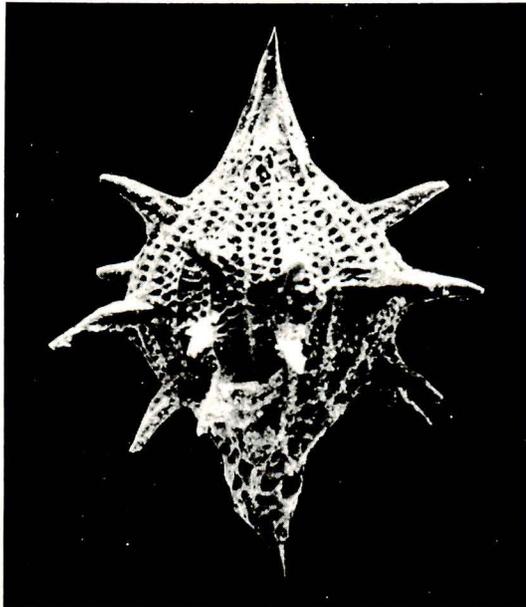


日本古生物学会
報告・紀事

Transactions and Proceedings
of the
Palaeontological Society of Japan

New Series No. 144



日本古生物学会

Palaeontological Society of Japan

December 30, 1986

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The fossil on the cover is *Unuma (Spinunuma) echinatus* ICHIKAWA and YAO, a Middle Jurassic multisegmented radiolaria from Unuma, Gifu Prefecture, central Japan (photo by A. YAO, × 260).

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821. EARLY CRETACEOUS *PULSIDIS* (BIVALVIA) FROM JAPAN*

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Abstract. Five species in the genus *Pulsidis* Ota including four new species, *i.e.*, *P. angulata*, sp. nov., *P. sanchuensis*, sp. nov., *P. tashiroi*, sp. nov. and *P. rostrata*, sp. nov., are described from fourteen localities of Lower Cretaceous in Japan on the ground of my own collections as well as the hitherto treated ones.

Introduction

Since the genus *Pulsidis* was established by Ota (1964), several species referable to this bivalve genus have been described from the Cretaceous brackish-water deposits in Japan. However, some of them should be re-examined taxonomically. In the present paper, I attempted to the taxonomy and to determine their stratigraphic ranges based upon the numerous specimens collected from the various localities in Japan.

Recently, the correlation for the non-marine and brackish-water deposits in the Cretaceous of Japan has become much clearer in the light of the interrelation with the ammonite-bearing marine formations (Matsumoto *et al.*, 1982). The brackish-water deposits which contain fossils of *Pulsidis* occur at various stratigraphic levels. Therefore, it may be possible to know the geological ages of the classified species.

The specimens described in this paper are mostly kept in the Geological Collections of Faculty of Science, Kochi University (KSG), Kochi and Department of Earth Sciences, Fukuoka University of Education (GT), Fukuoka.

Localities and geological data

The localities of the fossils described in this paper are recorded below with a brief note on the lithology, stratigraphic position and geological age. Readers may refer to Text-fig. 1 for the geographic position of the localities.

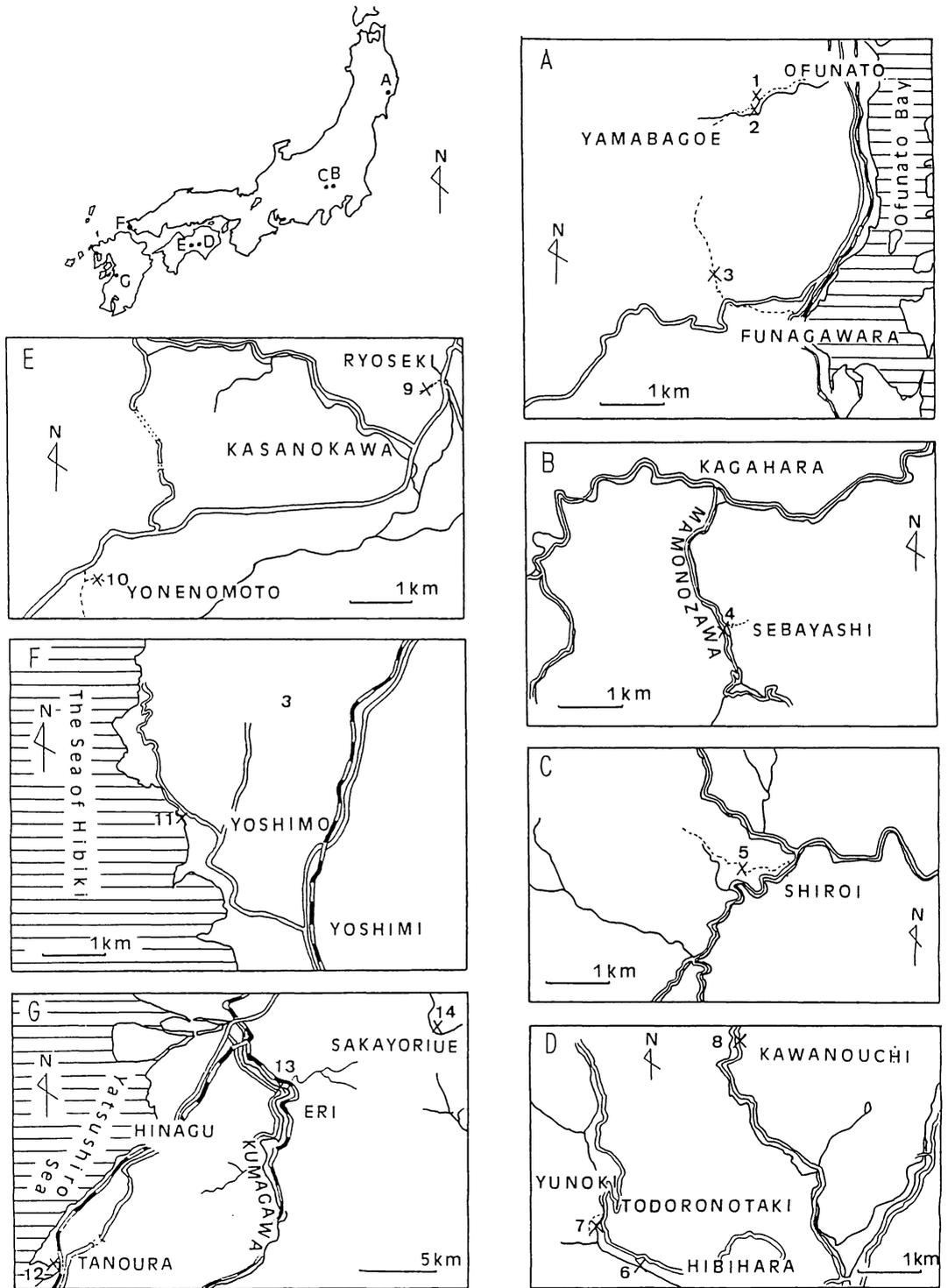
Loc. 1. Black carbonaceous shale in the upper part of the Funagawara Formation at a quarry near Yamabagoe, about 2 km west from the center of Ofunato City (Onuki and Mori, 1961). The characteristic species are *Nanonavis yokoyamai* (Yabe et Nagao) and *Isodomella shiroiensis* (Yabe et Nagao) which are marine and brackish-water molluscs. An ammonite *Crioceratites ishiwarai* (Yabe et Shimizu) which occurs in the same formation indicates Upper Hauterivian (Obata and Matsumoto, in Matsumoto *et al.*, 1982). Hauterivian.

Loc. 2. Black carbonaceous shale and fine-grained sandstone in the upper part of the Funagawara Formation at a roadside exposure, near Yamabagoe. This locality is of the same stratigraphic position as Loc. 1. Hauterivian.

Loc. 3. Fine-grained sandstone in the upper part of the Funagawara Formation at a roadside exposure, about 1.2 km northwest of Funagawara, Ofunato City. This is also of the same stratigraphic position as Loc. 1. Hauterivian.

Loc. 4. Black shale of the lower part of the Sebayashi Formation on the east side of the River Mamozawa, near Sebayashi, south of

* Received July 15, 1985; revised manuscript received July 19, 1986; read January 22, 1984 at Kyoto University.



Text-fig. 1. Map showing fossil localities.

Kagahara, Nakazato-mura, Tano-gun, Gunma Prefecture. Brackish-water molluscs such as *Costocyrena radiatostriata* (Yabe et Nagao), *Isognomon sanchuensis* (Yabe et Nagao), *Tetoria sanchuensis* (Yabe et Nagao) etc. occur abundantly in this shale. Upper Barremian or Lower Aptian (Obata and Matsukawa in Matsumoto *et al.*, 1982; Matsukawa, 1983).

Loc. 5. Dark gray shale and fine-grained sandstone of the upper part of the Shiroi Formation at roadside exposure, near Shiroi, Ueno-mura, Tano-gun, Gunma Prefecture. The characteristic species are *Hayamina naumanni* (Neumayr), *Costocyrena otsukai* (Yabe et Nagao) and *Isodomella shiroiensis* (Yabe et Nagao) which are brackish-water molluscs. Hauterivian? (Matsukawa, 1979, 1983).

Loc. 6. Dark gray siltstone in the basal part of the Hibihara Formation at the dam site of Hibihara, Kahoku-cho, Kami-gun, Kochi Prefecture. The characteristic species are *Costocyrena minor* Ohta, *Barbatia hibiharensis* Tashiro et Kozai and *Brachidontes pyriformis* Tashiro et Kozai. Probably Lower Aptian (Tashiro and Kozai, 1984; Tanaka *et al.*, 1984).

Loc. 7. Dark gray siltstone in the lower part of the Yunoki Formation at a river side outcrop of Todoronotaki, near Yunoki, Kahoku-cho, Kami-gun, Kochi Prefecture. This horizon is called the "*Costocyrena* Bed". The characteristic species is *Costocyrena radiatostriata* (Yabe et Nagao), and mega-phytofossils are occurred in the lower part of this shale. Probably Upper Barremian (ditto).

Loc. 8. Fine-grained sandstone in the basal part of the Hibihara Formation at a roadside exposure, about 500 m south of Kawanouchi, Monobe-mura, Kami-gun, Kochi Prefecture. The characteristic species are *Hayamina* sp. and *Costocyrena minor* Ohta. This locality is probably of the same horizon as Loc. 6. Probably Lower Aptian (Tashiro *et al.*, 1980).

Loc. 9. Siltstone, exposed on roadside, about 800 m south of Ryoseki, Nankoku City, Kochi Prefecture. This locality was referred to the Hibihara Formation by Ishizaki (1960). Later *Shastrioceras* aff. *S. nipponicus* Matsumoto was collected from the lower horizon of this siltstone. Judging from this ammonite, this locality is probably assigned to the Yunoki Formation. Probably Barremian.

Loc. 10. Fine- to medium-grained sandstone in the upper part of the Ryoseki Formation at a roadside exposure of Yonenomoto, Kochi City. The characteristic species is *Costocyrena otsukai* (Yabe et Nagao). Probably Hauterivian (Tashiro and Kozai, 1984).

Loc. 11. Dark gray, fine-grained sandy shale in the Yoshimo, Shimonoseki City, Yamaguchi Prefecture. Brackish-water molluscs from the formation had been described by many authors (Hase, 1960). Neocomian.

Loc. 12. Siltstone in the lower part of the Kawaguchi Formation on a coast of Tanoura, Tanoura-cho, Ashikita-gun, Kumamoto Prefecture. It contains characteristic brackish-water molluscs, e.g., *Eomiodon matsumotoi* Ohta, *Isodomella matsumotoi* Ohta and *Eoursivivas matsumotoi* (Hase). Neocomian (Ohta, 1977).

Loc. 13. Dark-gray sandy shale in the upper part of the Kawaguchi Formation on the north-east side of the River Kumagawa, near Kawaguchi, Sakamoto-mura, Yatsushiro-gun, Kumamoto Prefecture. This locality is the type-locality of the Kawaguchi Formation, which consists of dark-gray sandy shale and fine-grained sandstone in alternation. Many brackish-water molluscs are occurred there (Ohta, 1977). Neocomian.

Loc. 14. Dark-gray sandy shale in the upper part of the Kawaguchi Formation at a roadside exposure of Sakayoriue, Toyo-mura, Yatsushiro-gun, Kumamoto Prefecture. The characteristic species are *Hayamina naumanni* (Neumayr), *Eomiodon matsumotoi* Ohta, *Tetoria yoshimoensis* Ohta and *Eoursivivas matsumotoi* (Hase) (Ohta, 1977). Neocomian.

Systematic description

Family Corbulidae Lamarck, 1818

Subfamily Corbulinae Lamarck, 1818

Genus *Pulsidis* Ohta, 1964

Type species:—*Pulsidis nagatoensis* Ota, 1964: Yoshimo Formation, Yamaguchi Prefecture: Neocomian.

Diagnosis:—Shell small, inequivalve, inequilateral, elongate trigonal and posteriorly rostrated; right valve larger than left valve; test thin; surface ornamented with regular concentric

ribs; internal margin of right valve grooved for reception of left valve; cardinal tooth of right valve generally small; resilial pit large, deep; chondrophore prominent, triangular, with out median ridge.

Remarks.—Hase (1960) described *Corbula matsumotoi* on the basis of the specimens from the Lower Cretaceous Kawaguchi Formation in Kumamoto Prefecture and Yoshimo Formation in Yamaguchi Prefecture. Ota (1964), however, established the genus *Eoursivivas* on the specimens from the Kawaguchi Formation and *Pulsidis* on those from the Yoshimo Formation.

In this genus, ratio of H/L is gradually small with growth. This genus is closely similar to *Caryocorbula* Gardner, 1926, but evidently differs in having no median ridge on the chondrophore. It is similar to *Caestocorbula* Vincent, 1910 in the features of hinge structure, but discriminated from the latter in its smaller cardinal tooth of right valve and lack of siphonal plate.

Ota (1964) described *Pulsidis okadai* Ota and *Aloides higoensis* Matsumoto, but in my opinion, *P. okadai* and *A. higoensis* do not belong to *Pulsidis*. The former is probably referable to *Nipponicorbula* because both valves have weak radial ribs on the disk, and the latter to *Caestocorbula* because the cardinal tooth of right valve is large and the test is thick. The specimens which were described as *P. higoensis* by Shikama and Suzuki, 1982 from the Lower Cretaceous of Choshi, Chiba Prefecture, were treated as *Caestocorbula shikamai* Hayami by Hayami (Hayami and Oji, 1980).

Pulsidis nagatoensis Ota

Pl. 95, Figs. 1—4.

1964. *Pulsidis nagatoensis* Ota, p. 20. text-fig. 1, pl. 20, figs. 1—14, 25.
1975. *Pulsidis nagatoensis* Ota; Hayami, p. 146.

Material.—The holotype is an internal mould of right valve (GT. Y6301) illustrated by Ota (1964, pl. 20, fig. 1). It was collected from the

Yoshimo Formation at Yoshimo, Shimonoseki City, Yamaguchi Prefecture. About 150 specimens from Locs. 9—14 and 7 are also concerned with the description below.

Diagnosis.—Small-sized species of *Pulsidis* characterized by shortly rostrated shell, umbo situated at mid-length of valve and a shallow radial groove on area.

Description.—Shell small, moderately inflated, subtrigonal, a little longer than high, and rostrated to postero-ventral edge; right valve larger than left; test thin; area demarcated from disk by a weak posterior carina, divided into two parts by a shallow median radial groove; antero-dorsal margin short, broadly arched or nearly straight; postero-dorsal margin long, subhorizontal, but weakly concave near umbo; ventral margin broadly arched; posterior margin subtruncated; umbo located at nearly mid-length from front of valve, moderately prominent and slightly prosogyrate; surface ornamented with concentric ribs, which are round-topped, regularly spaced, broader than their interspaces, denser in posterior half than in anterior; internal margin of right valve distinctly grooved as a receptional scar of margin of left valve; inner areal part flat; cardinal tooth of right valve triangular, relatively large, but narrower and rounded at top; resilial pit large, situated on posterior side of cardinal tooth; anterior adductor scar weakly impressed, long-elliptical; posterior adductor scar well marked, larger than anterior one; chondrophore relatively broad, separated from dorsal margin by a shallow groove.

