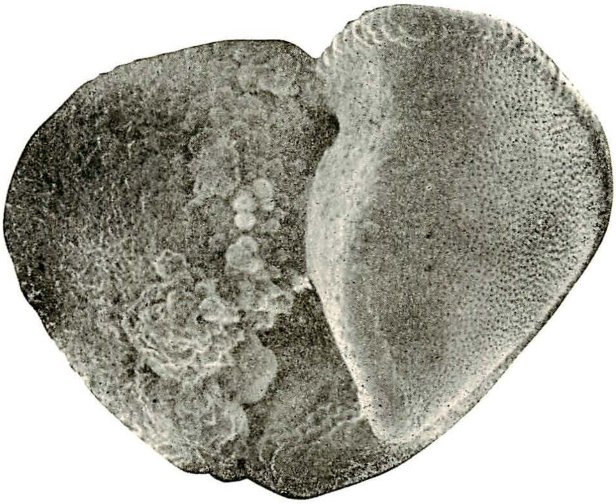
日本古生物学會
報告・紀事

Transactions and Proceedings of the Palaeontological Society of Japan

New Series No. 76



日本古生物学会

Palaeontological Society of Japan
December 10th, 1969

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Fossils on the cover is *Globorotalia truncatulinoides* (D'ORBIGNY, 1839).
The photograph was taken on a scanning electron microscope, JEOL-JSM-2, ×100.

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PALAEONTOLOGICAL SOCIETY OF JAPAN
Geological Institute, Faculty of Science, University of Tokyo, Tokyo 113, Japan
Sole agent: University of Tokyo Press

Trans. Proc. Palaeont. Soc. Japan, N.S., No. 76, pp. 165-176, pls. 18, 19, Dec. 10, 1969

558. LOWER CRETACEOUS AMMONITES FROM THE MIYAKO GROUP PART 3

SOME DOUVILLEICERATIDS FROM THE MIYAKO GROUP

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下部白亜系宮古層群産アンモナイト (その 3), 宮古層群産 douvilleiceratids: 宮古層群に産するアンモナイトのうち, Douvilleiceratidae 科の *Eodouvilleiceras* 属 2種と *Douvilleiceras* 属 1 種を識別記載した。前者は平井賀層下部の上部より産出し, 後者は平井賀層最上部から明戸層全般にかけて産出する。この産出順序に関する事実は, 諸外国における知識と比較するとき, きわめて調和的である。西欧の示帯化石 *D. mammillatum* の産出により, 明戸層ならびに平井賀層最上部はおそらく下部 Albian の上部に対比されるであろう。いっぽう, *Eodouvilleiceras* 属 2 種の産出から, 平井賀層下部が上部 Aptian の上部に対比される可能性はますます強まった。 小 畠 郁 生

Introduction

Some species of the Lower Cretaceous ammonites from the Miyako Group were described in my previous papers (1967a, b). Subsequently (HANAI et al., 1968) the stratigraphic division and succession of selected species of ammonites from the Miyako Group were shown in a table. On that occasion the Aketo Formation, the uppermost member of the Group, was provisionally assigned to the Lower Albian, without, however, definite indices. In the present part, I describe three species belonging to the family Douvilleiceratidae. The Douvilleiceratidae consist of only a few genera but are important in that they are representative of the Douvilleicerataceae and comprise good index species of Aptian to Albian ages.

I wish to record here my cordial thanks to Dr. Tetsuro HANAI of the University of Tokyo and to Dr. Itaru HAYAMI of Kyushu University, for their kind cooperation in the field work and in various other ways. I desire to express my sincere thanks to Professor Tatsuro MATSUMOTO of Kyushu University, who had encouraged me during the course of this study, shared his precious time with me in fruitful discussion, and furthermore made a critical review of the first draft. Thanks are extended to Dr. Hiroshi OZAKI and Miss Reiko FUSEJIMA of the National Science Museum for their help in many ways. Financial support was defrayed by the Ministry of Education as the Grant in Aid for Scientific Researches.

Systematic Descriptions

Order Ammonoidea

Superfamily Douvilleicerataceae

* Received April 1, 1969; read January 25, 1969, at Tokyo.

Family Douvilleiceratidae

Subfamily Douvilleiceratinae PARONA & BONARELLI, 1897

Genus *Eodouvilleiceras* CASEY, 1961

Type species.—*Douvilleiceras horridum* RIEDEL, 1937 (designated by CASEY, 1961).

Remarks.—CASEY (1961, p. 191) described concisely the diagnosis of the genus, to which a few species were referred (1961, p. 191; 1962, p. 260). Recently, MATSUMOTO (1968, p. 143) described a species of the genus from the Tomochi Formation, Kyushu. In this paper two species from the Miyako Group are described. They came from the upper part of the Upper Aptian.

Eodouvilleiceras matsumotoi, sp. nov.

Pl. 18, figs. 2, 3, 5; Pl. 19, fig. 2; text-fig. 1.

Holotype.—NSM 7272 from loc. Hn. 4201 (OBATA coll.).

Paratypes.—Two specimens, NSM 7269 and 7281, from the type locality (OBATA coll.); NSM 7263 and 7264 from loc. Hn. 4151 (OBATA coll.); NSM 7268 from the same locality (HANAI coll.); IGPS 87145, a fragment, from loc. Hn. 4152 (YEHARA coll.).

Description.—Whorls are much depressed and coronate, except for the young which shows a rather cadicone stage below 10 mm. in diameter. The maximum thickness is at some distance below the midflank. Width of umbilicus is fairly wide to moderate, decreasing with growth. The umbilical wall is high and steep near its base, becomes rounded upward, passing into a subangular top, slightly above the umbilical shoulder, where the whorl is broadest. The inflated flanks are convergent toward the venter. The ribs start from the umbilical shoulder, slightly concave on the flank, and are very gently projected on the venter in younger stages, but in later stages they become straight, slightly prorsiradiate on the flank, and then radially cross the venter. The ribs are broad but very low, and are separated by interspaces which are nearly as wide as the ribs. The lirae are discernible in the interspaces on the shell. There are eighteen ribs in a whorl of a late stage (e. g. NSM 7272), but six in an earlier whorl (e. g. NSM 7264).

At the stage below 5 mm. in diameter, a tubercle appears first on the most inflated part of the flank (e. g. NSM 7273). In addition, a ventro-lateral tubercle appears on the rib at about 7 mm. in diameter (e. g. NSM 7264), and lastly a tubercle appears on the umbilical end of the rib at about 16 mm. in diameter (i. e. NSM 7272). The lateral tubercles are rather clavate in the young stage between 5-8 mm in diameter (e. g. NSM 7264 and 7272), but become conical later (i. e. NSM 7272). In later stages there are two ventro-lateral tubercles on each rib, but lateral tubercle is sometimes absent. The ventro-lateral tubercles are rather spinose and are nearly as large as the lateral ones in later stages. The umbilical tubercles are much smaller than the lateral and ventro-lateral ones.

The suture is rather simple. Following WIEDMANN's formula (1966, p. 34), it consists of $EL(LvLd)U(UvUd)I$. E is deep and of moderate breadth. L is the broadest and is divided into Lv and Ld by a comparatively large, subquadrate saddle. Lv is oblique, much smaller than E and is asymmetrically incised with small folioles. Ld is smaller than Lv and is oblique. U is asymmetrically divided into Uv and Ud by a foliole.

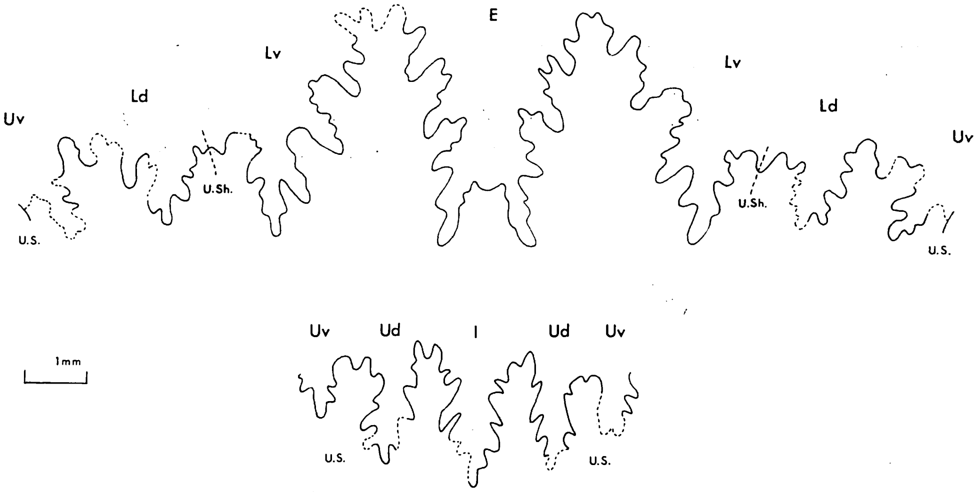

Fig. 1. *Eodouvilleiceras matsumotoi* sp. nov. Suture of the holotype, NSM 7272, from the Hiraiga Formation, at whorl-height=3.8 mm, breadth=7.5 mm.

Uv is small and situated on the outer side of the umbilical seam. *Ud* is almost vertical and deeper than *Uv*. *I* is fairly narrow but larger than *Ud*. The first lateral saddle between *E* and *L* is the tallest, massive, asymmetric in outline, with a steeper ventral slope, multipartite with several lobules, decreasing in breadth toward the top. The saddle between *L* and *U* is subquadrate, and shallowly bipartite at the top. The saddle between *U* and *I* is fairly high and narrow.

Remarks.—The holotype, the largest of the present specimens, is much smaller than the hitherto known mature specimens of douvilleiceratids, but its morphological features are distinguished from the specimens of the known species.

Comparison.—The described specimens are closer to the holotype of *Eodouvilleiceras horridum* (RIEDEL) (1937, p. 29, pl. 6, figs. 1, 2) than to the specimen illustrated by CASEY (1962, p. 261, text-fig. 90), in the delicate and dense ribbing (18 per whorl), sharpness of tubercles and fairly large distance between two ventro-lateral tubercles. Since the suture of the holotype of *E. horridum* is insufficiently preserved and the incision of saddles is uncertain, an exact comparison cannot be expected between the two species under consideration. The main difference between the Miyakoan and the Colombian species is the position of the lateral tubercles. In the described species the lateral tubercles are situated below the mid-flank, while in *E. horridum* they are situated rather above the mid-flank.

The described species is distinguished from *Eodouvilleiceras* n. sp. (?) aff. *E. horridum* (RIEDEL) (MATSUMOTO, 1968, p. 143, pl. 2, fig. 2a-d) from the Tomochi Formation, Kyushu, in that it has a subangular, instead of rounded, top slightly above the umbilical shoulder and the lateral tubercles which are situated inside the mid-flank.

Eodouvilleiceras santafecinum (BURCKHARDT) from Colombia has more numerous ribs (cf. DOUVILLÉ, 1906, pl. 1, figs. 2, 2a) and more compressed whorl (cf.

*Measurements.**—

Specimen	Diameter	Umbilicus	Height	Breadth	B/H
NSM 7272	20.4(1)	7.8(0.38)	8.8(0.43)	13.3(0.65)	1.51
" (earlier stage)	14.9(1)	6.2(0.42)	5.0(0.34)	9.4(0.63)	1.88
NSM 7264	8.8(1)	4.0(0.45)	2.6(0.29)	5.4(0.61)	2.07
For comparison:					
Holotype of *E. horridum* [RIEDEL, 1937, p. 29]					
	68(1)	c. 26(0.38)	c. 25(0.37)	39(0.57)	1.56
E. horridum from the Upper Aptian, near Bogota, Colombia [CASEY, 1962, p. 261, estimated from text-fig. 90]					
	c. 54.6(1)	c. 21.3(0.39)	c. 20.0(0.37)	c. 30.6(0.56)	1.53
E. badkhyzicum from the Turkmenia, U.S.S.R. [URMANOVA, 1962, p. 76]					
1/28-14a	88(1)	33(0.38)	35.5(0.40)	54(0.61)	1.52
1/28-146	84(1)	30.5(0.36)	33.6(0.40)	46.2(0.55)	1.38
1/28-14b	73.5(1)	22.9(0.31)	27.6(0.38)	42(0.57)	1.52
1/28-14r	72(1)	24.6(0.34)	26.7(0.37)	40(0.55)	1.49
228	40(1)	17.7(0.44)	13(0.33)	24(0.60)	1.84
E. santafecinum [*Cheloniceras boulei*, BASSE, 1928, estimated from text-fig. 17 and pl. 8, fig. 4]					
Costal	92.8(1)	34.8(0.38)	35.7(0.38)	40.8(0.44)	1.14
Intercostal	91.4(1)	32.4(0.35)	30.3(0.33)	33.8(0.37)	1.11
E. santafecinum [*Douvilleiceras stoliczkanum*, DOUVILLÉ, 1905, estimated from pl. 1, fig. 2, 2a]					
	93.0(1)	28.9(0.31)	24.5(0.26)	30.8(0.33)	1.25

BASSE, 1928, p. 140, text-fig. 17) than the described species. In *E. santafecinum* the lateral tubercles are situated evidently outside the mid-flank.

The suture line of the described species is very similar to that of *Eodouvilleiceras clansayense* (JACOB) (p. 414, text-fig. 6) in the general outline, the incision of saddles, etc. The two species are similar also in the width of umbilicus and the ratio of breadth to height. However, they are clearly distinguished by the sharpness of ornamentation and the position of tubercles.

In *Eodouvilleiceras badkhyzicum* (URMANOVA) (1962, p. 76, text-figs. 1, 2) the ribs are more numerous and the lateral tubercles are situated somewhat farther outside than in the described species. The width of umbilicus and the ratio of breadth to height are similar between the Russian and the Miyako specimens.

Occurrence.—Loc. Hn. 4201, a calcareous concretion at Tairajima, southeast of Omoto village. In addition to this species, *Diadochoceras nodosocostatiforme* (SHIMIZU), *Eodouvilleiceras* sp., *Eotetragonites* sp., *Uhligella matsushimensis* (SHIMIZU), *Pseudohaploceras* (?) sp. and *Hypophylloceras* sp. occur at the same locality.

Loc. Hn. 4151, calcareous concretions in the upper fossiliferous bed at Matsushima, southeast of Omoto village. In

* Measurements are in mm.

addition to this species, *Diadochoceras nodosocostatiforme* (SHIMIZU), *Eodouvilleiceras* sp., *Valdedorsella getulina* (COQUAND), *Melchiorites yabei* (SHIMIZU), *Hypophylloceras* sp. and *Hamites* sp. occur at the same locality.

Loc. Hn. 4152, a calcareous concretion in the middle fossiliferous bed at Matsushima.

The above localities are all in Shimohei County, Iwate Prefecture. They are in the upper portion of the lower part of the Hiraiga Formation; Uppermost Aptian.

Eodouvilleiceras sp. nov. (?) aff. *E. matsumotoi* OBATA

Pl. 18, figs. 1, 4, 6; pl. 19, fig. 1; text-figs. 2, 3.

Material.—NSM 7261 from loc. Hn. 4151 (OBATA coll.). Four immature specimens, NSM 7265-7267, from loc. Hn. 4151 (HANAI coll.), NSM 7278 from the same locality (OBATA coll.), NSM 7270 from loc. Hn. 4201 (OBATA coll.) are comparable to the present species.

Description.—In the stage less than 20 mm. in diameter, whorls are depressed, showing coronate section, with point of maximum thickness moving in course of growth from nearly middle of the flank toward umbilical margin. Width of umbilicus is fairly narrow at about 20 mm. in diameter, being nearly a quarter of the diameter. But it is moderate at about 7 to 8 mm., being 35% of the total diameter. Umbilicus is bounded by rather high and steep wall, though rounded well at rim. The flanks are rounded, and the venter is very gently arched.

The ribs are straight, radial or slightly reclined, fairly broad and very low, rarely short, and are separated by interspaces which are wider than or nearly as wide as the ribs. Ribs are variable in strength; the shorter ones terminate just above the umbilical margin. Faint lirae are occasionally discernible on the interspaces. There are 12 ribs per whorl. In the very young specimens at about 7 to 8 mm. in diameter, ribs are distinct, counting 6 to 8 within a whorl, and separated by interspaces wider than the ribs, and lirae are rather sharp between the ribs.

