerininae DUNBAR & HENBEST, 1930

Genus *Parafusulina* DUNBAR & SKINNER, 1931

Type-species:—*Parafusulina wordensis* DUNBAR & SKINNER, 1931.

Parafusulina mongeri SADA & DANNER, sp. nov.

Pl. 12, figs. 1-5; Pl. 13, fig. 4

Description:—The shell of *Parafusulina mongeri* SADA & DANNER, sp. nov.

is large and elongate cylindrical, with a straight axis of coiling and bluntly pointed to rounded poles. The lateral slopes are convex. The shell of the holotype (Pl. 12, fig. 1) is 15.75 mm. in length and 3.67 mm. in width. Its form ratio is 4.29.

The outside diameter of the proloculus is 250 to 450 microns. The proloculus wall is 18 to 37 microns. The radius vectors of the 1st to the 7th volution of four specimens are 50-250, 350-450, 450-650, 600-900, 800-1250, 1050-1600 and 1500-2250 microns, respectively. The chamber is nearly the same in height throughout the length of the shell except the polar regions.

The spirotheca is composed of a tectum and coarsely alveolar keriotheca. The thickness of the spirotheca is 18-56, 18-37, 18-56, 56-75, 56-151 and 56-151 microns, respectively, for the 1st to the 6th volution.

The septa are thin, closely spaced, narrowly, highly and regularly fluted throughout the shell. Cuniculi are present in the outer volutions. The septal counts of a specimen are 14, 27, 29, 34, 41 and 40, respectively, for the 1st to the 6th volution. The tunnel is very narrow and less than 30 degrees in the outer volutions. The chambers along the axial region of the inner four to five volutions are filled with dense deposits.

Remarks:—Parafusulina mongeri SADA & DANNER, sp. nov. resembles *P. laudoni* SKINNER & WILDE from northwestern Washington more closely than any other known American species belonging to the genus. However, the former species can be distinguished from the latter by its cylindrical shell, the slower expansion of the shell, the smaller proloculus, the weaker and more regular septal fluting, the lighter axial fillings and the smaller tunnel angle. *Parafusulina mongeri*, sp. nov. bears a certain similarity to *P. belcheri* THORSTEINSSON (in HARKER & THORSTEINSSON, 1960, pp. 29-30, pl. 9, figs. 1-5; pl. 10, figs. 1-5) from Grinnell Peninsula, Arctic Archipelago. The major difference between these two species is that *P. belcheri* is smaller at maturity, has weaker septal fluting, a broad tunnel angle and no axial fillings.

Occurrence:—Abundant at Loc. "D1" in Chilliwack valley, British Columbia. All of the illustrated specimens (Pl. 12, figs. 1-4; Pl. 13, fig. 4) came from Loc. "D1".

Parafusulina laudoni SKINNER & WILDE

Pl. 13, figs. 1-3, 5-6

1966. *Parafusulina laudoni* SKINNER & WILDE. *Pal. Contrib. Univ. Kansas, Paper* 4, pp. 43-44, pl. 36, figs. 2-5.

Description:—The shell of *Parafusu-*

Explanation of Plate 12

All ×10 except fig. 5

Figs. 1-4. *Parafusulina mongeri* SADA & DANNER, sp. nov.
1. Axial section of holotype: Rg. No. D20. 2-3. Axial sections of paratype: Rg. Nos. D16 and D14, respectively. 4. Sagittal section: Rg. No. D10.

Fig. 5. Tangential section of *Parafusulina laudoni* SKINNER & WILDE showing cuniculi. ×66.6. Reg. No. M46.

Photos by K. SADA

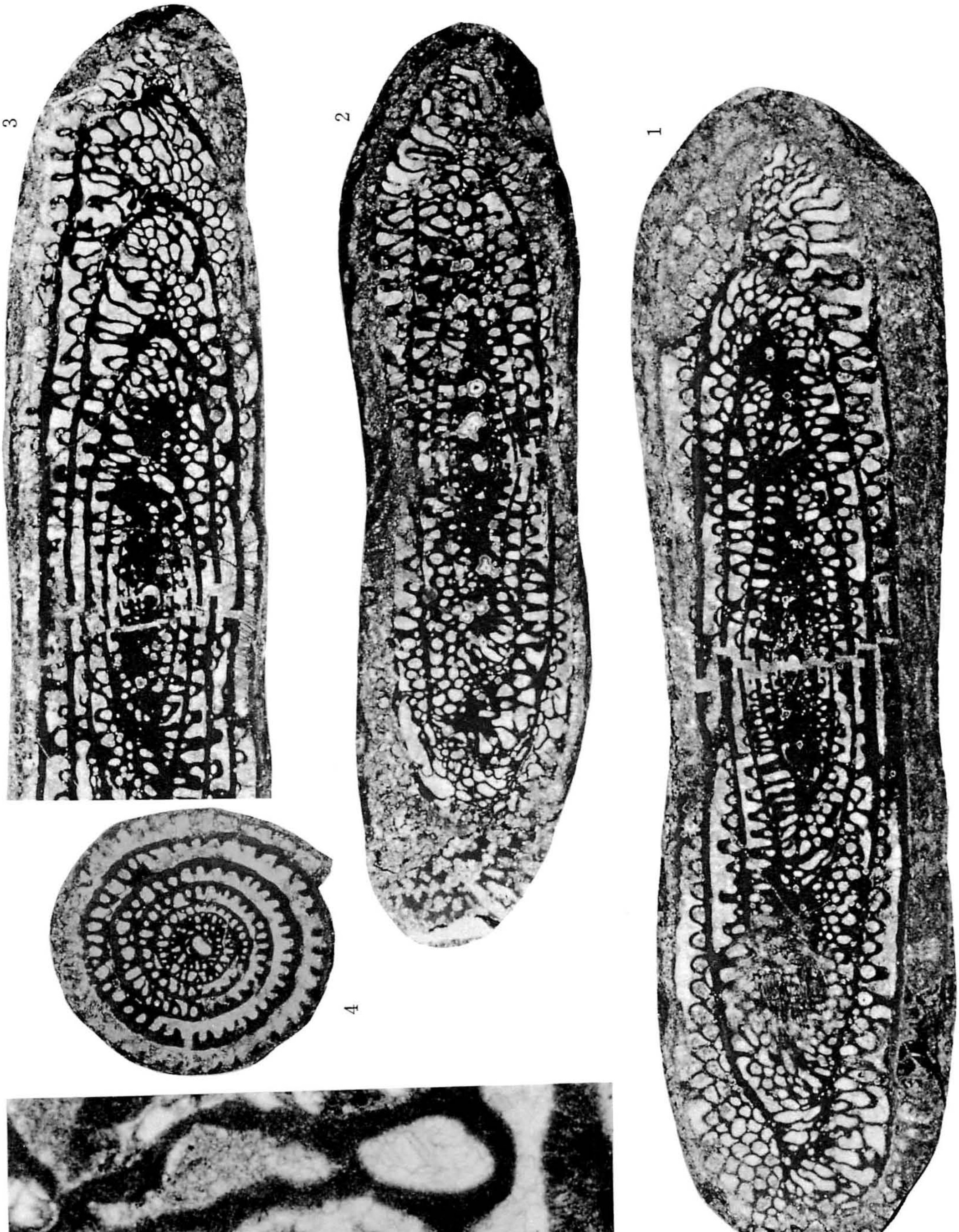

1
2
3
4
5

Table 2. Measurements of *Parafusulina mongeri* SADA & DANNER, sp. nov.

Specimen	Rg. No.	Pl.	fig.	L.	W.	R.	Prol.	Radius vector 1	2	3	4	5	6	7	Thickness of spirotheca 0	1	2	3	4	5	6
1	D20	12	1	15.75	3.67	4.29	.250	.200	.350	.550	.800	1.050	1.400		.018	.018	.037	.056	.075	.113	.151
2	D23	13	4	—	4.25	—	.450, .350	.250	.450	.650	.900	1.250	1.600	2.250	.037	.037	.037	.056	.075	.151	
3	D16	12	2	10.50	2.50	4.20	.300, .350	.050	.350	.450	.600	.800	1.050	1.500	.018	.018	.018	.018	.056	.056	.056
4	D14	12	3	—	3.75	—	.350	.250	.350	.500	.700	.950	1.200	1.650	.037	.056	.037	.075	.037	.094	.113
			Min.	10.50	2.50	4.20	.250	.050	.350	.450	.600	.800	1.050	1.500	.018	.018	.018	.018	.056	.056	.056
			Max.	15.75	4.25	4.29	.450	.250	.450	.650	.900	1.250	1.600	2.250	.037	.056	.037	.056	.075	.151	.151

lina laudoni SKINNER & WILDE is large and elongate subcylindrical, having a straight axis of coiling, bluntly pointed poles and convex lateral slopes. The shell of eight volutions of the typical specimen (Pl. 13, fig. 1) is 17.00 mm. long and 4.35 mm. wide, giving a form ratio of 3.90.

The proloculus is large and spherical to subspherical. Its outside diameter ranges from 350 to 550 microns. The proloculus wall is thin, measuring 37 microns. The radius vectors of the 1st to the 8th volution are 264-350, 434-550, 661-800, 887-1100, 1208-1600, 1605, 1907 and 2304 microns, respectively. The chamber is nearly the same in height throughout the length of the shell except at the extreme polar regions.

The spirotheca consists of a tectum and coarsely alveolar keriotheca. The thickness of the spirotheca of the 1st to the 8th volution of two specimens is 37, 37, 37-56, 56-94, 75-113, 94, 113 and 113 microns, respectively.

The septa are strongly fluted throughout the length of the shell. The phrenotheca are developed partly in the outer volutions. The septal counts of a specimen (Pl. 13, fig. 5) are 11, 22, 31, 40, 43 and 44, respectively, for the 1st to the 6th volution. Their number in the 7th volution is unknown because of the incomplete test. Cuniculi are present in the outer volutions. The tunnel angles are 40 to 45 degrees in the 6th volution of a typical specimen. Heavy dense deposits are present along the axial region.

Remarks:—In the shell-form, the internal biocharacters and the measured values, the present specimens show striking similarities to the specimens described under the name of *Parafusulina laudoni* by SKINNER & WILDE (1966) from the Permian Chilliwack Group on the north side of Black Mountain in Whatcom

County, Washington. They may be conspecific. The typical specimen (Pl. 13, fig. 1) is slightly larger in size than the holotype (SKINNER & WILDE, 1966, pl. 36, fig. 2) of *P. laudoni*, but this falls within the limits of the individual variation of the species.

Occurrence:—Abundant at Loc. "M1" in Chilliwack area, British Columbia. All of the illustrated specimens (Pl. 13, figs. 1-3, 5-6) came from Loc. "M1".

References

CAIRNES, C.E. (1944): Hope Sheet; *Geol. Survey Canada Map* 737A.

COOGAN, A.H. (1960): Stratigraphy and Paleontology of the Permian Nosoni and Dekkas Formations (Bollibokka Group). *California Univ., Pub. Geol. Sci.*, Vol. 36, no. 5, pp. 243-316.

DALY, R.A. (1912): Geology of the North American Cordillera at the forty-ninth Parallel. *Geol. Survey Canada Memoir* 38.

DANNER, W.R. (1957): Stratigraphic reconnaissance in the Northwestern Cascade Mountains and San Juan Islands of Washington State. Unpublished Ph. D. thesis, Univ. of Washington.

HARKER, P. & THORSTEINSSON, R. (1960): Permian rocks and faunas of Grinnel Peninsula, Arctic Archipelago. *Geol. Surv. Canada Mem.* 309, pp. 1-89.

HILLHOUSE, D.N. (1965): Geology of the Vedder Mountain (Silver Lake) Area. Unpublished M. Sc. thesis, Univ. of British Columbia.

MONGER, J.W.H. (1966): The stratigraphy and structure of the type-area of the Chilliwack Group, Southwestern British Columbia. Unpublished Ph. D. thesis, Univ. of British Columbia.

SKINNER, J.W. & WILDE, G.L. (1965): Permian biostratigraphy and fusulinid faunas of the Shasta Lake area, northern California. *Pal. Contr. Univ. Kansas, Protozoa, Article* 6, pp. 1-98.

SKINNER, J.W. & WILDE, G.L. (1966): Permian fusulinids from Pacific Northwest and Alaska. *Pal. Contr. Univ. Kansas. Paper* 4, pp. 1-64.

THOMPSON, M.L., WHEELER, H.E. & HAZZARD, J.C. (1946): Permian Fusulinids of California. *Geal. Soc. Amer., Mem.* 17 p. 1-77.

Explanation of Plate 13

All ×10

Figs. 1-3, 5-6. *Parafusulina laudoni* SKINNER & WILDE

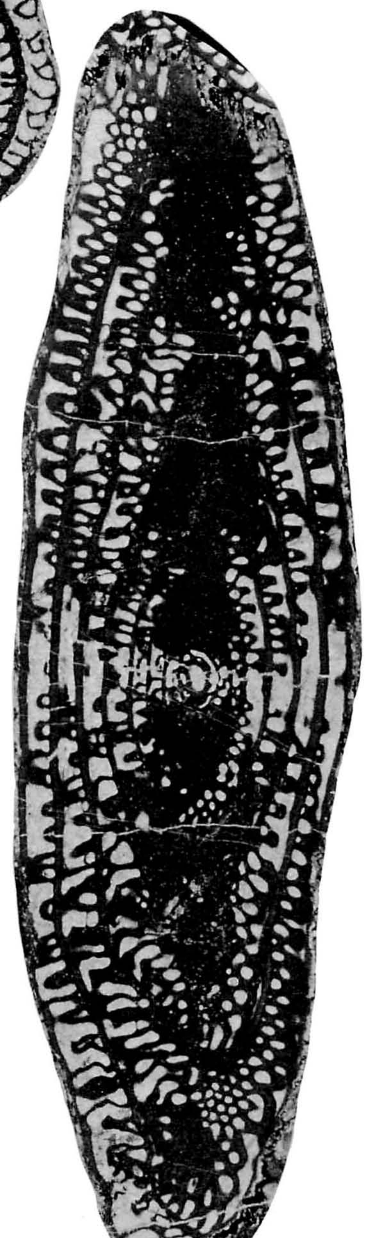
1-3. Axial sections: Rg. Nos. M52, M53 (the immature specimen) and M39, respectively.

5-6. Sagittal sections: Rg. Nos. M59b and M59a, respectively.

Fig. 4. *Parafusulina mongeri* SADA & DANNER, sp. nov.

4. Axial section: Rg. No. D23.

Photos by K. SADA.


1


2


3


4


5


6

Trans. Proc. Palaeont. Soc. Japan, N.S., No. 90, pp. 81-94, June 30, 1973

617. OMMA-MANGANJIAN MOLLUSCAN FAUNA IN THE FUTATSUI AREA OF NORTHERN AKITA, JAPAN*

KIYOTAKA CHINZEI

Geological Institute, University of Tokyo, Hongo, Tokyo 113

秋田県北部二ツ井地方の大桑万願寺動物群：自生群または自生個体についてみると，二ツ井付近に分布する鮮新統に含まれる貝化石群には，相伴って発見される種の組合せと個体頻度の相異によって四つの群集型が識別される。すなわち鮮新統下部の泥相中の *Nuculana robai* と *Turritella nipponica* などの巻貝に富む群集，その上位の細粒砂相の下半分にみられる *T. saishuensis, Limopsis tokaiensis, Acila nakazimai* を主とする群集，上半部の *T. saishuensis, Macoma tokyoensis, Mercenaria stimpsoni* などで特徴づけられる群集，および中部の小区域にみられる *Felaniella usta, Thracia kakumana* の群集である。鮮新統上部の中粒砂相には，*Umbonium akitanum, Glycymeris yessoensis* の多い他生群があり，これを仮に中粒砂を代表する，5番目の群集として扱う。これらの群集の分布は岩相の分布と一致し，その境は岩相の境とともに時間面を切る。一方この鮮新統は全体として海退・浅海化の傾向下における堆積物と判断され，群集の時空分布は，基本的には海の浅化，海域の縮少という環境変化に支配されるが，各群集の境界の位置は岩相の分布に規定されているといえる。すなわち下位から上位への群集の排列は，当時の海底における深所から浅所への群集の変化をある程度まで示唆するとみてよい。二ツ井でみられるこのような群集型とその相互関係は，大桑万願寺動物群の一つの代表的な例と思われ，同じ組成の群集が各地に認められる。

鎮 西 清 高

Introduction

The molluscan fauna in the marine Pliocene of the Japan Sea coast of Honshu has been generally called the Omma-Manganjian fauna. The name was proposed by OTUKA (1939a) who described the fauna as "a fauna of the Japan Sea during the Pliocene". It has been thought to be composed of cold deep water inhabitants (OTUKA, 1939b; HATAI and NISIYAMA, 1939 etc.). CHINZEI (1963) noted that species characteristic to the fauna are mostly dwellers of off-shore muddy or fine sandy bottoms with elements intermingled from gravelly facies. He regarded the fauna as representative of the off-shore assemblages of the Pliocene in Northeast Japan, and compared it with the shallow sea assemblages of the Tatsunokuchian fauna.