Observation.—In the adult specimens, shell-length is about 10 mm in the right valve and 9 mm in the left valve. Although the external concentric ribs are more or less weathered, some specimens show clearly concentric ribs on the entire surface. The number of ribs about 5 in the distance of 1 mm in height. Apical angle is generally about 100° in the young specimens, but in the adult specimens 120°—130° in the right valve and 105°—115° in the left valve, respectively. H/L of the valve is 0.70 on an average in the right valve and 0.73 in the left.

Measurements (in mm):—

Specimens	L	H	B	U	H/L	U/L
KSG-K001, R.in.m.	8.7	6.2	—	4.5	0.61	0.52
KSG-K003, L.in.m.	7.3	5.6	—	4.0	0.77	0.55
KSG-K044, L.ex.m.	9.8	6.9	1.9	4.6	0.70	0.47
KSG-K005, R.in.m.	9.0	6.3	—	4.1	0.70	0.46
KSG-K006A, R.in.m.	9.8	6.5	—	4.5	0.66	0.46
KSG-K006B, R.in.m.	9.0	6.4	—	4.6	0.71	0.51
KSG-K006C, R.in.m.	9.2	6.9	—	4.5	0.71	0.50
KSG-K006D, L.in.m.	7.4	5.7	—	3.6	0.77	0.49
KSG-K007, L.in.m.	8.6	6.2	—	4.8	0.72	0.56
KSG-K008, R.ex.m.	10.7	7.1	1.6	4.9	0.66	0.46
KSG-K009, L.in.m.	7.1	4.5	—	3.5	0.63	0.49
KSG-K010, R.in.m.	7.9	6.0	—	4.7	0.76	0.59
KSG-K011, L.ex.m.	9.1	6.8	3.0	4.0	0.75	0.43
KSG-K012, R.ex.m.	9.6	6.5	3.7	4.5	0.68	0.47

L.=left valve, R.=right valve, ex.m.=external mould, in.m.=internal mould, H=height, L=length, B=breadth, U=distance from beak to anterior end.

Ratio of U/L is 0.46 on an average in the right valve and 0.51 in the left. The umbo of the right valve is more anteriorly located than of the left.

Occurrence:—Abundant at Locs. 9 and 11, common at Locs. 12 and 14 and rare at Locs. 7 and 10. Total stratigraphic range is Neocomian.

Pulsidis angulata, sp. nov.

Pl. 95, Figs. 17—21.

Material:—Holotype, KSG-K022, internal mould of left valve; 9 paratypes; KSG-K017 and KSG-K014, internal moulds of right valves; KSG-K023 and KSG-K019, internal moulds of left valves; KSG-K021, external mould of left valve; KSG-K018, KSG-K024, KSG-K025 and KSG-K020, external moulds of right valves; all the specimens were collected from Loc. 2.

Diagnosis:—Small-sized species of *Pulsidis* characterized by shortly rostrated right valve, slightly smaller, less rostrated left valve and distinctly angulate posterior carina.

Description:—Shell small, subelliptical in

outline, moderately inflated; right valve a little larger than left, shortly rostrated to posterior; test thin; umbo situated at about mid-length of valve, slightly prosogyrate; anterior dorsal margin short, slightly convex; posterior dorsal margin nearly straight or gently concave; posterior margin vertically truncated; anterior margin semicircular; ventral margin gently arched; posterior carina distinctly angulated, extended from umbo to postero-ventral corner, defining postero-dorsal area from disk; area narrow, nearly flattened, longer in right valve than left; surface ornamented with fine concentric ribs which are round-topped, regularly spaced, denser on posterior part, narrower than their interspaces; interior of right valve grooved to receive the margin of left valve; pallial line not sinuate, indistinctly impressed; cardinal tooth of right valve triangular, rounded in upper part; resilial pit triangular, smaller than cardinal tooth, deeply excavated, located on posterior side of cardinal tooth; chondrophore prominent, triangular, narrow but elongate, parallel to posterior dorsal margin.

Measurements (in mm):—

Specimens	L	H	B	U	H/L	U/L
KSG-K022, L.in.m.	6.4	3.5	—	3.0	0.55	0.47
KSG-K017, R.in.m.	7.2	4.3	—	3.5	0.60	0.49
KSG-K014, R.in.m.	5.6	3.9	—	2.8	0.70	0.50
KSG-K023, L.in.m.	5.9	3.9	—	2.9	0.66	0.49
KSG-K021, L.ex.m.	5.4	3.6	1.0	2.8	0.67	0.51
KSG-K019, L.in.m.	5.2	3.4	—	2.3	0.65	0.44
KSG-K020, R.ex.m.	6.3	4.3	1.4	3.3	0.68	0.52
KSG-K018, R.ex.m.	6.0	4.0	1.9	3.7	0.67	0.62
KSG-K015, L.ex.m.	5.2	3.3	1.5	2.9	0.63	0.56
KSG-K013, R.ex.m.	7.3	4.6	1.9	3.7	0.63	0.51
KSG-K016, R.ex.m.	6.1	3.5	1.2	2.8	0.57	0.46
KSG-K024, R.ex.m.	6.3	3.8	1.3	2.8	0.60	0.44
KSG-K025, R.ex.m.	5.4	3.6	2.0	2.6	0.67	0.48

Observation:—The outline of this new species is variable from triangular to pyriform. Surface ornamentation is well preserved in many specimens. Ratio of U/L is rather constant, being 0.40 on an average in right valve and 0.38 in left valve.

Comparison:—This new species is generally similar to *Pulsidis nagatoensis* Ota, 1964, as described before, but differs from the latter in having distinct posterior carina and anteriorly located umbo. It is similar to *Corbula globosa* Tamura, 1959, from the Upper Jurassic Sakamoto Formation in Kumamoto Prefecture, in the triangular outline, but the angulated posterior carina is distinctly sharper in this species.

Occurrence:—Common at Locs. 1 and 2 and rare at Locs. 3 and 5. Hauterivian.

Pulsidis sanchuensis, sp. nov.

Pl. 95, Figs. 22–30.

Material:—Holotype, KSG-K086, internal mould of right valve; three paratypes; KSG-K087, internal mould of left valve; KSG-K088, external mould of right valve; KSG-K089, external mould of left valve; other 16 specimens are also at hand; all the specimens were collected

from Loc. 4.

Diagnosis:—Small-sized species of *Pulsidis* characterized by well rostrated right valve, shortly rostrated left valve, absence of median groove on area and umbo situated at one-third of shell-length in right valve.

Description:—Shell of moderate size, inequilateral, rostrated posteriorly, inequivalve; right valve larger than left; test thin; anterior dorsal margin slightly concave; posterior dorsal margin gently concave; ventral margin gently arched; umbo slightly prosogyrate, situated at about one-third from anterior extremity in right valve but about a half of shell-length in left valve; area flattened, longer in the right valve than in the left; surface covered with fine concentric ribs, which are round-topped, regularly spaced, narrower than their interspaces; pallial line indistinct; posterior adductor scar elliptical, clearly impressed, faint larger than anterior one; resilial pit deep, large; chondrophore small, slightly prominent.

Observation:—In the adult specimens, average of shell-length is about 8 mm in the right valve but 6 mm in the left. Surface ornamentation is well preserved. The concentric ribs are strong and regularly spaced, numbering about 5 in the distance of 1 mm along height of the adult speci-

Measurements (in mm):—

Specimens	L	H	B	U	H/L	U/L
KSG-K086, R.in.m.	7.5	4.6	—	2.4	0.61	0.32
KSG-K087, L.in.m.	3.4	2.6	—	1.5	0.77	0.44
KSG-K088, R.ex.m.	6.1	3.6	1.4	2.6	0.59	0.43
KSG-K089, L.ex.m.	5.0	3.5	1.6	2.1	0.70	0.42
KSG-K090, R.in.m.	5.8	3.4	—	2.0	0.59	0.34
KSG-K091, L.	6.6+	4.5	1.9	3.2	—	—
KSG-K092, R.ex.m.	7.1+	5.3	1.4	2.7	—	—
KSG-K093, R.ex.m.	6.5	3.7	2.2	2.7	0.57	0.42
KSG-K094, R.	6.6	3.5	2.3	2.0	0.53	0.30
KSG-K095, L.	5.0	3.6	1.2	2.3	0.72	0.46

mens. In the adult specimens, the apical angle is 100° – 110° in the right valve and 90° – 100° in the left.

Comparison:—This new species is similar to *Pulsidis angulata*, sp. nov. in its trigonal outline of the left valve, but is distinguished from the latter by its more rostrated right valve and indistinct posterior carina. This new species evidently differs from *Pulsidis nagatoensis* in its longer area of the right valve.

Occurrence:—Rare at Loc. 4. Upper Barremian or Lower Aptian.

Pulsidis tashiroi, sp. nov.

Pl. 95, Figs. 5–9.

Material:—Holotype, KSG-K042, right valve; nine paratypes; KSG-K038, KSG-K039A and KSG-K046, internal moulds of left valves; KSG-K039B, KSG-K045, KSG-K044, KSG-K047 and KSG-K048, right valves; KSG-K049, left valve; all these type-specimens were collected from Loc. 7.

Diagnosis:—Shell medium-sized for the genus, elongate pyriform in outline, with rostrum gradually narrowed to posterior end and faintly grooved area. Right valve slightly larger than left.

Description:—Shell moderately inflated, inequilateral, elongate subpyriform, much longer than high, gradually rostrated to posterior edge;

right valve slightly larger than left; test thick for genus; umbo small, slightly prosogyrate, situated at about one-third of shell length from front in right valve but somewhat more posteriorly in left; surface ornamented with concentric ribs; concentric ribs round-topped, narrower than their interspaces; area elongated, faintly grooved along its median line; a low ridge extended from umbo to postero-ventral margin, defining area from disk; anterior dorsal margin slightly arched; posterior dorsal margin a little concave near umbo but slightly convex in later half; posterior end subvertically truncated; ventral margin broadly arched; interior of area flattened; inner marginal part of right valve shallowly grooved to receive the margin of left valve; pallial line indistinct; cardinal tooth of right valve triangular, low, small; chondrophore small, thin, triangular, connected with posterior dorsal margin.

Observation:—The apical angle is measured 120° – 130° in the adult specimens. The surface ornamentation is more or less weathered in most specimens, but a specimen, KSG-K039B, shows distinct concentric ribs on the surface.

Comparison:—This new species has smaller cardinal tooth and chondrophore in the right valve than those of *Pulsidis nagatoensis*. This new species is somewhat similar to *Pulsidis sanchuensis*, sp. nov. in the feature of the ribs, but differs from the latter having gradually

Measurements (in mm):—

Specimens	L	H	B	U	H/L	U/L
KSG-K042, R.	15.5	5.5	—	5.0	0.35	0.32
KSG-K038, L.in.m.	14.2	8.0	—	5.2	0.56	0.37
KSG-K039A, L.in.m.	12.6	5.7	—	5.5	0.45	0.44
KSG-K039B, R.	12.7	7.3	—	5.5	0.57	0.43
KSG-K045, R.	15.7	8.0	2.0	6.2	0.51	0.39
KSG-K044, R.	15.7	8.9	2.2	5.1	0.58	0.33
KSG-K046, L.in.m.	13.4	7.1	—	4.1	0.53	0.38
KSG-K047, R.	13.2	6.6	1.9	4.5	0.50	0.34
KSG-K048, R.	9.7+	5.0	2.1	3.8	0.51-	0.39-
KSG-K049, L.	11.6	5.9	—	5.0	0.51	0.43

narrowed posterior rostrum. This species is also similar to "*Pulsidis*" *higoensis* (Matsumoto, 1938), from the Goshyonoura Group of Kumamoto Prefecture, in view of the outline and surface ornamentation, but has more crowded concentric ribs. *Pulsidis angulata*, sp. nov. is also clearly distinguishable from this new species by distinct posterior carina.

Occurrence:—Rare at Locs. 7 and 9. Probably Barremian.

Pulsidis rostrata, sp. nov.

Pl. 95, Figs. 10–16.

Material:—Holotype, KSG-K026, external mould of right valve from Loc. 6; 12 paratypes; KSG-K028 and -K029, external moulds of right valves from Loc. 6; KSG-K030 and -K031 from Loc. 8 and KSG-K032 and -K033 from Loc. 6, internal moulds of right valves; KSG-K034, external mould of left valve from Loc. 6; KSG-K035 and -K036 from Loc. 6 and KSG-K037 from Loc. 8, internal moulds of left valves; KSG-K098, -K099 and other about 100 specimens from Locs. 6 and 8.

Diagnosis:—Shell medium-sized for genus, and characterized by a narrowly elongated and pointed posterior rostrum in right valve; densely spaced concentric ribs on external surface and a distinct radial median groove on area.

Description:—Shell moderate in size, inequi-

valve, highly inequilateral, much longer than high, elongate-trigonal, abruptly narrowed towards posterior part with long and gradually tapering rostrum; right valve larger than left; test comparatively thin; anterior dorsal margin short, slightly arcuate; posterior dorsal margin broadly arched; ventral margin arched in anterior part but slightly concave or nearly straight in posterior part; posterior end subvertically truncated; umbo situated at more anterior than one-third of shell length from anterior extremity in right valve, but more posterior than one-third from anterior extremity in left, slightly prosogyrate, a little prominent; area with a strong radial median groove and also with regularly spaced concentric ribs; disk covered with regular concentric ribs being rounded at top; interior margin of right valve grooved to receive the left valve; an internal radial ridge extends from umbo to margin of inner area; pallial line indistinctly impressed, curved with an acute angle under posterior adductor scar; cardinal tooth of right valve triangular, small; resilial pit large, deep, located on posterior side of cardinal tooth; chondrophore narrow, scarcely separated from dorsal margin by a shallow groove.

Observation:—The posterior rostrum is constantly long. The surface ornamentation is well preserved. The concentric ribs are very fine, numbering about 60 on the whole surface. About

Measurements (in mm):-

Specimens	L	H	B	U	H/L	U/L
KSG-K026, R.ex.m.	7.9	3.0	1.3	2.8	0.38	0.35
KSG-K028, R.ex.m.	7.5	3.5	1.4	2.9	0.47	0.39
KSG-K029, R.ex.m.	9.9	4.8	1.5	2.9	0.48	0.29
KSG-K030, R.in.m.	9.5	4.3	—	3.8	0.45	0.40
KSG-K031, R.in.m.	10.8	5.3	—	3.9	0.49	0.36
KSG-K032, R.in.m.	7.7	3.9	—	2.5	0.51	0.32
KSG-K033, R.in.m.	8.8	2.9	—	3.0	0.33	0.34
KSG-K034, L.ex.m.	6.9	3.2	2.0	2.8	0.46	0.41
KSG-K035, L.in.m.	8.2	4.5	—	4.1	0.55	0.50
KSG-K036, L.in.m.	8.9	3.3	—	2.9	0.37	0.33
KSG-K037, L.in.m.	10.1	4.7	—	4.1	0.47	0.41

11 ribs are counted in the distance of 1 mm in height near the ventral margin of adult specimens. The apical angle at the adult specimens is 120° – 130° in the right valve and 110° – 120° in the left. The angle in younger specimens is generally smaller, about 100° .

Comparison:—This new species is different from *Pulsidis angulata*, sp. nov. in its finer concentric ribs, radial groove on the area, and less definite posterior carina. The new species is similar to "*Pulsidis*" *higoensis* in the outline, but has a median groove on the area. In the adult specimens, the new species differs from *Pulsidis nagatoensis* in its anterior location of umbo, finer concentric ribs, distinct median radial groove on much elongated area, but in the younger specimens this new species is very similar to *Pulsidis nagatoensis* in the subtrigonal outline. For this reason, it could have been derived from *P. nagatoensis*.

Occurrence:—Abundant at Locs. 6 and 8. Probably Lower Aptian.

Acknowledgments

I wish to express my thanks to Professor Masayuki Tashiro of Kochi University, for his pertinent instruction and reading the first draft. Thanks are also due to Emeritus Professor Tatsuro Matsumoto of Kyushu University, for

his critical reading the manuscript with encouragement, Emeritus Professor Yoshihisa Ohta (=Ota) of Fukuoka University of Education, for his valuable suggestion, and Dr. Keisaku Tanaka of former staff of Geological Survey of Japan, Professor Itaru Hayami of the University of Tokyo, Mr. Masao Otsuka of Kogen Junior-high School in Kumamoto, and Dr. Tomoki Kase of the National Science Museum for their kind helps for this study.