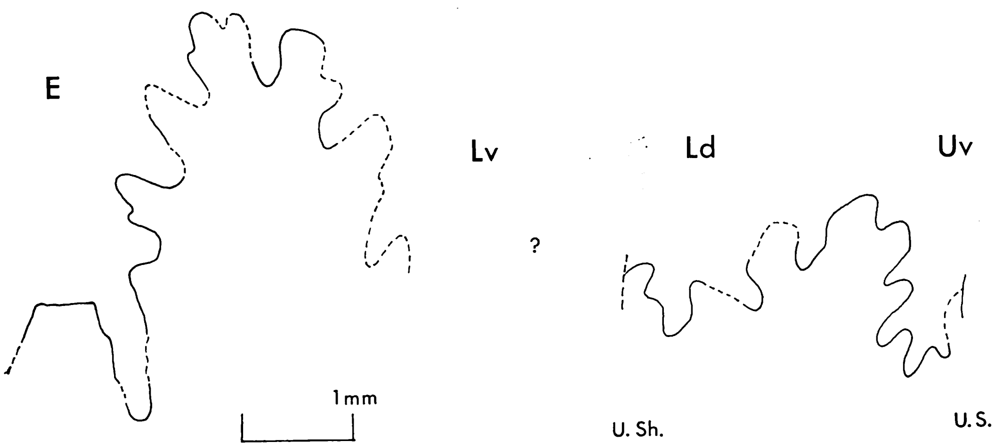

Fig. 2. *Eodouvilleiceras* sp. nov. (?) aff. *E. matsumotoi* OBATA. NSM 7261, from the Hiraiga Formation, at whorl-height=4.4 mm, breadth=7.4 mm.

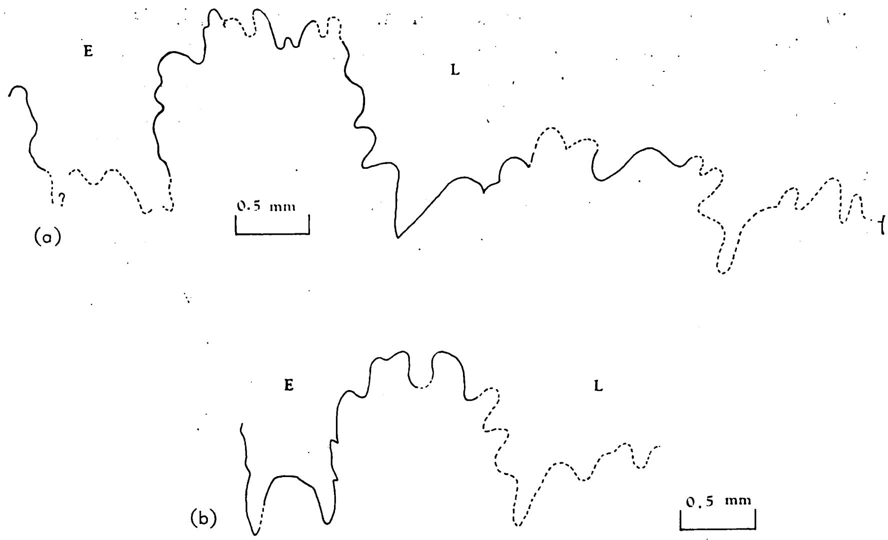

Fig. 3. *Eodouvilleiceras* sp. nov. (?) aff. *E. matsumotoi* OBATA.
NSM 7266, from the Hiraiga Formation.
a: at whorl-height=3.0 mm, breadth=4.4 mm.
b: at whorl-height=1.8 mm, breadth=2.8 mm.

Each rib has two conical and approximated tubercles on the venter. Lateral tubercles on the part where the thickness is maximum are a little smaller and less than the ventral tubercles. Umbilical tubercles, though indistinct, begin to appear at the stage of about 20 mm. in diameter. In the very young specimens at about 7 to 8 mm. in diameter, ventral tubercles are bullate whereas lateral ones are conical. And, sometimes from the lateral tubercles a lira projects.

Simple sutures of douvilleiceratid type are poorly preserved. In a young specimen, e. g. NSM 7266, the suture is simple and the first lateral saddle is comparatively broad and low.

Measurements.—

Specimen	Diameter	Umbilicus	Height	Breadth	B/H	
NSM 7261 (deformed)	20. 5(1)	5. 6(0. 27)	9. 2(0. 45)	11. 9(0. 58)	1. 29	
NSM 7261 (1/4 vol. earlier)	17. 3(1)	4. 4(0. 25)	7. 1(0. 41)	10. 0(0. 58)	1. 40	costal
			6. 4(0. 37)	8. 7(0. 50)	1. 35	inter-costal
NSM 7262	———	———	9. 8	15. 5	1. 58	costal
”	———	———	8. 9	13. 8	1. 55	inter-costal
NSM 7266	7. 9(1)	2. 8(0. 35)	3. 2(0. 41)	4. 4(0. 55)	1. 38	
NSM 7267	6. 8(1)	2. 4(0. 35)	2. 6(0. 38)	3. 9(0. 57)	1. 50	

Remarks.—The described specimens have features that seem to suggest a new species, but I hesitate to propose a new specific name for the reasons given below.

Comparison.—The species resembles *Eodouvilleiceras matsumotoi* OBATA, in the simple ribbing, mammilliform but undivided ventral tubercles, depressed whorls, as well as the general pattern of sutures. The present species has more coarse and less numerous ribs and nodes than *E. matsumotoi*. The former has a short distance between the two ventral tubercles, while the latter has a large distance between the two ventro-lateral tubercles. In the latter there is a subangular top slightly above the umbilical shoulder and the umbilicus is wider and the whorl is more depressed than the former.

There is, however, a peculiar fragmentary specimen which seems to be intermediate between the two species in question. The example is NSM 7262, in which the flanks are rounded, showing the character of the present species, but has fairly delicate ornaments and has a large distance between the two ventro-lateral tubercles. In short, the species described here probably represents a new species related to *E. matsumotoi*. The establishment of the new species is, however, suspended until more specimens are obtained. The present species also resembles *E. horridum* (RIEDEL, 1937, p. 29; pl. 6, figs. 1, 2; pl. 14, fig. 11) from the Upper Aptian of Colombia. Above all, our specimens are similar to the specimen mentioned by CASEY (1962, p. 261, text-fig. 90) in that the distance between the two ventral tubercles is short and the ribs are coarse. The Colombian specimen has, however, a wider umbilicus and somewhat more depressed whorls than ours. Furthermore, there is no distinct umbilical tubercle in the Miyako specimens at about 20 mm. in diameter. In these points the specimen illustrated by CASEY agrees well with the holotype of *E. horridum.*

The described species is distinguished from *Eodouvilleiceras* n. sp. (?) aff. *E. horridum* (RIEDEL) (MATSUMOTO, 1968, p. 143, pl. 2, fig. 2a–c), from the Tomochi Formation of Kyushu. In the former the ribs are less crowded, the flanks are more rounded, the umbilicus is probably narrower, and the distance between the two ventral tubercles is shorter than in the latter.

In lateral view the described specimens considerably resemble one of the French specimens described and illustrated by JACOB as *Douvilleiceras clansayense* (1905, p. 413, pl. 13, fig. 4a–c), in the coarseness and density of ribbing, absence or weakness of umbilical tubercles, and in the douvilleiceratid type suture. In the French specimen the lateral tubercles are situated outside the mid-flank, while in the Japanese specimens they are situated inside the mid-flank. Furthermore, the French specimen as estimated from fig. 4a–b is similar to *E. horridum* in showing 40% of the umbilicus to the whole diameter, and having 1.6 ratio of whorl breadth to height. Thus, the French specimen is dissimilar to the Japanese specimens in dimensions.

Eodouvilleiceras santafecinum (BURCKHARDT), described by BASSE as *Cheloniceras boulei* (1928, p. 139, text-fig. 17, pl. 8, fig. 4) from the uppermost Aptian of Colombia has denser ribbing and a longer distance between the two ventral tubercles than the Miyako specimens, and has distinct umbilical tubercles. In the former the lateral tubercles are clearly situated farther outside than ours. Furthermore, the South American species, as seen in the figures, has a wider umbilicus and much compressed whorl. In these points the specimen described and illustrated by DOUVILLÉ as *Douvilleiceras stoliczkanum* (1906, pl. 1, fig. 2, 2a) somewhat approaches to the Miyako specimens. Anyhow, *E. santafecinum* seems to be largely different from the species from the Miyako Group.

Eodouvilleiceras badkhyzicum (URMANOVA) (1962, p. 76, text-figs. 1, 2) from the Upper Aptian of Turkmenia, U.S.S.R., has denser ribbing than the specimens from Miyako. In the Russian species the umbilical tubercles are distinct and the lateral tubercles seem to be situated outside the mid-flank, while they are somewhat inside it in the latter. As MATSUMOTO (1968, p. 144) has already pointed out, *Eodouvilleiceras badkhyzicum* (URMANOVA) closely resembles the holotype of *E. horridum* (RIEDEL) (1937, pl. 6, figs. 1, 2) in the depressed whorl, moderate width of umbilicus, and in the sharpness and density of ribs and tubercles. Thus, the former may fall in the variation of the latter, even if the minor difference in number of ribs is taken into consideration.

Occurrence.—Loc. Hn. 4151, a calcareous concretion in the upper fossiliferous bed at Matsushima. In addition to this species, *Valdedorsella getulina* (COQUAND), *Melchiorites yabei* (SHIMIZU), *Diadochoceras nodosocostatiforme* (SHIMIZU), *Eodouvilleiceras matsumotoi* OBATA, *Hypophylloceras* sp. and *Hamites* sp. occur in the same concretion.

Loc. Hn. 4201, a calcareous concretion in the sandstone at Tairajima. In addition to this species, *Diadochoceras* (?) sp. and *Eodouvilleiceras matsumotoi* OBATA occur in the same concretion.

The above localities are in the southeast of Omoto village, Shimohei County, Iwate Prefecture. They are in the upper portion of the lower part of the Hiraiga Formation; Uppermost Aptian.

Genus *Douvilleiceras* GROSSOUVRE, 1893

Type species.—*Ammonites mammillatus* SCHLOTHEIM, 1913.

Synonymy.—*Trinitoceras* SCOTT, 1940.

Diagnosis.—The genus was clearly defined by CASEY (1962, p. 260).

Remarks.—The well-known species, *Douvilleiceras mammillatum* (SCHLOTHEIM), has now proved to occur in the Miyako Group. The beds that yielded the species are stratigraphically higher than the *Eodouvilleiceras* localities, but no transitional material is available at present.

Douvilleiceras mammillatum (SCHLOTHEIM)

Pl. 19, figs. 3, 5.

*Synonymy**.—

1813. *Ammonites mammillatus* SCHLOTHEIM, *Taschenb. gesam. Miner.*, 7, Abt. 1, p. 111.
1962. *Douvilleiceras mammillatus* (SCHLOTHEIM), CASEY, *Palaeont. Soc.*, vol. 116, no. 499, p. 265, pl. 40, figs. 4, 5; pl. 41, figs. 4a, b, 5–7, 8a, b; pl. 42, figs. 6, 9a, b, 10a, b; text-figs. 94a–e, 95a, b, 102a–c.

Material.—A deformed adult specimen, NSM 7274, from a boulder probably derived from loc. Hn. 6200 (OBATA and KANEKO coll.). A deformed adult fragment, NSM 7275 from loc. Hn. 6203 (OBATA coll.). A few young specimens of douvilleiceratids are also examined;

* For a full list of synonymy of *D. mammillatum*, see CASEY, 1962, p. 265–266, 271, 272.

for example, NSM 7276 probably derived from loc. Hn. 6200 (OBATA coll.).

Description.—Whorls are fairly or much depressed, rather polygonal in section, with maximum breadth at the umbilical margin. Umbilicus is moderately wide, nearly one-third diameter, bounded by high, generally smooth and almost vertical wall, which passes into a rounded umbilical shoulder.

Ribs are numerous and closely spaced, counting thirty-two per whorl in NSM 7274 and ten per one-fourth whorl in NSM 7275. They are straight, almost radial, and separated by interspaces nearly as narrow as the ribs. Most of them are long, but some are shorter than the others and terminate just above the umbilical margin. Ribs are variable in strength.

Ventral tubercles are subacute, rather conical, and the distance between each two on the same rib is fairly small. Umbilical tubercles are small and rather bullate. Between the ventral and the umbilical tubercles, there are several rows of lateral tubercles which are small and mammillary.

Suture lines are incompletely preserved. A suture on the earlier part of the shell is rather simple but with minor incisions of moderate size.

Measurements.—

Specimen	Diameter	Umbilicus	Height	Breadth	B/H
NSM 7274	77.7(1)	29.3(0.38)	26.8(0.34)	41.9(0.53)	1.53
NSM 7274 (1/4 vol. earlier)	48.6(1)	14.6(0.30)	23.0(0.47)	32.9(0.68)	1.43

Remarks.—CASEY (1962, p. 265-274) described precisely the character and variation of *D. mammillatum.* A few specimens from the Miyako Group are referred to this species, although there are minor individual differences.

Comparison.—Of the two named varieties of *D. mammillatum* described by CASEY, *D. mammillatum* var. *aequinodum* seems to be closest to the specimens from Miyako. In NSM 7274 the ribs are more closely spaced than those of the typical form of *D. mammillatum.* There are about thirty-two ribs in the former at 78 mm. in diameter, whereas twenty-two in the typical specimen, e. g. BM. C 12491, neotype, at 79 mm in diameter (estimated from CASEY, 1962, pl. 41, fig. 4a, b). Estimating from the preserved adult fragment, NSM 7275, the number of ribs seems to be about forty per whorl at about 90 mm. in diameter. The lateral tubercles of the two specimens are less prominent than in typical *D. mammillatum.* Thus, the Japanese specimens are closer to *D. mammillatum* var. *aequinodum* which has about thirty-five ribs at 100 mm. in diameter.

Occurrence.—Loc. Hn. 6200, a muddy, calcareous fine-grained sandstone at Hiraname on the northeastern coast of Tanohata village, Shimohei County, Iwate Prefecture. In addition to this species, *Calliphylloceras* sp., *Phyllopachyceras* (?) sp., *Valdedorsella* sp., *Desmoceras* sp., *Hulenites* sp., *Pseudoleymeriella* sp., *Pictetia* sp., *Ptychoceras* sp., and other heteromorph ammonites occur at the same locality. *Caenholectypus peridoneus* (NISHIYAMA) is abundant there. The sandstone is in the upper part of the Aketo Formation; Lower Albian.

Loc. Hn. 6203, alternation of fine-grained muddy sandstone and sandy mudstone at Hiraname. The specimen was obtained from the sandy mudstone. In addition to this species, *Hypophylloceras* (?) sp., *Melchiorites* (?) sp., *Hulenites* (?) sp., *Ptychoceras* sp., and other heteromorph ammonites occur at the same locality. *Hemiaster* sp. is abundant. The mudstone is in the uppermost part of the Hiraiga Formation; Lower Albian.

Concluding Remarks

Summarizing the result I list below the species of the douvilleiceratids from the Miyako Group which have been described above. The stratigraphic position of each species is indicated in brackets.

(1) *Eodouvilleiceras matsumotoi* OBATA sp. nov. [Upper portion of the lower part of the Hiraiga Formation]

(2) *Eodouvilleiceras* sp. nov. (?) aff. *E. matsumotoi* OBATA [Upper portion of the lower part of the Hiraiga Formation]

(3) *Douvilleiceras mammillatum* (SCHLOTHEIM) [Upper part of the Aketo Formation; Uppermost part of the Hiraiga Formation]

Occurrence of *Eodouvilleiceras* in the Upper Aptian of Colombia, Russia, France, California and Venezuela is mentioned by CASEY (1961, p. 191; 1962, p. 261, 263). In Japan, *Eodouvilleiceras* n. sp. (?) aff. *E. horridum* (RIEDEL) is reported from the Tomochi Formation of Kyushu (MATSUMOTO et al., 1968). Thus, *Eodouvilleiceras* seems to be fairly common in the circum-Pacific region as well as in Europe and other regions. *Douvilleiceras mammillatum* (SCHLOTHEIM) is a well-known species and is regarded as an important index of the upper part of the Lower Albian in England (CASEY, 1961). The distribution of *Douvilleiceras* seems to be world-wide and the occurrence of *Douvilleiceras* is limited mostly to the Lower Albian except for a few species that survived into the Middle Albian (CASEY, 1962, p. 263).