In detail, however, the composition of the fauna varies remarkably in different areas and at different localities, even in areas typical of the Omma-Manganjian fauna such as Kanazawa (HATAI and NISIYAMA, 1939; KASENO and MATSUURA, 1965) and Manganji in southern Akita (OTUKA, 1936). This suggests that the fauna includes assemblages representing various types of environments, and that the fauna does not always represent an off-shore community. Detailed analysis has only been done by KASENO and

* Received Nov. 17, 1972; read Jan. 16, 1973 at Sendai.

MATSUURA (1965) on the fauna in the Kanazawa area. KASENO and MATSUURA concluded that the molluscan fauna of the Omma formation is composed mainly of upper sublittoral species, although the shells are mostly transported and mixed with those of different habitats.

In this paper, the writer will present a brief description of the molluscan assemblages in the Pliocene deposits of the Futatsui area, northern Akita Prefecture. This area is known as one where molluscan fossils belonging to the Omma-Manganjian fauna are found abundantly.

Analysis is made of the modes of fossil occurrence and the type of sediments that contain the fossils. Five types of molluscan assemblages can be distinguished when discussion is confined to the autochthonous individuals or individuals transported only a short distance. Each type of assemblage is characterized by two or three predominant or common species, and is in a particular sedimentary facies. In this respect, an assemblage may be regarded as a unit whose constituents have a close ecological relationship to each other.

The combined occurrence of these assemblages including the species composition of each assemblage is considered to be typical of the Omma-Manganjian type molluscan fauna.

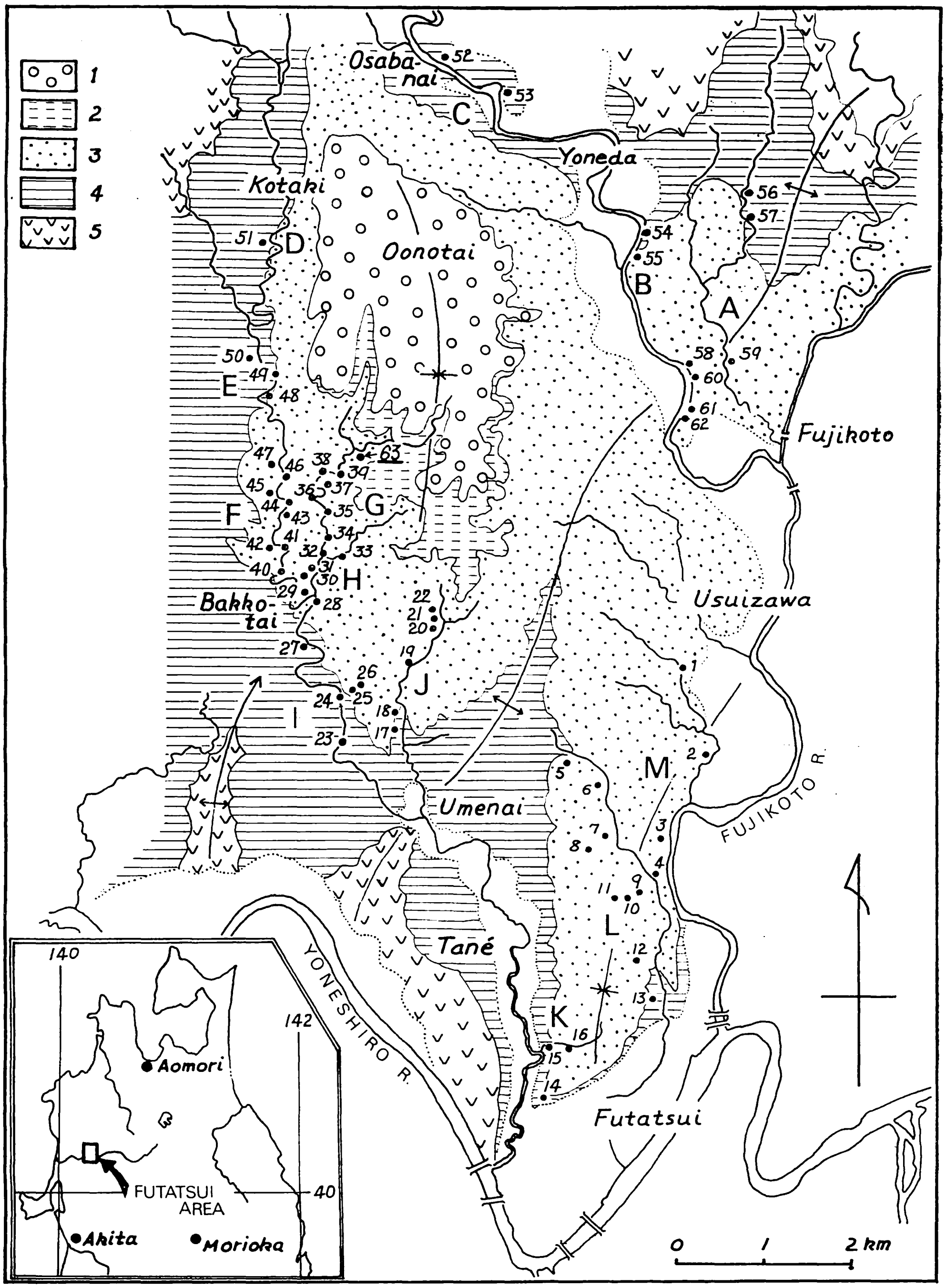
Acknowledgements: Professor Tetsuro HANAI and the writer's colleagues at the Geological Insitute, University of Tokyo made valuable suggestions during the course of the study. Comments on stratigraphical problems were made by Dr. Jiro HIRAYAMA of the Geological Survey of Japan. The manuscript was read by Professor T. HANAI, and Mr. John GRIMMER of the University of California, Los Angeles. The writer wishes to express his deep thanks to these persons.

Outline of stratigraphy and description of sedimentary facies

The Futatsui area is situated at the northeastern corner of the Akita oil-field. The upper part of the marine Neogene is exposed in this area forming gentle folds with a NNE-SSW trend. The stratigraphy of the Neogene deposits in this area is similar to that in the type-section of the oil-field in the Akita area. In the study area the formations are dominated by marine clastic deposits, while the Neogene deposits exposed to the immediate east and the north of the study area are rich in altered volcanic materials known as the Green-Tuff.

The lowest horizon exposed in the area is the Upper Nanakura tuff member of the Fujikotogawa formation (HIRAYAMA and SUMI, 1963). It is composed of fine acidic pumices containing large numbers of pumice blocks and other lithic fragments. The tuff is correlated with the top of the upper Miocene Funakawa formation of the Akita area.

The Upper Nanakura tuff is overlain conformably by a grey massive siltstone more than 450 m thick. This siltstone is a part of the Kobinaizawa formation (HIRAYAMA and SUMI, 1963). The main part of the siltstone is correlated with the Tentokuji formation as judged from the stratigraphic position and lithology. It is a coarse-grained homogeneous siltstone, and is tuffaceous, containing small fragments of volcanic glass, plagioclase, hornblende and other crystals. Thin layers of pumice-tuff and tuffaceous fine-grained sandstone are found rarely. The upper part of the siltstone becomes sandy, and is intercalated by very fine-grained silty sandstone. Mol-



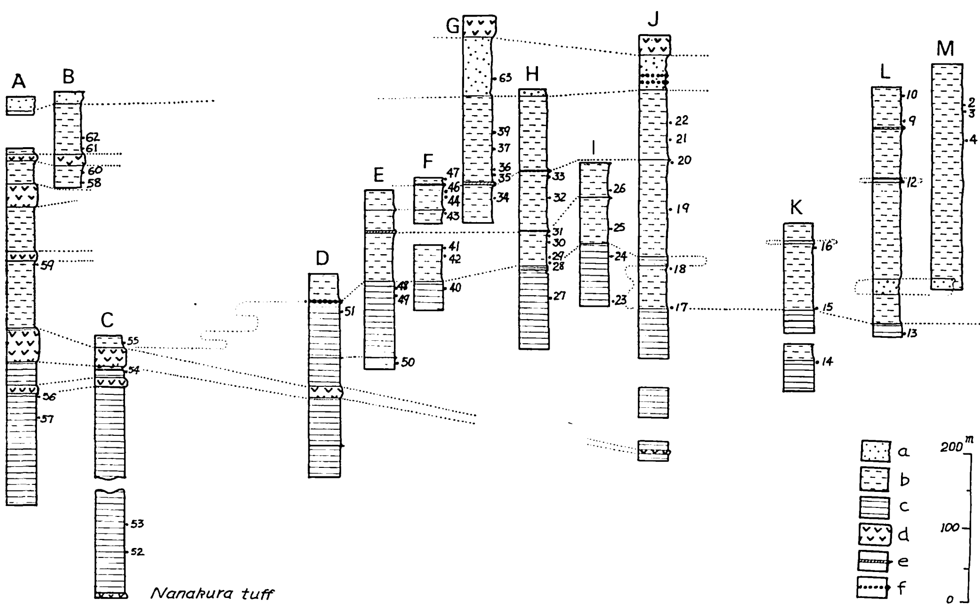
Text-fig. 1. Geologic map and fossil localities of the Futatsui area.

1-63 : fossil localities; A-M : the locations where the columnar sections (Text-fig. 2) are measured. Symbols for geologic map; 1 : sands and gravels, 2 : bedded pumice tuff, 3 : fine- and medium-grained sandstone, 4 : siltstone, 5 : the Upper Nanakura tuff.

luscan remains are found sporadically in the upper horizon of the siltstone. They are the assemblage of muddy facies referred to in the following sections. Foraminifera are also found in the siltstone.

Near the northeastern corner of the area, between Locs. 49 and 51, a conglomerate lens 50 cm to 2 m thick is intercalated between the siltstone and an overlying fine-grained sandstone. It is composed of andesitic granules and pebbles, and contains abundant water-worn fragments of shells.

The siltstone is overlain conformably by fine-grained sandstone. The sandstone probably corresponds to the Sasaoka formation of the Akita area although the stratigraphic relationship between the two is not possible to ascertain directly because the sandstone is separated from other areas of the oil-field by anticlinal highs of the underlying formations. The lithology of the sandstone resembles the Tofuiwa facies (TAKAYASU, 1861) of the upper Sasaoka formation at the type locality. The sandstone is massive or very weakly bedded with interbedded layers of pumice-tuff. It is mainly composed of well-sorted grains of volcanic rocks, crystals and pumices. The sand fraction is 75 to 85 percent in general, and the modes of the frequency distributions of the grains average approximately 3.5ϕ. Medium- to coarse-grained strata are exceptionally seen in the lower part of the sandstone in the southeastern corner of the area (columns L and M in Text-fig. 2). Thin layers of siltstone are also seen in the southwest. The sandstone contains rich molluscan fauna. They are grouped in



Text-fig. 2. Columnar sections of the upper Neogene deposits in the Futatsui area, indicating the stratigraphic horizon of fossil localities.

A-M correspond to the localities indicated in Text-fig. 1. Symbols for sedimentary facies; a: medium-grained sandstone, b: fine-grained sandstone, c: siltstone, d: pumice tuff, e: thin tuff layer, f: conglomerate.

this paper as the assemblages of the fine-grained sand facies.

As shown in Text-fig. 2, the boundary between the sandstone and the underlying siltstone obliquely crosses the interbedded pumice-tuff layers which are probably isochronous horizons. The sandstone occurs at the lowest horizon in the northeastern part of the area while the uppermost horizon of the siltstone is seen in the western part of the area. The sandstone is thickest in the northeast where it is approximately 400 m thick. It is 250 to 300 m thick in the west.

The upper part of the sandstone grades upward into a medium-grained loose sandstone mineralogically similar to the fine-grained part. This medium-grained sandstone is poorly stratified and rich in pumice grains. A cluster of molluscan shells was found in a lower horizon of the medium-grained sandstone in the western part of the area (Loc. 63 of Text-fig. 1). Median diameter of the grains of the sandstone at Loc. 63 is 2.1ϕ and the sand content is approximately 65%.

The sandstone is overlain by well bedded light grey pumice tuff beds. The tuff beds are covered by thick alternating sands and gravels which form the plateau of Oonotai. Judging from their sedimentary features these tuff and gravel beds were considered by HIRAYAMA and SUMI (1963) to be of fresh water origin. As they are nearly horizontal, they probably cover the underlying slightly inclined sandstone unconformably.

Modes of fossil occurrence

The sediments in which fossil molluscs are found can be divided into four types, mud, fine-grained sand, medium-grained sand, and gravels. The modes of fossil occurrence can be closely correlated with these sediment types.

1. Muddy facies. The muddy facies fauna is most common in the siltstone beds which correspond to the Tentokuji formation. The fauna also occurs sporadically in silty layers interbedded in the lower part of the fine-grained sandstone.

Molluscs are scattered in the siltstone with a frequency, in general, of 1 to 5 per square-meter of the outcrop. The individuals usually do not have a particular orientation. At Locs. 14 and 40, such flat shells as *Nuculana* and *Pandora*, are found lying parallel to the bedding planes of thin patches of very fine-grained sandstone. Most of the bivalves occur with conjoined valves except for some specimens of *Serripes groenlandica*. Minute sculpture of the shell-surface and even fragile protoconchs of some gastropods are well preserved. There is no indication of transportation.

2. Fine-grained sand facies. Fossils can be seen at most of the exposures of the fine-grained sandstone, and they are especially abundant in the western area. In the usual case, they are scattered very densely, and do not form particular fossil beds. Exceptions are found at Locs. 22, 31, 36, 38, 39 and 43, where the shells are clustered in beds. The number of individuals varies from 6 (Loc. 62) to more than 400 (Loc. 45) per square-meter of exposure surface.

Bivalves are mostly conjoined even when occurring in clusters. They are randomly oriented in the sandstone except for *Mya cuneiformis* which is nearly vertical with the posterior upwards. Gastropods, represented abundantly by *Turritella saishuensis*, do not show any marked orientation. The majority of bivalves and gastropods do not show evidence of transportation by water.

3. Medium-grained sand facies. A bed of shells was found at Loc. 63 in the medium-grained sandstone. It is a lens 20 cm in maximum thickness and more than 6 m in length. Bivalves are invariably represented by odd valves which are arranged parallel to the bedding plane. Broken and fragmental shells are abundant. Although the surface sculpture of the shells is well preserved, they were undoubtedly transported and accumulated by water. Tests of the flat echinoid, *Echinarachnius* cf. *humilis* Nisiyama, are found in the lower part of the shell bed.

4. Gravel facies. The gravel facies fauna is found in the lenticular conglomerate at the base of the fine-grained sandstone. Molluscs are all worn and broken. They are mixed with the gravels. The shells were probably transported by water from remote places.

Molluscan assemblages

Judging from the modes of occurrence described above, the molluscs found in the muddy and the fine sand facies can be regarded as autochthonous, preserved at or near the place of their origin. The species observed at an outcrop are considered to have some ecological rela-

Table 1. List of molluscan fossils found in muddy facies in the Futatsui area.