This study was supported in part by Grant-in-Aid for Scientific Research from the Ministry of Education, Science and Culture, project nos. 58916031 and 59916034.

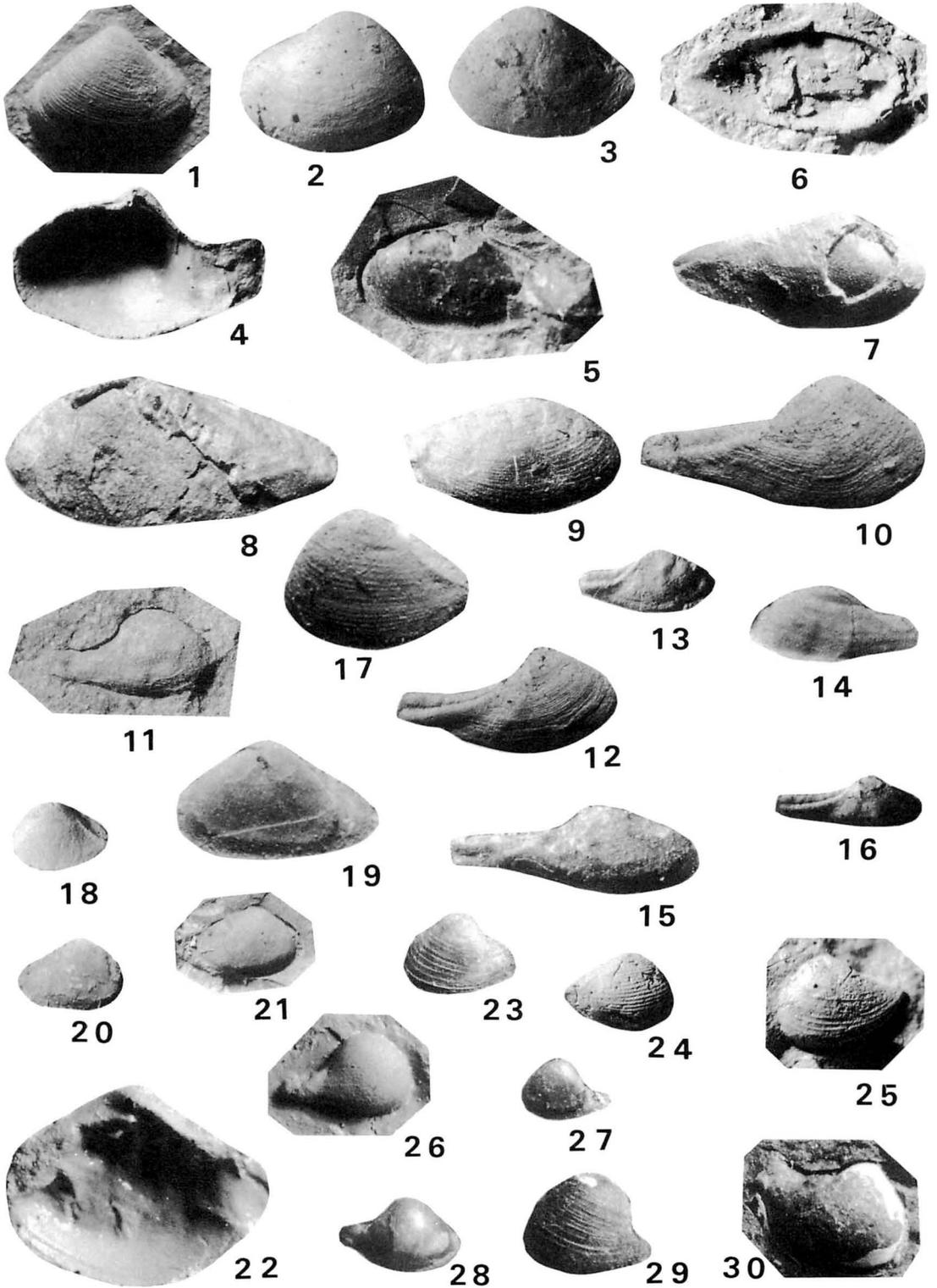
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Explanation of Plate 95

- Figs. 1-4. *Pulsidis nagatoensis* Ota P. 482
Gum cast of external moulds (Fig. 1, KSG-K011, $\times 3$; Fig. 2, KSG-K012, $\times 3$; Fig. 3, KSG-K004, $\times 3$). Gum cast of internal mould (Fig. 4, KSG-K002, $\times 3$).
- Figs. 5-9. *Pulsidis tashiroi*, sp. nov. P. 483
Internal mould (Fig. 5, KSG-K039A, $\times 2.5$). Gum cast of internal mould (Fig. 6, KSG-K046, $\times 3$). External moulds (Fig. 7, KSG-K042, $\times 2.5$; Fig. 8, KSG-K038, $\times 3.5$; Fig. 9, KSG-K039B, $\times 2.5$).
- Figs. 10-16. *Pulsidis rostrata*, sp. nov. P. 486
Gum cast of external moulds (Fig. 10, KSG-K029, $\times 4.5$; Fig. 12, KSG-K026, $\times 4$; Fig. 13, KSG-K098, $\times 2.5$; Fig. 16, KSG-K027, $\times 2$). Internal moulds (Fig. 11, KSG-K031, $\times 3$; Fig. 14, KSG-K036, $\times 2.5$; Fig. 15, KSG-K099, $\times 3$).
- Figs. 17-21. *Pulsidis angulata*, sp. nov. P. 483
Gum cast of external moulds (Fig. 17, KSG-K015, $\times 6$; Fig. 18, KSG-K021, $\times 3$). Internal moulds (Fig. 19, KSG-K022, $\times 6$; Fig. 20, KSG-K017, $\times 3$; Fig. 21, KSG-K014, $\times 3$).
- Figs. 22-30. *Pulsidis sanchuensis*, sp. nov. P. 483
Gum cast of internal moulds (Fig. 22, KSG-K096, $\times 7$; Fig. 24, KSG-K088, $\times 3.5$; Fig. 25, KSG-K089, $\times 4$; Fig. 26, KSG-K092, $\times 3$). External moulds (Fig. 23, KSG-K095, $\times 3$; Fig. 29, KSG-K091, $\times 4$). Internal moulds (Fig. 27, KSG-K087, $\times 3$; Fig. 28, KSG-K090, $\times 4$; Fig. 30, KSG-K086, $\times 5$).



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 Japanese with English abstract).

Eri 衣領, Funagawara 船河原, Hibihara 日比原, Hinagu 日奈久, Kagahara 神ヶ原, Kasa-
 nokawa 笠ノ川, Kawaguchi 川口, Kawanouchi 川の内, Kumagawa 球磨川, Mamonozawa
 間物沢, Ofunato 大船渡, Ryoseki 領石, Sakamoto 坂本, Sakayoriue 坂ヨリ上, Sebayashi
 瀬林, Shiroi 白井, Tanoura 田浦, Todoronotaki 轟の滝, Yamabagoe 山馬越, Yonenomoto
 米元, Yoshimi 吉見, Yoshimo 吉母, Yunoki 柚ノ木.

日本の前期白亜系産 *Pulsidis* 属について: これまで記載されてきた *Pulsidis* 属を再検
 討した。その結果これまで *Pulsidis* 属に含まれていた *P. higoensis* 及び *P. okadai* を
 本属から除外し, 新たに4新種を含む5種を記載した。それらは *Pulsidis nagatoensis* Ota,
P. angulata, sp. nov., *P. sanchuensis*, sp. nov., *P. tashiroi*, sp. nov., *P. rostrata*, sp.
 nov. である。 香西 武

822. PALYNOLOGICAL STUDY OF 200-METER CORE SAMPLES
FROM LAKE BIWA, CENTRAL JAPAN
II: THE PALAEOVEGETATIONAL AND PALAEOCLIMATIC
CHANGES DURING THE CA. 250,000 — 100,000 YEARS B. P.*

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Kanazawa University, Kanazawa 920, Japan

Abstract. The writer had stated an outline of the palaeovegetational and palaeoclimatic changes during the last 600,000 years from the point of view of palynological investigation of samples taken at intervals of 5 m throughout a 200-meter core drilled at the lake bottom 65 m of water depth in Lake Biwa, Japan. The writer further treated about 200 samples taken at intervals of 25 cm over about 50 m between 55 m- to 110 m-horizons of the 200-meter long core for analyses of the detailed vegetational and climatic changes in and around the lake during about 150,000 years between about 250,000 years B.P. and 100,000 years B.P.

On the basis of the pollen diagrams, the lacustrine deposits during the time 250,000 to 100,000 years B.P. are divided palynologically into four pollen zones.

In the global correlation between the palaeoclimate from Lake Biwa, other terrestrial records from Central Europe, the sea level changes from Southern Kanto in Japan and Western Mediterranean, and the oxygen isotope records from the Caribbean Sea and Equatorial Pacific *etc.*, the writer found a remarkably noticeable similarity between major trends from them.

Introduction

The present writer had reported on outline of the palaeovegetational and palaeoclimatic changes during the last about 600,000 years based on the palynological analyses of samples taken at intervals of about 5 meters throughout a 200-meter core obtained from Lake Biwa, Central Japan (Fuji, 1973, 1983, Fuji & Horie,

1972, 1977). The climatic curve and ages ascertainable from Lake Biwa were found to display a similarity to the palaeotemperature curve (oxygen isotope ratio determination) from the Caribbean Sea (Emiliani & Shackleton, 1974) and the Equatorial Pacific (Shackleton & Opdyke, 1976, 1977), and to the environmental changes (loess, palaeosol and gastropod faunal records) from Central Europe (Kukla, 1970,

*: Received October 7 1985; revised manuscript received October 11, 1986; Read June 18, 1977 at Shizuoka University and June 24, 1984 at Akita University.

Contribution from the Department of Earth Science, Faculty of Education, Kanazawa University; New Series No. 119.

1975).

The writer further treated about 200 samples taken at intervals of 25 cm throughout about 50 meters from 55 meters to 110 meters—horizons in depth of the 200-meter core for analyses of the detailed vegetational and climatic changes around Lake Biwa in the period, about 150,000 years, between about 250,000 years B.P. and about 100,000 years B.P.

In this article, the vegetational and climatic changes ascertainable from Lake Biwa in the period between about 250,000 years ago and about 100,000 years ago will be discussed from the view point of palynological analyses.

Additionally the topography, geology, vegetation, and climate around Lake Biwa, and detailed description on the method for reconstruction of palaeoclimate were already given in the writer's paper (Fuji, 1983).

Acknowledgments

I am greatly indebted to Emeritus Prof. Herbert E. Wright Jr. of the Limnological Research Centre, University of Minnesota, Minneapolis, U.S.A., and to Prof. Shoji Horie of the Institute of Palaeolimnology and Palaeo-environment on Lake Biwa, Kyoto University for their kind advice and for the helpful critical reading of the manuscript. I am indeed grateful for the support and encouragement of Emeritus Prof. Teiichi Kobayashi of University of Tokyo during this investigation. I also acknowledge the help of the member of the Lake Biwa Palaeolimnological Research Group, especially the late Prof. Naoto Kawai of Osaka University, Prof. Takuo Yokoyama of Doshisha University, Prof. Sei'ichi Kanari of Hokkaido University, and Prof. Nobuyuki Nakai of Nagoya University. My investigation was possible through a Scientific Grant from the Ministry of Education, Japanese Government for fifteen years (1971 to 1985) and a help of University of Minnesota, U.S.A.

Palynological investigation

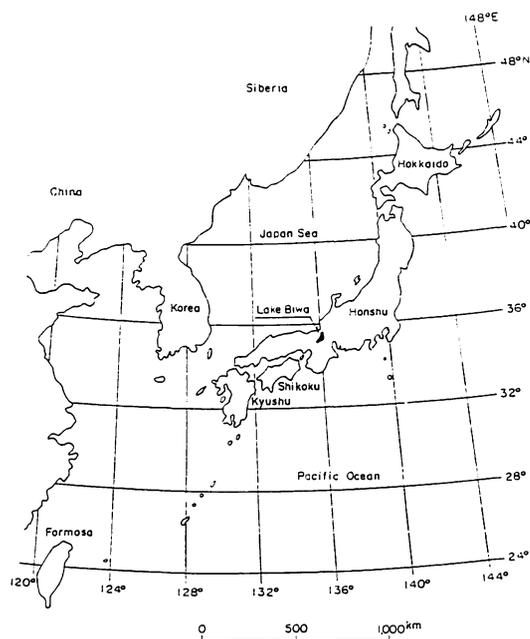
(A) Locality of the boring and samples

A 200-meter core used for the present palynological analyses was drilled in 1971 from the bottom of Lake Biwa 65 meters below the present lake water level. The core samples are composed mainly of dark greenish blue soft homogeneous muddy clay with about 30 thin volcanic ash layers. About 200 samples taken at intervals of about 25 cm from 55 meters to 110 meters below the present lake bottom were analyzed. The samples taken from the same horizons were analyzed for geochemical and organic chemical components, fossil diatom and microanimals, and also from the view points of palaeomagnetism and granulometric analyses.

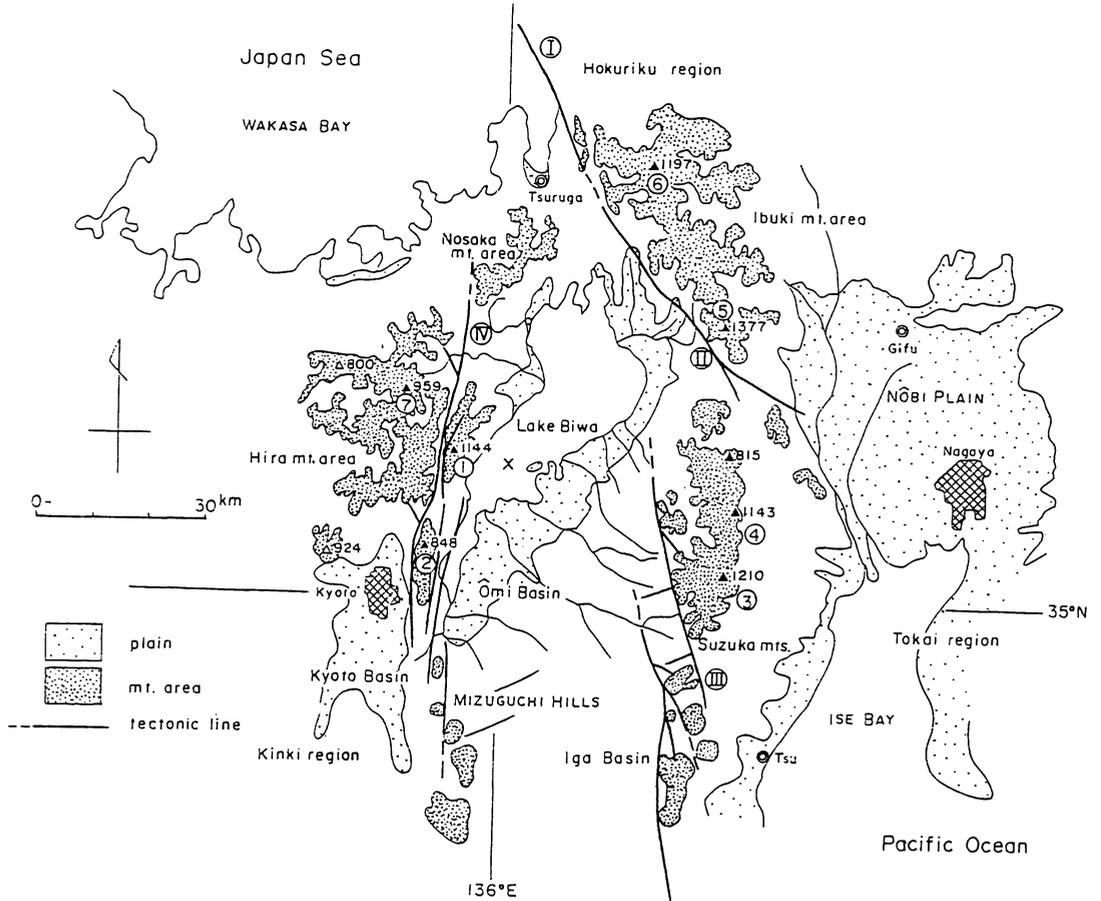
(B) Preparation and examination for pollen analyses

The samples were treated by the HF-KOH-acetolysis method, and then treated by a saturated solution of $ZnCl_2$.