Stratigraphically speaking, the three species described above came from a limited sequence of the Miyako Group. Two species of *Eodouvilleiceras* occur

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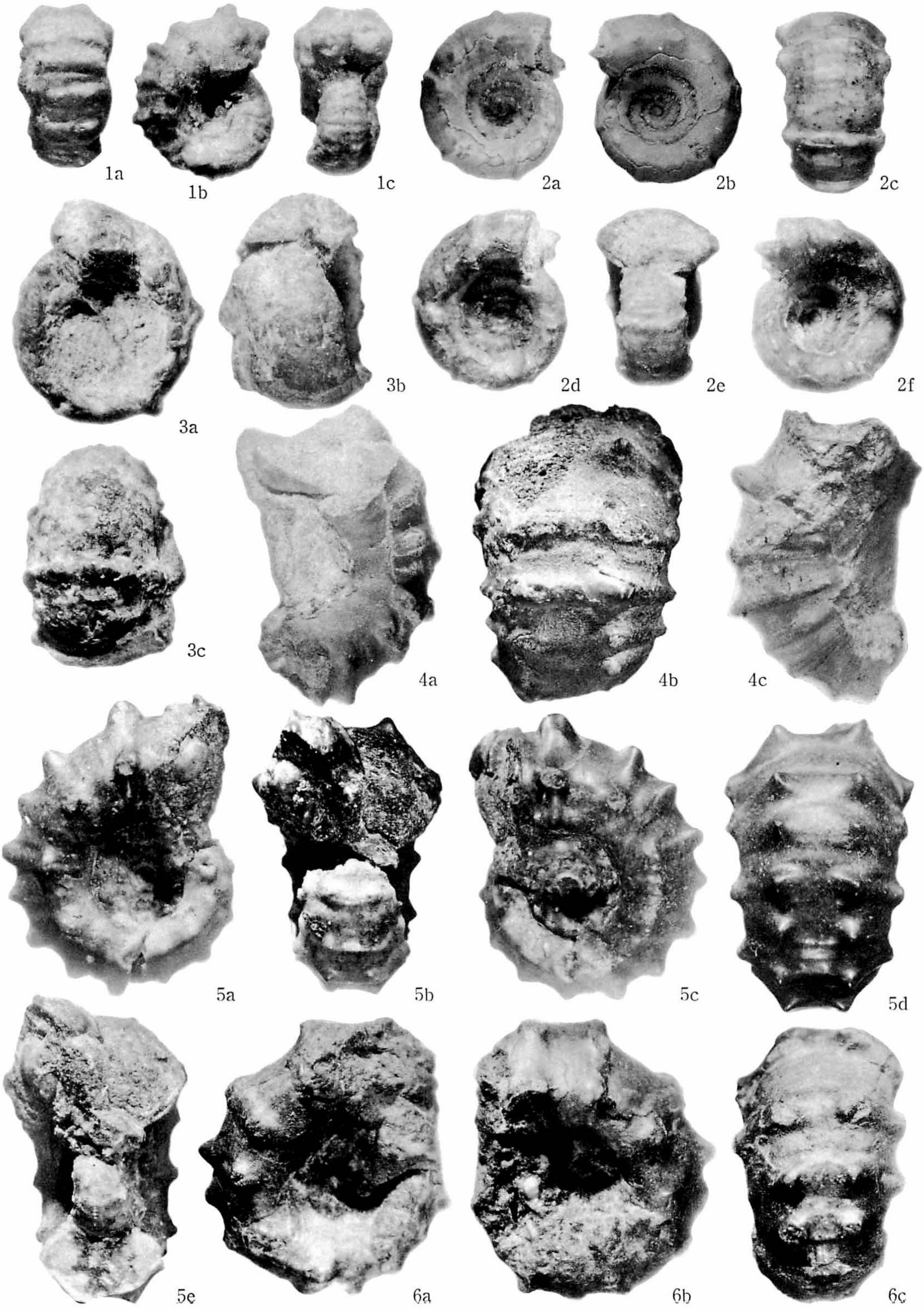
Explanation of Plate 18

Figs. 1, 4, 6. *Eodouvilleiceras* sp. nov. (?) aff. *E. matsumotoi* OBATA.
Fig. 1. NSM 7266, very young specimen, ×3. Ventral (a), lateral (b) and frontal (c) views.
Fig. 4. NSM 7262, specimen intermediate between the present species and *E. matsumotoi*, ×2. Lateral (a, c) and ventral (b) views.
Fig. 6. NSM 7261, largest specimen, ×2. Lateral (a, b) and ventral (c) views.

Figs. 2, 3, 5. *Eodouvilleiceras matsumotoi* OBATA, sp. nov.
Fig. 2. NSM 7264, paratype, ×3. Lateral (a, b) views with whitening. Ventral (c), lateral (d, f) and frontal (e) views without whitening.
Fig. 3. NSM 7268, paratype, ×3. Lateral (a), frontal (b) and ventral (c) views.
Fig. 5. NSM 7272, holotype, ×2. Lateral (a, c), frontal (b) and ventral (d) views and cross-section (e).

All photos without whitening unless stated otherwise.
NSM: Department of Paleontology, National Science Museum, Tokyo.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in the upper portion of the lower part of the Hiraiga Formation, while no specimens of *Douvilleiceras* have been found below the upper level of the upper part, from which only one specimen has been obtained. In the overlying Aketo Formation, several specimens of *Douvilleiceras* have been obtained. This sequence of the douvilleiceratid species in the Miyako Group is interesting. Thus, the whole Aketo Formation and the uppermost part of the Hiraiga Formation are probably assigned to the upper part of the Lower Albian, while the lower part of the latter is assigned to the upper part of the Upper Aptian.

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Aketo	明 戸
Hiraiga	平井賀
Hiraname	平波目
Matsushima	松 島
Miyako	宮 古
Omoto	小 本
Shimohei	下閉伊
Tairajima	平 島
Tanohata	田野畑
Tomochi	砥 用

Explanation of Plate 19

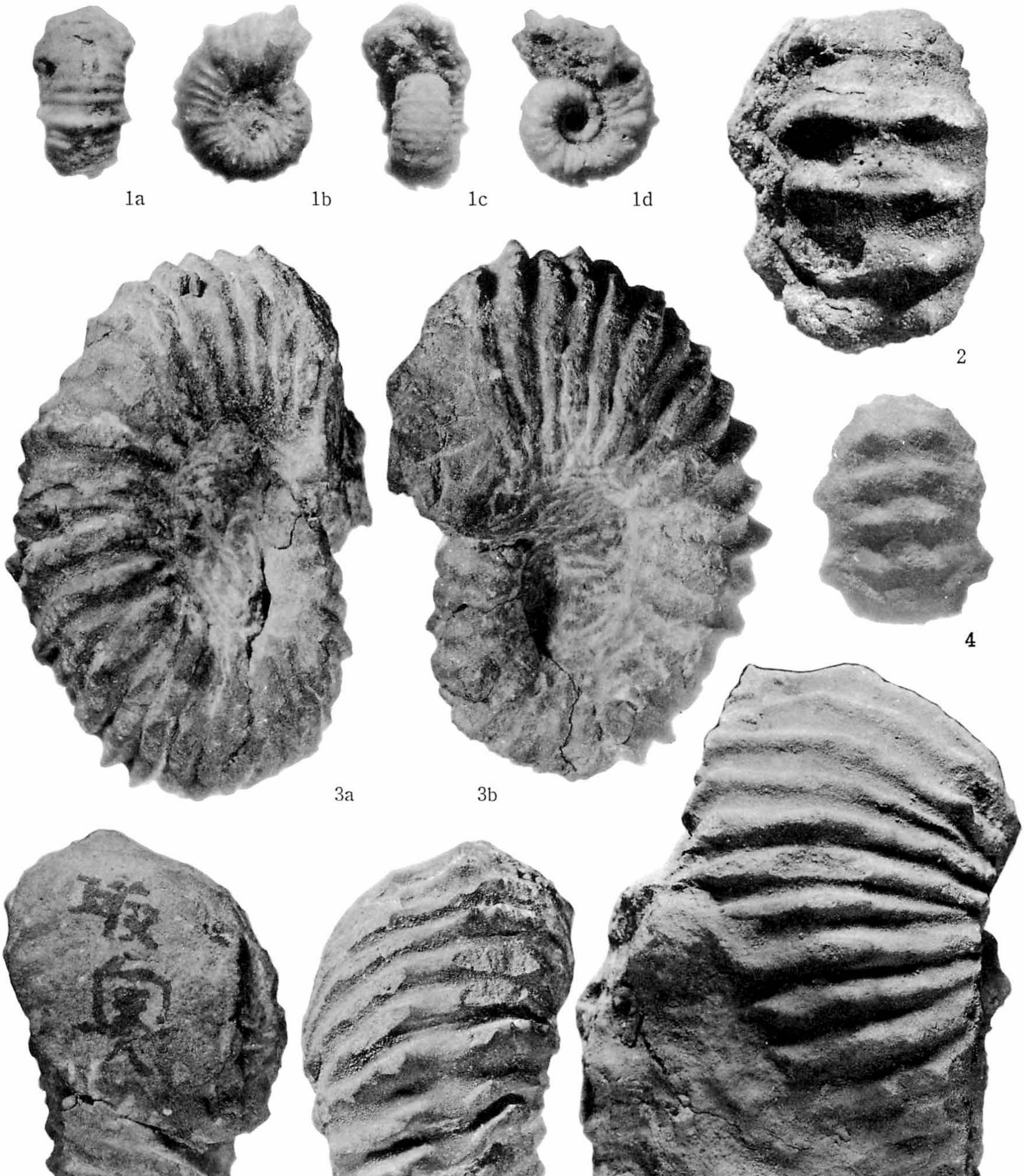
Fig. 1. *Eodouvilleiceras* sp. nov. (?) aff. *E. matsumotoi* OBATA.
NSM 7267, very young specimen, ×3. Ventral (a), lateral (b, d) and frontal (c) views.

Fig. 2. *Eodouvilleiceras matsumotoi* OBATA, sp. nov.
IGPS 87145, fragmentary specimen, ×2. Ventral view.

Figs. 3, 5. *Douvilleiceras mammillatum* (SCHLOTHEIM)
Fig. 3. NSM 7274, deformed adult specimen, ×1. Lateral (a, b), frontal (c) and ventral (d) views.
Fig. 5. NSM 7275, deformed fragmentary specimen, ×1. Ventro-lateral view.

Fig. 4. *Douvilleiceras* (?) sp.
NSM 7276, fragmentary young specimen, ×2. Ventral view.

All photos without whitening. NSM: Department of Paleontology, National Science Museum, Tokyo. IGPS: Institute of Geology and Paleontology, Tohoku University, Sendai.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Trans. Proc. Palaeont. Soc. Japan, N.S., No. 76, pp. 177-184, pl. 20, Dec. 10, 1969

559. A NEW AMMONITE FROM THE SHIMANTOGAWA GROUP OF SHIKOKU*

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四国の四万十川層群産のアンモナイト新種：高知県土佐市浅井の四万十帯から新たに発見されたアンモナイトは *Dipoloceras* (*Diplasioceras*) に属し，既知種のどれとも区別できる特異性があるので，新種として記載する。このアンモナイトはかつて報告された土佐市北山産の *Dipoloceras* aff. *fredericksburgense* とともに，下部白亜系アルビアンの中部を示す。これに関連して，いわゆる薬山層と堂ガ奈路層との関係についての可能な一解釈を記す。またこの機会に四万十川層の堆積環境について，アンモナイトの見地からの見解を述べる。貴重な化石を発見し快く研究に提供された長谷川清治・塩見孝男の両氏に深く敬意を表する。

松本達郎・平田茂留

Introduction

The Shimantogawa Group is distributed extensively in the southern part of the Outer Zone of Southwest Japan. It consists mainly of shale and sandstone in various grades of thickness and has occasional interbeds or lentils of conglomerate, basaltic lava, tuffite, chert and limestone. While trace fossils of the flysch type are frequently found in the strata of the group, the megafossils are generally rare. Ammonites are specially scarce, but they are valuable for the age-determination of the strata and for the interpretation of sedimentary conditions. Therefore endeavour has been paid in searching out ammonoids.

Since one of us (MATSUMOTO et al., 1952), together with coauthors, described Cretaceous ammonites from the Shimantogawa Group of Shikoku several more ammonites have been reported from the same group and its extension. The hitherto identified species are Aptian *Cheloniceras* sp. aff. *C. minimum* CASEY and *Cheloniceras shimizui* NAKAI and HADA (1966), Middle Albian *Dipoloceras* sp. aff. *D. fredericksburgense* SCOTT (MATSUMOTO et al., 1952), Upper Albian (?) *Stoliczkaia japonica* (MATSUMOTO,

* Received May 8, 1969; read June 15, 1969.

1952)* and *Neophlycticeras* (?) sp. (fragment from Nii, recently found by N. NONAKA** and identified by T. M.), Turonian *Collignoniceras* (*Selwynoceras*) sp. nov. (?) (MATSUMOTO et al., 1966), Campanian *Maorites* sp. (undescribed specimens found by Y. YUASA from Nishi, Jôbe, Ehime Prefecture, identified by T. M.), Maastrichtian *Diplomoceras* cf. *notabile* (WHITEAVES) (listed and illustrated by KATTO, 1961) and *Gaudryceras* (*Vertebrites*) *kayei* (FORBES) (KATTO, 1961; SUYARI et al., 1967). In addition several species of Coniacian ammonites had already been reported (YEHARA, 1924; YABE, 1927) from the Uwajima Group, which is situated in the Shimanto belt but used to be separated from the Shimantogawa Group on account of particular litho- and biofacies.

On January 12th, 1969, Messrs Kiyoharu HASEGAWA and Takao SHIOMI discovered an interesting specimen of ammonite from a locality about 10 km southeast of Sakawa and about 15 km southwest of Kochi (Fig. 1). They kindly presented it to one of us (M. H.). After HIRATA's preliminary study it was forwarded to the other of us (T. M.). We describe in this paper a result of our study of the ammonite to enrich the available information.

Before going further we wish to thank Mr. Masafumi ARITA and Dr. Itaru HAYAMI for their kind help and discussion. Miss Yuko WADA assisted us in drafting.

* This was identified with *Kazanskyella* with a query. It is very close to *Stoliczkaia notha* (SEELEY, 1865) (see SPATH, 1931, p. 335, text-fig. 110; pl. 31, figs. 5, 6, 8, 11; pl. 32, fig. 6) but is distinguished by less projection of the ribs on the septate whorl. (T.M.)

** I thank Dr. T. KOBAYASHI and Mr. Naoharu NONAKA who kindly put the specimen at my disposal. (T.M.) The specimen is now in the posession of N. NONAKA in Sakawa.

Palaeontological Description

Superfamily Acanthocerataceae

Family Brancoceratidae SPATH, 1933

Genus *Dipoloceras* HYATT, 1900

Subgenus *Diplasioceras* VAN HOEPEN, 1946

Type species.—*Diplasioceras fallax* VAN HOEPEN, 1946.

Remarks.—*Diplasioceras* was set up by VAN HOEPEN (1946, p. 203) for a single species *D. fallax* VAN HOEPEN (1946, p. 203, figs. 178-181), from the Albian of South Africa. The generic diagnosis was given as follows: "Keeled ammonites of the Gault. Young forms with rectangular section and with flat flanks. The young forms have no old mouth-edges. There are umbilical tubercles from where ribs are visible. Older whorls with spiral ornament. Ribs on younger whorls round and nearly straight. There is no ventral tubercle on young whorls, but the ventral ends of the ribs are broadened. The ribs of later whorls are sharp and they project ventrally."

COLLIGNON (1949, p. 23) treated *Diplasioceras* as a subgenus of *Dipoloceras* HYATT, 1900 [type-species *Ammonites cristatus* DELUC *in* BRONGNIART, 1822] and described *D.* (*Diplasioceras*) *hirtzi* COLLIGNON (1949, p. 24, pl. 3, figs. 2, 3; text-fig. 7), *D.* (*Diplasioceras*) *besairiei* COLLIGNON (1949, p. 25, pl. 3, fig. 4; text-fig. 8) and *D.* (*Diplasioceras*) sp. aff. *fredericksburgense* SCOTT (COLLIGNON, 1949, p. 26, pl. 4, fig. 1; pl. 6, fig. 2, text-fig. 9) from the Albian of Madagascar. Subsequently he added one more species, *D.* (*Diplasioceras*) *horridum* COLLIGNON (1963, p. 148, pl. 300, figs. 1298, 1299). According to COLLIGNON (1963) these Madagascar species occur in the zone of *Dipolo-*

ceras cristatum.

In the monograph of the Texas Mojsisovicziinae YOUNG (1966) regarded *Diplasioceras* VAN HOEPEN as a synonym of *Dipoloceras*.

I agree with COLLIGNON (1946; 1963) and WRIGHT (1957) in treating *Diplasioceras* as a subgenus of *Dipoloceras*, accepting the subgeneric diagnosis described in the *Treatise*.