Species / Assemblage / Locality	*Nuculana - Turritella nipponica*																
	12	13	14	17	18	23	24	27	40	48	49	50	51	52	53	56	57
Turritella nipponica YOKOYAMA	O	O	•	O	O		•				•				•	•	
Fulgoraria prevostiana (CROSSE)							•	•			•	•					
Buccinum tsubai KURODA						•	•										
Neptunea sp.			•												•		•
Tectonatica tugaruana (NOMURA & HATAI)							•					•			•		
Fusitriton oregonensis (REDFIELD)																	•
Propebela sp.							•										
Admete tabatai (YOKOYAMA)							•								•		
Rectiplanes sadoensis (YOKOYAMA)							•				•	•					
Turricula kaderleyi (LISCHKE)							•										
Nuculana robai KURODA						O	O	O	O		•	O		O	•		
Macoma calcarea (GMELIN)	•						•			O			O		•		
Serripes groenlandica BRUGUIERE							•	•		•			•				•
Pandora pulchella (YOKOYAMA)							•		•	•	•			•			
Acila cf. *insignis* (GOULD)														•			
Limopsis tokaiensis YOKOYAMA				O	◎						•						
Limatula kurodai OYAMA									•								
Panomya beringiana DALL							•										
Panomya simotomensis OTUKA	•					O											
Clinocardium sp.											•		O				
Portlandia japonica (ADAMS et REEVE)												•		•			
Nuculana sp.			O														
Ennucula tenuis (MONTAGU)						•											
Nuculana yokoyamai KURODA							•										
Lucinoma acutilineatum (CONRAD)							•										
Venericardia ferruginea (CLESSIN)													•				
Periploma sp.						•											
Palliolum peckhami (GABB)							•										
Astarte borealis (SCHUMACHER)													O				
Thyasira bisecta (CONRAD)			•			•	•									•	
Siphonodentalium sp.							•										

Individual number / m^2 of outcrop; ◎ 10 - 6, O 5 - 3, • < 2 tionship to each other.

Molluscs found in the medium-grained sand facies were apparently transported as noted above. They are, however, treated here tentatively as an assemblage of the medium-grained sand facies since they are thought to have lived not far from the place of deposition judging from the state of preservation. The assemblage contained in the gravel facies is a mixture of species from more than one habitat.

1. Muddy facies

Molluscs found in the muddy facies are listed in Table 1. The difference in species composition by locality is noticeable. This may result partly from the chance of observation because the density of individuals in the sediment is extremely low.

The muddy facies fauna is characterized by a richness of gastropod species compared with the assemblages in the fine-grained sand facies. The fauna may be called the *Nuculana—Turritella nipponica** assemblage since *Nuculana robai* and *Turritella nipponica* are the species most commonly seen in the muddy facies. Other characteristic species of the assemblage are *Rectiplanes sadoensis*, *Fulgoraria prevostiana*, *Buccinum tsubai*, *Neptunea* sp., *Admete tabatai*, *Macoma calcarea*, *Pandora pulchella*, *Panomya beringiana*, *Thyasira bisecta*, *Portlandia japonica*, etc. The assemblage is typically seen at Loc. 24.

Turritella nipponica is relatively common in the upper part of the siltstone and in the silty layers interbedded in the fine-grained sandstone. In these lithologies the species associated with *T. nipponica* are more or less different from those found in the typical assemblage. *Nuculana robai* and gastropods are generally absent. In some localities, e.g., Locs. 17 and 18, *T. nipponica* is associated with *Limopsis tokaiensis* and no other molluscan species. *Limopsis tokaiensis* is commonly found in the *Turritella—Limopsis—Acila* assemblage of the fine-grained sand facies. These facts suggest that the variety of assemblage characterized by *T. nipponica* and *Limopsis tokaiensis* is the transitional between the typical muddy facies assemblage and the fine-grained sand facies assemblage.

2. Fine-grained sand facies

The molluscan fauna contained in the fine-grained sand facies is characterized by the predominant occurrence of *Turritella saishuensis motidukii*, *Mya cuneiformis* and *Macoma tokyoensis*, except in the northeastern part of the area where the former two species are rare. The fauna can be divided into two major assemblages on the basis of the difference in species associated with the dominant three forms. The assemblages are *Turritella saishuensis—Limopsis—Acila nakazimai*, and *Turritella saishuensis—Macoma tokyoensis—Mercenaria*. Although no appreciable difference can be detected between the sediments containing the two assemblages, the stratigraphic distribution of the faunas is different. The *Turritella—Limopsis—Acila* assemblage is concentrated in the lower part of the fine-grained sandstone, whereas the *Turritella—Macoma—Mercenaria* assemblage is characteristic of the middle part.

In addition to the two assemblages above, an assemblage dominated by *Felaniella usta* and *Thracia kakumana*

* Because two species each of *Turritella*, *Macoma*, and *Acila* are recognized in this area, the assemblages are termed by the species names in order to discriminate between them.

Table 2. List of molluscan fossils found in fine-grained

Assemblage	*Turritella saishuensis - Limopsis - Acila nakazimai*															*Felaniella - Thracia*		
Species \ Locality	15	16	19	20	25	26	28	29	30	31	33	34	41	42	45	35	36	1
Turritella saishuensis motidukii OTUKA	◎	—	●	●	—	●	◎	●	◎	◎	◎	◎	●	◎	●			
Mohnia sp.															•			
Macoma tokyoensis MAKIYAMA					•		•		•						•	◎		◎
Mercenaria stimpsoni (GOULD)		•											•		•	○		
Clinocardium sp.																		•
Anadara amicula (YOKOYAMA)															•			
Protothaca adamsi (REEVE)																•		•
Mya cuneiformis (BOHM)			•			•	•				•	•						
Thracia kakumana (YOKOYAMA)																●	●	
Serripes groenlandica BRUGUIERE											•							
Felaniella usta (GOULD)																●	●	
Dosinia japonica (REEVE)																•	•	○
Acila cf. *insignis* (GOULD)																•		
Glycymeris yessoensis (JAY)																•		
Patinopecten kurosawensis (YOKOYAMA)																		
Peronidia protovenulosa (NOMURA)																•	•	
Lucinoma acutilineatum (CONRAD)															•			
Thyasira bisecta (CONRAD)	•																	
Macoma calcarea (GMELIN)					•										○			
Yoldia notabilis YOKOYAMA																		
Spisula voyi (GABB)																	○	
Astarte borealis (SCHUMACHER)													•					
Panomya simotomensis OTUKA													•					
Venericardia ferruginea (CLESSIN)						◎			◎						◎			
Acila nakazimai OTUKA		○			●	●	●						○	●				
Limopsis tokaiensis YOKOYAMA			◎		●	●	◎	◎	◎	◎	•			◎	●			

Individual number / m^2 of outcrop: ● >10, ◎ 10 - 6, ○ 5 - 3, • < 2

is found in the middle horizon of the fine-grained sandstone.

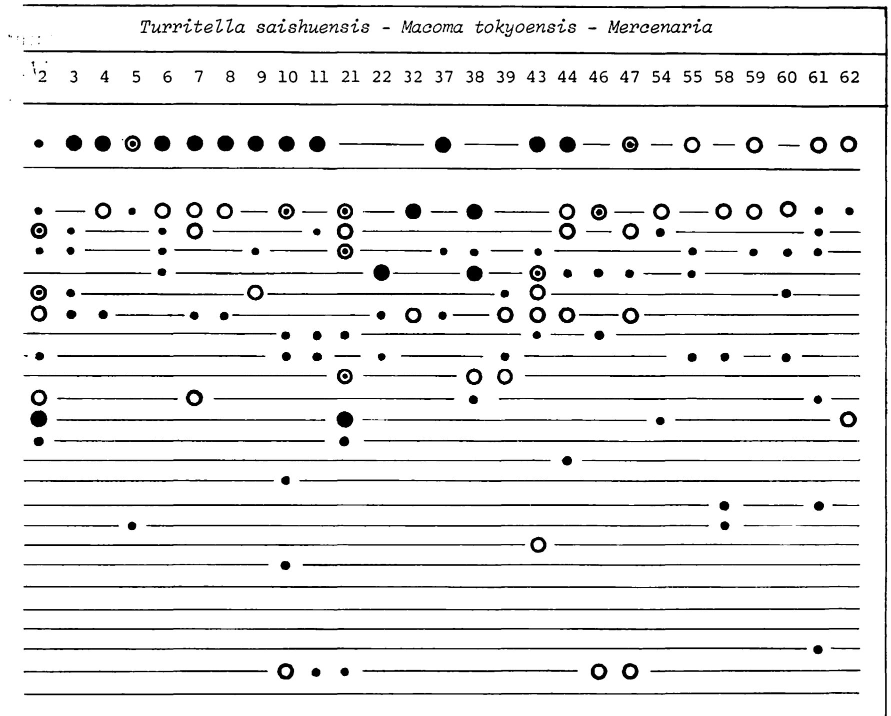
a) *Turritella saishuensis—Limopsis—Acila nakazimai* assemblage

This assemblage is characterized by the abundant occurrence of *Limopsis tokaiensis* and *Acila nakazimai* associated with *Turritella saishuensis motidukii.* In general *Mya cuneiformis*, *Venericardia ferruginea* and *Macoma tokyoensis* are also found commonly. Other subordinate species and individuals are few in number. The associations simply composed of *Turritella* or *Turritella* and *Mya* are included in this assemblage. This assemblage is concentrated in the lower part of the fine-grained sandstone and in the west.

Detailed study reveals that the association of species found on the same bedding plane or within a single layer is simple in composition, but varies with locality or horizon. The following associations of species can be recognized; species are arranged in the order of abundance of individuals.

Turritella (monospecific)	Loc. 20
Turritella—Mya	Locs. 26, 34
Turritella—Mya—Limopsis	Loc. 33
Turritella—Mya—Acila	Loc. 28
Turritella—Limopsis	Locs. 26, 29, 31
Turritella—Limopsis—Venericardia	Locs. 30, 45
Turritella—Acila—Limopsis	Loc. 42
Limopsis—Acila—Turritella	Loc. 26
Limopsis—Acila—Mya	Loc. 26

sand facies in the Futatsui area.



Limopsis—Venericardia Loc. 26
Limopsis—Mya Loc. 19

The greatest number of associations are found at Loc. 26, where five different associations are observed repeatedly within a 30 m sequence. The differences in species associations probably indicate minor environmental differences. *Acila* and *Venericardia* do not occur together. This may suggest that the two species were in competition for the same ecological niche, as the modes of life of these genera are quite similar to each other.

b) *Turritella saishuensis—Macoma tokyoensis—Mercenaria* assemblage

This assemblage is characterized by the common occurrence of *Macoma tokyoensis* and *Mercenaria stimpsoni* associated with *Protothaca adamsi, Anadara amicula, Clinocardium* sp., *Dosinia japonica*, and some other bivalves. *Turritella saishuensis motidukii* is abundant at most of the localities, and *Mya cuneiformis* is also commonly found. Other noteworthy species in this assemblage are *Tellina protovenulosa, Spisula voyi, Mactra kurikoma*, and *Patinopecten kurosawensis* although they are rare. These species have been reported from several areas of the Omma-Manganjian faunal distribution as the important constituents of the fauna. A large and well preserved shell of *Patinopecten kurosawensis* was collected at Loc. 44. Shells of *Serripes groenlandica* and *Glycymeris yessoensis* were recognized at several localities. They are rare, ordinarily occurring as single valves, some of which are broken. These species are probably not indigenous to the assemblage.

The relative abundance of some of the associated species is somewhat variable. The assemblages of Locs. 2 and 21 are dominated by *Acila insignis*, and those of Locs. 22 and 38 by *Anadara amicula*. In general, *Anadara amicula* becomes dominant toward the upper horizon of the fine-grained sandstone. At Locs. 22 and 38, shells of *Anadara amicula* are mostly conjoined valves which are found in shell beds 5 to 10 cm thick. *Macoma tokyoensis*, *Clinocardium* sp., etc., are found in the immediate upper and lower horizons of the *Anadara* beds, but are not seen within the beds.

At Loc. 43, the shells of *Turritella saishuensis*, *Protothaca adamsi*, and *Macoma tokyoensis* form an indistinct zone of shell cluster, while *Mya cuneiformis* specimens are found about 25 to 30 cm below the *Turritella* zone in their living position. These modes of occurrence seem to compare closely with the life habits of Recent allied forms. These *Mya* probably lived at the same time as *Turritella* and other molluscs, and the shell bed seems to have preserved this part of the benthic community at the time of deposition.

c) *Felaniella—Thracia* assemblage

This assemblage is found only at Locs. 35 and 36, both in the middle horizon of the fine-grained sandstone in the western part of the area. Loc. 35 is situated at a horizon about 3 m lower than that of Loc. 36. The shells form a loosely clustered shell bed at each locality.

Felaniella usta and *Thracia kakumana* are dominant at both localities. The former species is extremely abundant. *Macoma tokyoensis*, *Mercenaria stimpsoni*, and *Tellina protovenulosa* are species commonly associated with the dominant forms. *Turritella saishuensis* and *Mya cuneiformis* which are abundant in other assemblages of the fine-grained sand facies are absent in the shell beds and the surrounding sediments. A shell bed composed exclusively of conjoined shells of *Felaniella usta* occurs along with the *Felaniella—Thracia* bed at Loc. 36.

3. Medium-grained sand facies

As mentioned, molluscs were found in the medium-grained sand facies only at Loc. 63 where they form a thin lenticular shell bed. The most abundant species in the bed is *Umbonium akitanum*. It is associated with *Glycymeris yessoensis* and *Dosinia japonica*. Small individuals of *Mercenaria stimpsoni* and *Clinocardium* sp. are also found in the shell bed. The bivalves are all dissociated. *Dosinia*, *Mercenaria*, and *Clinocardium* are common in the *Turritella—Macoma—Mercenaria* assemblage of the fine-grained sand facies. The assemblage of the medium-grained sand facies is named the *Umbonium—Glycymeris* assemblage, and tentatively regarded as typical of the molluscan fauna in the medium-grained sand facies.

4. Gravel facies

The assemblage found in the conglomerate is identified as a mixture derived from two or more different habitats. *Mercenaria stimpsoni*, *Felaniella usta*, etc. are found commonly in the fine-grained sand facies, while the rest of the species, *Glycymeris* sp., *Patinopecten* sp., *Swiftopecten* sp., are not found from the other facies in the study area.

Discussion

The molluscan assemblages seen in the upper Neogene deposits of the Futatsui area are summarized as follows:

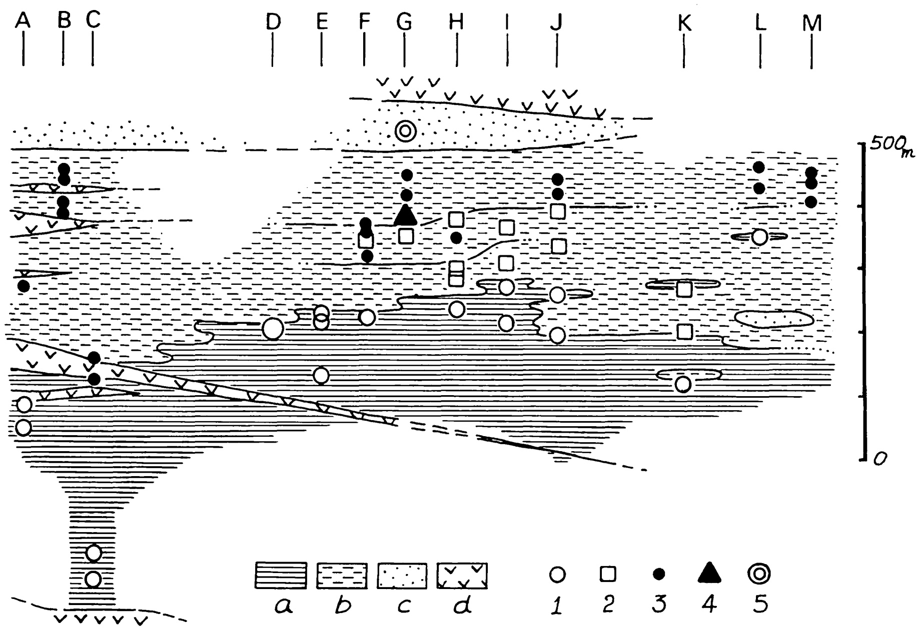
Muddy facies
- *Nuculana—Turritella nipponica* assemblage

Fine-grained sand facies
- *Turritella saishuensis—Limopsis—Acila nakazimai* ass.
- *Turritella saishuensis—Macoma tokyoensis—Mercenaria* ass.
- *Felaniella—Thracia* ass.