The pollen grains and spores mounted on slides for a microscopic observation were identi-



Text-fig. 1. Locality map showing the studied area.



①: Mr. Hira, ②: Mt. Hiei, ③: Mt. Gozaisho, ④: Mt. Fujihara-dake, ⑤: Mt. Ibuki, ⑥: Mt. Mikuni-ga-dake, ⑦: Mt. Mikuni-dake, ①: Kaburaki tectonic line, ②: Yanagase tectonic line, ③: Suzuka tectonic line, x: boring locality.

Text-fig. 2. Topographic map of the Lake Biwa area, Central Japan (after Fuji, 1983).

fied and counted by use of a mechanical stage of a microscope (Olympus Nomarsky-type tricular microscope). The counting of pollen grains was continued until more than 1,000 arboreal pollen grains. The identification of pollen grains was conducted with the aid of a reference collection of about 500 slides of important trees, shrubs, and aquatic herbs of the Japanese Islands in possession of the Department of Earth Science, Kanazawa University, and also a reference collection of about 9,000 slides kept in the Limnological Research Centre, University of Minnesota,

Minneapolis, the United States of America.

(C) Construction of the diagrams

Shown from the left to the right in the pollen diagrams are sediment stratigraphy and lithofacies, depth in meter, spectrum number, fission-track dates, palaeomagnetic stratigraphy, pollen zoning, palaeoclimate, summary diagram, pollen profiles of each taxon and assemblage zones. The pollen sum was used on the pollen types concerned on the local situation and on the kind of deposits.

Percentages in the diagrams of this article are

shown on two scales; the scale with 10 × exaggeration permits the accurate plotting of minor curves and minor fluctuations. The summary diagram is composed of changes in the ratio between total AP and total NAP, and of the percentage of boreal type plants (Polar — Subpolar plants), Cool Temperate plants, Cool Temperate — Temperate plants, plants of the middle area of the Cool Temperate — Warm Temperate zone, and plants of the southern area of the Temperate — Subtropical zone, calculated on the basis of the warmth index (month-degrees) as described in a later section.

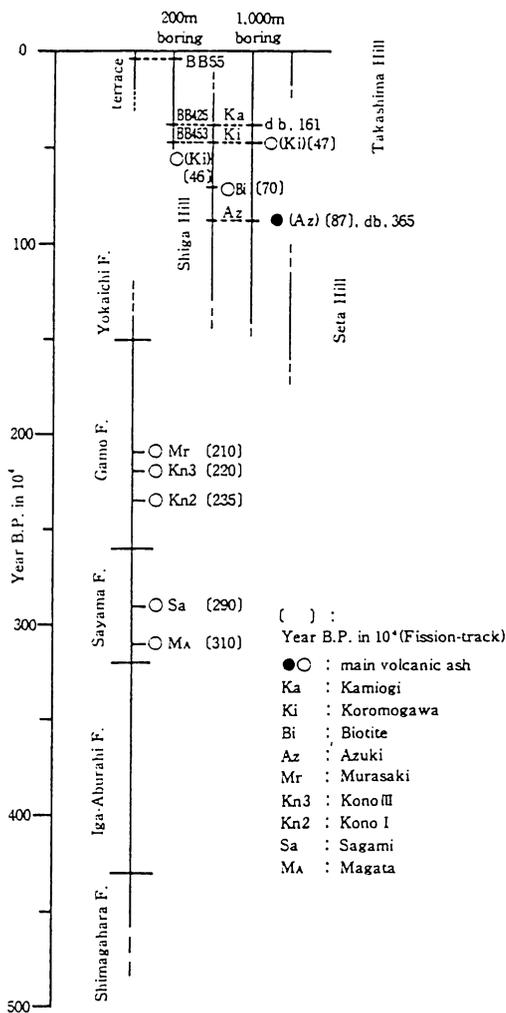
(D) Method for interpretation of palaeovegetation and climatic history

The writer depends upon the pollen analyses for the reconstruction of vegetation on the basis of the pollen spectra obtained from the 200-meter core samples. He has employed two methods, namely, (1) pollen spectra of the modern samples collected from Lake Biwa and its vicinity, and also from various localities of some climatic zones throughout the Japanese Islands, and (2) the warmth index (month-degrees). With regard to this index, the detailed descriptions were already given (Fuji, 1983).

(E) Dating and sedimentation rates

The dating of the core samples in the representative depth of the core gives important and useful information. The determination of the age for the upper 11.5 meters of the core obtained from Lake Biwa has been carried (Horie *et al.*, 1971). In the recent study of the 200-meter core samples, Nishimura and Yokohama (1975) present the invaluable data concerning the age-determination of the deeper horizon of the core by the fission-track method. These results enable the present writer to determine the date of the boundary between the glacial and interglacial ages, or between the stadial and interstadial, or of characteristic events in a climatic fluctuation of the ancient Lake Biwa.

The age was determined by applying a suitable curve-fitting method to the basic data obtained from the ^{14}C and fission-track methods as shown in Table 1. According to Kanari's calculation (Kanari & Takanoya, 1975), the absolute age at



Text-fig. 3. Chronological correlation among the Quaternary deposits in and around Lake Biwa (after Fuji, 1983).

the horizon of 200 meters below the bottom surface is 565,000 years B.P., which is not inconsistent with the stratigraphic data and the results inferred from the palaeomagnetism and palaeoclimate on the basis of the correlation between the writer's previous curve from Lake Biwa (samples from 5 meters interval) (Fuji, 1983) and Emiliani's generalized temperature curve (Emiliani & Shackleton, 1974) for the Caribbean Sea for the last about 700,000 years.

In 1973, a new method of age determination

was developed for the core under the condition of a constant sedimentation rate (Yamamoto *et al.*, 1973). The age of the respective layer of the 200-meter core is estimated for the constant sedimentation rate of 0.354 mm/yr., which corresponds well to the observed sedimentation rate at the present (Toyoda *et al.*, 1968).

(F) Zoning of pollen assemblage

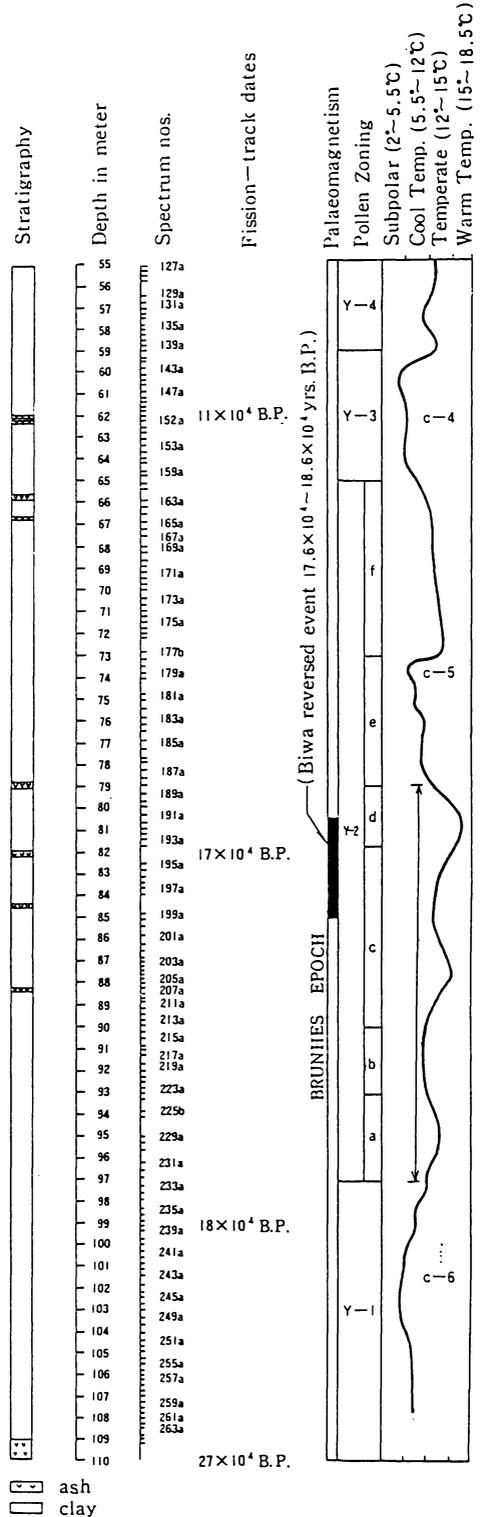
In order to facilitate description of pollen assemblages and their discussion, the pollen diagrams are divided into zones and subzones. These zones and subzones are based upon conspicuous changes in pollen percentages. Changes in the ratio, Total AP/Total NAP, can be described, while alternation of the values of one or two pollen types may also lead to the establishment of pollen zones. Where pollen zones display the same nature characterized by assemblage of pollen grains and spores, the present writer has attempted to indicate them under the same letter code in order to facilitate comparison. These pollen zones are restricted to the series of diagrams under discussion. Minor differences of the pollen assemblage in the zones lead to determining subzones.

According to the present writer's analyses, the deposits are divided into four pollen zones, Y-1, Y-2, Y-3, and Y-4 in an ascending order, and the Y-2 pollen zone is classified into six pollen subzones by minor differences of pollen assemblage and their characters.

- (1) Pollen Zone Y-1, depth: 108 – 97 m;
240,000 – 200,000 yr.B.P.

This zone is characterized by a large value of boreal conifers such as *Abies*, *Picea*, *Tsuga*, *Larix* and *Pinus haploxylon*-type. These conifers reach to 76 – 99% (about 90% on average). The characteristic plants growing only in the Subpolar or Subalpine zone (warmth index in month degrees: 15 – 55°) show the value of about 5% on average, though the plants range from 0.2 to 0.7% in the

Text-fig. 4. Stratigraphy, spectrum nos., fission-track data, palaeomagnetism, pollen zoning, and palaeoclimatic change of the 55 to 110 meters samples from a 200-meter core of Lake Biwa. Arrow part: climatic cord no. t-5



other pollen zones. In contrast to them, *Pinus diploxylon*-type, which includes the temperate *Pinus thunbergii* and *P. densiflora*, shows a low percentage. In this zone, trees such as *Ulmus*, *Betula* and *Fagus* large type which grow in the Cool Temperate zone, have the lowest value (average 1.5%) throughout all these pollen zones. The same phenomena are recognized in the frequency of plants (pollen grains) which grow in the Cool Temperate and Temperate zones, in the middle area of the Cool Temperate and Temperate zones, and in the southern area of the Temperate and Subtropical zones. The main component of the Y-1 pollen zone is *Abies* (55–86%), *Tsuga* (10–27%), *Picea* (5–15%), and *Pinus haploxylon*-type (4–8%).

(2) Pollen Zone Y-2, depth: 97–65 m;
200,000–126,000 yr.B.P.

The Y-2 pollen zone is characterized by the abundance of plants which grew in the Cool Temperate zone, and in the Cool Temperate and Temperate zones. However, on the frequency throughout all this zone, plants adapted to the climate of the southern part of the Temperate and Subtropical zones are not always abundant. Boreal conifers such as *Abies*, *Picea*, *Tsuga*, and *Larix* are few throughout this zone.

On the basis of fluctuations in the pollen values of boreal conifers and minor changes of other types, this zone is divided into six pollen subzones, Y-2-a, Y-2-b, Y-2-c, Y-2-d, Y-2-e, and Y-2-f.

Y-2-a Pollen Subzone, depth: 97–93 m;
200,000–193,000 yr.B.P.

This pollen subzone is characterized by a drastic change of pollen assemblage; accordingly, boreal conifers including Subpolar plants such as *Pinus haploxylon*-type show an abrupt decrease (lowering to 52% from 90%) in comparison with the Y-1 pollen zone. In contrast to them, the pollen frequency of plants which thrive in the Cool Temperate and Temperate zones shows a higher value than that of the Y-1 pollen zone, although the relative frequency of plants which grow in the southern part of the Temperate and Subtropical zones do not increase as much as that of the Cool Temperate plant. This pollen assembl-

age is shown as follows: Subpolar or Subalpine plants (only conifers) 0.9%, boreal conifers 52%, Cool Temperate plants 5.5%, Cool Temperate–Temperate plants 0.9%; the main component is *Abies* (23–51%)–*Cryptomeria* (6–28%)–*Pinus diploxylon*-type (12–14%)–*Tsuga* (9–13%)–*Alnus* (9%)–*Fagus* small type (7%)–*Lepidobalanus* (3–7%).

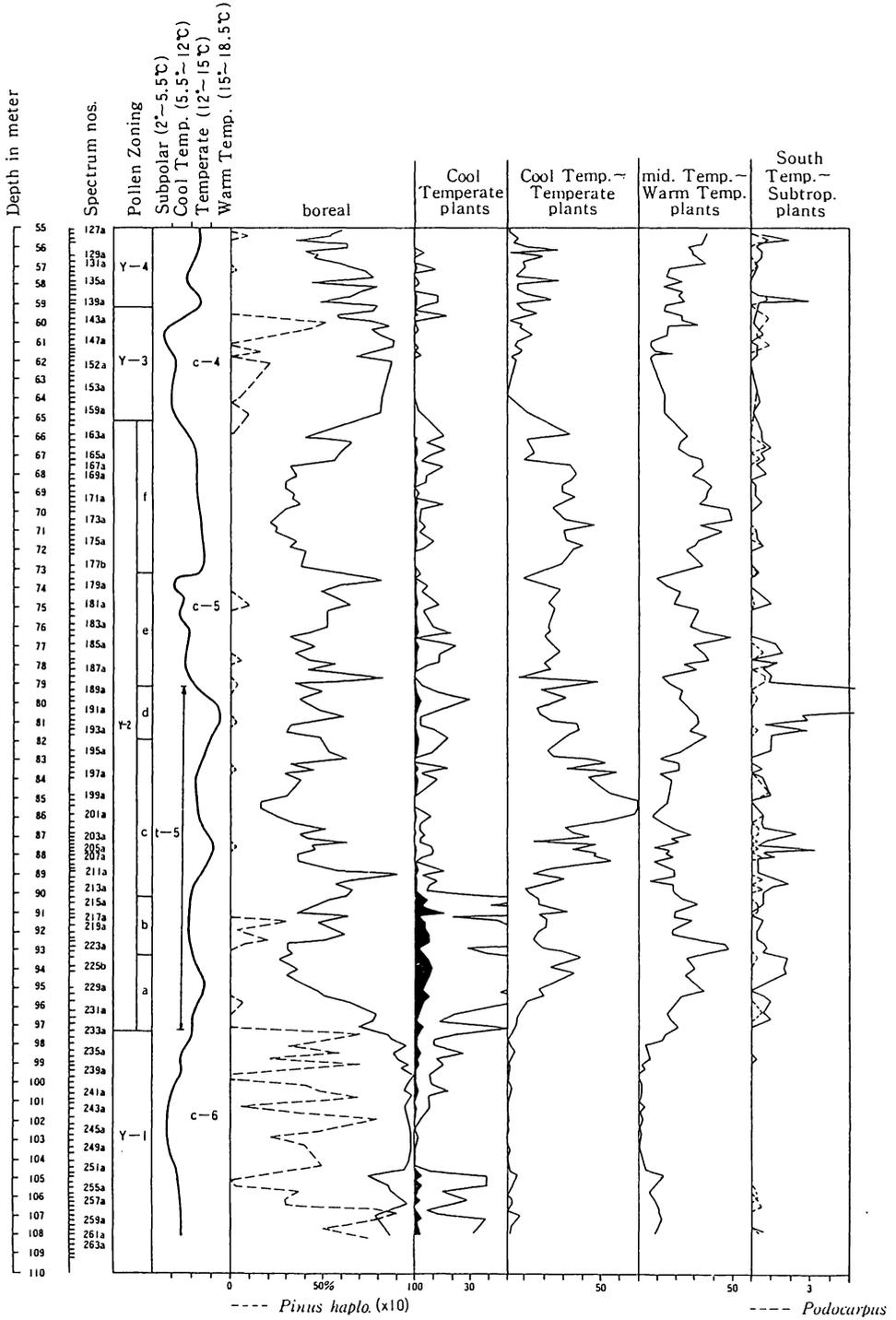
Y-2-b Pollen Subzone, depth: 93–90 m;
193,000–185,000 yr.B.P.