Dipoloceras (*Diplasioceras*) *tosaense* sp. nov.

Pl. 20, Fig. 1a-c

Holotype.—M. HIRATA Collection No. 7002 (internal mould) and No. 7003 (external mould), now preserved at the Geological Museum in Makino Botanical Garden, Kochi. No other specimens are available.

Specific characters.—As the specimen is secondarily compressed, the following measurements show approximate and apparent dimensions (in millimeters):

diameter: 89.0 (1), umbilicus=32.0 (.36), height = 34.5 (.39), breadth > 13.5 × 2 = 27.0 (.30).

The whorl is rather evolute but fairly rapidly increases its height and accordingly the umbilicus is of moderate width. The inner whorls are rather compressed, with flat flanks and low and steep umbilical wall. The outer whorl has more convex flanks and rounded umbilical shoulders. The ventral keel is prominent, bordered on either side by a sulcus, and on the outer whorl it is below the level of the ventrolateral ends of rib.

The ribs begin to appear at about the diameter of 5 mm and are for about a whorl crowded and flattened on the main part of the flank and have umbilical bullae and ventrolateral thickening. Some of them are simple and others bifurcated.

In the succeeding stage, with diameters from 20 mm to 55 mm, the ribs are rounded, more or less flexuous, numerous and separated by interspaces which are nearly as narrow as the ribs. Every second or third rib is more flexuous than others, showing a stronger backward curve on the inner half of the flank and then a forward curve on the outer half. It has a bifurcated or intercalated shorter rib in front of it. Every rib has a ventrolateral thickening or weak tubercle. Some, if not all, of the long ribs are somewhat elevated near the umbilical margin, forming umbilical bullae. On the whorl of this stage the spiral ornaments become distinct, crossing the radial ribs.

The succeeding outer whorl is unfortunately deficient in its earlier part, where only the tendency toward more spacing of the ribs can be discernible. In the last part of the outer whorl the ribs are sharply elevated and distinct, being separated by much wider interspaces. They are mostly long, only slightly flexuous or nearly straight, and have occasionally intercalated shorter ones. They are elevated more strongly at the umbilical shoulder and at the ventrolateral edge and remarkably projected on the venter. Some of the ribs are stronger than others, if not remarkably flared. The spiral ornaments are distinct on the ribs but the interspaces are covered with radial lirae. The apertural margin is more sigmoidal than the ribs.

The sutures, which are imperfectly exposed, are probably of *Dipoloceras* type.

Comparison.—Although a single specimen is available, it is so distinctive that it can be regarded as representing a new species.

The present species is certainly referred to the subgenus *Diplasioceras*, because its inner whorls are flat-sided and have umbilical and weak ventrolateral tubercles and its outer whorl has convex flanks and distant, sharply elevated, slightly curved ribs.

In the same respects and in the moderately rapidly growing whorls the present species is similar to *Dipoloceras* (*Diplasioceras*) *fallax* VAN HOEPEN. The distinction is in that the former has more flexuous and less crowded ribs on the whorl of the middle growth-stage and sharper ribs on the outer whorl than the latter. The spiral ornament covers almost the entire length of the ribs in the former, but it is discerned on the outer half of the ribs in the latter.

The present species is less evolute and less widely umbilicate than *D.* (*Diplasioceras*) *basairiei* COLLIGNON and *D.* (*Diplasioceras*) *hirtzi* COLLIGNON. The ribs of our species are more sigmoidal on the inner whorls and more strongly projected on the ventrolateral part than those of the Madagascar species.

It is interesting to note that the septate shell of the present species is in certain respects similar to the larger shell of *Rhytidoceras elegans* VAN HOEPEN (1941, p. 64, figs. 14-18) (COLLIGNON, 1963, p. 150, pl. 301, fig. 1303) of a higher zone, although the bifurcated or intercalated ribs occur more frequently in the latter. The sharply elevated ribs which overhang on the ventral keel on the body-whorl are diagnostic of the present species. We would not discuss much the availability of the genus *Rhytidoceras* VAN HOEPEN, 1941. If it is accepted, as COLLIGNON does, it is likely to have caenogenetically derived from such species as *Dipoloceras* (*Diplasioceras*) *tosaense*.

Occurrence.—The described specimen came from a layer of greenish dark grey shale in a formation (called the Hayama Formation) of shale with intercalated sandstone exposed at No. 1603, Nakahashi, Azai, Hewa, Tosa-shi, Shikoku (Lat. 33°27′20″N, Long. 133°22′40″E).

Geological Setting

The formation from which the described ammonite came was once referred by KOBAYASHI (1941, p. 394) to the Nishigawa Series which he regarded as being synchronous with the Upper Jurassic Torinosu Series.

On the grounds of several fossils and other lines of evidence KATTO (1961) concluded that the formations in the northern half of the Shimanto belt of Kochi Prefecture are assigned to various stages of the Cretaceous. The newly discovered ammonite locality is within the area of his Hayama Formation, which he ascribed to the Gyliakian, i. e. Cenomanian and Turonian. One of the reasons of this correlation may be that he observed that the Hayama Formation is younger than the Doganaro Formation, which, in turn, is referred to the Miyakoan (Aptian and Albian). In addition to KATTO's megafossils, HAYAMI and KAWASAWA (1967) added more molluscan species from three localities near Doganaro, which clearly indicate the Miyakoan age of the Doganaro Formation. However, the bivalvian species have comparatively long stratigraphic ranges. Accordingly it is difficult to determine on that evidence alone whether the Doganaro Formation is Aptian and Albian, Aptian only, Albian only, or otherwise.

On the other hand KATTO's assignment of the Hayama Formation to the Gyliakian (Cenomanian and Turonian)

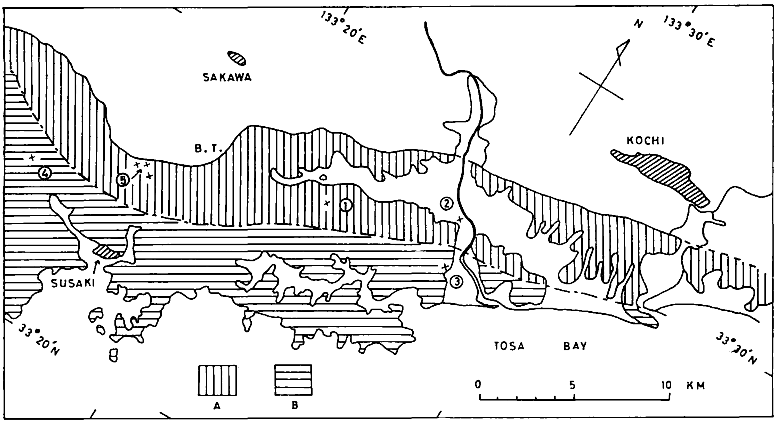

Fig. 1. Index map of selected fossil localities of the Shimantogawa Group (hatched).
A: the so-called Hayama and Doganaro Formation (Aptian to Middle Albian),
B: Susaki Formation (Upper Albian and Upper Cretaceous). 1–4: ammonite localities,
1: Azai (here described), 2: Kitayama, 3: Nii, 4: Taru;
5: localities of bivalves near Doganaro, described by HAYAMI et al., 1967.
B.T.: Butsuzo tectonic line.

is inconsistent with his list of species (KATTO, 1961, p. 61) in which *Dipoloceras* aff. *fredericksburgense* from Kitayama is included. This ammonite species evidently indicates an Albian age, probably upper Middle Albian.

Dipoloceras (*Diplasioceras*) *tosaense*, described above, likewise indicates an Albian age, probably the same upper Middle Albian. The two localities are separated for about 8 km from each other, but situated approximately on the same line of the general structural trend (Fig. 1), probably belonging to the same member of greenish grey shale.

Be that as it may, the ammonite bearing member of the Hayama Formation is certainly of an Albian age, unless the ammonites were derived fossils. The ammonite specimen described in this paper has the body-whorl and, furthermore, its apertural margin is preserved. Therefore the possibility of the derived fossil is denied. It must have been deposited on a muddy submarine bottom under a quiet condition, without strong action of erosion and transportation nor effect of rolling.

According to M. ARITA's preliminary observation (personal information kindly given to one of us [T. M.]) the ammonite bearing greenish grey shale occupies the upper part of the "Hayama Formation" in this area and is underlain by the greenish shale of Doganaro which contains conglomerate, limestone and fossiliferous layers of HAYAMI and KAWASAWA (1967). In other words the so-called Hayama Formation and the Doganaro could possibly be parts of one and the same formation.* We would agree with ARITA's interpretation on the grounds of our excursion to the

* If this is confirmed with sufficient evidence, the Hayama Formation would fall in the synonym of the Doganaro Formation in a revised sense. The Hayama Formation (KATTO, 1961) is a homonym of the Tertiary Hayama Formation of WATANABE (1925) and other authors.

area. In the Doganaro area the member of sandy siltstone from which the Miyakoan bivalves were obtained contains lenticular limestone. It resembles the member of sandy siltstone in the Chikanaga area, Ehime Prefecture, which also contains lenticular limestone near the ammonite bearing bed. The ammonites of the Chikanaga area, *Cheloniceras* (*Cheloniceras*) aff. *minimum* CASEY and *Cheloniceras* (*Cheloniceras*) *shimizui* NAKAI and HADA (1966) indicate an Aptian age. Therefore we are inclined to consider that the Doganaro Formation in the revised sense (which includes the so-called Hayama) can be ascribed to the Miyakoan and that it probably ranges from Aptian to Middle Albian.

The above is a preliminary remark which should be examined through more accurate geological mapping and additional fossil hunting.

One more remark should be given on the sedimentary environments of the Shimantogawa Group. Someone insists that it is the deposits of a bathyal condition of the continental slope, some others considers a comparatively off shore and deeper part of a geosyncline embedded by turbidites, and still others assume the possibility of a shallower sea condition. In this paper we would not discuss comprehensively the problem but try to get information from the described ammonites.

The nectoplanktonic shells of ammonites may be transported by currents to the places fairly distant from their original habitats. The solitary and very scarce occurrence of ammonites in several places of the Shimantogawa Group may suggest such a case. However, it cannot be overlooked that the hitherto described species are mostly those of ornate group, i. e. Hoplitaceae and Acanthocerataceae, which are usually common in the neritic environments. Moreover, the body-whorl is preserved in a majority of the described specimens, and even the apertural margin is preserved in the present case. Therefore, the ammonite shells must have been brought from a shallower habitat to the off-shore, muddy bottom without effect of destructive action.

Cretaceous deposits of more or less shallower facies are known in the Chichibu belt to the north of the Shimanto. For some reasons the hitherto identified ammonite species from the Shimanto belt are not identical with those of the Chichibu. This is probably due to the incompleteness of the collections. We should search out more ammonites from both belts.

In the so-called Shimanto belt itself there could be sediments of various environments. In fact the bivalve faunule, consisting of species of *Neithea*, *Plicatula*, *Amphidonte* and *Pterotrigonia*, from sandy siltstone near Doganaro, reported by HAYAMI et al. (1967), probably indicates that a neric environment did exist in a certain part of the Shimanto belt. In the case of the Aptian ammonites from Chikanaga, western Shikoku, reported by NAKAI and HADA (1966), the occurrence was not solitary, but a number of specimens of *Cheloniceras* were found from a sandy siltstone, although in a limited place. This may also suggest the existence of a shallower sediments in at least a part of the Shimanto belt. The well known fossiliferous Coniacian of the Uwajima Group, again in eastern Shikoku, may represent another, better displayed shallower environment within the Shimanto belt.

To sum up it is keenly needed to analyse the various kinds of facies in the stratigraphically subdivided units of the Shimantogawa Group and make clear their mutual relations as well as their relations with the better known facies in the Chichibu belt. This should be studied from various aspects of stratigraphy and sedimentology. Ammonites would play the part of an important aspect.

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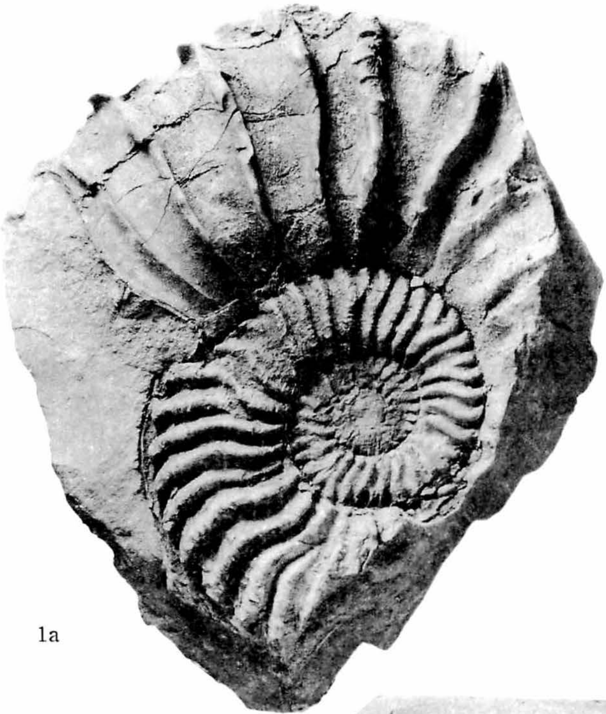
Azai	浅　井
Chikanaga	近　永
Doganaro	堂ガ奈路
Hayama	葉　山
Hewa	戸　波
Jôbe	城　辺
Kitayama	北　山
Kochi	高　知
Nakahashi	中　橋
Nii	新　居
Nishi	西
Nishigawa	西　川
Shimantogawa	四万十川
Sakawa	佐　川
Susaki	須　崎
Taru	樽
Torinosu	鳥ノ巣
Tosa-shi	土佐市
Uwajima	宇和島

Explanation of Plate 20

Fig. 1. *Dipoloceras* (*Diplasioceras*) *tosaense* sp. nov. .... p. 179
Holotype from Azai, Hewa, Tosa-shi, Kochi Prefecture. Lateral (a) and ventral (b) views of the internal mould (M.H. No. 7002); lateral view (c) of the external mould (M.H. No. 7003). Natural size.

The specimens are kept at the Geological Museum, MAKINO Botanical Garden, Kochi.

Kyushu University (I. HAYAMI) photo.



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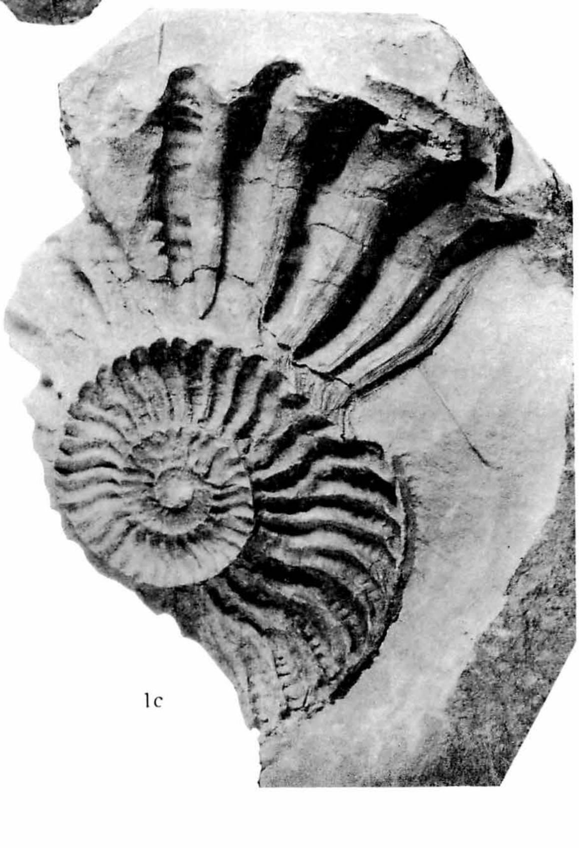

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560. FOSSIL SPORES AND POLLEN GRAINS FROM THE NEOGENE DEPOSITS IN NOTO PENINSULA, CENTRAL JAPAN—III

A PALYNOLOGICAL STUDY OF THE PLIOCENE OGINOYA AND LATE MIOCENE HIJIRIKAWA MEMBERS*

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能登半島新第三系産化石胞子・花粉—III；鮮新世荻谷層と中新世後期聖川（ひじりかわ）層の花粉学的研究：能登半島に広く分布する新第三系に含まれている化石胞子・花粉について研究を行った。今回はその第III報として，能登半島南部に分布する中新世後期の聖川層と鮮新世初頭の荻谷層の一部について，6 層準からの 6 試料について，各層準毎に，化石群集の構成・変化を明らかにし，既報の中新世後期の和倉層・中新世中期の山戸田層からの化石胞子・花粉群集と比較検討し，併せて，聖川層・荻谷層の堆積時の古気候・古地理学的環境，および地質時代についての考察を行った。 藤　則　雄

Introduction

The writer has been studying the fossil pollen grains and spores found from the diatomaceous deposits of Neogene age in the Hokuriku region.