Medium-grained sand facies
- *Umbonium—Glycymeris* ass.

The order of the assemblages corresponds in general to their stratigraphic distribution as shown in Text-fig. 3.

The distribution of assemblages coincides well with the distribution of the sedimentary facies. The boundary between the muddy facies assemblage and the fine-grained sand facies assemblage coincides with the sedimentary boundary which crosses the isochronous tuff beds obliquely. Moreover, the muddy facies mollusc *Turritella nipponica* and its associates, appear repeatedly in the silty layers in the lower part of the fine-grained sandstone. Accordingly the distribution of molluscs is seemingly controlled by the distribution of sedi-



Text-fig. 3. Schematic stratigraphic section of the Futatsui area and the distribution of the assemblages.

A-M correspond to the localities indicated in Text-fig. 1. Symbols for sedimentary facies and assemblages; a: siltstone, b: fine-grained sandstone, c: medium-grained sandstone, d: pumice tuff, 1: *Nuculana-Turritella nipponica* assemblage, 2: *Turritella saishuensis-Limopsis-Acila nakazimai* assemblage, 3: *T. saishuensis-Macoma tokyoensis-Mercenaria* assemblage, 4: *Felaniella-Thracia* assemblage, 5: *Umbonium-Glycymeris* assemblage.

mentary facies and not by the time-stratigraphic horizon.

The sediments become generally coarser in the upper horizons, and are finally covered by fresh water deposits. The distribution of formations in the area surrounding Futatsui also indicates the withdrawal of the marine environment towards the west and southwest during the Pliocene as discussed and illustrated by UEDA (1965).

Thus the vertical changes in the molluscan assemblages are controlled fundamentally by the regressive change of environment, and the limit of the distribution is defined by that of the sedimentary facies. The vertical succession of molluscan assemblages may also be indicative of the horizontal or geographical relation of the assemblages. The muddy facies assemblage probably represents an off-shore, deep water fauna, while the *Turritella—Macoma—Mercenaria* or the *Umbonium—Glycymeris* assemblages are the near shore and shallow water faunas. The ecological relationship in terms of depth between the latter two assemblages is not clear; there is, of course, a difference in sedimentary facies.

This conclusion agrees well with previous conclusion of the writer (CHINZEI, 1961) regarding the Pliocene molluscan fauna of the Sannohe group in eastern Aomori. In the middle and upper parts of the Sannohe group, the assemblages dominated by *Turritella nipponica, Rectiplanes sadoensis, Venericardia ferruginea* and other species common to the muddy facies assemblage of the Futatsui area are found in the central and deeper part of the sedimentary basin. The assemblages characterized by *Mercenaria, Peronidia, Anadara, Fortipecten* and other bivalved species are in the marginal and shallow facies of the basin. Genera of the molluscan fauna seen in the marginal facies of the Sannohe group, the Togawa faunule, are allied with the genera of the *Turritella—Macoma—Mercenaria* assemblage. *Anadara, Dosinia*, and some important constituents of the Togawa assemblages are represented by different species than those of the Futatsui assemblages. They are the same as the shallow embayment assemblages of the Tatsunokuchian fauna (CHINZEI and IWASAKI, 1967). Consequently, the shallow sea assemblages seen in the Futatsui area are considered to be ecologically parallel (THORSON, 1957) to those of the Sannohe area and the Tatsunokuchian fauna.

Molluscan assemblages composed of the specics found in the Futatsui area occur commonly in Pliocene deposits along the Japan Sea coast of Japan. The assemblages described by IWAI (1961) from the Narusawa formation in the Nishi-Tsugaru District, Aomori, are characterized by species common to the *Nuculana—Turritella nipponica* assemblage and also contain species which occur in the coarse-grained sand or gravelly facies which have not been recognized in the Futatsui area. The species found in the *Nuculana—Turritella* assemblage are the main constituents of the mudstone fauna of the Pliocene Nishiyama and Haizume formations in the Niigata oil-field (ITOIGAWA, 1958).

Among the molluscan assemblages reported by TAKAYASU (1961) from the fine-grained sandstone of the Sasaoka formation in the Akita oil-field, the assemblage of his Loc. 6 dominated by *Limopsis tokaiensis* is identical with one of the associations seen in the *Turritella—Limopsis—Acila* assemblage of the Futatsui area. Other assemblages of the Sasaoka formation are mixtures of elements belonging to two or three different assemblages in the Futatsui area. This conclusion is supported by the observation made by TAKAYASU (1961) that the shells of these assemblages are mostly odd valves and broken. The same is true for the assemblages contained in the Omma formation in Kanazawa.

Some of the species characteristic of the Omma-Manganjian fauna in other areas are absent or very rarely found in the Futatsui assemblages. They are such gastropod as *Epitonium* spp., *Cerastoderma* spp., *Trophonopsis* spp., and the bivalve *Astarte borealis* and allied species, *Chlamys* spp. and other pectinids, etc. They are most likely constituents of assemblage(s) whose habitats did not exist in the Futatsui area.

References

CHINZEI, K. (1961) : Molluscan fauna of the Pliocene Sannohe group of Northeast Honshu, Japan. 2. The faunule of the Togawa formation. *Jour. Fac. Sci., Univ. Tokyo, Sec. 2*, vol. 18, pt. 1, pp. 81-131, pls. 1-4.

—— (1963) : Notes on historical change of Neogene molluscan assemblages in Northeast Japan. "*Fossils*", no. 5, pp. 20-26 [in Japanese].

—— and IWASAKI, Y. (1967) : Paleoecology of shallow sea molluscan faunae in the Neogene deposits of Northeast Honshu, Japan. *Trans. Proc. Palaeont. Soc. Japan, N. S.*, no. 67, pp. 93-113.

HATAI, K. and NISIYAMA, S. (1939) : Remarks on certain fossils from the borderland of the Japan Sea. *Japan. Jour. Geol. Geogr.*, vol. 16, nos. 1-2, pp. 123-154, pl. 9.

HIRAYAMA, J. and SUMI, K. (1963) : Explanatory text of the geological map of Japan, scale 1 : 50,000, "Takanosu". *Geol. Surv. Japan.*

ITOIGAWA, J. (1955) : Molluscan fossils from the Niitsu, Higashiyama and Takezawa oil-fields, Niigata Prefecture, Japan. *Mem. Coll. Sci., Univ. Kyoto, Ser. B*, vol. 24, no. 4, pp. 249-263, pls. 1, 2.

IWAI, T. (1960) : Pliocene Mollusca from the Nishi-Tsugaru district, Aomori Prefecture, Japan. *Saito Ho-on Kai Mus., Res. Bull.*, no. 29, pp. 35-45, pl. 4.

KASENO, Y. and MATSUURA, N. (1965) : Pliocene shells from the Omma formation around Kanazawa City, Japan. *Sci. Rep., Kanazawa Univ.*, vol. 10, no. 1, pp. 27-62, pls. 1-20.

OTUKA, Y. (1936) : Pliocene Mollusca from Manganzi in Kotomo-mura, Akita Pref., Japan. *Jour. Geol. Soc. Japan (Trans. Proc. Palaeont. Soc. Japan)*, vol. 43, pp. 726-736, pl. 41.

—— (1939a) : Mollusca from the Cainozoic system of eastern Aomori Prefecture, Japan. *Jour. Geol. Soc. Japan*, vol. 46, no. 545, pp. 23-31, pl. 2.

—— (1939b) : Tertiary crustal deformations in Japan, with short remarks on Tertiary palaeography. *Jubilee Publ., Comm. Prof. H. Yabe*, vol. 1, pp. 481-519.

TAKAYASU, T. (1961) : On stratigraphy and fossil fauna in the environs of Tofuiwa, northern part of Akita City, Akita Prefecture; Study of Cenozoic fossil fauna in the region of Akita oil-field (part 1). *Rept. Res. Inst. Undergr. Res., Mining Coll., Akita Univ.*, no. 25, pp. 1-14, pls. 1-3.

THORSON, G. (1957) : Bottom communities (Sublittoral or shallow shelf). *In* Treatise on Marine Ecol. Paleoecol., *Geol. Soc. Amer., Mem.* 67, vol. 1, pp. 461-534.

UEDA, R. (1965) : Stratigraphy and tectogenesis of the Tertiary system of North Akita Prefecture, Japan. *Rept. Res. Inst. Undergr. Res., Mining Coll., Akita Univ.*, no. 32, pp. 1-71.

Fujikotogawa	藤琴川
Funakawa	船川
Futatsui	二ッ井
Haizume	灰爪
Kanazawa	金沢
Kobinaizawa	小比内沢
Manganji	万願寺
Nanakura	七座
Narusawa	鳴沢
Nishitsugaru	西津軽
Nishiyama	西山
Omma	大桑
Sannohe	三戸
Sasaoka	笹岡
Tatsunokuchi	竜の口
Tentokuji	天徳寺
Togawa	斗川
Tofuiwa	豆腐岩

Explanation of Plate 14

Fig. 1. *Anadara amicula* (YOKOYAMA) ×1, Loc. 43, Reg. No. CM 8080.
Figs. 2a, b. *Macoma calcarea* (GMELIN) ×1, Loc. 43, Reg. No. CM 8081.
Fig. 3. *Acila (Truncacila) nakazimai* OTUKA ×1.5, Loc. 28, Reg. No. CM 8082.
Fig. 4. *Felaniella usta* (GOULD) ×1.5, Loc. 36, Reg. No. CM 8083.
Fig. 5. *Mercenaria stimpsoni* (GOULD) ×1, Loc. 44, Reg. No. CM 8084.
Fig. 6. *Thracia kakumana* (YOKOYAMA) ×1, Loc. 35, Reg. No. CM 8085.
Fig. 7. *Rectiplanes sadoensis* (YOKOYAMA) ×1.5, Loc. 49, Reg. No. CM 8086.
Fig. 8. *Limopsis tokaiensis* YOKOYAMA ×1.5, Loc. 30, Reg. No. CM 8087.
Figs. 9a, b. *Tectonatica tugaruana* NOMURA and HATAI ×1, Loc. 53, Reg. No. CM 8088.
Fig. 10. *Nuculana robai* (KURODA) ×2, Loc. 24, Reg. No. CM 8089.
Fig. 11. *Umbonium (Suchium) akitanum* SUZUKI ×1.5, Loc. 63, Reg. No. CM 8090.
Fig. 12. *Turritella saishuensis motidukii* OTUKA ×1.5, Loc. 30, Reg. No. CM 8091.
Fig. 13. *Turricula kaderleyi* (LISCHKE) ×1.5, Loc. 24, Reg. No. CM 8092.
Fig. 14. *Turritella nipponica* YOKOYAMA ×1.5, Loc. 53, Reg. No. CM 8093.
Fig. 15. *Mya cuneiformis* (BÖHM) ×1, Loc. 25, Reg. No. CM 8094.

(All specimens are stored at the Department of Historical Geology and Palaeontology, University Museum, University of Tokyo)

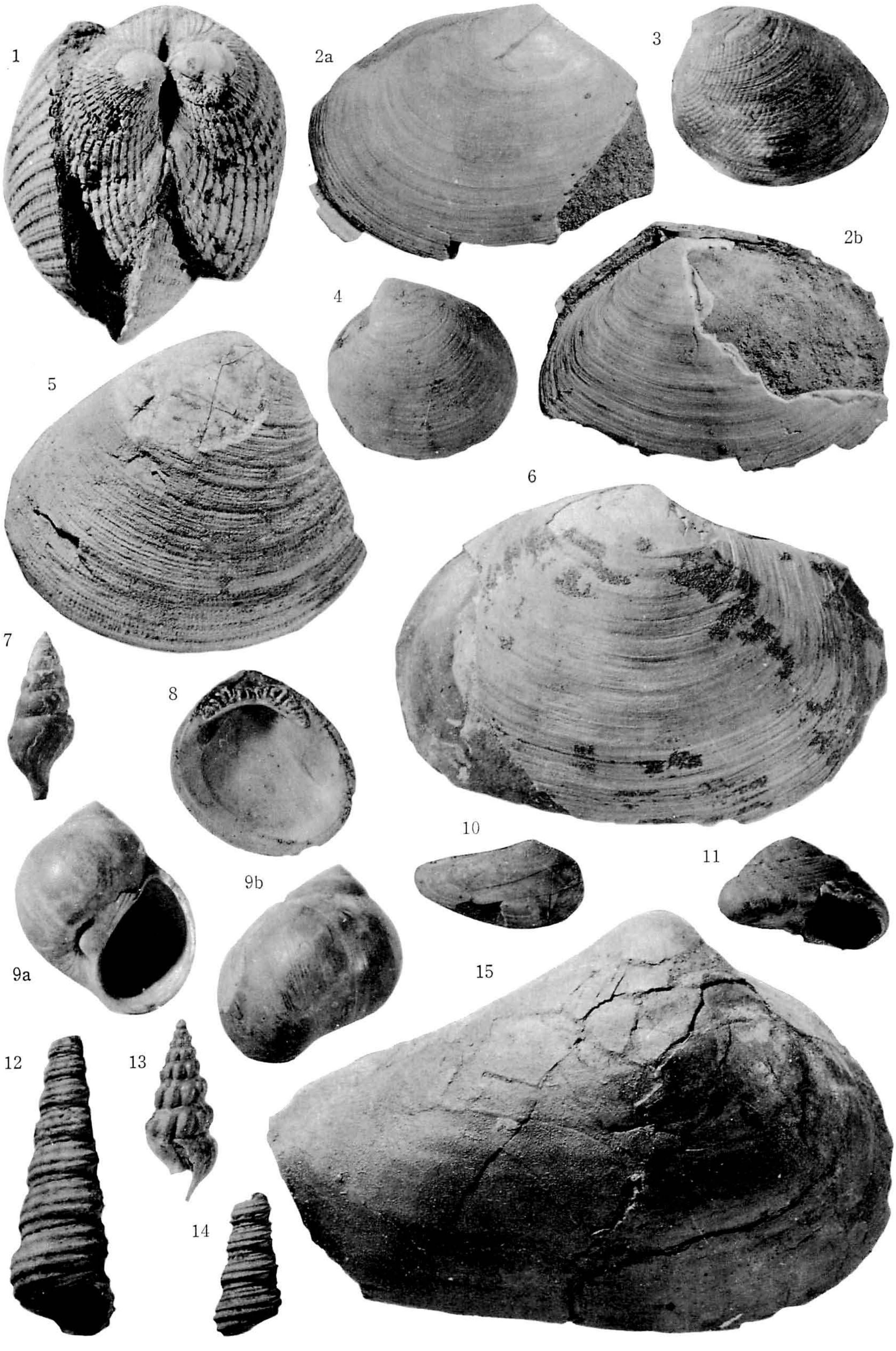


Photo by ISHIBASHI

Trans. Proc. Palaeont. Soc. Japan, N.S., No. 90, pp. 95-98, June 30, 1973

618. EARLY CARBONIFEROUS VISÉAN FAUNAS DISCOVERED FROM MITSUZAWA, SOUTHEASTERN PART OF THE KWANTO MASSIF PART I. GASTROPODS*

SUMIO SAKAGAMI

Department of Geology, Faculty of Education, Ehime University

関東山地南東部三ッ沢産前期石炭紀ビゼー世動物群. その1. 腹足類：東京都下武蔵五日市町北方約 6 km の三ッ沢で発見された腹足類，腕足類，さんご類，こけ虫類，海百合類などからなる動物群のうち，腹足類1種：*Mourlonia hayasakai* SHIKAMA and NISHIDA を記載した。この種は秋吉石灰岩 *Millerella yobarensis* 帯と *Fusulinella biconica* 帯から報告されたものであるが，三ッ沢産のものは *Millerella yobarensis* 帯産のものと特によく一致することを述べた。 坂上澄夫

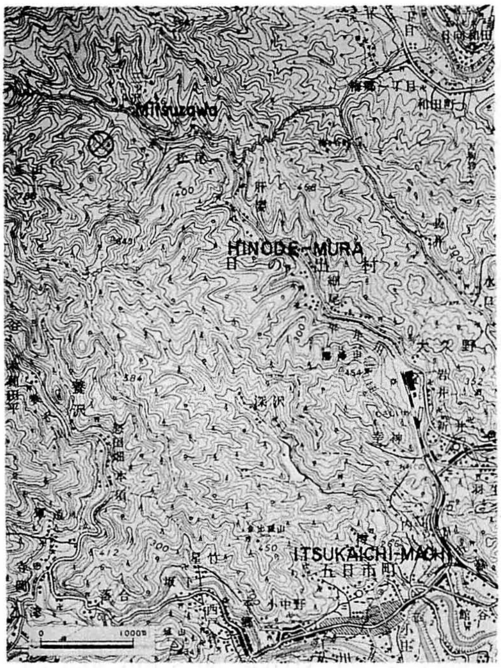
Introduction and Acknowledgments

It is well known that the Paleozoic and Mesozoic belts are arranged alternately in about NW-SE trend in the southeastern part of the Kwanto massif. The Paleozoic System is mostly of Permian age and includes the Upper Carboniferous *Fusulinella* and *Fusulina* zones in small areas. No Lower Carboniferous strata have been known to date but the recent discovery (SAKAGAMI, 1972) of a fossil fauna including gastropods, brachiopods, corals, bryozoans and crinoidal stems from a limestone cropping out in the Mitsuzawa valley, Hinode-mura, Nishitama-gun, Tokyo-to, about 6 km NW of Itsukaichi-machi (town), points to the recognition of the Early Carboniferous Viséan age.