The main component of this pollen subzone is *Pinus diploxylon*-type (13–37%)–*Abies* (15–36%)–*Cryptomeria* (9–29%)–*Tsuga* (26%)–*Lepidobalanus* (10–15%)–*Fagus* large type (4–16%). This pollen assemblage is as follows: Subpolar or Subalpine plants 0.3–3% (average 1.2%), boreal conifers 31–64% (average 49%), Cool Temperate plants 2–16% (average 6.2%), Cool Temperate–Temperate plants 12–32% (average 18%), middle area of the Cool Temperate–Temperate plants 17–47% (average 27%), and south area of the Temperate–Subtropical plants 0.2–0.8% (average 0.5%). As mentioned above this subzone is characterized by a little increase of plants of the Cool Temperate zone and a decrease of boreal conifers, especially the frequency of plants of the Cool Temperate zone has the highest value throughout the samples.

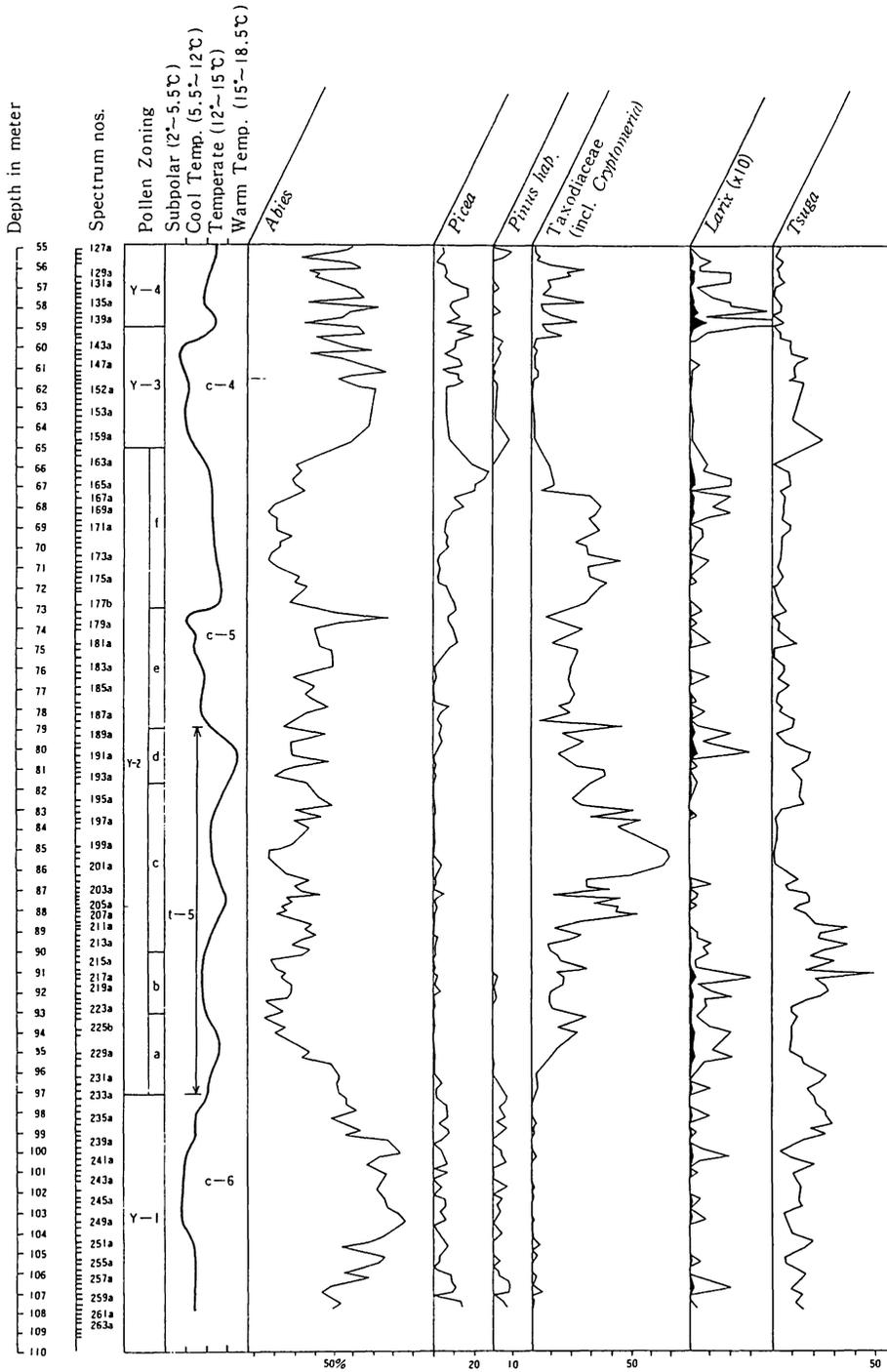
Y-2-c Pollen Subzone, depth: 90–82 m;
185,000–166,000 yr.B.P.

This pollen subzone is characterized by the smallest value of Subpolar or Subalpine plants throughout all the samples treated at the present and, in contrast to the above-mentioned phenomenon, by the largest value of plants thriving in the Cool Temperate–Temperate zones over all the samples. The pollen assemblage of this pollen subzone is shown as follows: Subpolar plants 0–1% (average 0.2%), boreal conifers 16–70% (average 44%), Cool Temperate plants 0–1.9% (average 0.6%), plants in the Cool Temperate–Temperate 14–69% (average 39%), plants growing in the middle area of the Cool Temperate and Temperate zones 7–36% (average 16%), plants thriving in the southern area of the Temperate and Subtropical zones 0–3.3% (average 0.8%).

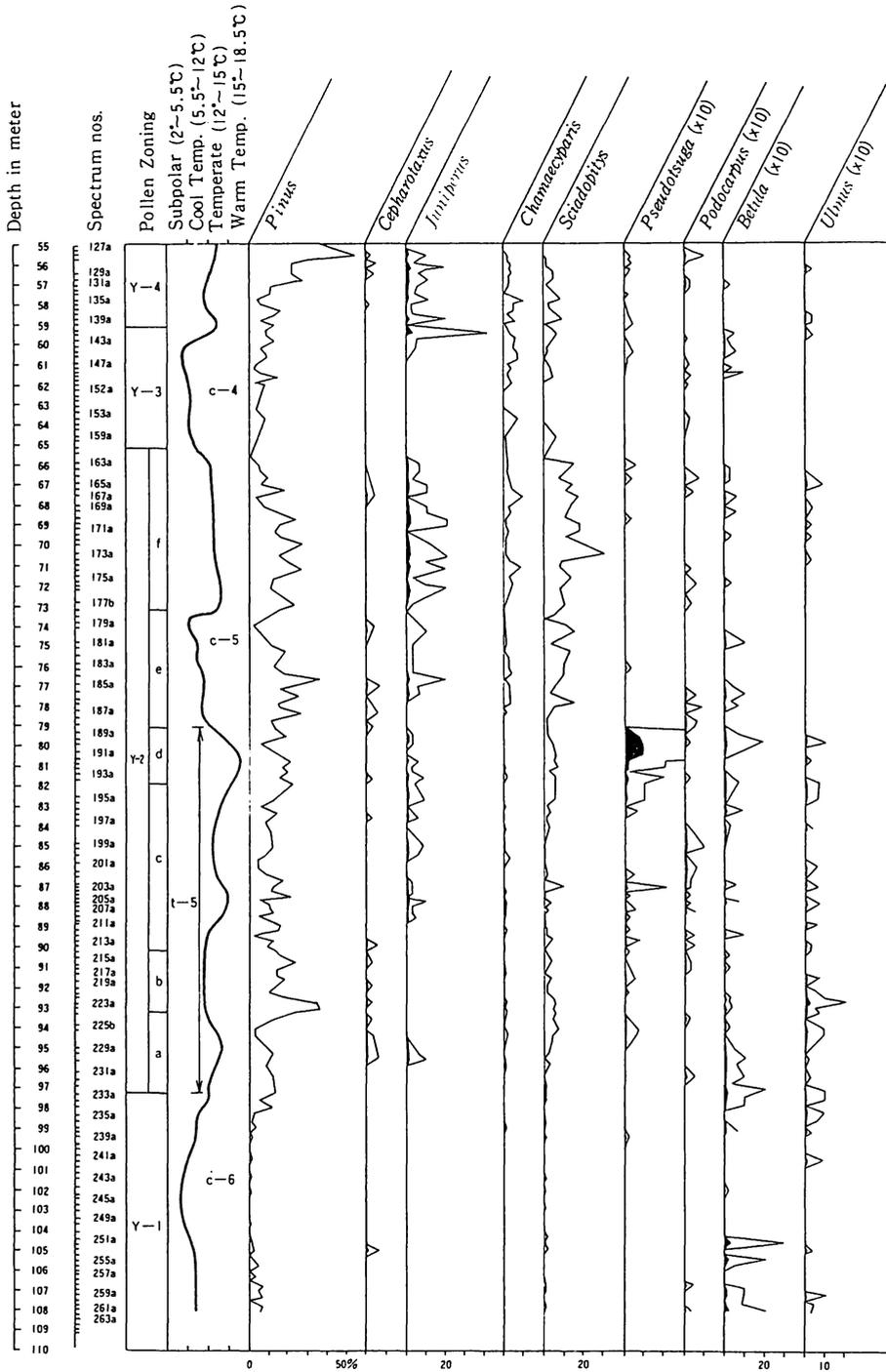
The main element of this pollen subzone is



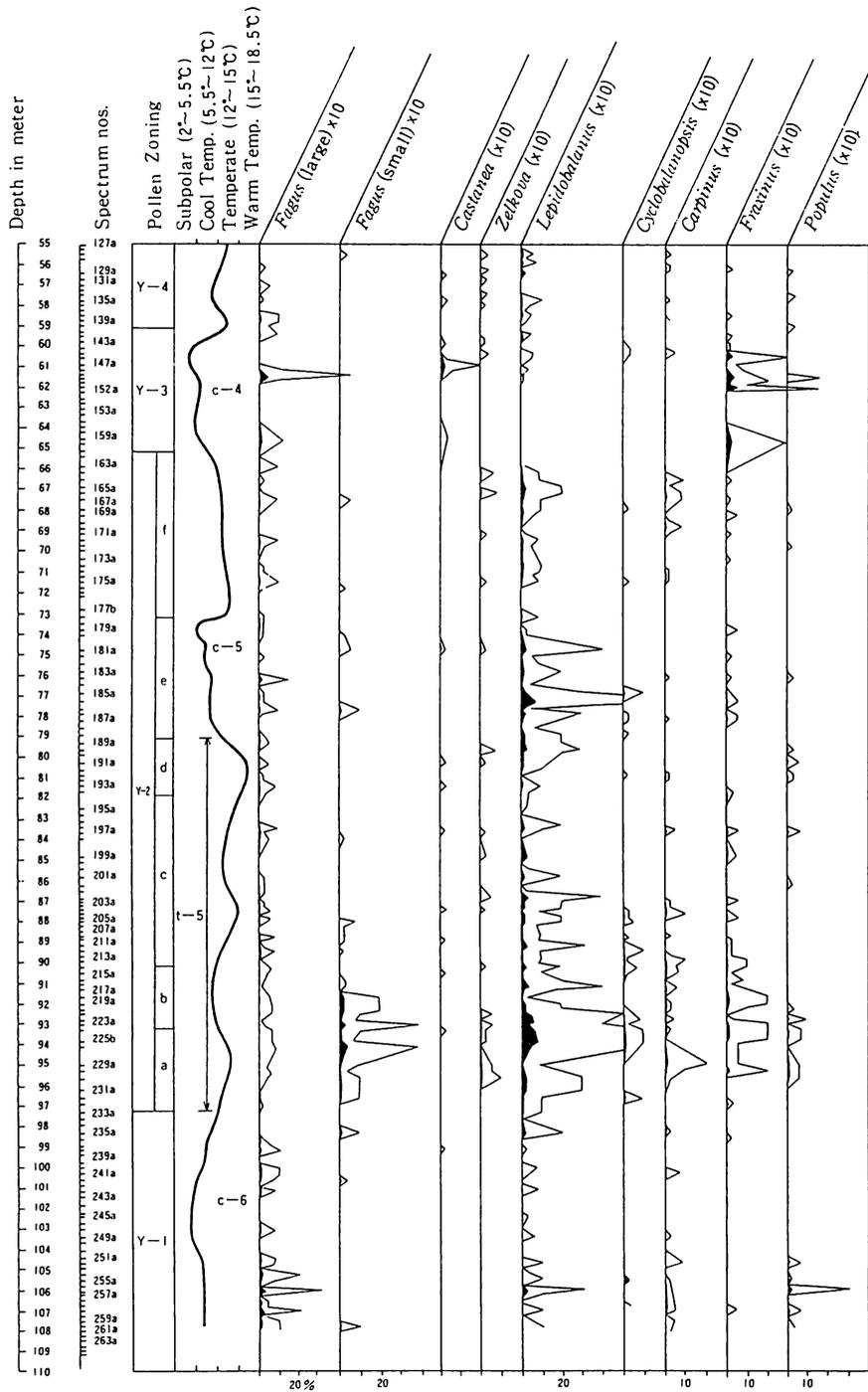
Text-fig. 5. Summary diagram of the 55 to 110 meters samples from the 200-meter core.



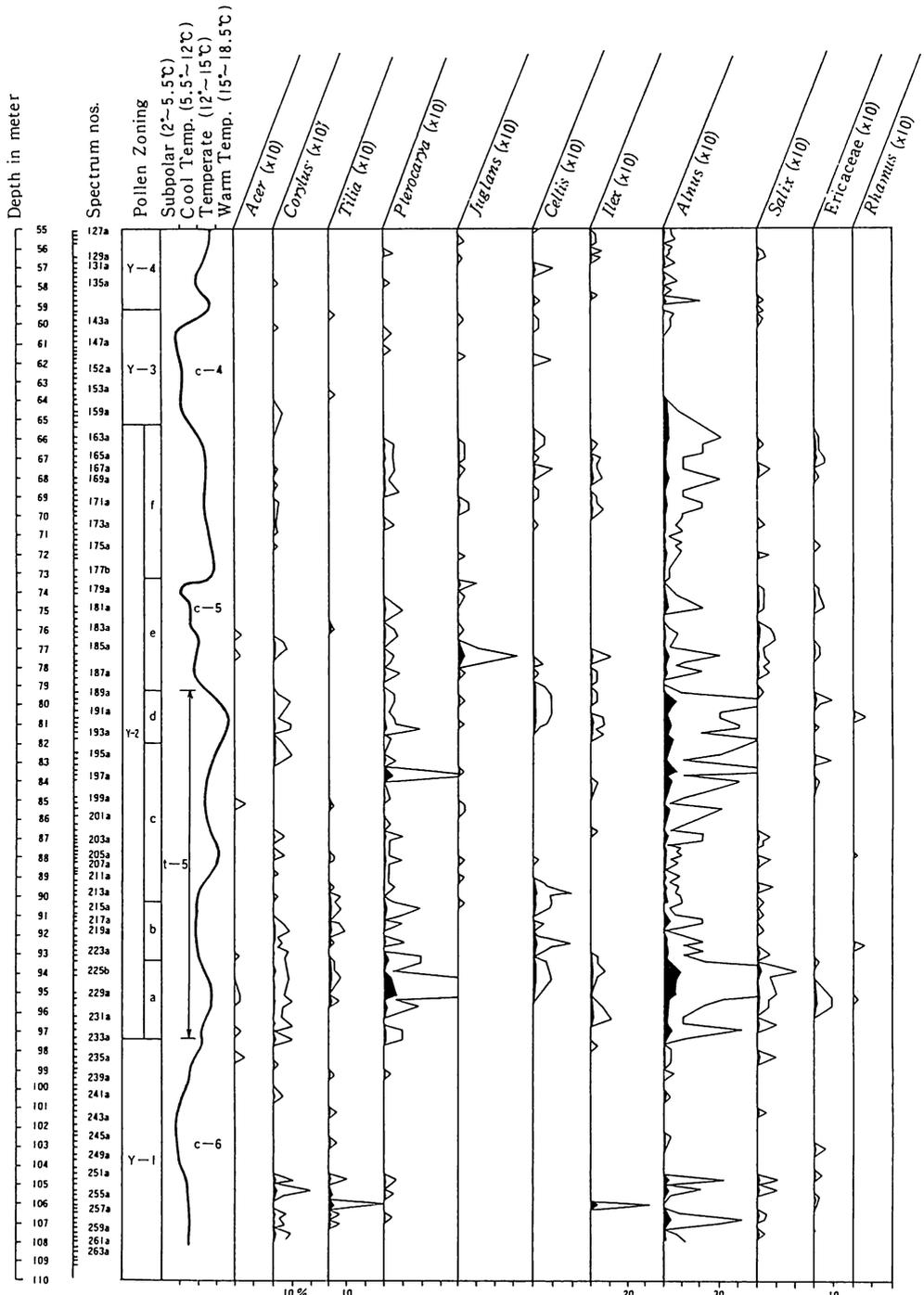
Text-fig. 6. Conifers pollen diagram of the 55 to 110 meters samples from the 200-meter core.