The present article is the third report on the palynological researches of the diatomaceous muddy deposits and treats the spores and pollen grains collected from the Late Miocene Hijirikawa Member distributed in and around Hijirikawa and Kuwanoin, Shio Town, in the central part of the Noto Peninsula.

The scope of the research on the microfossils is the systematic determination of the fossil pollen grains and spores and the reconstruction of the palaeoclimatic condition and palaeoecological environment under which the Hijirikawa Member was deposited, and to make correlation and comparison of the conditions and environment of the Hijirikawa Member with the Wakura, Tsukada, I'izuka and Entsunagi diatomaceous mudstone Members distributed in the northern and central parts of Noto Peninsula.

* Received May 24, 1969; read September 22, 1968, at the 100th Meeting of the Palaeontological Society of Japan held at the Kanazawa University, Kanazawa; Contribution from the Institute of Earth Science, Kanazawa University, New series No. 9.

Acknowledgements

The writer thanks Professor Kotora HATAI of the Institute of Geology and Paleontology, Tohoku University, Sendai City, for his advice during the course of palynological researches and reading the manuscript. Appreciation is due to Mr. Mineo MISAWA of the Sakuragaoka High School, Kanazawa City, for his suggestions and information on the stratigraphy and collection of the samples for the palynological investigation.

Deep gratitude is expressed to Mr. Kôichi NAKAGAWA of the Institute of Earth Sciences, Faculty of Science, Kanazawa University, Kanazawa City, for his advice on the Miocene and Pliocene tectonic movement in the area studied. Sincere thanks are expressed to Emeritus Professor Dr. Wataru ICHIKAWA and Professor Yoshio KASENO both of the Institute of Earth Sciences, Faculty of Science, Kanazawa University, for their valuable suggestions on the diatoms and informations on the biostratigraphy of the area studied.

The present research was supported by a grant for Scientific Research from the Ministry of Education of the Japanese Government.

Outline of the Geology

Many diatomaceous mudstones of Neogene age are widely distributed in the central and northern parts of Noto Peninsula. They are mainly composed of homogeneous silty mudstone characterized with the dominance of fossil micro-organisms. In the southern part of the peninsula the diatomaceous deposits are distributed locally and their rock-facies are variable, especially around Mt. Hôdatsu.

In the area north of Mt. Hôdatsu the Neogene deposits which overlie the Hida gneiss complex with unconformity are divisible into seven members in ascending order as follows: the Tsuboike alternation, Shingû conglomeratic sandstone, Tônokuma alternation, Hara sandstone, Hijirikawa mudstone, Oginoya siltstone and Oginoshima sandstone. These members are conformable with one another as shown in the correlation table (Table 1). Each stratigraphical unit is described below, in ascending order.

Table 1. Correlation table of the Neogene diatomaceous deposits distributed in Noto Peninsula, Central Japan. " —— ": diatomaceous deposits.

Geological Age	Oil Field in Japan	Hokuriku Region	Hijirikawa - Area	Nakajima - Area	Wakura-Notojima Area	Suzu Area
Pliocene	Shibikawa	Hanyu				
	Wakimoto	Himi	Oginoshima Oginoya		Kojima	
Late Miocene	Kitaura	Otokawa	"Hijirikawa"		Akasaki	
	Funakawa			"Kasashio"	"Wakura"	"I'izuka"
			Hara		glauconite	glauconite
Middle Miocene	Onnagawa	Higashibessho	Tonokuma Akage Shingu	Hamada	Nanao Akaura	"I'ida" "Hojuji" Higashiinnai
	Nishikurosawa	Kurosedani		Araya / Kusaki / Yamatoda	Nanohara	Yanagida
Early Miocene	Daijima	Iwaine		Anamizu	Anamizu	Anamizu

The Hida gneiss complex: This gneiss forms the basement the area southwest of Mt. Hôdatsu, and is distributed locally. The rock-facies is mainly biotite hornblende gneiss intercalated with layers of thin crystalline limestone. In the southeastern part of the area studied some light green fluorite veins, which are N25°E in strike, are distributed locally. The gneiss and Neogene deposits are in unconformable or fault contact and generally have a E-W strike.

········· unconformity or fault ·········

The Tsuboike fine-grained sandstone and mudstone alternation Member: The type locality of this member is the outcrop at Tsuboike in Himi City, Toyama Prefecture. The member consists generally of an alternation of sandstone and mudstone. The sandstone is fine-grained and has yielded the large foraminifer *Myogypsina* sp. This member overlies the Hida Gneiss Group with unconformity and is overlain conformably by the Shingu conglomerate and sandstone Member.

——— conformity ———

The Shingu conglomerate and sandstone Member: This unit is distributed in the northern and southern parts of the surveyed area. It is overlain with conformity by the Tônokuma sandstone and mudstone alternation Member. The Shingu Member consists of conglomerate and sandstone, and the conglomerate is composed of angular and/or subangular pebbles derived from the Hida Metamorphic Group distributed in and around Mt. Hôdatsu. The sandstone is a very coarse-grained quartzose sandstone intercalated with many carbonaceous layers.

The upper part of the member generally shows typical graded bedding, and one unit of a graded bed is generally composed of granule and/or pebbles at the base and of mudstone at the top.

The thickness is about 600 meters in the southern part of the area of distribution.

The stratigraphical relation between this member and the basement rocks is a fault, and a conformity with the Tsuboike or Tônokuma Members. The member interfingers with the Tsuchikura sandstone, Shoshigahara sandstone and mudstone alternation and Akage hard shale Members.

····· interfingering with the Shingu Member ·····

The Akage hard shale Member: This member consists of a black or dark gray very hard tuffaceous (?) shale, alternating with a coarse-grained sandstone and hard shale in the lower part; remarkable banded structure is seen in part.

——— conformity ———

The Tonokuma alternation Member: This member is distributed at Tonokuma, Shoshigahara and Oitani, Shio Town, Hakui-gun. The lower part of the member is an alternation of bluish grayish green tuffaceous fine-grained sandstone and mudstone, showing graded bedding in a part; two or three layers of pumiceous tuff are contained in the middle part which consists of sandstone, and the upper part is an alternation of greenish gray fine-grained sandstone and hard mudstone.

The member yielded many marine molluscan fossils as *Acila divaricats* (HINDS), *Cardium* sp., *Clinocardium* sp., *Chlamys crassivenia* (YOKOYAMA), *Cuspidaria* sp., *Dentalium yokoyamai* (MAKIYAMA), *Diplodonta* sp., *Lucinoma annulata* (REEVE), *Macoma* sp., *Natica* sp., *Venericardia* sp., *Volsella* sp. (found from the upper part of the member), and plant fossils as *Fagus* sp., *Ficus* sp., *Salix* sp. (from the lower part).

The member is about 450 meters in thickness at Shoshigahara in the eastern part of the surveyed area and 40 to 70 meters at Hijirikawa, the western part.

——— conformity ———

The Hara sandstone Member: This member has been studied by M. MISAWA (1960), and is distributed at Hara, Shingu, Hiradoko, Ebisaka, Ichinoshima and Iwabuchi of Shio Town. The rock-facies is a light green or bluish gray fine- to medium-grained sandstone intercalated with some thin carbonaceous layers which bear bodly preserved plant remains.

The member is about 130 meters in thickness at Shoshigahara in the eastern part, 60 meters at Hijirikawa in the western part, and thins out in the northern part of the area studied.

——— conformity ———

The Hijirikawa mudstone Member: The member is distributed widely on the western and eastern sides of the boundary between Toyama and Ishikawa prefectures. Its lower part is a fissile mudstone and upper part consists of a massive diatomaceous mudstone, and there is a very thin medium- to fine-grained tuff layer (ca. 20 cm.) in the middle horizon. The member is characterized in the western area of the prefectural boundary by its northern part being of a massive mudstone whereas the southern part is an alternation of bluish green coarse- to medium-grained sandstone and mudstone. The megafossils are rare in the member, that is, the shaly mudstone of lower horizon of the member yielded only *Lucinoma concentrica* HIRAYAMA. Microfossils such as diatoms, sponge spicules, smaller foraminifers (*Martinottiella communis* and *Textularia* spp.) are common. The member is about 700 meters thick.

——— conformity ———

The Oginoya siltstone Member: The member is distributed locally in the northern part of the area drawn in the geological map. The maximum thickness is about 150 meters. The rock-facies is a homogeneous bluish gray very fine-grained sandstone and siltstone. Below the lower limit of the member, there is an intercalation of fine-grained tuff of 20 cm or more in thickness. The member has yielded many foraminiferal fossils as *Elphidium advenum*, *Eponides* spp., and also molluscs, diatoms and sponge spicules.

——— conformity ———

The Oginoshima sandstone Member: This member is distributed in the northwestern side of the foot of the hilly mountains in the area studied. The rock-facies is a yellowish brown fine- to medium-grained sandstone in part. The member is 60 to 75 meters in thickness.

The area studied is characterized by many parallel faults extending east to west in general. Consequently, the Neogene members of this area are displaced and partly overturned as verified by the graded bedding. The fault zone developed through successive stages of the upheaval movement of the Hôdatsu mountain block. Intimately related therewith is the development of the Tsuboike and Shingu dome structures. MISAWA (1960) pointed out that during this stage, named the Oginoya-Oginoshima stage, when the members were deposited a remarkable change in the environmental conditions took place, and this probably indicated a new phase of transgression. NAKAGAWA (1968) studied the minor faults in the Miocene members exposed in this area and concluded that they were developed either during or immediately after the deposition of the Shingu Member.

Palynological Research

(1) Foreword

As already stated different kinds of diatomaceous deposits occur in Noto Peninsula, and they have yielded abundant microfossils as diatoms, flagellates, pollen grains and spores. The several papers published on the deposits were concentrated to stratigraphical investigations, and no literature has appeared concerning the fossil pollen grains and spores until comparatively recently. The writer has been studying the Neogene system, especially the diatomaceous deposits, and the two previous works (FUJI, 1969a and 1969b) have summarized the palynology of the Miocene Wakura and Yamatoda Members, and the present paper is the third report.

The purpose of the present study is to interpret the significance of the pollen grains and spores from the samples collected from the Late Miocene Hijirikawa Member, mainly in terms of palaeoclimatic condition and palaeogeographical environment. These records are based on the reconstructions gained by the writer during his about ten years palynological researches.

(2) Sampling

The samples analysed in the investigation were collected by the writer and

Mr. Mineo MISAWA, a student of our University, in the summer season of 1959 and 1960. The sampling localities and stratigraphical horizons of the samples are shown respectively in Figs. 1 and 2. These samples are from the upper part of the Hijirikawa and the lower part of the Oginoya Members and the western slope of the Shingu dome on the northern side of Mt. Hôdatsu.

(3) Preparation of Materials and Method of Study

The preparation of the materials and method of study for the previous present palynological investigation are the same as described in the papers (FUJI, 1969a and 1969b).

All of the slides containing the specimens registered in the present research are deposited in the collection of the Institute of Earth Science, Faculty of Education, Kanazawa University (register abbreviation: EKZJ), Kanazawa City, Japan.

(4) Description of the Pollen Grain and Spore Assemblages

(a) General Statement

A living flora is composed of the species which are adapted to the physical condition and biological phenomena which constitute the environment. But the fossil assemblage of any locality

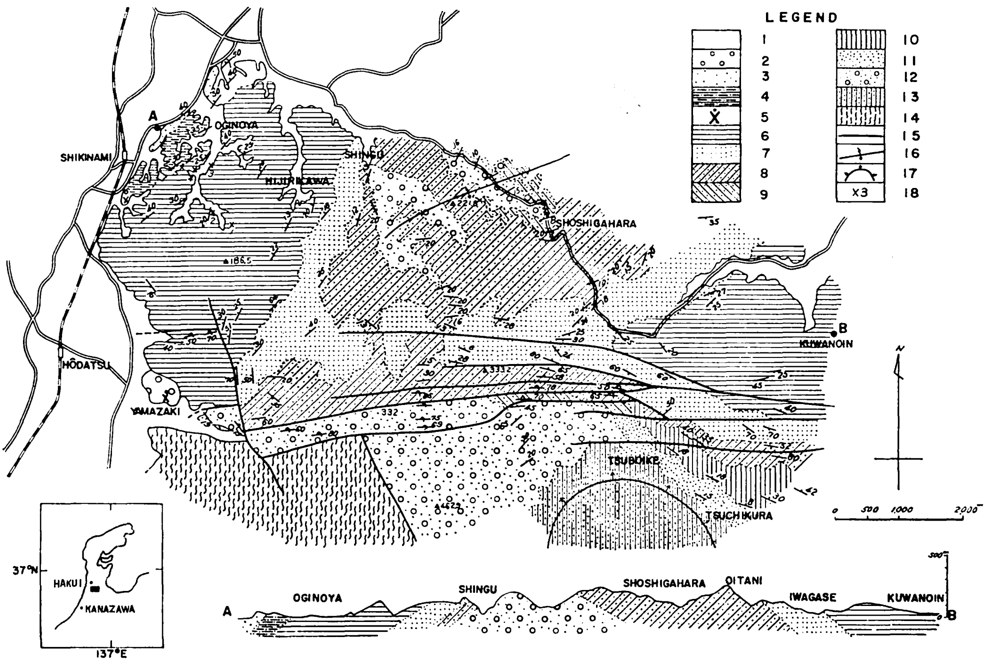

Fig. 1. Geological map of the Hijirikawa area, the southern part of Noto Peninsula, Central Japan (Compiled by N. FUJI , 1968; after M. MISAWA, 1960 MS; N. FUJI, 1963 MS; K. NAKAGAWA, 1968 MS). 1: Holocene deposits, 2: Pleistocene deposits, 3: Oginoshima Member, 4: Oginoya M., 5: Yamazaki mollusc-bearing bed, 6: Hijirikawa M., 7: Hara M., 8: Tônokuma M., 9: Shoshigahara M., 10: Akage M., 11: Tsuchikura M., 12: Shingu M., 13: Tsuboike M., 14: Hida Gneiss Group, 15: fault, 16: anticline, 17: dome structure, 18: sampling localities.

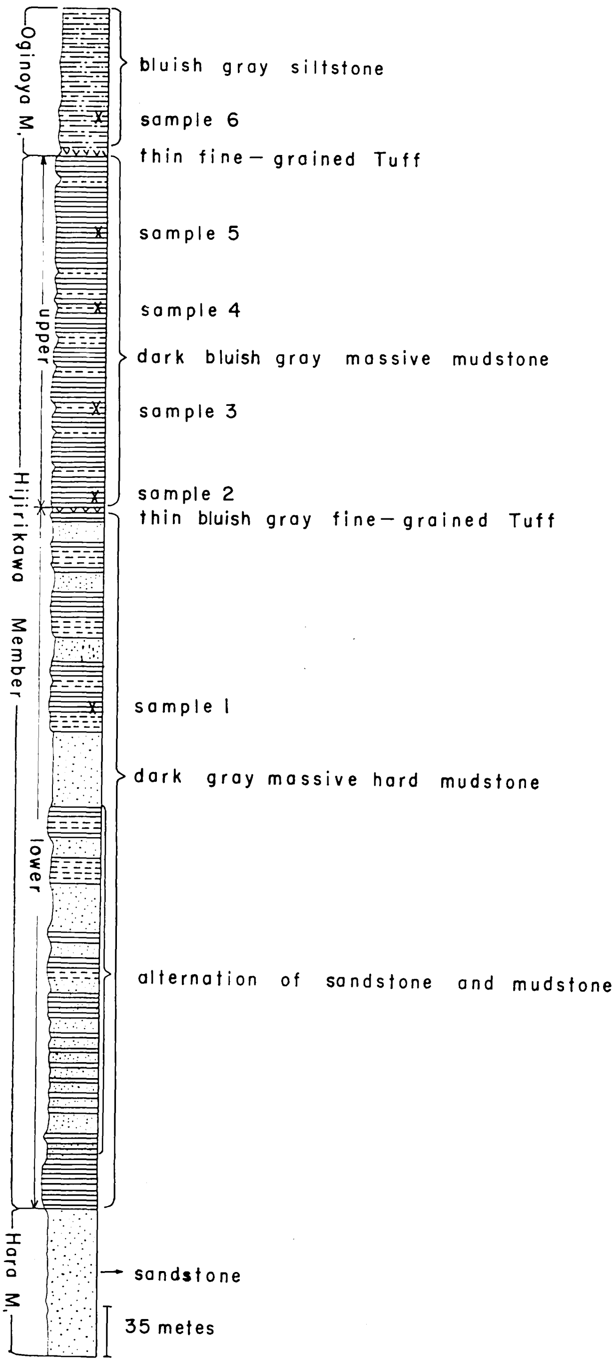

Fig. 2. Columnar section showing the horizons of the samples.

may be the total accumulation composed of a biocoenosis and/or a thanatocoenosis. Therefore, it is necessary to make an analysis of the fossil composition from the viewpoint of the presence or absence, abundancy and distribution of every climatic element to know the palaeoclimatic condition and palaeogeographical environment at the time of deposition.