The fossil bearing limestone at Mitsuzawa is about 4 m thick, whitish gray in color, interbedded with chert and shows N 15°E strike, 50°S dip, and has been included in the Katsuboyama Paleozoic zone by FUJIMOTO (HUZIMOTO, 1936). The Katsuboyama Paleozoic zone consists mainly of greywacke and shale in alternation intercalated with clayslate, chert, quartzite, schalstein, conglomerate, including the fusulinid limestones. The geological age of this zone was considered to range from Lower to Upper Permian by FUJIMOTO but the discovery of *Fusulinella* cf. *pseudobocki* by SAKAGAMI (1955, MS.) from a small limestone cropping out in Hosoo-iri (valley), about 3 km SSE from the Mitsuzawa limestone has proved the existence of Carboniferous there.

In the present article one gastropod, *Mourlonia hayasakai* SHIKAMA and NISHIDA, is described from the Mitsuzawa limestone. The brachiopod, coral and bryozoan faunas will be described paleontologically in forthcoming papers by Drs. J. YANAGIDA, N. YAMAGIWA and S. SAKAGAMI. Discussion of the

* Received Jan. 26, 1973; read June 3, 1972 at Utsunomiya.



Text-fig. 1. Map showing the locality of the Early Carboniferous Mitsuzawa fauna

fauna and its geologic age will be presented in Part IV. Bryozoans by SAKAGAMI.

Here I would like to express my sincere gratitude to Professor Kotora HATAI of the Institute of Geology and Palaeontology, Faculty of Science, Tohoku University for his kind supervision and constant encouragement. Further, I wish to express my cordial thanks to Drs. Juichi YANAGIDA of Kyushu University and Nobuo YAMAGIWA of the Osaka University of Education for their kind cooperations in the present study.

Description of Species

Genus *Mourlonia* DE KONINCK, 1883

Subgenus *Mourlonia* DE KONINCK, 1883

Mourlonia (*Mourlonia*) *hayasakai* SHIKAMA and NISHIDA

Text-figures 2 (1–5).

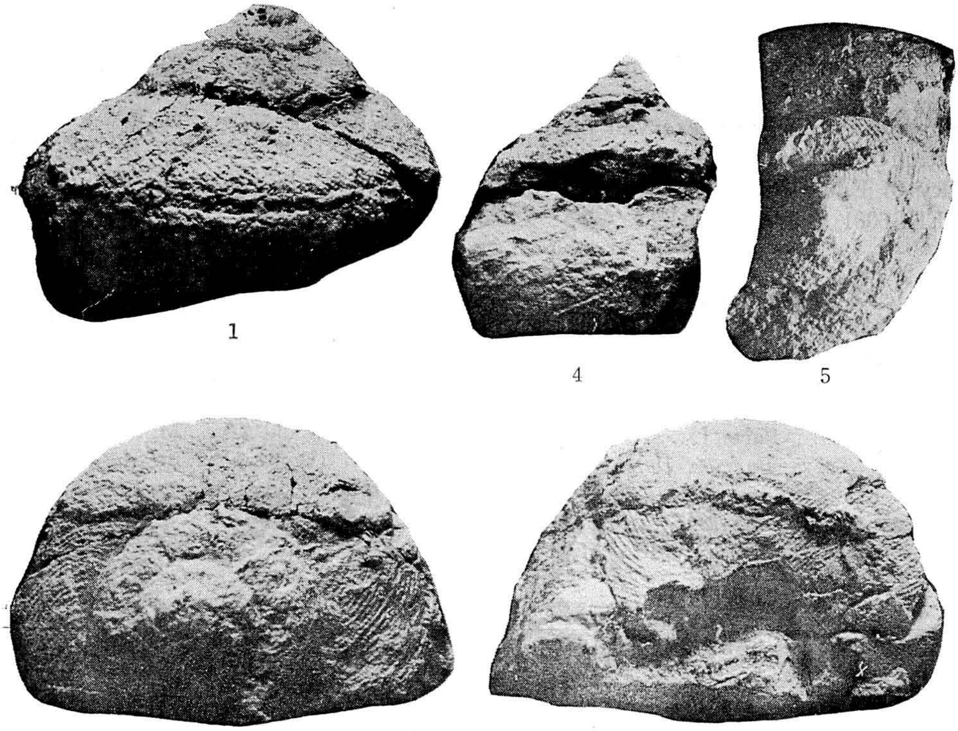
1968. *Mourlonia* (*Maurlonia*) *hayasakai* SHIKAMA and NISHIDA, p. 212, 213, pl. 24, figs. 1–6.

Shell of moderate size conical, turbiniform, coiling dextral and consisting of 4 rapidly increasing whorls. Height of shell less than diameter. Spire angle about 100°. Whorls expanded, rather narrowly convex, gently curved, suture furrowed, base of shell more or less flattened. Selenizone slightly concave, less than 1 mm in maximum width at outer whorl, delimited by two spiral lirae and situated just above the suture. Umbilicus may be phaneromphalous. Shell ornamentation fine, growth lines regularly spaced, numerous, strongly prosocline, slightly convex forward above the selenizone and orthocline below it.

Measurements:—

Number of whorls	4.5 ?
Height	22.5 mm
Diameter	28.5 mm
H/D ratio	0.79
Spire angle	100°

Remarks:—Although one of two specimens at hand is deformed and incomplete, the other is well preserved and identical with *Mourlonia* (*Mourlonia*) *hayasakai* described originally by SHIKAMA and NISHIDA (1968) from the *Millerella* sp. α zone (=*Millerella yobarensis* zone of TORIYAMA and OTA, 1971) to the *Fusulinella biconica* zone in the Akiyoshi Limestone Group. Among the seven specimens referred to *M. hayasakai* by


1 4 5 2 3

Text-fig. 2. *Mourlonia* (*Mourlonia*) *hayasakai* SHIKAMA and NISHIDA from the Mitsuzawa Limestone.
1-3. Lateral, apical and umbilical views of one specimen (Cat. No. EEG6001), ×2.
4, 5. Lateral and apical views of the other specimen (Cat. No. EEG6002), ×2.

SHIKAMA and NISHIDA measurements were given of four, namely the holotype, paratypes A, D and E. The paratype E was obtained from the *Millerella yobarensis* zone and the other three from the *Fusulinella biconica* zone. The specimens from the two fossil zones seem to show different ratios of height to diameter; namely, the ratios in the specimens including the holotype from the *Fusulinella biconica* zone show 0.93 to 1.0, while that in paratype E from the *Millerella yobarensis* zone is 0.78. The ratio in the present specimen is 0.79 and in this feature, it is nearest to SHIKAMA and NISHIDA's Paratype E, but the shell size is almost twice of the latter. Further it is considered that there is no change in the ratio of height to diameter through the growth of the shell, because the holotype and paratype A have different size in spite of having the same ratios. If H/D ratio changes phylogenetically, the present form and Paratype E from Akiyoshi should be separated from *M. hayasakai* as independent species or subspecies. However, more detailed examination must be reserved because of the few number of specimens at hand.

Geological age:—Probably Upper Viséan of the Early Carboniferous.

Repository and Specimen No:—The present specimees are preserved in the Collection of the Department of Geology, Faculty of Eduction, Ehime University. Nos. EEG6001 and EEG6002.

References

FUJIMOTO, H. (HUZIMOTO, H.) (1936) : Stratigraphical and palaeontological studies of the Titibu System of the Kwanto-mountainland. Part 1. Stratigraphy. *Sci. Rep. Tokyo Bunrika Daigaku*, Sec. C, No. 4, pp. 157-188, pls. 27-29.

SAKAGAMI, S. (1955, MS) : Stratigraphical and palaeontological studies of the northern part of Itsukaichi and the northwestern part of Ome, Nishitama-gun, Tokyo-to. *Graduation Thesis of Tokyo Univ. Educ.*

—— (1972) : Discovery of the early Carboniferous Viséan fauna from the Kwanto massif. *Jour. Geol. Soc. Japan*, Vol. 78, No. 4, p. 216. [in Japanese]

SHIKAMA, T. and NISHIDA, T. (1968) : On some species of Carboniferous Pleurotomariaceans from Akiyoshi (Molluscan paleontology of the Akiyoshi limestone Group—III). *Trans. Proc. Palaeont. Soc. Japan*, No. 69, pp. 211-217, pls. 24, 25.

TORIYAMA, R. and OTA, M. (1972) : Akiyoshidai (Guide book for the geological excursion). Geol. Soc. Japan, 29 pp. [in Japanese]

Mitsuzawa	三ツ沢	Itsukaichi-machi	五日市町
Hinode-mura	日の出村	Katsuboyama	勝峯山
Nishitama-gun	西多摩郡	Hosoo-iri	細尾入

Trans. Proc. Palaeont. Soc. Japan, N.S., No. 90, pp. 99-112, pls. 15, 16, June 30, 1973

619. EARLY CARBONIFEROUS VISÉAN FAUNAS DISCOVERED FROM MITSUZAWA, SOUTHEASTERN PART OF THE KWANTO MASSIF*
PART II. BRACHIOPODS

JUICHI YANAGIDA

Department of Geology, Faculty of Science,
Kyushu University, Fukuoka, 812

関東山地南東部三ツ沢産前期石炭紀ビゼー世動物群．その2．腕足類：東京都下武蔵五日市町三ツ沢に分布する海百合石灰岩中より腕足類の5種：*Schizophoria resupinata* (MARTIN), *Rugicostella sakagamii* YANAGIDA, sp. nov., *Undaria* sp., *Martinia* sp., *Spirifer* sp. を識別し記載した。これらのうちとくに *Rugicostella sakagamii* YANAGIDA, sp. nov. は秋吉石灰岩層群 *Millerella yowarensis* 帯石灰岩産の *R. nystiana* (DE KONINCK) に近縁であり，さらに本属の産出がビゼー統に限られることから時代の指示者として重要である。また *Schizophoria resupinata* (MARTIN) にみられる顕著な個体変異は後期ビゼー世の *S. resupinata* に共通する特徴であることから，時代論に有効な資料を提供することをのべた。

柳 田 寿 一

Introduction and acknowledgements

The discovery of the Early Carboniferous Visean faunas from a limestone of Mitsuzawa in the southeastern part of the Kwanto massif was recently reported by SAKAGAMI (1972), who gave a preliminary discussion on the outline of stratigraphy, the fossils obtained from the limestone, such as bryozoans, brachiopods, crinoids, corals and gastropods, and their geologic age. The writer was very fortunate to have an occasion of visiting the locality and to obtain a fair number of brachiopods under the kind guidance of Dr. SAKAGAMI.

This paper is a part of the palaeontological study of the Visean faunas from Mitsuzawa. The study on the species assemblage of the brachiopods described here led to a conclusion that the geologic age of them is assigned to the Late Visean.

The writer is greatly indebted to Dr. Sumio SAKAGAMI who gave him every facility in the field work and provided him many brachiopod specimens. His sincere thanks are also due to Professor Ryuzo TORIYAMA for kind reading the manuscript.

Remarks on the brachiopod species assemblage

The assemblage is characterized by the following brachiopod species: *Schizophoria resupinata* (MARTIN), *Rugicostella sakagamii* YANAGIDA, sp. nov., *Undaria*

* Received Feb. 1, 1973; read October 28, 1972 at Matsuyama.

sp., *Martinia* sp., *Spirifer* sp.. Among them the former two species are very important for discussing their geologic age. *Schizophoria resupinata* is the type species of *Schizophoria*, showing the wide distribution in Eurasian continent and ranging through the Tournaisian and Viséan with the most abundant occurrence in the Upper Viséan in the European standard of the Lower Carboniferous.

As stated in the chapter of systematic palaeontology *S. resupinata* from Mitsuzawa appears to be fairly variable in its shape. It consists of four extreme forms, with several intermediate ones among them. If the four extreme forms are compared with the Belgian Dinantian ones, *S. resupinata* var. *pinguis*, var. *dorsosinuata* and var. *rotundata* described by DEMANET (1934) and *S. resupinata* s. s. are the closest forms, respectively corresponding to each of them. Among the Mitsuzawa forms those compared with var. *dorsosinuata* and var. *rotundata* are small and rather doubtful in their discrimination. On the other hand the strongly inflated form is undoubtedly referable to DEMANET's var. *pinguis* in its outline, mode of inflation and its slightly uniplicate anterior commissure. As far as our present knowledge is concerned *S. resupinata* var. *pinguis* is known from the Upper Tournaisian to Upper Viséan and most abundant in the Upper Viséan in the Lower Carboniferous of England and Belgium.

Rugicostella sakagamii, the newly established species in this genus, is closely related to *R. nystiana*, the type species of this genus, which is only known from the Visean of Belgium, England and Japan. *R. nystiana* was originally described by DE KONINCK (1842) under the name of *Productus nystianus* from the Viséan of Visé, Belgium. In England the same species was also described by DAVIDSON (1861) from the Lower Scar limestone of Settle, Yorkshire. The geology and the faunal succession of this region was shown in detail by GARWOOD and GOODYEAR (1924). According to them *Rugicostella nystiana* occurs in a limestone of D_2 subzone with a fair kinds of brachiopods, corals and other fossils. In Japan YANAGIDA (1965) discriminated *R. nystiana* from the *Millerella yowarensis* zone (TORIYAMA and OTA, 1971) of the Akiyoshi limestone Group at Yowara (or Yobara) with many kinds of other brachiopods. The writer correlated the age of the limestone with the Late Visean.

Undaria sp. externally strongly resembles *U. erminea* (DE KONINCK) which is known from the Viséan of Visé, Belgium. The genus *Undaria* is known only in the Viséan.

Two indeterminable species of *Martinia* and *Spirifer* are rather difficult to compare with other distinct species of these genera. A special attention is given to the existence of a weak fasciculation in *Spirifer* sp. In this characteristics with external configuration of pedicle and brachial valves, it is considered that *S. liangchowensis* CHAO from the Viséan of northwest China is highly comparable with the present species.

Summarizing the above discussion the species assemblage of Mitsuzawa brachiopods is unique in its constitution and closely related with the Upper Visean brachiopods of Europe and Asia.