Text-fig. 7. Conifers and deciduous broad leaved plant pollen diagram from the 200-meter core.



Text-fig. 8. Broad leaved plant pollen diagram from the 200-meter core (1).



Text-fig. 9. Broad leaved plant pollen diagram from the 200-meter core (2).

Cryptomeria (21–69%) — *Abies* (19–46%) — *Pinus diploxylon*-type (5–22%)—*Tsuga* (2–16%) — *Lepidobalanus* (4%) — *Sciadopitys* (2–5%).

Y-2-d Pollen Subzone, depth: 82–79 m; 166,000 — 158,000 yr.B.P.

This pollen subzone is characterized by the largest amount of plants thriving in the southern part of the Temperate — Subtropical zones. The percentage of *Podocarpus* ranges from 0.3 to 1.2% (average 0.3%). The main component of this pollen subzone is *Cryptomeria* (17–46%)—*Abies* (22–43%) — *Pinus diploxylon*-type (18–20%) — *Tsuga* (10–19%); and also, Subpolar or Subalpine zone 0–3% (average 0.9%), boreal conifers 30–63% (average 42%), Cool Temperate plants 0.3–3% (average 1.0%), Cool Temperate — Temperate plants 16–48% (average 29%), plants in the middle part of the Cool Temperate — Temperate zones 15–31% (average 26%), and plants in the southern part of the Temperate — Subtropical zones 0.6–9.6% (average 4.5%).

Y-2-e Pollen Subzone, depth: 79–73 m; 185,000 — 144,000 yr.B.P.

In this pollen subzone, a decrease of plants in the southern part of the Temperate — Subtropical zones is matched by a similar increase in the value of boreal conifers. The pollen assemblage is shown by boreal conifers 32–83% (average 54%), Subpolar plants 0–1% (average 0.3%), Cool Temperate plants 0–2.4% (average 0.7%), plants in the Cool Temperate — Temperate zones 5–48% (average 21%), plants in the middle part of the Cool Temperate — Temperate zones 9–49% (average 27%), and plants growing in the southern part of the Temperate — Subtropical zones 0–2% (average 0.5%). The main component of this pollen subzone is *Abies* (24–70%), *Pinus diploxylon*-type (10–35%), *Cryptomeria* (14–27%), and *Sciadopitys* (about 10%). Besides these conifers, *Sciadopitys* is one of evergreen conifers and grows only in the recent montane areas of the Kii Peninsula, Shikoku and Kyushu regions, and also this pollen subzone is characterized by a higher value of this plant.

Y-2-f Pollen Subzone, depth: 73–65 m; 144,000 — 126,000 yr.B.P.

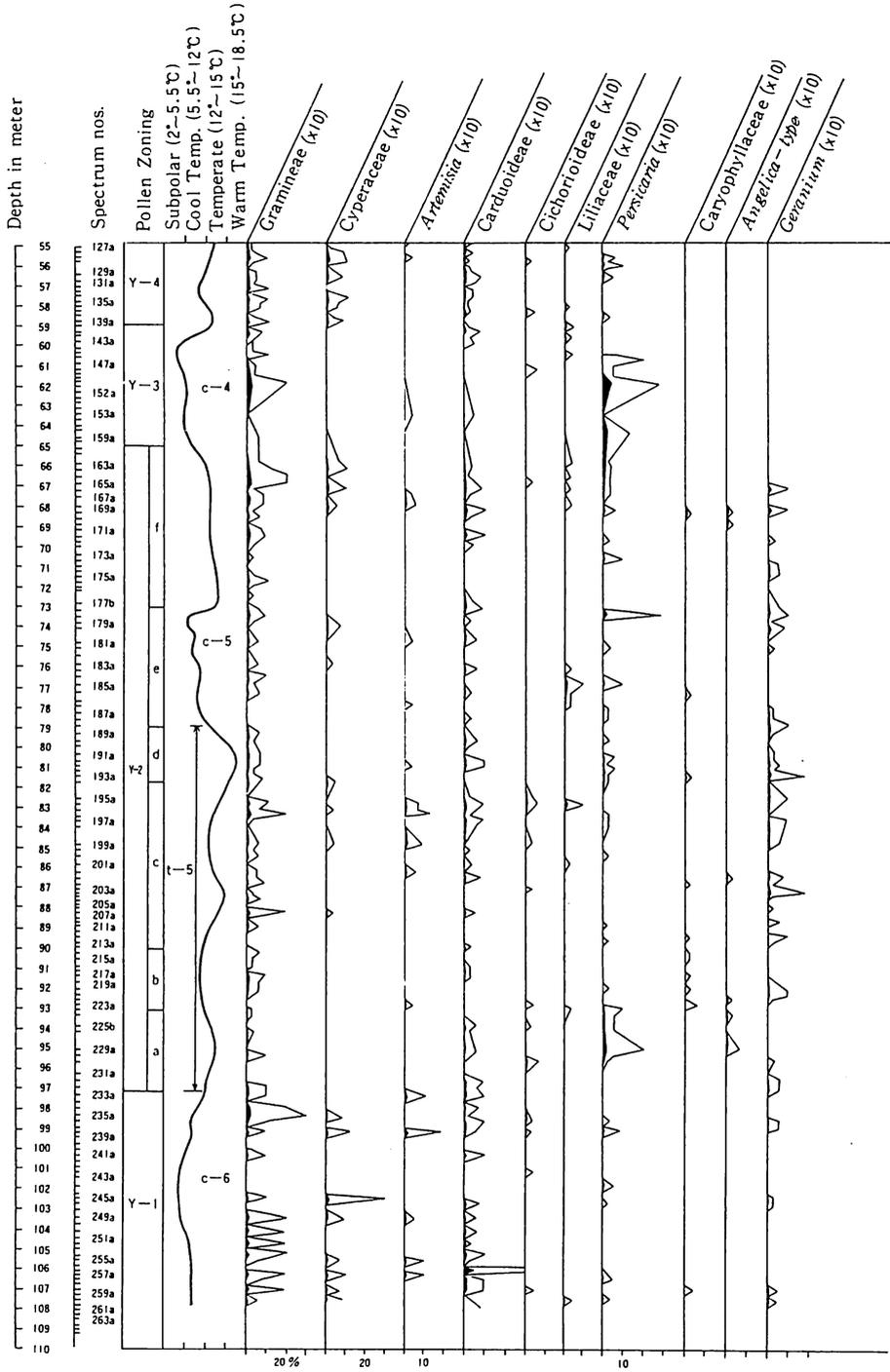
This pollen subzone is characterized by a decrease of boreal conifers. This decrease is matched by an increase of plants of the Cool Temperate — Temperate zones. The pollen assemblage of this pollen subzone is shown by *Cryptomeria* (12–46%)—*Abies* (14–45%) — *Sciadopitys* (11–29%).

(3) Pollen Zone Y-3, depth: 65 — 59 m; 126,000 — 113,000 yr.B.P.

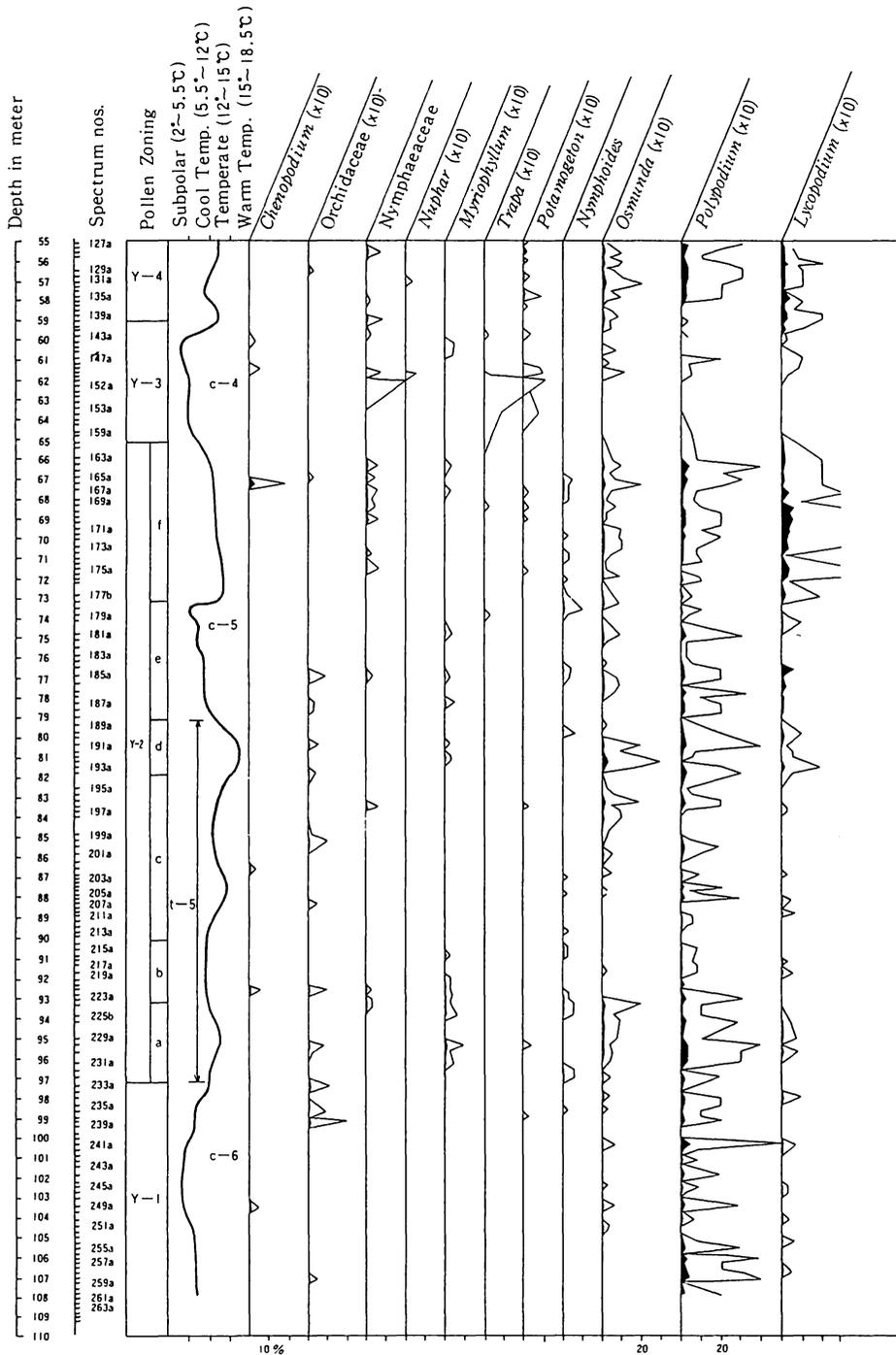
This pollen zone is characterized by a drastic increase of boreal conifers (up to about 80%) and Subpolar plants (up to 2%), and by a decrease of plants of the Cool Temperate — Temperate zones and of the middle area of the Cool Temperate — Temperate zones. The pollen assemblage is shown by Subpolar or Subalpine plants 0.8 — 5% (average 2%), boreal conifers 57–88% (average 80%), Cool Temperate plants 0–2% (average 0.6%), plants of the Cool Temperate — Temperate zones 0.4–7.5% (average 0.2%), plants in the middle area of the Cool Temperate — Warm Temperate zones 6–19% (average 11%), and plants in the southern Temperate — Subtropical zone 0–0.4% (average 0.1%). The main component is *Abies* (average about 55%)—*Picea*—*Tsuga*—*Cryptomeria*.

(4) Pollen Zone Y-4, depth: 59–55 m; 113,000–104,000 yr.B.P.

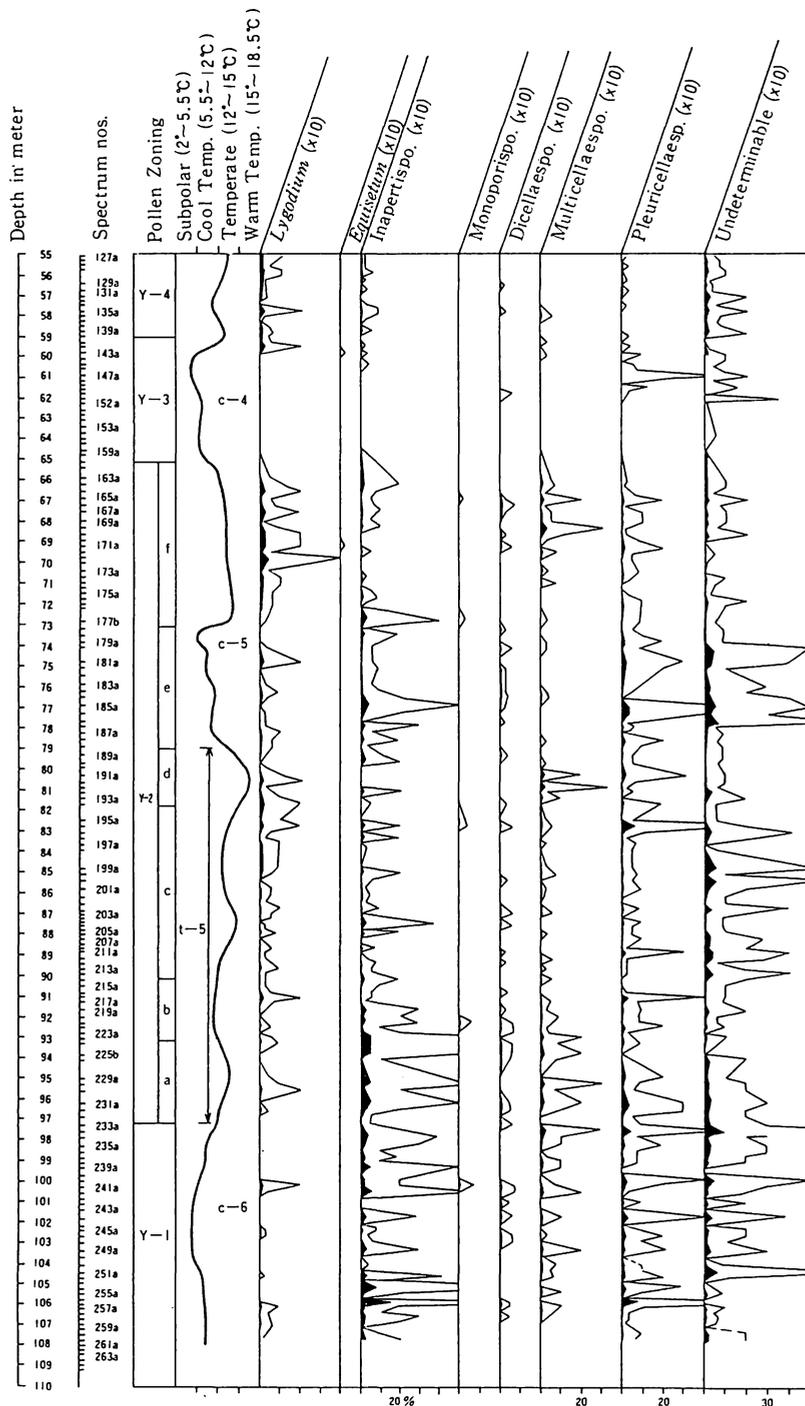
In this pollen zone, a drastic increase of plants growing in the Cool Temperate — Temperate zones and in the middle area of the Cool Temperate—Warm Temperate zones is matched by an abrupt decrease of boreal conifers and Subpolar plants. The pollen assemblage is shown as follows: Subalpine or Subpolar plants 0–4% (average 1.5%), boreal conifers 34–81% (average 57%), plants of the Cool Temperate zone 0 — 1.3% (average 0.3%), plants in the Cool Temperate—Temperate zones 2–29% (average 12%), plants in the middle area of the Cool Temperate — Warm Temperate zones 13–59% (average 29%), and plants in the southern Temperate—Subtropical zones 0–2% (average 0.8%).