(b) Stratigraphical Relations of the Samples

The localities of the samples studied are distributed in the present field. The stratigraphical position of these samples can be illustrated as a columnar section and for the sake of convenience are called horizons in this study. Here, the term horizon is used to denote the same or nearly same stratigraphic position or level within the stratigraphic unit.

The samples analysed in the present study can be classified into the six horizons shown in the columnar section (Fig. 2).

(c) Description of the assemblages

The assemblages of the fossil spores and pollen grains found from the six samples are shown in Figs. 3, 4, 5 and 6.

Sample 1:

The mixed sample is from an outcrop of Locality No. 1 (Fig. 1), where is situated at about 2,000 meters southeast of the Shikinami Station of

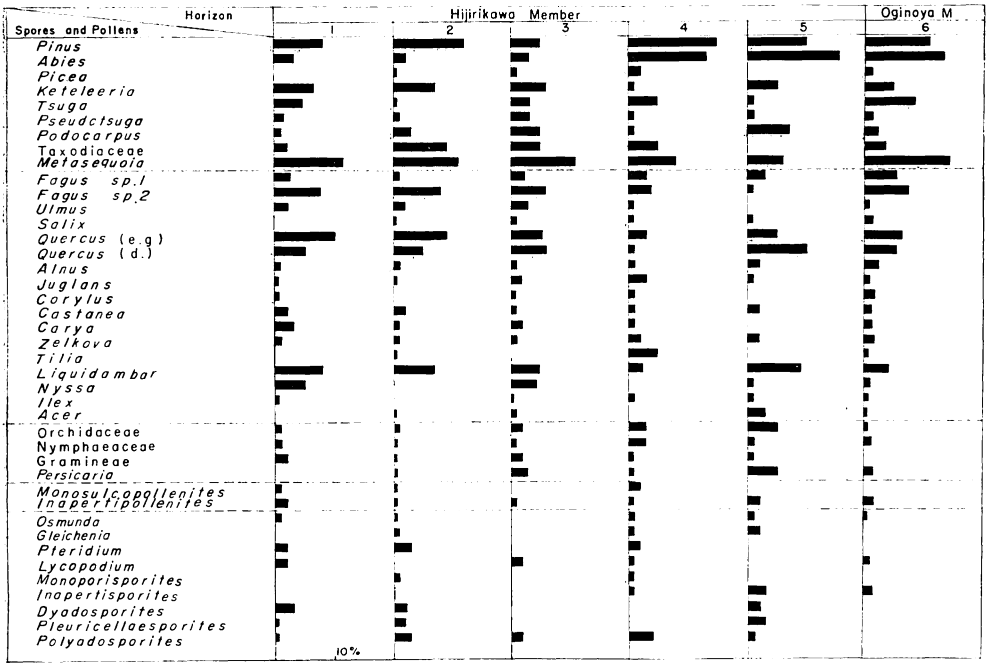

Fig. 3. Pollen diagram (1) of the Hijirikawa and Oginoya Members. Numbers refer to Figs. 1 and 2.

the Japanese National Nanao Railway and about 1,250 meters southwest of Hijirikawa. It belongs to the upper horizon of the lower part of the Hijirikawa Member.

This sample yielded; Gymnosperm-eight genera; Dicotyledon-ten genera and four subgenera; Monocotyledon—three families and one genus; two in-determinable pollen grains, and spores-six genera. Among them, *Metasequoia* is abundant, showing the highest concent-ration (11.5 per cent) in this composite sample. The Genus *Quercus* is classi-fied into two types, one is of large size and other of small size, based on the diameter of the pollen grain, and the latter belongs to the evergreen type. *Pinus* and *Liquidambar* are frequent, amounting to more than about 7 per cent. Deciduous *Quercus, Nyssa* and *Tsuga* are common, ranging from 4 to 6 per cent. Gymnosperm total 36 per cent, Dicotyledon, Monocotyledon and Pteridophyta are 48 per cent, 4 per cent and 8 per cent respectively.

As shown in some text-figures and tables, plants having different havitats are distinguished among the treated composite sample.

The plants which are distributed in the cold climatic region are denoted by "A" in Fig. 4, and are *Larix, Abies, Fagus* and *Betula*. *Keteleeria, Pseudo-tsuga, Metasequoia, Cunninghamia, Gly-ptostrobus*, and *Taiwania*, the evergreen *Quercus* and *Liquidambar* are the repre-sentative plants of a warm temperate and subtropical region as denoted by "B" in Fig. 4. *Pinus, Tsuga,* and Taxodiaceae without the warm elements above-mentioned, and the deciduous

Quercus, Zelkova, Ulmus, Salix, Acer, Juglans, Castanea, Tilia, and *Ilex* are the representative plants of the temperate to cool temperate region as for example the Hokuriku region. They are denoted by "C" in Fig. 4. According to the present analysis, the plants belonging to the element "A" appear with a very low frequency of 6 per cent of the total. On the contrary, the plants of the warmer type denoted by "B" and the cool temperate type "C" are respectively 38 per cent and 56 per cent. The frequency of the spores which certainly belongs to Pteridophyta is as high as that of a ordinary marine deposit, ranging from 8 per cent to 10 per cent. The frequency of the plants distributed widely in the warm temperate and subtropical region and found in the

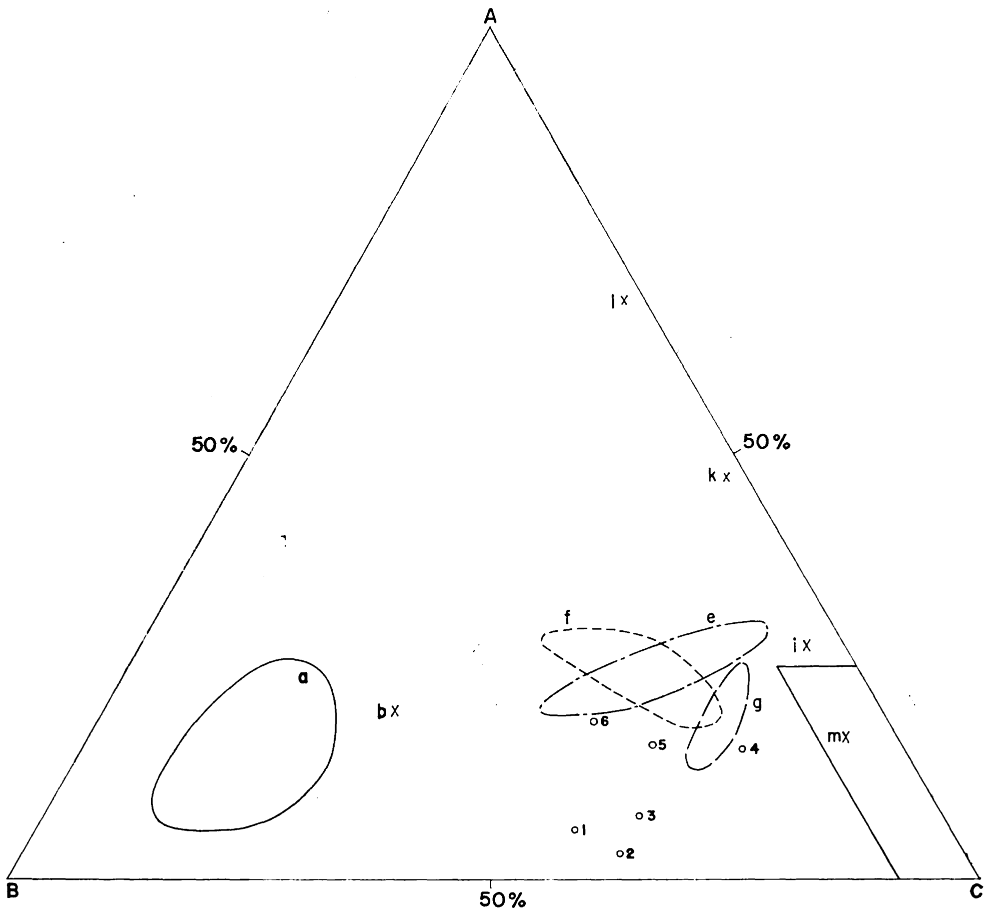

Fig. 4. Pollen diagram (2): Triangular diagram showing the relationship between cold and cool climatic, temperate climatic and warm climatic elements found from several samples of the Hijirikawa and Oginoya Members. Numbers refer to Figs. 1 and 2. a: Yamatoda Member, b: Sunagozaka M., e: Hojuji M., f: I'ida M., g: Wakura M., i: Nakayama-toge M., k: Takakubo M., l: Omma M., 1-5: Hijirikawa M., 6: Oginoya M., m: the present deposits of Hôjozu-gata Lagoon, Toyama Prefecture.

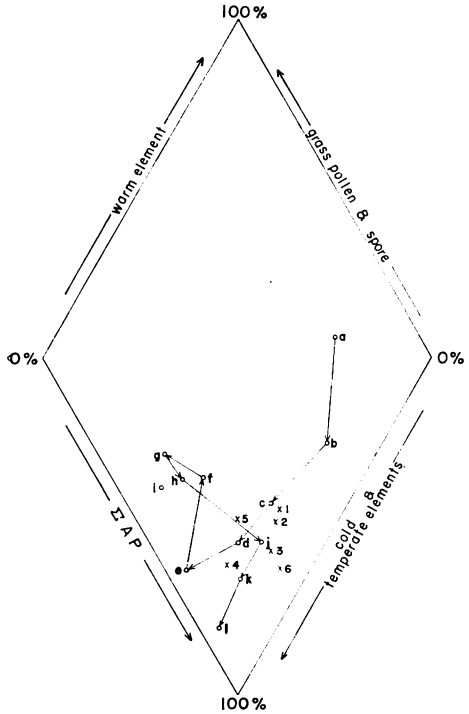

Fig. 5. Pollen diagram (3): Quadrilateral diagram showing the palaeoclimatic condition and palaeogeographical environment during the sedimentation of the Hijirikawa and Oginoya Members. a: Yamatoda Member, b: Sunagozaka M., c: Higashi-'in'nai M., d: Najimi M., e: Hojuji M., f: I'ida M., g: Wakura M., h: I'izuka M., i: Nakayama-toge M., j: Hijirikawa M., k: Takakubo M., l: Omma M., 1–5: Hijirikawa M., 6: Oginoya M.

fossil flora shows the highest ratio among the treated samples, and this is a characteristic feature of the flora.

To facilitate considerations on the ecological environments under which some ancient plants lived, their modern equivalents are grouped into four habitats, namely, upland, mixed-slope, stream-side or riparian, and lake or marshy elements. From the viewpoint of the significant statistics mentioned above the fossil pollen grains and spores can be classified into upland, mixed-slope and stream-side elements, occupying 16 per cent and 27 per cent, respectively.

Sample 2:

The composite sample from Locality No. 2, situated at about 1,500 meters southwest of Hijirikawa, was examined for the present study. Locality No. 2 belongs to the lowermost horizon of the upper part of the Hijirikawa Member. The composite sample yielded, Gymnosperm-nine genera (45 per cent); Dicotyledon-ten genera and four subgenera (37.5 per cent); Monocotyledon-three families and one genus (2.5 per cent); spore-nine genera (13 per cent). Among these taxa, *Pinus* is abundant and amounts to 12 per cent of the total frequency, being the highest in the sample. The fossil pollen grain of *Metasequoia* totals 11 per cent. Evergreen *Quercus*, *Keteleeria* and *Liquidambar* are frequent, being respectively 9 per cent, 7 per cent and 7 per cent of the total frequency. All of these genera which are representative plants of a warmer temperate and subtropical regions, are denoted by the component "B", amounting to 35 per cent. The cooler temperate plants denoted by "C" reach 62 per cent of the total. Whereas the other elements amount to only 3 per cent. Deciduous *Quercus* is common, reaching 5 per cent of the total.

On the other hand, with respect to the palaeoecological environment, the upland, mixed-slope and stream-side elements are respectively 15 per cent, 60 per cent and 25 per cent of the total frequency.

Sample 3:

This sample is from an outcrop of

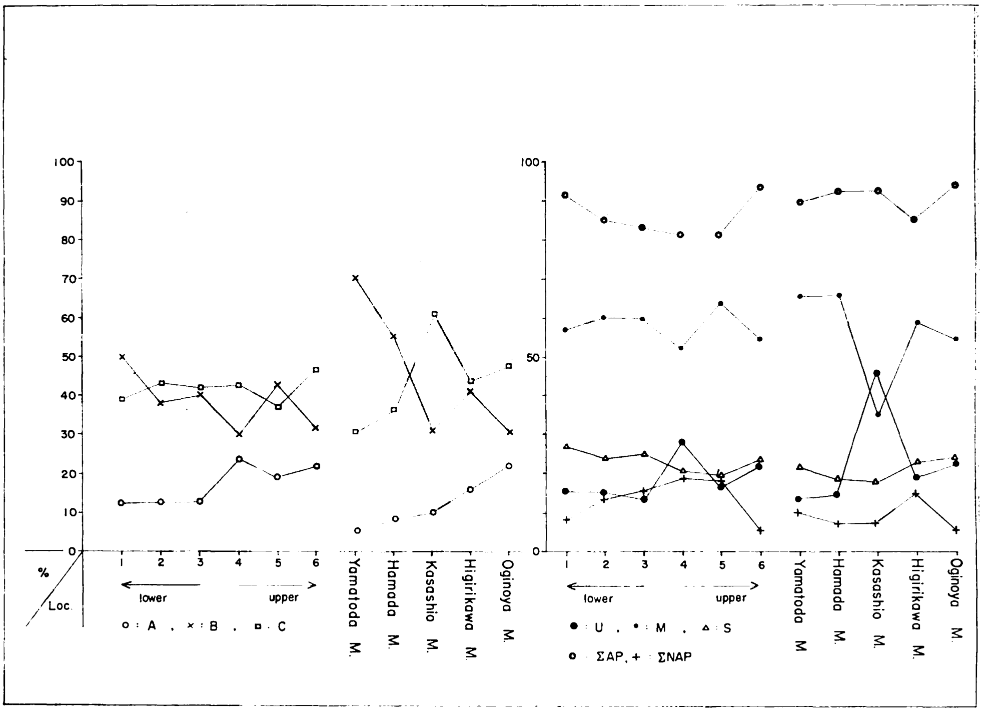

Fig. 6. Pollen diagram (4) showing the relationship between cold and cool climatic, temperate climatic, warm climatic, upland, mixed-slope and riparian elements found from several samples of the Hijirikawa and Oginoya Members.

Locality No. 3 (Fig. 1), situated at about 1,300 meters south of Oginoya. From sample 3, which occupies stratigraphically the lower horizon of the upper part of the Hijirikawa Member, *Metasequoia* is found in 11 per cent of the total frequency. *Keteleeria*, deciduous *Quercus*, *Fagus* sp. 2, evergreen *Quercus*, *Pinus*, *Liquidambar* and *Nyssa* are common, ranging from 4 per cent to 6 per cent. The element " A " amounts to 8.5 per cent, element " B " to 31 per cent, and element " C " to 60.5 per cent.

This sample yielded, Gymnosperm-nine genera (43 per cent of the total); Dicotyledon-14 genera and four subgenera (44 per cent); Monocotyledon-three families and one genus (8 per cent); spore-only two genera, namely, *Lycoposium* and *Polyadosporites* (4 per cent).

And from the viewpoint of the palaeoecological environment, the upland, mixed-slope and stream-side elements amount to 13 per cent, 60 per cent and 27 per cent respectively.