Systematic Palaeontology

Superfamily Enteletacea WAAGEN, 1884

Family Enteletidae WAAGEN, 1884

Subfamily Schizophoriinae SCHUCHERT and LEVENE, 1929

Genus *Schizophoria* King, 1850

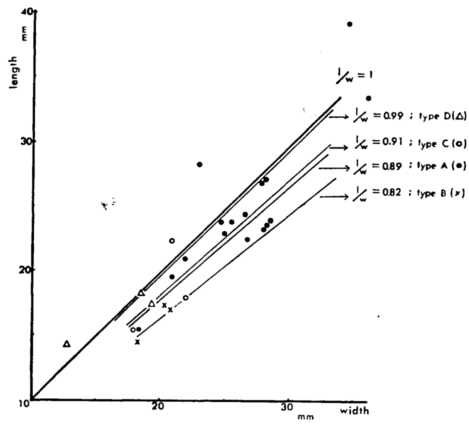
Type-species:—Conchyliolites (Anomites) resupinatus Martin, 1809.

Schizophoria resupinata (Martin)

Pl. 16, figs. 3-9

1809. *Conchyliolites (Anomites) resupinatus* Martin, p. 12, pl. 49, figs. 13, 14.
1842-4. *Orthis resupinata*, de Koninck, p. 226, pl. 13, figs. 9, 10.
1863. —— ——, Davidson, Palaeontogr. Soc. Monogr., p. 130, pl. 29, figs. 1-7, pl. 30, figs. 1-5.
1923. *Schizophoria resupinata*, Demanet, Mém. Inst. Géol. Univ. Louvain, vol. 2, p. 119, pl. 5, fig. 1.
1923. —— —— var. *lata* Demanet, Ibid., vol. 2, p. 122, pl. 5, fig. 4.
1934. *Schizophoria resupinata*, Demanet, Mém. Mus. Roy. d'Hist. Nat. Belg., no. 61, p. 47, pl. 3, figs. 1-5.
1934. —— —— var. *lata*, Demanet, Ibid., no. 61, p. 50, pl. 3, figs. 6-8.
1934. —— —— var. *gigantea* Demanet, Ibid., no. 61, p. 60, pl. 4, figs. 12, 13.
1934 —— —— var. *rotundata* Demanet, Ibid., no. 61, p. 51, pl. 3, figs. 9-13.
1934. —— —— var. *dorsosinuata* Demanet, Ibid., no. 61, p. 53, pl. 3, figs. 14, 15.
1934. —— —— var. *pinguis* Demanet, Ibid., no. 6, p. 59, pl. 4, figs. 9-11.
1941. *Schizophoria resupinata*, Bond, Geol. Assoc., London, vol. 52, pt. 4, p. 289, pl. 21, figs. A-C.
1954. —— ——, Parkinson, J. Paleont., vol. 28, p. 368, figs. 1, 2a-e.
1957. *Schizophoria* cf. *S. resupinata*, Campbell, Ibid., vol. 31, p. 48, pl. 12, figs. 1-5.
1962. *Schizophoria* aff. *S. resupinata*, Yanagida, Mem. Fac. Sci., Kyushu Univ., vol. 12, no. 1, p. 122, pl. 21, figs. 4-13.
1968. *Schizophoria resupinata*, Pocock, Palaeontology, vol. 11, pt. 1, p. 80, pl. 18, fig. 7.
1968. —— —— var. *dorsosinuata*, Brunton, Bull. Brit. Museum (Nat. Hist.), vol. 16, no. 1, p. 11, pl. 2, figs. 7-37.
1971. *Schizophoria* cf. *S. resupinata*, Roberts, Bur. Min. Res., Geol. Geophysics Australia, Bull., no. 122, pl. 1, figs. 6-32.

Material:—About thirty-five specimens are available under the heading with twenty-seven better preserved ones. The internal structures are shown by serial

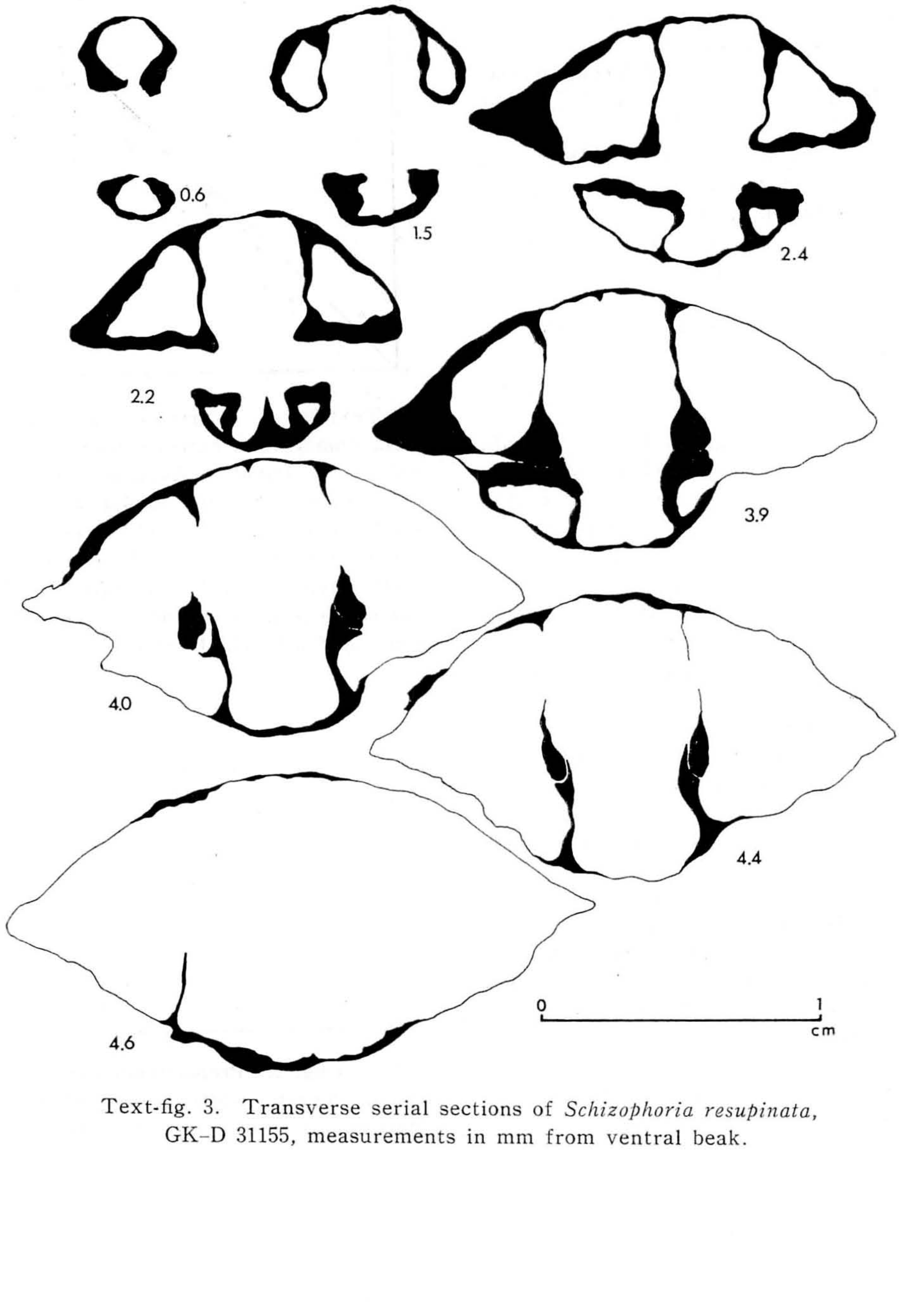


Text-fig. 1. Variations in size and form among four extreme forms of *Schizophoria resupinata*. Average form ratio of type A (0.89) for twelve articulated shells, one brachial and three pedicle valves; type B (0.82) for three articulated shells; type C (0.91) for three brachial valves; type D (0.99) for two articulated shells and a brachial valve.

Text-fig. 2. Proportional composition among length, width and thickness of brachial valves of *Schizophoria resupinata*.

sections of a specimen, GK-D 31155.

Description:—The shell is small to medium, biconvex to moderately dorsibiconvex, wider than long to nearly equi-dimensional, with the largest width at the mid-length. Hinge line is variable in length, about a half to two thirds the shell width. The pedicle valve is weakly to very slightly convex with the largest convexity near the umbo, nearly flat on anterior half. The brachial valve is very variable in its convexity and the broad median sulcus is developed in some specimens. Both valves are ornamented by fine costellae, usually four to five in 1 mm at 10 mm from beak. In well pre-



Text-fig. 3. Transverse serial sections of *Schizophoria resupinata*, GK-D 31155, measurements in mm from ventral beak.

served specimen the coarser costellae with anteriorly developed spine base are observed. Tightly arranged growth lines are scattered in some specimens. Anterior commissure is rectimarginate to broadly sulcate.

The pedicle valve interior is with strong teeth supported by strong parallel dental plates, diverging anteriorly and extending about a fifth length of shell. The median septum is very low, slightly increasing in height anteriorly. The brachial valve interior is with deep dental sockets, articulating teeth. Stout brachiophores extend anteriorly nearly same length with dental plates and the inner extremities of them seem to be interlocked with each other.

Dimension of 10 specimens in mm:

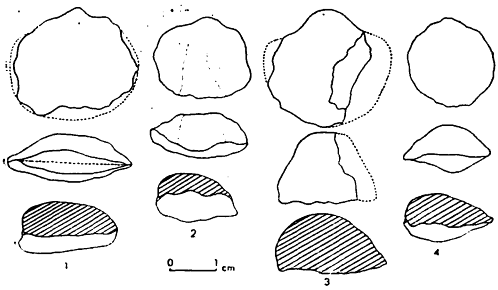
specimen number		length	width	thickness		hinge line	form ratio (l/w)
				ped. v.	bra. v.		
GK-D 31134	similar to var. *rotundata* by DEMANET	18.5	18.7	5.5	4.5	8.9	0.99
〃 31133		17.6	19.5	4.5	6.0		0.90
〃 31129	correspond to var. *pinguis* by DEMANET	22.4	21.0		11.0		1.07
〃 31131		18.0	22.0		9.5		0.82
〃 31137	similar to var. *dorsosinuata* by DEMANET	17.5	20.5	4.7	5.5	13.7	0.85
〃 31138		14.5	18.3	3.4	4.8	10.5	0.79
〃 31155		24.5	26.5	7.0	4.0	14.5	0.92
〃 31136		22.3	26.6		6.8		
〃 31151		33.5	36.0	17.0	12.5	21.0	0.93
〃 31153		23.9	25.5	5.0	7.3	13.0	0.94

Statistics of length (l), width (w), thickness (th) and form ratio (fr) of brachial valves of *Schizophoria resupinata* specimens are as follows:

$\bar{l}(\sigma)=21.98(4.95)$, $\bar{w}(\sigma)=23.87(5.32)$, $\overline{th}(\sigma)=7.49(2.56)$, $\overline{fr}(\sigma)=0.90(0.07)$, $n=26$.

Remarks:—Comparing with the neotype chosen by GEORGE and PONSFORD (1938) the Japanese specimens are all very small but the morphological characters are quite in harmony with each other. It is already known that the neotype is much larger than the average in this species.

It is well known that *Schizophoria resupinata* shows several variations in its form. DEMANET (1923, 1934) established the following varieties on the Belgian Lower Carboniferous specimens: *dorsosinuata, gigantea, lata, pinguis* and *rotundata*. They were discussed in detail by BOND (1941) and POCOCK (1968). The available specimens at hand respectively show the individual variation, and it is possible to group them into four extreme forms, type A, B, C and D. If the division by DEMANET is followed, they are respectively named as follows: type A, *Schizophoria resupinata* s. s. (19 speci-



Text-fig. 4. Variations in form of *Schizophoria resupinata*, showing four extreme forms, 1 for type A, 2 for type B, 3 for type C and 4 for type D.

mens); type B, ? var. *dorsosinuata* (2 specimens); type C, var. *pinguis* (3 specimens); and type D, ? var. *rotundata* (3 specimens). Nevertheless, several intermediate forms are also discriminated among the specimens which are referred to *S. resupinata* s. s.. The writer followed POCOCK (1968) who considered these varieties by DEMANET to be included under *S. resupinata* because that they represent the extreme individual variation.

Superfamily Productacea GRAY, 1840

Family Institinidae MUIR-WOOD and COOPER, 1960

Genus *Rugicostella* MUIR-WOOD and COOPER, 1960

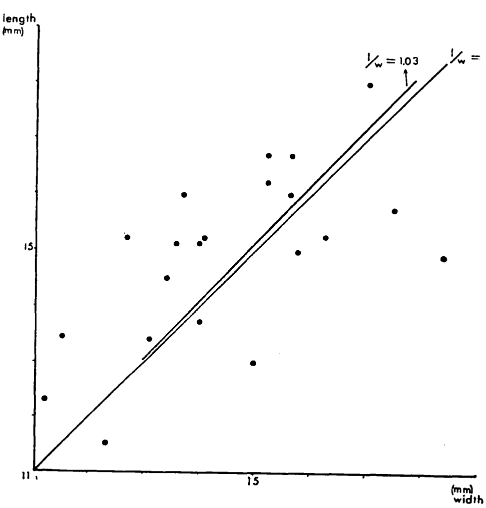
Type-species:—*Productus nystianus* DE KONINCK, 1842.

Rugicostella sakagamii YANAGIDA, sp. nov.

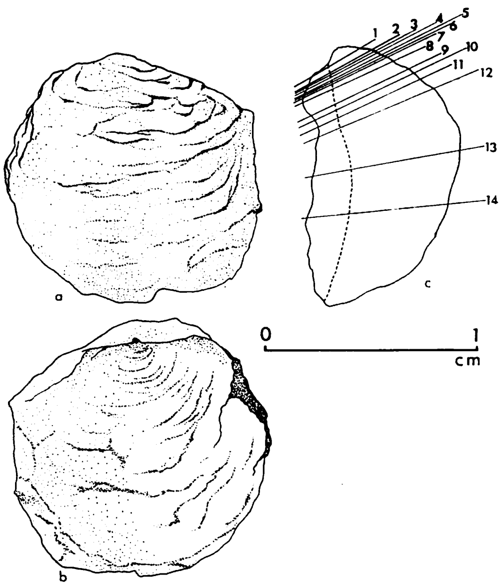
Pl. 15, figs. 1-8

Material:—Holotype, GK-D 31168 (Pl. 15, fig. 2). More than 30 specimens are available. Internal structures are shown by serial sections of a specimen representing the visceral disc, GK-D 31191, and other two specimens, GK-D 31160 and 31161.

Description:—The shell is small and subcircular. The hinge line is shorter than the largest width of the shell. The pedicle valve is moderately convex with slightly convex visceral disc and short trail. The visceral disc is strongly geniculated with a very weak cincture between the trail. The cincture is remarkably emphasized by exfoliation of shell surface. The short trail is nearly at right angles to visceral disc. The brachial valve is with slightly concave visceral disc and short trail. The geniculation is remarkable and the cincture is weak. The pedicle valve is ornamented by closely arranged rugae on the whole surface of the visceral disc, about three to four in the distance of 2 mm on central median part of the visceral disc, and posteriorly more remarkable than anterior surface. The trail is ornamented by short irregular costellae, about five



Text-fig. 5. Variations in size and form of pedicle valves of *Rugicostella sakagamii* YANAGIDA, sp. nov.



Text-fig. 6. a, b. Ventral and dorsal views of an incomplete visceral disc of *Rugicostella sakagamii* YANAGIDA, sp. nov., GK-D 31191. c. Profile of the same specimen showing positions of transverse serial sections. Each number respectively corresponds to that of Fig. 7.