Text-fig. 10. Non-arboreal pollen digram from the 200-meter core (1).



Text-fig. 11. Non arboreal pollen diagram from the 200-meter core (2).



Text-fig. 12. Non-arboreal pollen diagram from the 200-meter core (3).

Discussion on the interpretation of vegetation and climatic history

Pollen Zone Y-1 is characterized by a high percentage of boreal conifers. The maximum value for *Pinus haploxylon*-type, one of the representative plants of the Subpolar or Subalpine zone in the Japanese Island, reaches to about 5% on average in this zone, which is the highest value over all the samples. In contrast, trees growing in the other climatic zones are not abundant. In addition, boreal conifers reach to the highest value of 76–99% (average 90%). Judging from such pollen assemblages and frequencies of the other pollen zones, the climate at that time of this zone may have been as cold as that in the northern part of the Cool Temperate zone. This cold climatic age is correlated with the “c-6” in the present writer’s previous paper (Fuji, 1983).

Pollen Subzone Y-2-a is characterized generally by a drastic decrease (low to 50% from 90%) of boreal conifers, and by a high percentage of plants in the Cool Temperate — Temperate zones in comparison with the Y-1 Pollen Zone. *Abies*, *Cryptomeria*, *Pinus diploxylon*-type and *Tsuga* are the main component in this pollen subzone. The climate at the time of Pollen Subzone Y-2-a was perhaps similar to that of the Cool Temperate—Temperate zones. Therefore, the climate at that time may have been corresponded to that of the Cool Temperate — Temperate zones.

Pollen Subzone Y-2-b is featured by the abundance of plants growing in the Cool Temperate zone and in the middle area of the Cool Temperate from the view point of palaeovegetation. The frequency of *Podocarpus* pollen is more than those of Pollen Subzone Y-2-a and Pollen Zone Y-1. Accordingly, the climate at that time may have been as warm as that of Pollen Subzone Y-2-a.

Pollen Subzone Y-2-c is characterized by the smallest value of Subpolar-type plants and the largest value of plants thriving in the Cool Temperate — Temperate zones. In addition, plants in the Cool Temperate zone show a drastic

decrease. Judging from these data, the climate at that time may have perhaps been similar to that of the southern part of the Cool Temperate — Warm Temperate zones.

In the Y-2-d Pollen Subzone, plants in the southern area of the Temperate — Warm Temperate zones have the highest value (average 4.5%), and, in contrast, plants thriving in the Subpolar and the Cool Temperate zones show a smaller value. Therefore, the climate at the time of Pollen Subzone Y-2-d was perhaps that of the southern area of the Temperate — Warm Temperate zones.

Pollen Subzone Y-2-e is characterized by a decrease of plants in the southern area of the Temperate — Warm Temperate zones and by a similar increase in the value of boreal conifers.

Therefore, the climate at the time of Subzone Y-2-e may have been that of the middle area of the Cool Temperate zone.

Pollen Subzone Y-2-f is characterized by a decrease of boreal conifers and, in contrast to this phenomenon, plants of the Cool Temperate — Temperate zones and of the middle area of the Cool Temperate — Warm Temperate zones decreased. Namely, the climate at the time of this pollen subzone may have been similar to that of the northern area of the Temperate zone. As mentioned above, from the view point of the palaeoclimate, Pollen Zone Y-2 may perhaps be one of the interglacial age, and is divided into six subzones. The palaeoclimate at the time of Pollen Zone Y-2 was clearly warmer than those of Pollen Zones Y-1 and Y-3. Most of this pollen zone correspond to the “t-3” mentioned in the present writer’s previous paper (Fuji, 1983).

Pollen Zone Y-3 is characterized by a drastic increase of boreal conifers and by an increase of plants of the Cool Temperate — Temperate zones and of the middle area of the Cool Temperate — Warm Temperate zones. Therefore, the climate at the time of this pollen zone may have correspond to a climate of the northern area of the Cool Temperate zone and this time was perhaps one of the glacial age. This pollen zone is correlated with the “c-4” of the present writer’s previous paper (Fuji, 1983).

Pollen Zone Y-4 is characterized by a drastic increase of plants in the Cool Temperate — Temperate zones and in the middle area of the Cool Temperate — Warm Temperate zones and by an abrupt decrease of boreal conifer trees. The climate at that time may have been similar to that of the middle area of the Cool Temperate zone or that of the northern area of the Temperate zone.

Data for “time-stratigraphy”

Ages of boundaries between the pollen zones can be estimated by some means such as ¹⁴C, fission-track, sedimentary rate, and palaeomagnetic stratigraphy *etc.* (Horie, 1984).

In regard with radioactive age of an upper part of the 200-meter core, the following data are obtained by Isotopes A Telldyne Co. (Horie *et al.*, 1971).

0.8±0.05 m in depth . . .	1,430±95 yr.B.P.
4.5±0.15 m in depth . .	3,650±105 yr.B.P.
11.5±0.2 m in depth . .	14,980±460 yr.B.P.

Within the core samples some volcanic ash layers are intercalated. They are at least about forty layers, from which Nishimura and Yokoyama (1975) could successfully obtain the following ages by fission-track method as follows:

37 m in depth	8×10 ⁴ yr.B.P.
62 m in depth	11×10 ⁴ yr.B.P.
82 m in depth	17×10 ⁴ yr.B.P.
99 m in depth	18×10 ⁴ yr.B.P.
110 m in depth	27×10 ⁴ yr.B.P.
181 m in depth	46×10 ⁴ yr.B.P.

In a chronostratigraphic investigation of the core samples, it is necessary to establish the rationale of interpolating between the discrete values of absolute dates. A depositional layer, which once deposited on the surface of the lake bottom, begins to contrast its thickness through the consolidation process under the cumulative load of deposits having a unit section, a depositional layer of thickness $d\zeta$ with bulk density ρ_B , which is situated at the depth ζ beneath the bottom surface at present, is originally that which had deposited on the surface t years ago, form-

ing a layer of thickness dS with bulk density ρ_{BO} . During these t years, the layer has experienced contractions of Δ per unit thickness through consolidation, so that $d\zeta = dS (1 - \Delta)$. Since the contraction is due to the squeezing of water, the equation of mass conservation then is $\rho_B (1 - \Delta) = \rho_{BO} - \rho\Delta$, where ρ is the density of water. Thus, the integration of dS over the last t years, that is, the total thickness if not yet consolidated, is

$$S = \int_0^t \frac{d\zeta}{1 - \Delta} = \int_0^t \frac{\rho_B - \rho}{\rho_{BO} - \rho} d\zeta \dots\dots\dots (1)$$

While, assuming the sedimentation rate $h(t)$ to be constant (= h_0),

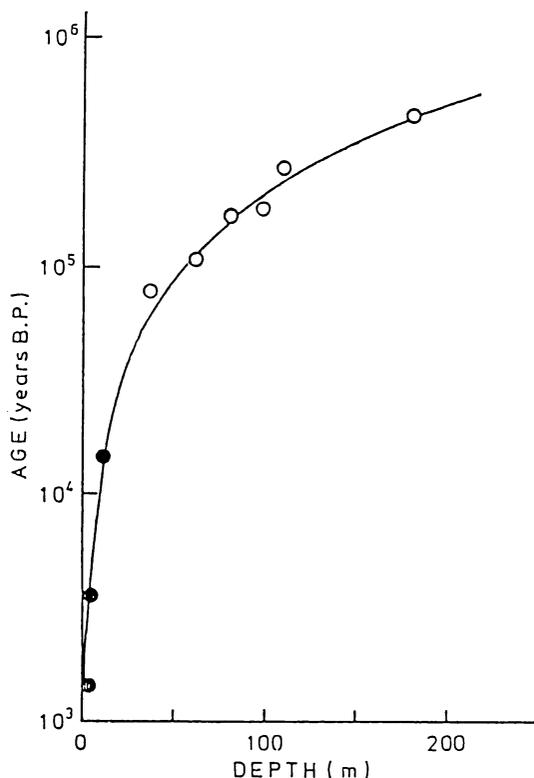
$$S = \int_0^t h(t)dt = h_0 t \dots\dots\dots (2)$$

Hence, equating (2) to (1) yields:

$$t = \frac{1}{h_0 (\rho_{BO} - \rho)} \int_0^t (\rho_B - \rho) d\zeta \dots\dots\dots (3)$$

Equation (3) ensures the age-scaling along the core sample, when the vertical profile of bulk density and reference ages are given. According to Equation (3), a preliminary age-scale for the 200-meter core was composed in reference to the ¹⁴C (Horie *et al.*, 1971) and fission-track dates (Nishimura *et al.*, 1975). The age-scale is empirically modified as shown in Text-fig. 13 (Yamamoto, 1976). On the basis of the age-scale figure (Text-fig. 13), ages of every meter of the 200-meter core are shown in Table 1 (Yamamoto & Higashihara, 1978).

According to the palaeomagnetic stratigraphy (Horie, 1984), the polarity epoch of the 200-meter core belongs to the Brunhes normal polarity epoch since ca. 0.7 million years ago. Within the core, there appear four magnetic anomalies. The age of the youngest event (50 to 55 m in depth of the 200-meter core) in the four magnetic anomaly events is 100,000 yr.B.P., and so close to the age of the Blake event, which was discovered from the deposits collected from the Atlantic and Caribbean Sea, and of which age



Text-fig. 13. An empirically modified age-scale (solid line), with nine reference ages including three ^{14}C dates (solid circle) and six fission-track dates (open circle) (After Yamamoto, 1976).

was found to be between 114,000 and 108,000 yr.B.P.

Correlation between the deep-sea and terrestrial records, and discussion

The International Subcommittee on Stratigraphic Classification recognized generally three principal categories of stratigraphic subdivision for use through the geologic column. These categories are lithostratigraphy, biostratigraphy, and chronostratigraphy. However, in regard with the Quaternary stratigraphy, these are imperfect.

The Quaternary possesses rather special features that make it unique in the geologic record. Therefore, there is a growing consensus that the subdivisions of the most recent part of the strati-

graphic record should follow the geologic procedures, and two further categories have been employed. These are morphostratigraphy and climatostratigraphy.

Climatostratigraphy is undoubtedly useful concept and, insofar as the Quaternary at mid- and high-latitudes tends to be subdivided into glacial and interglacial periods.

In the deep-seas, long sequences of relatively undisturbed sediments are preserved records which frequently extend back beyond the beginning of the Quaternary. Within these sediments, the microfauna contains a record of changing oxygen isotope ratios which do not only provide evidence for the past glacial and interglacial oscillations, but also form the basis for stratigraphic subdivision and long distance correlation. Sediments from deep-seas hold a number of advantages over terrestrial sequences from the point of view of stratigraphic subdivision and correlation throughout the world as follows:

- (1) The records are more commonly continuous and relatively undisturbed.
- (2) A common technique such as oxygen isotope analysis can be used.
- (3) As the oxygen isotopic changes are a consequence of climatic changes, they are used for climatostratigraphy.
- (4) The sedimentary records can be dated and correlated by the independent method of palaeomagnetic stratigraphy.

However, if terrestrial sequences provide the following certain characteristic features, correlation between the marine and terrestrial successions can be established.

- (1) A lengthy stratigraphic record must be available.
- (2) Within terrestrial sequences, evidence of climatic change must be clear and unequivocal.
- (3) The record of sedimentation must be continuous.
- (4) The terrestrial sequences can be dated by palaeomagnetic or radiometric method.

The most impressive and important example of lake sediment sequences as one of standards for the world-wide correlation of terrestrial

Table 1 An empirically modified age-scale (After Yamamoto, 1976)

Depth ζ (m)	Age t (10 ³ yr. B. P.)						
1	1.39	51	95.49	101	214.26	151	365.07
2	2.24	52	97.65	102	216.98	152	368.29
3	3.24	53	99.82	103	219.73	153	371.54
4	4.31	54	101.98	104	222.44	154	374.75
5	5.47	55	104.17	105	224.58)	155	378.00
6	6.77	56	106.32	106	228.00	156	381.25
7	8.09	57	108.50	107	230.77	157	384.45
8	9.50	58	110.69	108	233.58	158	387.69
9	10.98	59	112.90	109	236.39	159	390.96
10	12.54	60	115.07	110	239.23	160	394.19
11	14.14	61	117.28	111	242.06	161	397.42
12	15.82	62	119.49	112	244.93	162	400.69
13	17.48	63	121.73	113	247.80	163	403.91
14	19.22	64	123.96	114	250.70	164	407.17
15	21.04	65	126.19	115	253.60	165	410.42
16	22.84	66	128.42	116	256.49	166	413.68
17	24.72	67	130.69	117	259.42	167	416.89
18	26.59	68	132.95	118	262.38	168	420.14
19	28.49	69	135.20	119	265.34	169	423.38
20	30.43	70	137.45	120	268.29	170	426.63
21	32.40	71	139.74	121	271.28	171	429.90
22	34.36	72	142.06	122	274.27	172	433.14
23	36.39	73	144.34	123	277.28	173	436.37
24	38.37	74	146.66	124	280.30	174	439.61
25	40.43	75	149.01	125	283.31	175	442.84
26	42.48	76	151.36	126	286.36	176	446.10
27	44.52	77	153.70	127	289.40	177	449.32
28	46.59	78	156.08	128	292.47	178	452.55
29	48.65	79	158.46	129	295.51	179	455.80
30	50.75	80	160.83	130	298.61	180	459.02
31	52.84	81	163.24	131	301.68	181	462.24
32	54.93	82	165.64	132	304.78	182	465.49
33	57.04	83	168.08	133	307.91	183	468.70
34	59.15	84	170.52	134	311.00	184	471.94
35	61.25	85	172.99	135	314.13	185	475.15
36	63.39	86	175.45	136	317.29	186	478.39
37	65.52	87	177.92	137	320.41	187	481.59
38	67.64	88	180.42	138	323.56	188	484.80
39	69.76	89	182.95	139	326.75	189	488.03
40	71.87	90	185.48	140	329.89	190	491.23
41	74.02	91	188.01	141	333.07	191	494.45
42	76.15	92	190.57	142	336.25	192	497.65
43	78.29	93	193.12	143	339.43	193	500.87
44	80.42	94	195.72	144	342.63	194	504.06
45	82.58	95	198.34	145	345.80	195	507.28
46	84.74	96	200.97	146	349.00	196	510.47
47	86.89	97	203.59	147	352.20	197	513.68
48	89.04	98	206.24	148	355.43	198	516.86
49	91.18	99	208.89	149	358.62	199	520.08
50	93.31	100	211.58	150	361.85	200	523.25

record is the record from Lake Biwa, Japan (Lowe & Walter, 1984). Namely, lacustrine sediments obtained from Lake Biwa accept four indispensable conditions as above-mentioned. In addition, although sediments of both cold and warm times are complete within sediments from the deep-seas, we cannot evaluate changes in climate over short times because of the extremely small rate of sedimentation in the deep-seas.