Sample 4:

Sample 4 belongs stratigraphically to the middle horizon of the upper part of the Hijirikawa Member, and was collected from an outcrop of Locality No. 4, situated at about 1,300 meters east of the Shikinami Station of the Japanese National Nanao Railway. From this composite sample, *Pinus*, *Abies* and *Metasequoia* belonging to the Gymnosperm (eight genera and one family) were found, they amount about 48 per cent; Dicotyledon-11 genera and four subgenera (30.5 per cent); Monocotyledon-three genera (4 per cent); and two indeterminable pollen grains. Among them, *Pinus* is very abundant, reaching 15 per cent of the total frequency. Its frequency shows the highest concentration in this mixed sample. *Abies* belonging to one of the plants of a cooler or cold region, is abundant, amounting to 13 per cent of the total frequency. *Metaequoia* is frequent, being 8 per cent. *Tsuga*, Taxodiaceae without warm elements, *Fagus* sp. 2, *Tilia* and *Pleuricellaesporites* are common, ranging from, 4 per cent to 6 per cent. The component " A ", " B " and " C " are respectively 14 per cent, 13 per cent and 73 per cent of the total. The plants denoted by " C " which are distributed widely in the present cool temperate zone gradually increase in comparison to others as shown in Fig. 3, and on the other hand the warm elements denoted by " B " gradually decrease.

The plants growing in the upland environment amount to 28 per cent of the total frequency, and the mixed-slope and stream-side elements are 51 per cent and 21 per cent respectively.

Sample 5:

The composite sample from Locality No. 5, situated at about 1,500 meters south of Oginoshima, occupies stratigraphically the uppermost horizon of the Hijirikawa Member. In the sample, *Abies* is a very abundant, its frequency being 16 per cent. *Pinus* and deciduous *Quercus* are abundant, and *Liquidambar* and *Podocarpus* are frequent, and the other genera are common. Gymnosperm, Dicotyledon, Monocotyledon and spores are respectively 38 per cent, 38.5 per cent, 10 per cent and 11.5 per cent. The A, B and C elements amount to 13 per cent, 25 per cent and 62 per cent respectively. The upland, mixed-slope and riparian plants are respectively 16 per cent, 64 per cent and 20 per cent of the total frequency.

Sample 6:

As shown in Fig. 1, the mixed sample was collected from Locality No. 6, at about 1,300 meters east of the Shikinami Station. The sample belongs to the lowermost horizon of the Early Pliocene Oginoya Member. From the composite sample, *Metasequoia*, *Abies* and *Pinus* are abundant in frequency, amounting to 13 per cent, 12 per cent and 11 per cent respectively, namely, the pollen flora of this horizon is represented. By *Metasequoia* and *Abies*. *Tsuga* and *Fagus* sp. 2 are frequent, and the others are common. Gymnosperm, Dicotyledon, Monocotyledon and spores are 52.5 per cent, 37.3 per cent and 7.5 per cent respectively. The A, B and C components amount to 19 per cent, 30 per cent and 51 per cent respectively.

It is noteworthy that the pollen grains of *Liquidambar* are found from this horizon of the Early Pliocene Oginoya Member.

The upland, mixed-slope and stream-side elements are respectively 21 per cent, 55 per cent and 24 per cent.

(5) Discussion

A general interpretation is made of the physical conditions prevailing during the growth of the sedimentary basin in which the flora was found on the basis of an analysis of the fossil spores and pollen grains. In this section, the writer will be given a discussions on the palaeoclimatic condition, palaeogeographical environment and geological age of the stratigraphical units based upon the palynological and field researches.

(a) Palaeoclimatic Condition

From the analysis of the pollen grain and spore assemblages, that is to say, on the basis of the association of their dominant genera and/or species, the general characters of the palaeoclimatic condition can be presented. The methods for analysing the assemblages for palaeoclimatic interpretation have been proposed by ERDTMAN (1954), FAEGRI and IVERSEN (1963) and the writer (FUJI, 1969a and 1969b).

According to the writer's investigation, as shown in the triangular diagram (Fig. 4), quadrilateral diagram (Fig. 5), the warm and subtropical plants denoted by "B" in Fig. 4 such as *Liquidambar* and *Metasequoia* found from the Hijirikawa and Oginoya Members are much less than those from the Yamatoda and Sunagozaka Members which corresponded to the Daijima age of the Middle Miocene Epoch in number of specimens, namely the latter contains from 61 per cent to 85 per cent of the total frequency, and the former only 30 per cent to 50 per cent. This result is closely similar to the analytical result on the fossil pollen assemblage from the Hojuji and I'ida diatomaceous mudstone Members (FUJI, 1966) which are situated in the northern part of Noto Peninsula. However, with respect to the cool and cold elements found in the pollen-floras as the Wakura and Yamatoda floras, the elements from the Hijirikawa Member amount to 10 per cent to 24 per cent of the total frequency, though the elements found in the Oginoya Member is 20 per cent of the total frequency.

With respect to the relative frequency of the warm temperate and subtropical climatic elements found throughout the Hijirikawa Member, it can be said that higher the horizon is, the lower the frequency becomes. On the other hand, it is important and interesting that the higher the horizon is, the higher the frequency of the cool and/or cold elements becomes.

Comparison between the fossil plants and the living equivalents whose climatic requirements are known is frequently used for climatic analysis of a fossil flora. Where the modern relationships are known definitely, this method is probably useful for accurate information. The Neogene species are comparatively modernized in morphological features, so it is not difficult to compare them with their living equivalents with some exceptions. The genera composing the Neogene floras in the Japanese Islands are mostly distributed now in East Asia, and nearly all of the temperate Dicotyledons genera in the fossil flora are now growing in the Japanese Islands. And exotic genera are sometimes common in the fossil flora. The exotic coniferous genera as *Metasequoia*,

Table 2. Modern equivalents of the fossil microplants from the Hijirikawa and Oginoya Members and their modern distribution.

Modern Distribution

1: Saghalien and Kurile Is., 2: Hokkaido, 3: Northern Honshû, 4: Central Honshû, 5: Southwestern Honshû, 6: Kyûshû and Shikoku, 7: Formosa and Loochoo Is., 8: Korea, 9: North China, 10: Central China, 11: Southeastern China, 12: Southwestern China, 13: Manchuria and Primorskaya Prov.

Habitat

U: upland, M: mixed-slope, R: riparian and stream-side

Table 2.

Fossil microplants	Near fossil macroplants	Modern equivalent macroplants	1	Japan					7	8	China				13	14	Habitat
				2	3	4	5	6			9	10	11	12			
Pinus	*P. palaeopentaphylla*	*P. parviflora*		×	×	×											U
Abies	*A. protofirma*	*A. firma*			×	×	×	×									M
Picea	*P. kaneharai*	*P. polita*				×	×	×									U
	P. jessoensis	*P. jessoensis*	×	×						×					×		M
	P. koribai	*P. excelsa*														×	M
Keteleeria	*K. ezoana*	*K. davidiana*							×			×	×	×			M
Tsuga	*T. aburaensis*	*T. diversifolia*			×	×	×	×									U
	T. miocenica	*T. longibracteata*												×			M
Pseudotsuga	*P. ezoana*	*P. japonica*															U
Podocarpus																	
Taxodiaceae	*Cun. protokonishii*	*C. konishii*							×								U
	Gly. europaeus	*G. pensilis*											×				R
	Met. occidentalis	*M. glyptostroboides*										×					M
	Seq. affinis	*S. sempervirens*														×	M
	Tai. japonica	*T. cryptomeroides*							×				×	×			U
	Tax. dubium	*T. distichum*														×	R
Fagus	*F. palaeocrenata*	*F. crenata*	×	×	×	×	×										M～U
	F. protojaponica	*F. serrata*		×	×	×	×										M
Ulmus	*U. protojaponica*	*U. japonica*	×	×	×	×			×	×	×				×		R
	U. protolaciniata	*U. laciniata*	×	×	×	×			×	×	×						M
	U. subparvifolia	*U. parvifolia*					×	×				×	×				M
Salix	*S. k-suzukii*	*S. jessoensis*		×	×	×											R
Quercus (evergreen)	*Q. protosalicina*	*Q. salicina*		×	×	×	×		×								M
Quercus (deciduous)	*Q. miocrispula*	*Q. crispula*	×	×	×	×	×			×	×	×			×		M
	Q. protodentata	*Q. dentata*	×	×	×	×	×		×	×	×	×		×	×		M
	Q. protoserrata	*Q. serrata*	×	×	×	×	×			×	×	×	×	×			M～R
Alnus	*A. miojaponica*	*A. japonica*	×	×	×	×	×						×		×		R
	A. protohirsuta	*A. hirsuta*	×	×	×	×	×								×		M～R
	A. protomaximowicziana	*A. maximowicziana*	×	×	×				×						×		U
Juglans	*J. nipponica*	*J. ailanthifolia*	×	×	×	×	×	×									R
Corylus																	
Castanea	*C. miocrenata*	*C. crenata*	×	×	×	×	×										M
Carya	*C. miocathayensis*	*C. cathayensis*										×	×				M
Zelkova	*Z. ungeri*	*Z. serrata*		×	×	×	×		×			×	×				M
Tilia	*T. distans*	*T. amuraensis*								×	×	×					M
	T. miohenryana	*T. henryana*										×	×				M
	T. protojaponica	*T. japonica*		×	×	×	×	×							×		M
Liquidambar	*L. mioformosana*	*L. formosana*						×				×	×	×			R
Nyssa																	
Ilex	*I. cornuta*	*I. cornuta*										×	×				M～R
Acer	*A. nordenski ldi*	*A. palmatum*			×	×	×	×				×	×				M
	A. palaeodiabolicum	*A. diabolicum*			×	×	×	×									M
	A. palaeorufinerve	*A. rufinerve*			×	×	×	×									M
	A. protojaponicum	*A. japonicum*		×	×	×	×	×									M
	A. protosieboldianum	*A. sieboldianum*		×	×	×	×	×									M
	A. prototrifidium	*A. trifidium*										×	×				M
	A. pseudocarpinifolium	*A. carpinifolium*			×	×	×	×									M
	A. submayri	*A. mono*		×	×	×	×	×		×	×			×	×		M
	A. subpictum	*A. mono*		×	×	×	×	×		×	×			×	×		M

Glyptostrobus, Sequoia, Pseudolarix and *Keteleeria* are found throughout the Neogene floras of the Japanese Islands, and they are now mostly living in China, and some of them are known in the western part of North America.

The nearest living equivalents of the pollen-floras from the Hijirikawa Member and their modern distribution in East Asia are shown in Table 2.

According to this table, the Hijirikawa and Oginoya pollen-floras consist mainly of the temperate genera with some warm climatic elements. The dominant genera among the temperate flora are *Alnus, Fagus, Castanea, Quercus, Ulmus, Zelkova, Acer* and *Tilia*. Their modern equivalent species are mostly distributed in the Japanese Islands proper, especially in the northern part of Honshû and Hokkaidô. Further, the pollen-floras from the Hijirikawa and Oginoya Members sometimes contain many exotic conifers such as *Metasequoia* (or *Cunninghamia, Taiwania, Glyptostrobus*) and *Liquidambar* of the Dicotyledons, though the exotic conifers are not abundant in number of specimens and are rather relicts which survived from the previous Middle Miocene Epoch. Thus, according to the writer's research, the pollen floras from the Hijirikawa and Oginoya Members are composed of mixed temperate and warm elements in floristic composition as already described in the previous part of this work.

From the viewpoint of leaf character analysis reported on the Late Miocene floras from various localities in the Japanese Islands, these pollen floras are related to the present temperate or somewhat warm temperate forest now growing in the central and southern parts of the Japanese Islands, and they seem to have grown under a warm temperate climatic condition. However, the reduction of warm and subtropical plants evidently indicates that the temperature had lowered in comparison with that of the Middle Miocene Yamatoda and Sunagozaka Members.

The Oginoya pollen-flora somewhat resembles the forest now growing in the central or northern parts of the Japanese Islands. The floristic composition of the fossil floras of this stage, Early Pliocene, varies by the localities, so that the climate at that time shows local difference. The predominance of beech, deciduous oak, elm, birch found from this flora, provide a basis for concluding that the climate during the Early Pliocene was temperate or rather cooler temperate in most regions of the Noto Peninsula. Furthermore, this pollen-flora has comparatively abundant coniferous trees, and the fact probably indicates that the climatic conditions were rather humid and the temperature not so high during the summer season. On the other hand, several warm climate elements as *Liquidambar, Cinnamomum* and *Metasequoia* are considered to have been able to overwinter in the lowland area.

Thus, from the Yamatoda or Sunagozaka (FUJI, 1969b) to the Oginoya pollen-flora the Neogene pollen-floras of the Hokuriku region seem to have gradually changed in their vegetation being first represented by lowland elements that changed to a flora represented by mountain elements without any considerable change of generic association. This may not be due to the elevation of the depositional site, but rather to the increased cooling and aridity of the climatic condition. In consequence of the lowering of the temperature during the Hijirikawa stage, the warm temperate or subtropical plants had gradually migrated to the lowland southern region of

East Asia, whereas, on the other hand, the mountain cool temperate elements seem to have become dominant throughout the Japanese Islands during the Pliocene Epoch according to the present writer's and the other palaeobotanist's studies.

(b) Palaeogeographical Environment

In order to facilitate the considerations on the probable palaeogeographical environments under which some ancient plants lived, the modern equivalents of the fossil species can be grouped according to their habitats into four types of upland, mixed-slope, stream-side or riparian, and lake or marshy elements.

The Hijirikawa and Oginoya pollen-floras are in number of specimens mainly composed of mixed-slope or mixed-slope—riparian plants, and also contain upland—mixed-slope plants abundantly. That is, these floras seem to represent a mixed-slope to riparian forest. For instance, in the assemblage from the Hijirikawa Member the mixed-slope plants amount to 60 per cent of the total frequency, the stream-side and/or riparian elements 23 per cent and the remainder belong to the upland elements, and with respect to the Oginoya Member they are respectively 56 per cent, 34 per cent and 10 per cent.

On the other hand, judging from the palynological results, the lithofacies, poor contents of planktonic foraminifers, fossil diatom assemblages and diversity in the thickness of the deposits, the sea under which the Hijirikawa Member was deposited during the Late Miocene seems to have been a strait in the Hakui-Hijirikawa area in the southern part of the Noto Peninsula, though the palaeogeographical environment in the Wakura-Notojima area of the central part of Noto Peninsula was a closed embayment probably connected with the lagoon during that age. The palaeogeographical environment during the Late Miocene Epoch is shown in the palaeogeographical map in Fig. 7.

The frequency of grass-pollen grains and spores, which are denoted by Σ NAP in Fig. 6, has been generally concluded to be related to the geographical environments. Accordingly, such presumption on the marine terrain is supported by that the frequency of the grass-pollen grains and spores is about 15 per cent in the Hijirikawa Member and 6 per cent in the Oginoya Member, though the non-arboreal pollen grains and spores found from the Wakura and I'izuka Members range from 36 per cent to 50 per cent and from 46 per cent to 52 per cent respectively. Namely, as shown in the palynological data mentioned above, these data suggest that the sedimentary basin where the non-arboreal pollen grains and spores are abundant in a relative frequency was situated near a land and also was a more or less closed embayment.

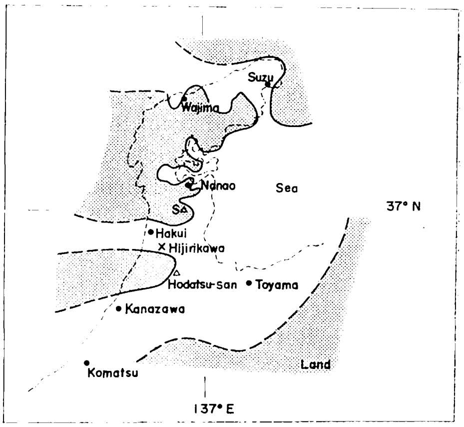

Fig. 7. The palaeogeographical map during the sedimentation of the Hijirikawa Member (the Otokawa stage of Late Miocene age) (After Y. KASENO, 1963).

(c) Geological Age

The correlation and age determination of the Neogene floras have been frequently done by the use of several characteristic fossils and assemblages in the Japanese Islands. On the basis of the researches which have been done by H. YABE, E. KON'NO, S. ENDO, S. OISHI, K. HUZIOKA, H. MATSUO, K. SUZUKI, T. TANAI, and many other palaeobotanists, TANAI classified the Neogene floras of Japan into six types, considering the floristic composition and components, and with the geological ages indicated by them. These types are in ascending order the Ainoura (Earliest Miocene), Aniai (Early Miocene), Daijima (Middle Miocene), Mitoku (Late Miocene to Mio-Pliocene), Shinjô (Early Pliocene) and Akashi (Late Pliocene) types.