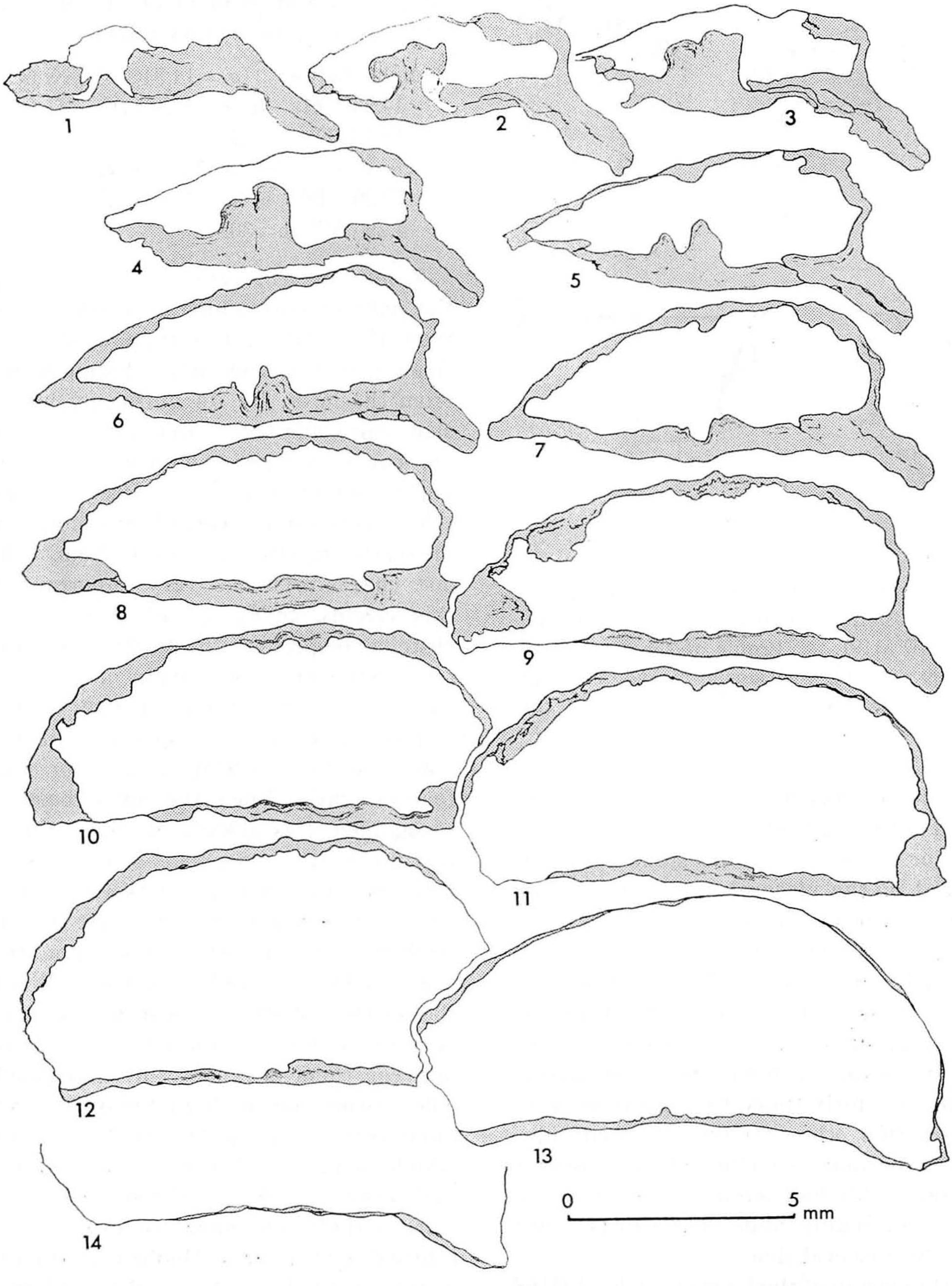
in the distance of 5 mm on anterior part, and often with spine bases at their anterior extremities. Fine spines are scattered on the visceral disc. The brachial valve is ornamented only by weak, even rugae. The pedicle valve interior is with raised diductor scars. The brachial valve interior is with a distinct, trilobate cardinal process having two lobes completely in contact near the posterior margin, but anteriorly they are slightly separate with each other. Myophore is considered to be more complex at the posterior margin. Median septum is low and narrow, extending about two-thirds length of the visceral disc.

Dimension of the holotype (GK-D 31168) is as follows (in mm): length, 16.7; width, 15.2; height, 10.5; form ratio (l/w), 1.09. Statistics of length (l), width (w), height (h), and form ratio (fr) of *Rugicostella sakagami* are as follows:

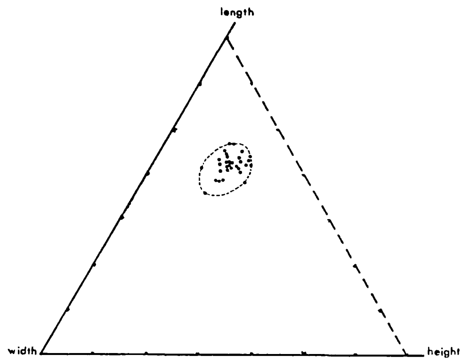
Pedicle valve: $\bar{l}(\sigma)=14.94(1.61)$, $\bar{w}(\sigma)=14.53(1.84)$, $\bar{h}(\sigma)=7.79(1.92)$, $\bar{fr}(\sigma)=1.03(0.09)$, $n=21$.

Visceral disc of pedicle valve: $\bar{l}(\sigma)=12.20(1.18)$, $\bar{w}(\sigma)=12.69(1.70)$, $\bar{h}(\sigma)=4.29(0.95)$, $n=30$.

Remarks:—Rugicostella sakagamii is the only species which is known other than *R. nystiana*, the type species of this genus. It is apparently distinguished from the latter by its uniformly larger size, more numerous and less remarkable rugae, weaker cincture on pedicle valve, and more numerous irregular costellae with spine bases often recognizable on the anterior margin of them. The last characteristic is very important in this species. In *R. nystiana* most of the costellae begin near the cincture and extend to the anterior margin of trail. In *R. sakagamii* the costellae are very short comparing with the length of trail and many costellae appear on anterior surface of trail. When the spine base is recognized it is always at the anterior margin of the costella. Therefore in this case the costella seems to be prostrate spine ridge. The cincture on the pedicle valve is very weak when the shell surface is well preserved. When the surface of the visceral disc or trail is more or less exfoliated the cincture between them is remarkably impressed. The morphological character of the cardinal process is similar to *R. nystiana*, which is clearly shown by MUIR-WOOD and COOPER (1960). Three specimens were serially sectioned to observe the internal characters. Bilobed character of the cardinal process is observed in a specimen, GK-D 31191, which shows the delicate complex shape of the myophore near the posterior extremity. This char-



Text-fig. 7. Transverse serial sections of *Rugicostella sakagamii* YANAGIDA, sp. nov., GK-D 31191 (see Text-fig. 6).



Text-fig. 8. Proportional composition among length, width and height of thirty-one visceral discs of *Rugicostella sakagamii* YANAGIDA, sp. nov.

acter is not recognized in other two specimens.

YANAGIDA (1965) discriminated *R. nystiana* from the *Millerella yowarensis* zone of the Akiyoshi limestone Group, Southwest Japan. The present specimens are externally very similar to those of the Akiyoshi specimens. However, the former is clearly distinguishable from the latter by the above stated characters.

Family Linoproductidae STEHLI, 1954

Subfamily Linoproductinae STEHLI, 1954

Genus *Undaria* MUIR-WOOD and COOPER, 1960

Type-species:—Undaria manxensis MUIR-WOOD and COOPER, 1960.

Undaria sp.

Pl. 15, fig. 9

Material:—Incomplete pedicle valve, GK-D 31245, is available under the heading with the following dimension: length, 18mm+ ; width, 18.5mm ; height, approx. 15mm.

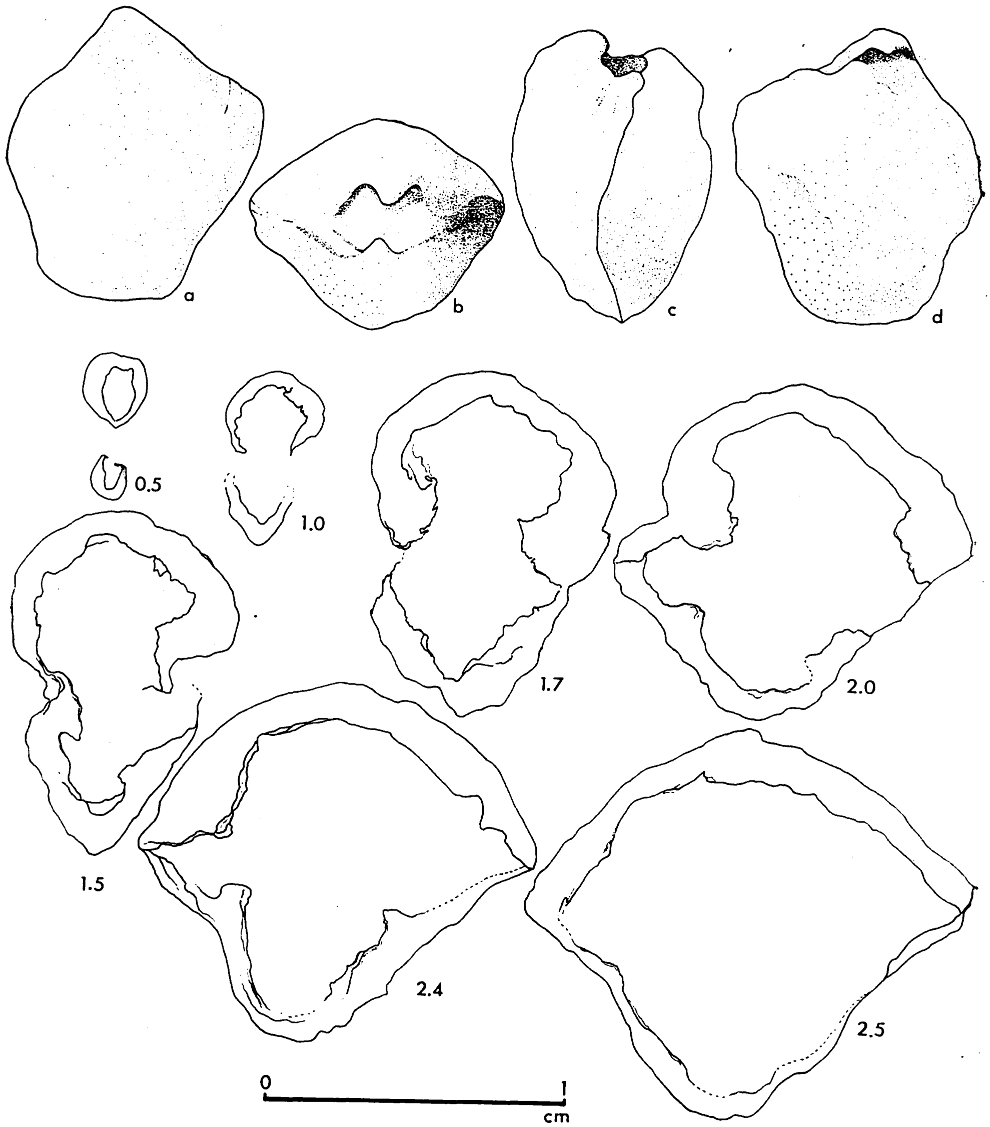
Descriptive remarks:—The shell is medium, weakly convex longitudinally with the largest convexity at anterior to the umbo, and slightly longer than wide with a short hinge line and steep flanks. The venter is rather flattened. The outline of the pedicle valve is suggested to be oval and the trail is probably not preserved. The widest part may be slightly posterior to the mid-length of the valve. The surface of the valve is ornamented by remarkable rugae and fine capillae. The rugae are irregular in width, counting about five on the venter and distributed on the whole surface of the valve. They are often intercalated or bifurcated with rounded crest. The capillae are much less remarkable comparing with the rugae.

The rugose ornament with fine capillae, steep flanks, elongate oval outline and slightly convex pedicle valve of the Mitsuzawa specimen well represent the characters of *Undaria*. The specimen is incomplete but slightly asymmetrical outline is also suggested from its outline. In these characters the Mitsuzawa species is considered to be very closely related with *Undaria erminea* (DE KONINCK) from the Visean of Visé, Belgium. The Belgian species has a long trail. The Mitsuzawa specimen represents only a posterior part of trail and the detailed comparison with the Belgian specimen is difficult. But the remaining parts of pedicle valves are well in harmony with each other. It is probable that both species are conspecific with each other.

Superfamily Reticulariacea WAAGEN, 1883

Family Martiniidae WAAGEN, 1883

Genus *Martinia* M'COY, 1884



Text-fig. 9. Ventral, posterior, lateral and dorsal views (a-d) of a small specimen of *Martinia* sp., GK-D 31233, and transverse serial sections of the same specimen with measurements in mm from ventral beak.

Type-species:—*Spirifer glaber* SOWERBY, 1820

Martinia sp.

Pl. 15, figs. 10–14

Material:—About fourty specimens are examined, of which complete ones are very few and most of them are very incomplete pedicle valves.

Descriptive remarks:—The shell is small, equally biconvex with the pedicle valve slightly more convex than the brachial one, and transversely subround to equal in length and width with the widest part at the mid-length of the shell. The hinge line is about two-thirds the width of the shell. The anterior commissure is gently uniplicate.

The pedicle valve is uniformly convex both transversely and longitudinally. The cardinal extremities are well rounded. The beak is strongly incurved over the delthyrium. The delthyrium may be open. The interarea is very low and concave. The sulcus is very faint and narrow, obscurely distinguished on anterior third of the valve. The surface of the valve is very smooth only with fine, tightly arranged growth lines and sometimes with very fine radial striae on anterior half. The brachial valve is slightly swollen longitudinally but no distinct fold is observed. The beak is slightly convex and rather erect with a short distance between the opposite beak. The ornamentation of the valve is same with the opposite valve. The pedicle valve interior is without dental plates and median septum. Radial vascular markings are partly observable on the mould of a pedicle valve. The brachial valve interior is with small sockets, receiving teeth.

Dimensions of ten specimens in mm.

specimen number	length	width	thickness	length of hinge line	form ratio (length/width)
GK-D 31218	13.5	13.9	7.6	6.7	0.97
〃 31219	14.9	14.3	8.5	8.9	1.04
〃 31215	9.8	9.7	5.3	5.8	1.00
〃 31236 (ped. valve)	15.5	14.2	6.0	approx. 8	1.09
〃 31204 (〃)	9.0	12.7	4.5	6.0	0.70
〃 31216 (〃)	11.0	11.0	3.5	6.3	1.00
〃 31213 (〃)	11.1	11.8	4.9	9.25	0.94
〃 31220 (〃)	13.8	approx. 14	4.3	8.3	0.98
〃 31217 (bra. valve)	11.5	12.2	2.8	approx. 8	0.94
〃 31207 (〃)	18.0	approx. 18	approx. 6	14.0	1.00

The Mitsuzawa specimens are characterized by uniformly small size, very faint sulcus and no distinct fold. In these points of views the Mitsuzawa species is externally very similar to *Martinia decora* var. *longa* described by GRÖBER (1908) and WANG, JING and FANG (1964) from the Lower and Middle Carboniferous of the Sinkiang, western China. The slight differences between them are on the sulcus and fold, which are much weaker in the Mitsuzawa specimens than the other, Superfamily Spiriferacea KING, 1846

Family Spiriferidae KING, 1846

Genus *Spirifer* SOWERBY, 1816

Type-species:—Conchyliolithus (Anomia) striatus MARTIN, 1793

Spirifer sp.

Pl. 16, figs. 1, 2

Material:—Two incomplete specimens, respectively slightly deformed pedicle and brachial valve, are at hand. The dimension of them is not given exactly.

Descriptive remarks:—The shell is medium to large. The pedicle valve outline is suggested to be transverse and slightly convex with the hinge line nearly equal to the largest width of the shell. The sulcus is broad and round bottomed, originating near the umbo. The umbo is slightly incurved over the delthyrium. The width of the basal part of the delthyrium is about a sixth length of the hinge line. The interarea is slightly concave medianly, becoming flat toward the cardinal extremities with very fine denticle grooves on the exfoliated surface. The pedicle valve is ornamented by simple rounded costae with rare bifurcation. About eight costae are counted on the sulcus. The brachial valve is moderately convex transversely and longitudinally with a prominent rounded fold. The surface ornamentation is same with the opposite valve. Very weak broad fasciculation is pos-

Explanation of Plate 15

All figures ×1.5

Fig. 1–8. *Rugicostella sakagamii* YANAGIDA, sp. nov.

1a–d. Posterior, ventral, anterior and lateral views of an incomplete pedicle valve, GK-D 31170.

2a–d. Posterior, ventral, anterior and lateral views of the holotype, GK-D 31168.

3a–e. Dorsal, posterior, ventral, anterior and lateral views of an incomplete shell, GK-D 31167.