The Hijirikawa and Oginoya pollen-floras are very similar in generic composition to the Mitoku-type flora. They contain some exotic elements which are found abundantly in the Middle Miocene Noroshi and Yamatoda floras. These exotic elements are commonly found in the Late Miocene floras of Europe and in the western part of the United States of America, where modernized plants are dominant. Thus, in comparison with various floras of the Neogene in the Japanese Islands and from the viewpoint of the stratigraphical evidences of these two members, the Hijirikawa and Oginoya pollen-floras can be nearly correlated with the Mitoku-type flora.

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Explanation of Plate 21

Fig. 1. *Picea*, lateral view, 84 μ; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20145.

Fig. 2. *Abies*, oblique lateral view, 104 μ; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20146.

Fig. 3. *Pinus*, oblique polar view, 64 μ; Locality No. 2, near Mt. Suemoriyama, Oshimizu Town; the lowermost horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20147.

Fig. 4. *Pinus*, polar view, a surface pattern structure of grain, 48 μ; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20148.

Fig. 5. *Pinus*, polar view, a surface pattern structure of air-sack, 48 μ; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20148.

Fig. 6. *Pinus*, polar view, 64 μ; Locality No. 3, Oginoya, Shio Town; the lower horizon of upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20149.

Fig. 7. *Metasequoia*, lateral view, 26 μ; Locality No. 4, Oginoya, Shio Town; the middle horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20150.

Fig. 8. *Tsuga*, polar view, 62 μ; Locality No. 2, near Mt. Suemoriyama, Oshimizu Town; the lowermost horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20151.

Fig. 9. *Tsuga*, polar view, 70 μ; Locality No. 2, near Mt. Suemoriyama, Oshimizu Town; the lowermost horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20152.

Fig. 10. *Inapertipollenites* sp., 54 μ; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20153.

Fig. 11. Taxodiaceae, lateral view, 36 μ; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20154.

Fig. 12. *Pleuricellaesporites* sp. a, lateral view; Locality No. 2, near Mt. Suemoriyama, Oshimizu Town; the lowermost horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20155.

Fig. 13. *Pleuricellaesporites* sp. b, lateral view; Locality No. 2, near Mt. Suemoriyama, Oshimizu Town; the lowermost horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20156.

Fig. 14. *Pleuricellaesporites* sp. c, lateral view; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20157.

Fig. 15. *Pleuricellaesporites* sp. d, lateral view, 36 μ; Locality No. 4, Oginoya, Shio Town; the middle horizon of the Hijirikawa Member; EKZJ coll. cat. no. 20158.

Fig. 16. *Pseudotsuga*, lateral view, 92 μ; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20159.

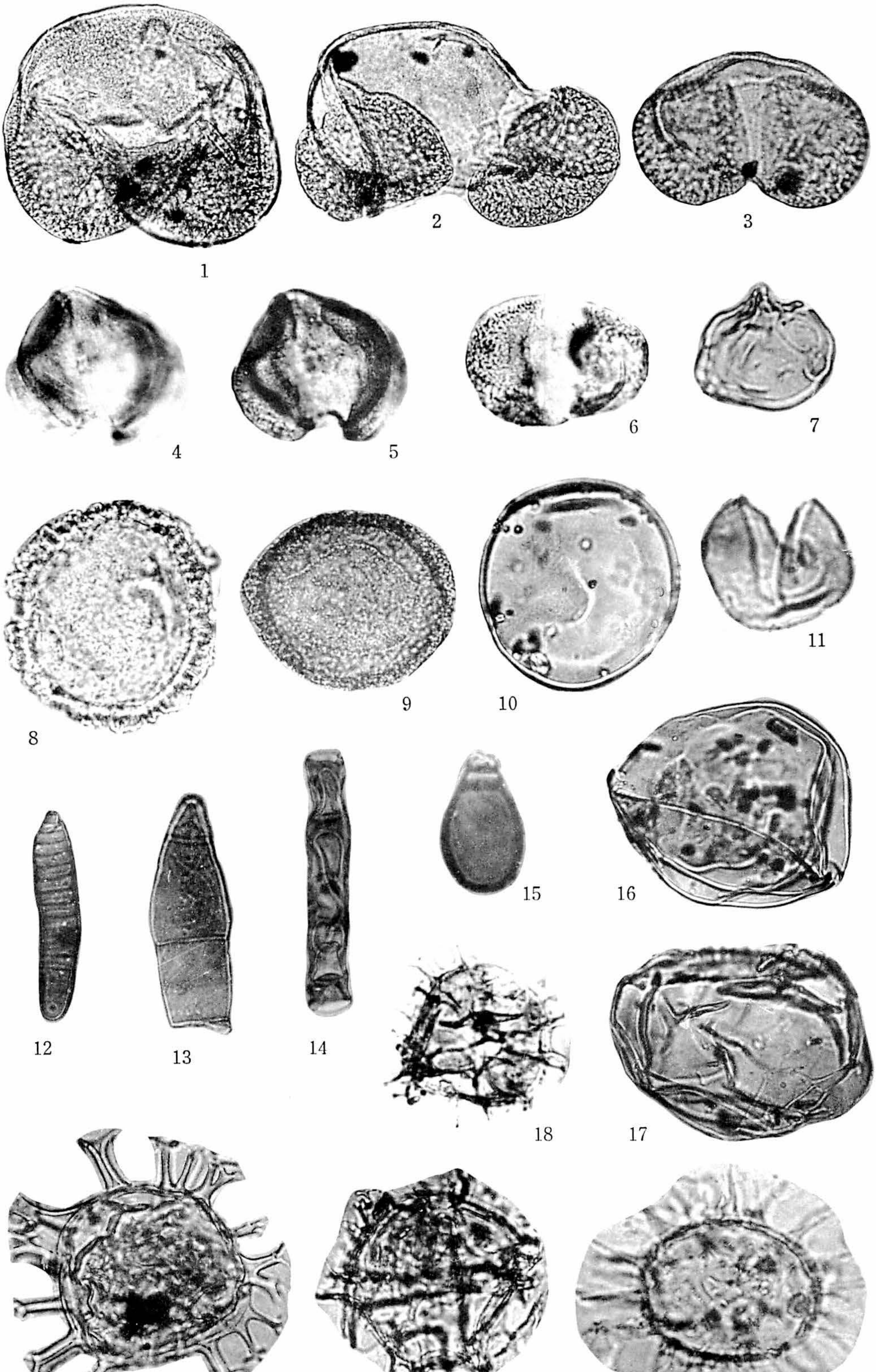
Fig. 17. *Pseudotsuga*, lateral view, 100 μ; Locality No. 5, Shikinami, Shio Town; the upper horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20160.

Fig. 18. *Hysterichosphaeridium* sp., lateral view, 42 μ; Locality No. 5, Shikinami, Shio Town; the upper horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20161.

Fig. 19. *Hysterichosphaeridium* sp., lateral view, 64 μ; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20162.

Fig. 20. *Hysterichosphaeridium* sp., lateral view, 50 μ; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20163.

Fig. 21. *Hysterichosphaeridium* sp., lateral view, 58 μ; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20164.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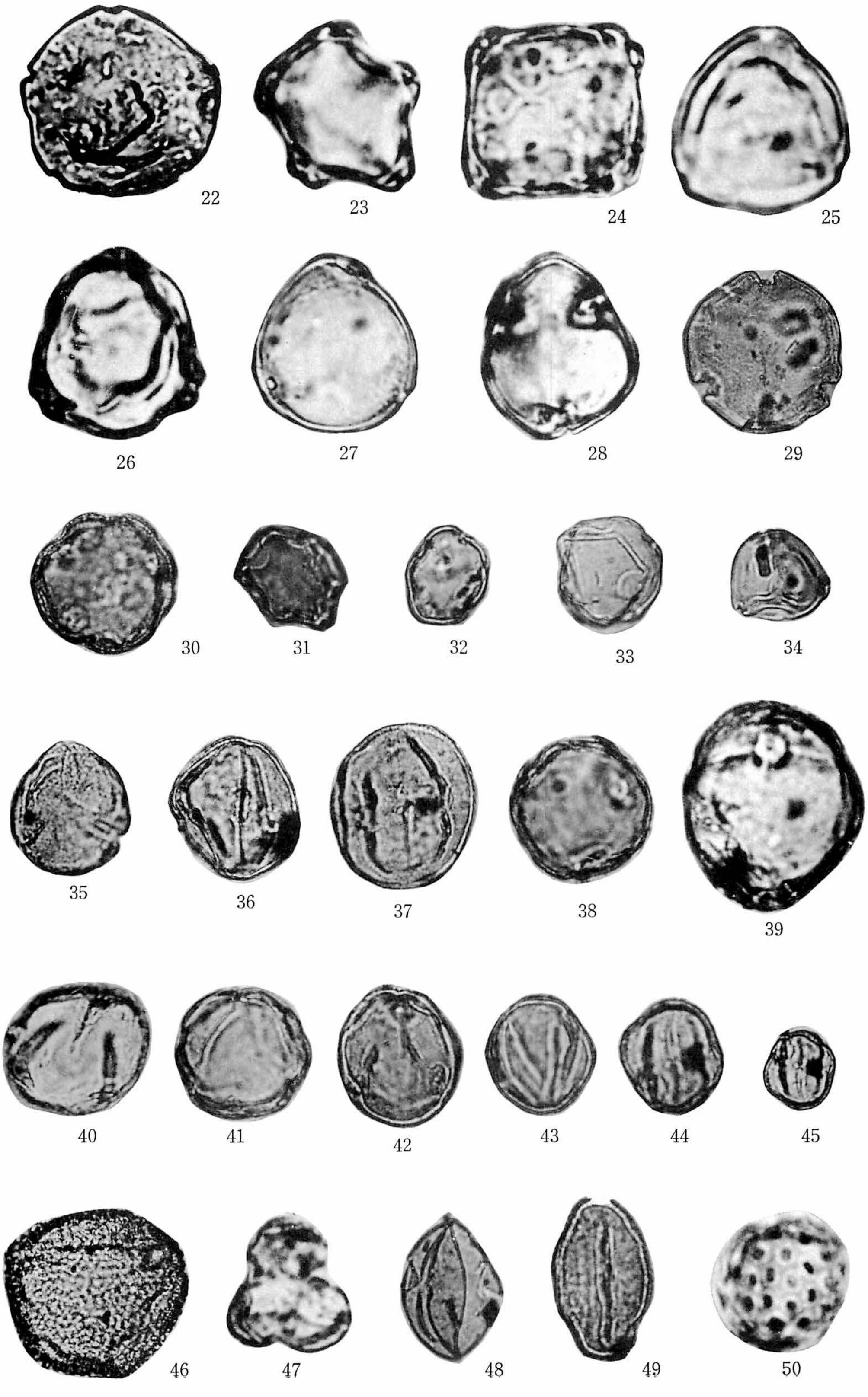
Ainoura	相ノ浦
Akage	赤毛
Akashi	明石
Aniai	阿仁合
Daijima	台島
Ebisaka	海老坂
Entsunagi	縁繋
Hakui	羽咋
Hara	原
Hida	飛騨
Hijirikawa	聖川
Hiradoko	平床
Hôdatsu-san	宝達山
Hojuji	法住寺
Hokkaidô	北海道
Hokuriku	北陸
Honshû	本州
Ichinoshima	一ノ島
I'izuka	飯塚
Ishikawa	石川
Iwabuchi	岩渕
Kanazawa	金沢
Kuwanoin	桑ノ院
Mitoku	三徳
Nanao	七尾
Noto	能登
Noto-jima	能登島
Oginoshima	荻ノ島
Oginoya	荻ノ谷
Oitani	老谷
Sakuragaoka	桜ケ丘
Shikinami	敷波
Shingu	新宮
Shinjô	新庄
Shio	志雄
Shoshigahara	所司ケ原
Sunagozaka	砂子坂
Tônokuma	当ノ熊
Toyama	富山
Tsuboike	坪池
Tsuchikura	土倉
Tsukada	塚田
Wakura	和倉
Yamatoda	山戸田

Explanation of Plate 22

Fig. 22. *Zelkova*, polar view, 38 μ; Locality No. 1, Hijirikawa, Shio Town; the lowermost horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20165.
Fig. 23. *Alnus*, polar view, 30 μ; Locality No. 3, Oginoya, Shio Town; the lower horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20166.
Fig. 24. *Myriophyllum*, polar view, 37 μ; Locality No. 1, Hijirikawa, Shio Town; the lowermost horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20167.
Fig. 25. *Carya*, polar view, 48 μ; Locality No. 5, Shikinami, Shio Town; the upper horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20168.
Fig. 26. *Betula*, polar view, 40 μ; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20169.
Fig. 27. *Carya*, polar view, 42 μ; Locality No. 1, Hijirikawa, Shio Town; the lowermost horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20170.
Fig. 28. *Tilia*, polar view, 27 μ; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20171.
Fig. 29. Cf. *Tilia*, polar view, 31 μ; Locality No. 3, Oginoya, Shio Town; the lower horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20172.
Fig. 30. *Liquidambar*, lateral view, 30 μ; Locality No. 6, Syuku, Oshimizu Town; the lower horizon of the Oginoya Member; EKZJ coll. cat. no. 20173.
Fig. 31. *Alnus*, polar view, 24 μ; Locality No. 4, Oginoya, Shio Town; the middle horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20174.
Fig. 32. *Juglans*, lateral view, 40 μ; Locality No. 2, near Mt. Suemoriyama, Oshimizu Town; the lowermost horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20175.
Fig. 33. Cf. *Juglans*, lateral view, 42 μ; Locality No. 3, Oginoya, Shio Town; the lower horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20176.
Fig. 34. *Corylus*, lateral view, 28 μ; Locality No. 5, Shikinami, Shio Town; the upper horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20177.
Fig. 35. *Nyssa*, polar view, 35 μ; Locality No. 4, Oginoya, Shio Town; the middle horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20178.
Fig. 36. *Fagus*, equatorial view, 32 μ; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20179.
Fig. 37. *Fagus*, equatorial view, 30 μ; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20180.
Fig. 38. *Fagus*, oblique polar view, 46 μ; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20181.
Fig. 39. *Fagus*, oblique polar view, 40 μ; Locality No. 4, Oginoya, Shio Town; the middle horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20182.
Fig. 40. *Fagus*, oblique equatorial view, 32 μ; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20183.
Fig. 41. *Fagus*, oblique equatorial view, 42 μ; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20184.
Fig. 42. *Fagus*, oblique polar view, 40 μ; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20185.
Fig. 43. *Quercus* (deciduous), oblique equatorial view, 42 μ; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20186.
Fig. 44. *Quercus* (deciduous), equatorial view, 36 μ; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20187.
Fig. 45. *Quercus* (evergreen), equatorial view, 23 μ; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20188.
Fig. 46. ? *Tricolporopollenites* sp., polar view, 32 μ; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20189.
Fig. 47. *Salix*, polar view, 28 μ; Locality No. 4, Oginoya, Shio Town; the middle horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20190.
Fig. 48. *Monoletepollenites* sp., equatorial view, 36 μ; Locality No. 5, Shikinami, Shio Town; the upper horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20191.
Fig. 49. Cf. *Monoletepollenites* sp., equatorial view, 33 μ; Locality No. 5, Shikinami, Shio Town; the upper horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20192.
Fig. 50. *Chenopodium*, equatorial view, 34 μ; Locality No. 1, Hijirikawa, Shio Town; the lower horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20193.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例　会　通　知

	開催地	開催日	講演申込締切日
1970年総会，年会	東北大学	1970年1月19,20日	1969年12月1日
104回例会	茨城大学	1970年6月	

NEWS

◎ 1st Interamerican Micropaleontological Coloquium が，1970年7月19〜30日に Texas で開かれる。これは Texas の上部白亜系生層序の模式地を巡検して標本を採集するための会合である。外国人会員数には制限があり，22名まで（先着順）。参加費は1人 325$（宿泊費その他を含む）。1970年5月15日までに 81.25$ をそえて，Dr. Emile A. Pessagno Jr., Univ. of Texas at Dallas, P.O. Box 30365, Dallas, Texas 75230 あて申込む。詳細については本学会事務局に問合せられたい。

◎ 本会誌の出版費の一部は文部省研究成果刊行費による。

1969年12月5日　印刷
1969年12月10日　発行

日本古生物学会報告・紀事
新篇第76号
600円

発行者　日本古生物学会
東京大学理学部地質学教室内

編集者　鹿間時夫

（振替口座東京84780番）

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　富田元

Transactions and Proceedings of the Palaeontological Society of Japan

New Series No. 76 December 10, 1969

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TRANSACTIONS