4. Visceral disc of an incomplete pedicle valve, GK-D 31203.

5. Dorsal view of visceral disc of an incomplete brachial valve, GK-D 31303.

6a, b. Ventral and posterior views of visceral disc of an incomplete pedicle valve, GK-D 31177.

7a–c. Anterior, posterior and lateral views of an incomplete pedicle valve, GK-D 31158.

7d. Visceral disc of brachial valve of the same specimen.

8a–c. Ventral, anterior and posterior views of an incomplete pedicle valve, GK-D 31156.

Fig. 9. *Undaria* sp.

9a, b. Ventral and lateral views of an incomplete pedicle valve, GK-D 31245.

Figs. 10–14. *Martinia* sp.

10a–c. Dorsal, ventral and lateral views of a complete shell, GK-D 31218.

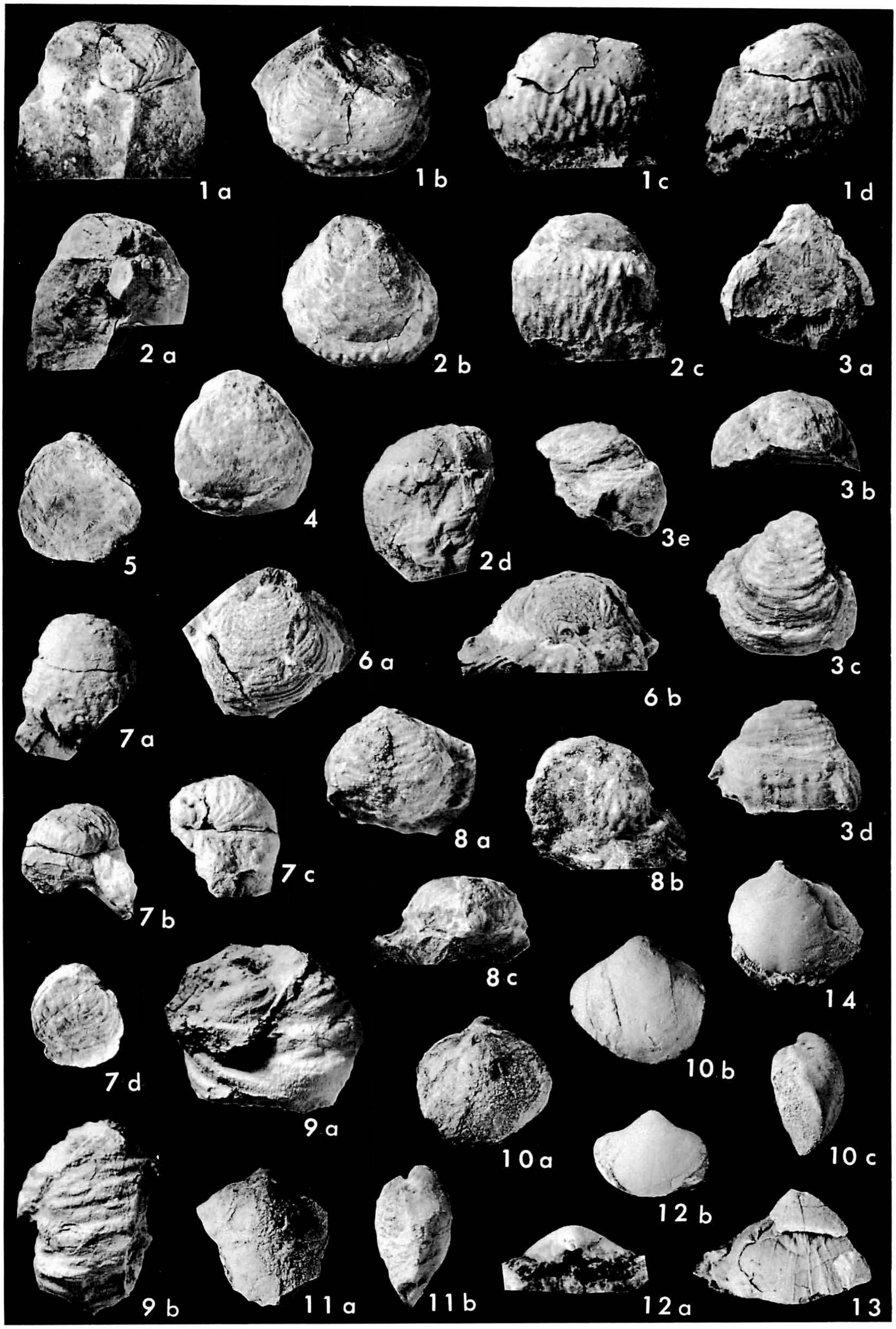
11a, b. Dorsal and lateral views of an incomplete shell, GK-31220.

12a, b. Posterior and ventral views of a small pedicle valve, GK-D 31204.

13. Incomplete pedicle valve showing the mould of radial vascular markings, GK-D 31206.

14. Incomplete pedicle valve, GK-D 31216.

Photos by YANAGIDA, with whitening.


1 a
1 b
1 c
1 d
2 a
2 b
2 c
3 a
4
5
2 d
3 e
3 b
6 a
6 b
3 c
7 a
8 a
8 b
3 d
7 b
7 c
8 c
14
7 d
9 a
10 a
10 b
10 c
12 b
9 b
11 a
11 b
12 a
13

teriorly observable on a wing.

The above stated characters of the Mitsuzawa specimens, especially the strongly convex and slightly fasciculate brachial valve with prominent fold strongly recall those of *Spirifer liangchowensis* CHAO from the Visean Choniukou Formation of Kansu, northwestern China.

References

BOND, G. (1941): Species and variation in British and Belgian Carboniferous Schizophoriidae. *Proc. Geol. Assoc. London*, **52**, 285-303, pls. 21-22.

BRUNTON, C. H. C. (1968): Silicified brachiopods from the Visean of County Fermanagh (II). *Bull. Brit. Museum (Nat. Hist.)*, **16**, (1), 1-70, pls. 1-9.

CAMPBELL, K. S. W. (1957): A Lower Carboniferous brachiopod-coral fauna from New South Wales. *Jour. Paleont.*, **31**, (1), 34-98, pls. 11-17.

CHAO, Y. T. (1958): Carboniferous and Permian spiriferids of China. *Palaeont. Sinica*, ser. B, **5**, fasc. 2, 1-244, pls. 1-16.

DAVIDSON, T. (1857-1863): A monograph of the British Carboniferous Brachiopoda. *Palaeontgr. Soc. (Monogr.)*, pt. 5, 1-280, pls. 1-55.

DEMANET, F. (1923): Le Waulsortien de Sosoye. *Mém. Inst. Géol. Univ. Louvain*, **2**, 36-286, pls. 3-14.

—— (1934): Les brachiopodes du Dinantien de la Belgique. *Mém. Musée Royal D'Hist. Nat. Belgique*. (61), 1-116, pls. 1-10.

GARWOOD, E. J. and GOODYEAR, E. (1924): The Lower Carboniferous succession in the Settle district and along the line of the Craven faults. *Quart. Jour. Geol. Soc. London*. **80**, 184-273.

GEORGE, T.N. and PONSFORD, D. R. A. (1938): Notes on the morphology of *Schizophoria*. *Trans. Leeds Geol. Assoc.* **5**, pt. 4, pp. 227-245, pl. 5.

GRÖBER, P. (1908): Ueber die Faunen des untercarbonischen Transgressionsmeeres des zentralen Tian-Schan, die in der Umgebung des Sart-dscholpasses gefunden worden sind. *N. Jahrb. f. Min. Geol. Palaeont.*, B. B., **26**, 213-248, pls. 25-30.

KONINCK, L. G. DE. (1842-1844): Description des animaux fossiles qui se trouvent dans le terrain carbonifère de Belgique. iv+650 pp., Liège.

MUIR-WOOD, H. M. and COOPER, G. A. (1960): Morphology, classification and life habits of the Productoidea (Brachiopoda). *Mem. Geol. Soc. Amer.*, **81**, 1-447, pls. 1-135.

PARKINSON, D. (1954): Quantitative studies of brachiopods from the Lower Carboniferous reef limestones of England. *Jour. Paleont.*, **28**, (3), 367-381.

POCOCK, V. P. (1968): Carboniferous schizophoriid brachiopods from western Europe. *Palaeont.*, **11**, 64-93, pl. 18.

ROBERTS, J. (1971): Devonian and Carboniferous brachiopods from the Bonaparte gulf basin, northwestern Australia. *Bur. Min. Res. Geol. Geophysics, Bull.*, (122), 1-319, pls. 1-59.

SAKAGAMI, S. (1972): Discovery of the Early Carboniferous Visean fauna from the Kwanto massif. *Jour. Geol. Soc. Japan*, **78**, (4), 216 [in Japanese].

TORIYAMA, R. and OTA, M. (1971): The Akiyoshi plateau. Guide book for the geological excursion of the 78th Annual Meeting of the Geological Society o Japan, 1-29 [in Japanese].

VAUGHAN, A. (1915): Correlation of Din tian and Avonian. *Quart. Jour. Geol. London*, **71**, 1-52, pls. 1-7.

WANG, Y., JING, Y. G. and FANG, (editors) (1961): Chinese brac fossils pt. 2, 355-777, pls. 59-1 Chinese].

YANAGIDA, J. (1962): Carboniferous pods from Akiyoshi, Southwe pt. I. *Mem. Fac. Sci., Kyushu* (1), 87-127, pls. 14-21.

—— (1965): Carboniferous brac Akiyoshi, Southwest Japan **16**, (2), 113-142, pls. 25-28

Kwanto massif 関東山地 Mitsuzawa 三ツ沢 Yowara 江 原

Explanation of Plate 16

Fig. 2 ×1.25; all others ×1.5

Figs. 1, 2. *Spirifer* sp.

1a–c. Posterior, ventral and lateral views of an incomplete pedicle valve, GK–D 31250.

2. Incomplete brachial valve, GK–D 31248.

Figs. 3–9. *Schizophoria resupinata* (MARTIN)

3a–c. Lateral, posterior and ventral views of an incomplete brachial valve, GK–D 31129.

4. Incomplete brachial valve, GK–D 31140.

5. Incomplete brachial valve, GK–D 31136.

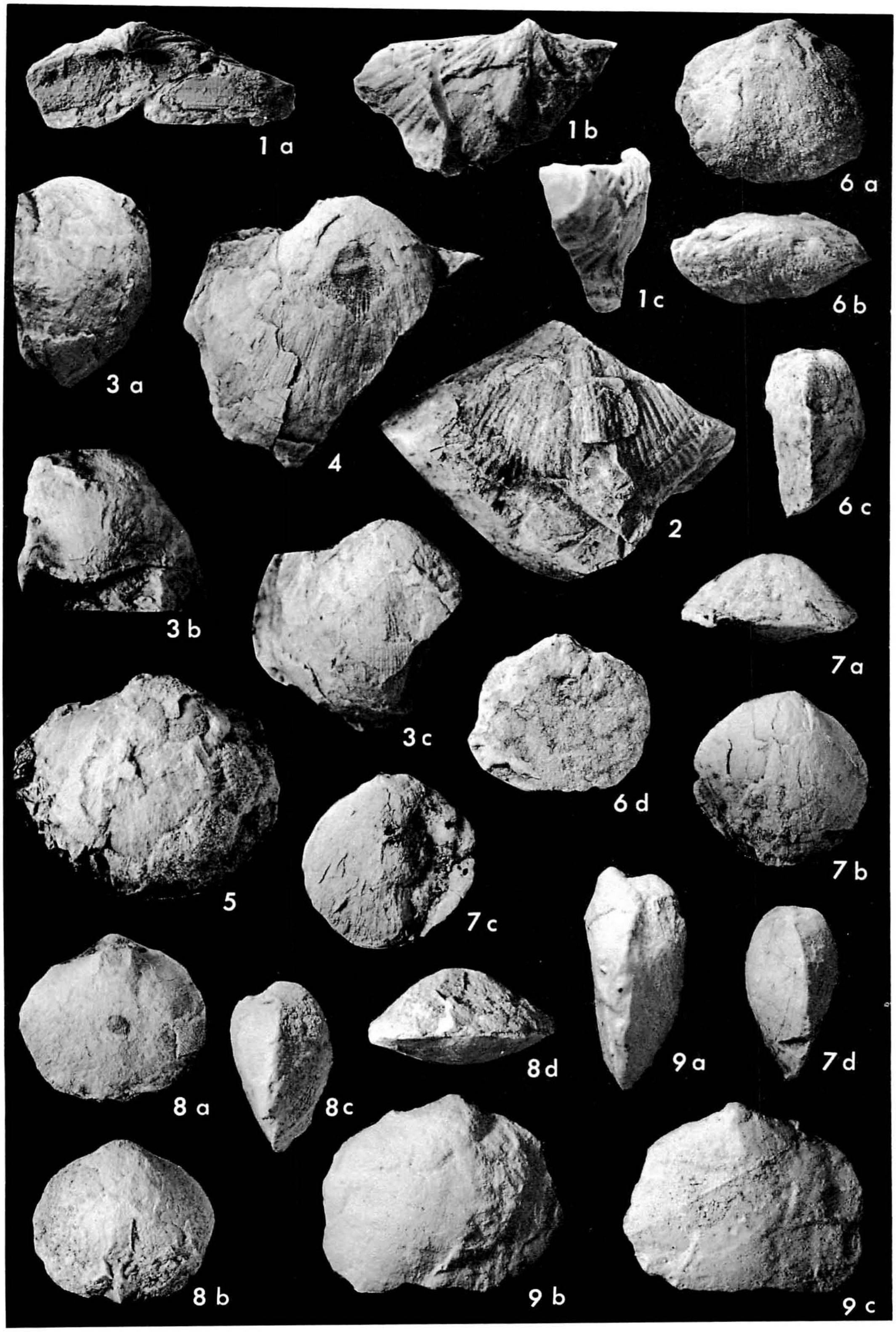
6a–d. Dorsal, anterior, lateral and ventral views of an incomplete shell, GK–D 31139.

7a–d. Anterior, dorsal, ventral and lateral views of an incomplete shell, GK–D 31134.

8a–d. Ventral, dorsal, lateral and anterior views of an incomplete shell, GK–D 31133.

9a–c. Lateral, dorsal and ventral views of a plaster cast, GK–D 31155.

Photos by YANAGIDA, with whitening.


1 a
1 b
1 c
2
3 a
3 b
3 c
4
5
6 a
6 b
6 c
6 d
7 a
7 b
7 c
7 d
8 a
8 b
8 c
8 d
9 a
9 b
9 c

例 会 等 の 通 知

	開催地	開催日	講演申込締切日
111回 例会	新潟大学	1973年6月23-24日	1973年4月20日
112回 例会	東京大学	1973年10月20日	1973年8月20日
1974年 総会・年会	九州大学	1974年1月11-12日	1973年11月10日

◎ 1974年総会・年会（九州大学）では「古無脊椎動物の系統分類に関する最近の進歩」（世話人 高柳洋吉・速水 格）が予定されている。

◎ 日本生化学会・日本植物学会・日本動物学会共同発行の「生物科学ニュース」編集委員会より，本会会員の購読の勧誘方を依頼してきたことをお知らせする。生物科学の各領域について，国際会議をはじめ，各種講演会，学術集会の案内，授賞ならびに研究助成金候補者，教官等の公募案内，学術会議等のニュースを掲載。B5判，約12ページ，毎月20日発行，年間予約購読料900円（送料込み），1部50円。問合せおよび申しこみ先は東京都文京区弥生2-4-16 学会誌刊行センター。

◎ 本会誌の出版費の一部は文部省研究成果刊行費による。

1973年6月15日 印刷
1973年6月20日 発行

日本古生物学会報告・紀事

新篇 第89号

900円

発行者 日本古生物学会
文京区弥生2-4-16
日本学会事務センター内
（振替口座東京84780番）

編集者 氏家 宏

印刷者 東京都練馬区豊玉北2ノ13
学術図書印刷株式会社 富田 潔

Transactions and Proceedings of the Palaeontological Society of Japan

New Series No. 90 June 20, 1973

CONTENTS

TRANSACTIONS