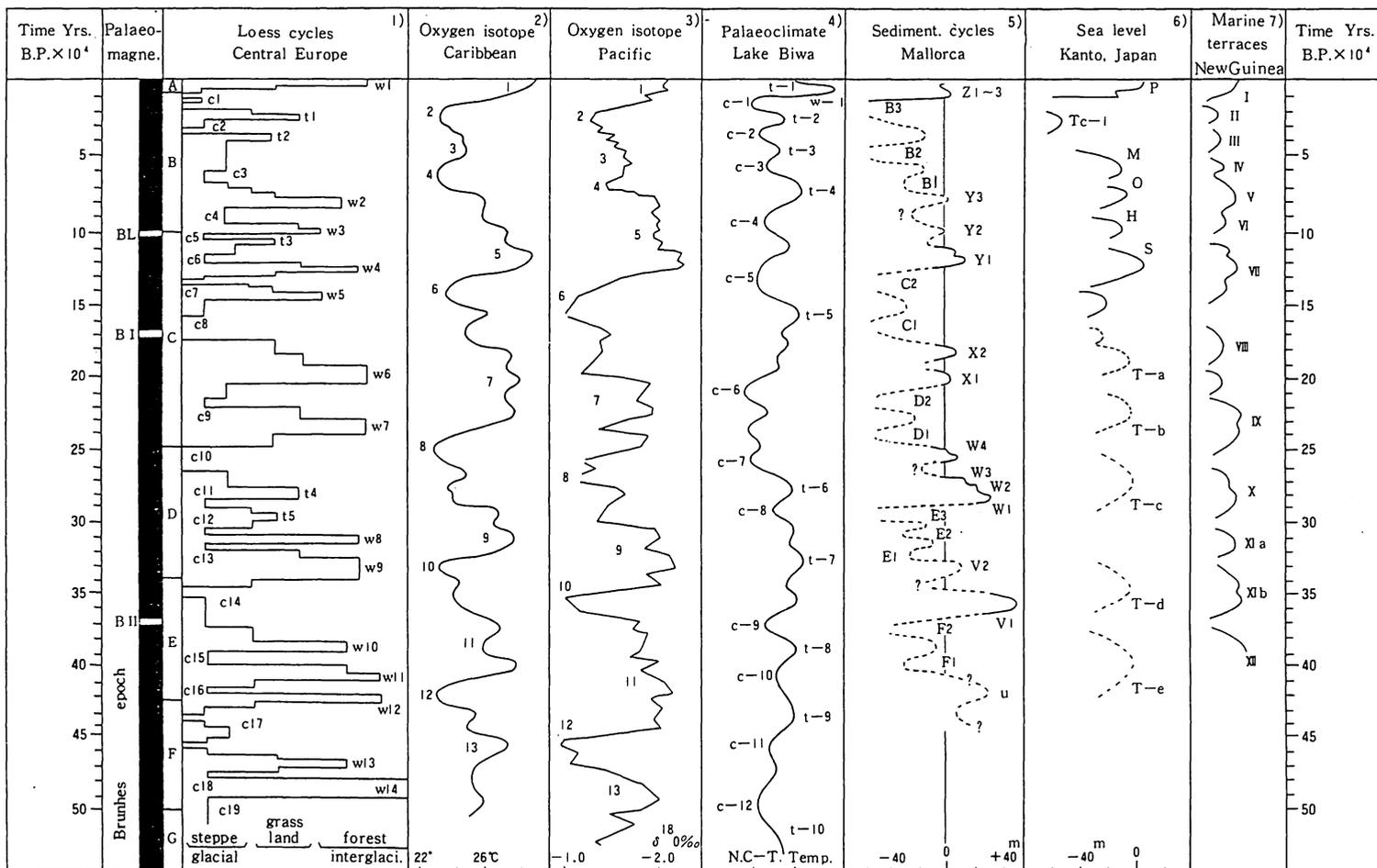
The tentative age-climate curve based upon a pollen analyses of the 200-meter core samples at 5 meters intervals was carried out by the present writer (Fuji, 1983, 1984; Fuji & Horie, 1977), and also more detailed curve checked by pollen analyses of both the 200-meter and 1,400-meter cores samples, and based upon a corrector empirically modified age-scale of the 200-meter core (Yamamoto & Higashihara, 1978) has been stated as shown in Text-fig. 13.

In the following part of this section, the writer will compare tentatively the climatic change from Lake Biwa with the oxygen isotope stratigraphy in the Caribbean Sea and Equatorial Pacific, environmental changes in Central Europe reconstructed by loess, palaeosol and gastropod faunal records, and Mediterranean and Japanese sedimentary cycles and relative sea level changes *etc.* However, both the palaeoclimatic changes in Lake Biwa and the global climatic changes have not been elucidated either. Namely, the global climatic changes should be based reasonably upon the various records from the deep-seas and terrestrial sequences, but the major changes have not been stated yet. And also, the present writer finished only a pollen analysis of the 200-meter core samples at 5 meters intervals, and of the 1,400-meter core samples at 6 meters intervals obtained from Lake Biwa. He, therefore, is working the detailed pollen analysis at 25 cm intervals of both the cores. After his detailed analysis, the palaeoclimatic changes in and around the lake will be elucidated. And, if the global climatic changes will be elucidated, the writer will try the detailed correlation between the climatic record from the lake and the major climatic changes throughout the world. Therefore, the correlation stated in the following

elucidation means of course tentatively.

Concerning the oxygen isotopic records from the Caribbean Sea, Emiliani (1955) and Emiliani & Shackleton (1974) divided the isotopic curves into sixteen stages. The present writer (Fuji, 1983) compared his palaeoclimatic curve with Emiliani's isotope temperature record depicted on the the modified time scale, and found a rather significant correlation between them. Especially, during the age about 270,000 to 100,000 years B.P., the c-5 and c-6 cold climatic periods, and the t-5 temperate climatic period described in this paper may be correlated with Emiliani's stage nos. 6, 8, and 7, respectively. The fact suggests that the palaeoclimatic change around Lake Biwa was primarily controlled by the global glacial-interglacial cycles, but in a few exceptional periods of short duration the climate was brought under the influence of a strong local character and/or a problem in regard to absolute age inferred.

The stratigraphic subdivision of the oxygen isotope record was subsequently extended analysis of sediments in Core V28-238 obtained from a depth of 3,120 m at $01^{\circ} 01' N$, $160^{\circ} 29' E$ on the Solomon Plateau in Western Pacific by Shackleton and Opdyke (1973). Within this core, twenty-three isotopic stages younger than Jaramillo Geomagnetic Event were recognized, and the record was interpreted as reflecting more or less continuous sediments since about 870,000 years B.P. And, the isotopic stages were also recognized in the upper part of Core V28-239. On comparison between the present writer's palaeotemperature curve and the record from V28-238 Core, a noticeable similarity between major trends of the two curves seems to be more than similarity between Emiliani's curve (Emiliani & Shackleton, 1974) and the palaeoclimate curve from Lake Biwa (Fuji, 1983; Fuji & Horie, 1977). That is, at that time described in this article, the Fuji's c-5 and c-6 cold periods, and t-5 mild climatic period may be corresponded to the Shackleton's stage nos. 6, 8, and 7, respectively. And also, in addition, the c-7 cold period may be correlated with the cold stage between stages nos. 8 and 9.



Text-fig. 14. Tentative comparison of the palaeoclimate from Lake Biwa, with oxygen isotope records from deep-seas, sedimentary cycles from Mallorca, sea level changes from Japan and New Guinea, and loess cycles from Central Europe.

- 1: Loess cycles and climate (Kukla, 1970, 1975). In loess cycles, w1 to w14, t1 to t5, and c1 to c19 are termed expediently for correlation by Fuji.
- 2: Isotope curve from the Caribbean Sea (Emiliani & Shackleton, 1974).
- 3: Isotope curve from Equatorial Pacific (Shackleton & Opdyke, 1973).
- 4: Palaeoclimatic change curve from Lake Biwa (Fuji, 1983).
- 5: Sedimentary cycles from Mallorca, Western Mediterranean (Butzer, 1975). Time before 30,000 years ago was estimated on the basis of Butzer's data (1975).
- 6: Sea level changes from Southern Kanto, Japan (Machida, 1975).
- 7: Marine terraces in New Guinea (Chappell, 1974). Time was estimated on the basis of Chappell's data (1974). In palaeomagnetic data, BL: Blake event, B I: Biwa I event, B II: Biwa II event.

On the sedimentary cycles and relative sea level changes, since changes of eustatic sea levels are partly related to climatic changes, there should be some broad correlation between dated sea level changes in regions not affected by glacio-isostasy and the glacial and interglacial cycles recorded in the deep-sea cores. There should be some correspondence between ages of lowered sea level and cold condition, although climatic change and sea level change may be slightly out of phase since time is required for the melting of the ice sheets following climatic improvement. Of course, a following few problems to be solved are in combining the sea level change with the climatic change: (a) Eustatic sea level changes from various regions throughout the world are affected by both the voluminal change of ocean water and tectonic movement; and (b) the correlation between the quantity of ice sheets and the global climate has not been well established.

A work on the Pleistocene sedimentary records of Mallorca in Western Mediterranean is a typical example for comparison between deep-sea and terrestrial records. Parts of the Mallorca littoral with arid climate are characterized by well-developed calcareous dunes, and widespread (Butzer, 1962). According to Butzer (1963), these aeolian sediments accumulated through deflation of freshly-exposed marine deposits during glacio-marine regressions, and each regression can be correlated with each glacial period in areas affected by glacier. Interglacial high sea levels are recorded by marine terraces and beach deposits. The shoreline stratigraphy in Mallorca is divided into six terrestrial and six marine hemicycles, which have been dated partly on the basis of biostratigraphy and radiometric dating of marine shells (Butzer, 1975). These sequence can be correlated with the loess sequence in Central Europe, and with the oxygen isotope records from the deep-sea floors.

As shown in Text-fig. 14, the palaeoclimatic curve from Lake Biwa (Fuji, 1983; Fuji & Horie, 1977) shows a significant correlation with the sedimentary cycles from Mallorca (Butzer, 1975) from the points of view of chronology and pat-

tern of change of curve. Namely, the following facts can be pointed out:

- (a) The postglacial relative high sea level (Z1, Z2, and Z3) coincides with the warm W-1 and mild climate t-1 periods.
- (b) The relative low stands of sea level (B3, B2, and B1) during the latest Pleistocene may be corresponded to the cold C-1, C-2, and C-3 periods, respectively.
- (c) And, especially concerning the present paper, the high sea levels inferred from the marine terraces Y1 and Y3 from Mediterranean are correlated with the cooler or mild climatic age between c-5 and c-4 periods from Lake Biwa, and with t-4 period, respectively.
- (d) The lower sea level C1 and C2 (Mediterranean) may be correlated with the slightly cold or cold c-5 period (Lake Biwa).
- (e) The high sea levels X1 and X2 (Mediterranean) coincide with the short temperate age just after the cold c-6 period, and with temperate t-5 period (Lake Biwa).
- (f) The low sea levels D1 and D2 (Mediterranean) are corresponded to the cold age between c-7 and c-6 periods (Lake Biwa), and to the cold c-6 period, respectively.

The fact as mentioned above, suggests that the high sea level corresponds to the temperate period of Lake Biwa, and that the low stand of sea level to the cold one. The facts as recognized between the curves from Lake Biwa and Mallorca can be pointed out by comparing the palaeoclimate curve from Lake Biwa with the sea level curve of Southern Kanto in Japan (Machida, 1975), and with the sea level curve from New Guinea (Chappell, 1974) as follows:

- (a) The high sea level P from Japan and I from New Guinea during the latest Pleistocene to Holocene is correlated with the warm w-1 and t-1 periods from Lake Biwa.
- (b) The relative low stand of sea level Tc-1 (Japan) and II (New Guinea) coincides with the cold c-1 period (Lake Biwa).
- (c) The high sea level suggested by the marine Misake M and Obaradai O (Japan) and V (New Guinea) may be corresponded to the

t-3 period (Lake Biwa).

- (d) And, especially concerning the present paper, the high sea level S (Japan) and VII (New Guinea) in the Shimosueyoshi transgression correlated with the Riss/Würm interglacial coincides with the temperate age between the c-5 and c-3 periods (Lake Biwa).
- (e) The high sea levels inferred from the marine T-a (Japan) and VIII (New Guinea), T-b and IX, T-c and X, T-d and XIb, and T-e and XII may be corresponded to the temperate t-5 (Lake Biwa), slightly cool age between the c-7 and c-6, the temperate t-6, temperate t-7 periods, and to the temperate t-8 period, respectively.

With regard to aeolian deposits, within lengthy aeolian depositional sequences from central Europe, one of standards for correlation in the Quaternary was provided. Many soil layers are intercalated in the loess sequences, and the complete succession appears to contain a record of glacial and interglacial conditions (Kukla, 1970, 1975). In the succession, the loess layers are interpreted as representing glacial condition, and on the other hand, the interbedded palaeosoils are considered to be indicative of interglacial condition. These records indicate that within the last 1.6 million years, seventeen major glacial and interglacial conditions have affected central Europe (Text-fig. 14).

As shown in Text-fig. 14, in comparison with the palaeoclimatic curve from Lake Biwa and the central European loess record (Kukla, 1970, 1975) for the past 500,000 years, the following facts can be pointed out:

- (a) The warm w1 age in the glacial cycle A from Europe coincides with the w-1 and t-1 periods from Lake Biwa.
- (b) The c1, t1, c2, t2, and c3 ages in the middle and late glacial cycle B (Europe) are correlated with the c-1, t-2, c-2, t-3 and c-3 periods from the lake, respectively.
- (c) The warm w2 and w3 ages (Europe) may be corresponded to the t-4 period (Lake

Biwa) from the view point of a pattern of climatic change.

- (d) The cold c5 and c6 ages (Europe) may be corresponded to the c-4 period (Lake Biwa) stated in this article.
- (e) The cold c7 and c8 ages in the early part of glacial cycle C (Europe) may coincide with the c-5 period (Lake Biwa), and the warm w5 age with the temperate age between the c-5 and c-4 periods, respectively.
- (f) The warm w6 and w7 ages in the early part of glacial cycle C (Europe) may be corresponded to the temperate t-5 period (Lake Biwa).

As described above, the writer can find a remarkably noticeable similarity between major trends of the records from Lake Biwa, other terrestrial sediments and the deep-seas. However, a more reliable conclusion will be arrived at when more absolute dates and palynological results will be obtained for the 200-meter and 1,400-meter cores from Lake Biwa.

Conclusions

- (1) Pollen diagrams were obtained from 200 samples during the 55 meters to about 110 meters-horizons of the 200-meter core which was drilled at the bottom 65 m below the present water surface of the lake in 1971.
According to the calculated age on the basis of the determination of ^{14}C , fission-track and palaeomagnetic stratigraphy, the age during the 55 meters- and 110 meters-horizons is from about 100,000 yr.B.P. to about 250,000 yr.B.P.
- (2) Judging from the pollen diagrams, the samples during the 55 meters- to 110 meters-horizons are divided into four pollen zones: Zones Y-1, Y-2, Y-3 and Y-4, and the Y-2 zone is further divided into six pollen sub-zones.
- (3) The palaeoclimate inferred on the basis of pollen assemblage of every sample is as follows:

periods palaeoclimate inferred

- Y-1 Period: Northern part of the Cool Temperate zone; corresponding to the c-6 period of the present writer's previous paper (Fuji, 1983), the 8 stage from the Shackleton and Opdyke's oxygen isotope curve, and to the D2 of the relative change curve of sea level from Mediterranean.
 - Y-2-a Subperiod: Southern part of the Cool Temperate - Temperate zones.
 - Y-2 b Subperiod: Middle part of the Cool Temperate zone.
 - Y-2-c Subperiod: Southern part of the Cool Temperate - Temperate zones.
 - Y-2-d Subperiod: Southern part of the Temperate - Warm Temperate zones.
Y-2-a to Y-2-d Subperiods correspond to the t-5 period from Lake Biwa, the 7 stage of the isotope curve, and to the X1 to X2 from Mediterranean.
 - Y-2-e Subperiod: Middle part of the Cool Temperate zone; corresponding to the c-5 from Lake Biwa, the 6 stage of the isotope curve, and to the C2 from Mediterranean.
 - Y-3 Period: Northern part of the Cool Temperate zone; corresponding to the c-4 period from Lake Biwa, and to the low sea level age between the Y2 and Y3 marine terraces in Mediterranean.
 - Y-4 Period: Middle part of the Cool Temperate zone - northern part of the Temperate zone.
- (4) Concerning the tentative correlation between the palaeoclimate from Lake Biwa, palaeotemperature from the deep-seas such as Caribbean Sea and Equatorial Pacific, environmental changes in Central Europe, and sea level changes in Mediterranean and Japan, the present writer can find a noticeable similarity between the records from above-mentioned regions as shown in Text-fig. 14.

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Aburaki 油木, Gamō 蒲生, Gifu 岐阜, Hokuriku region 北陸地方, Honshu 本州, Iga Basin 伊賀盆地, Ise Bay 伊勢湾, Kaburaki 甲楽城, Kinki region 近畿地方, Kyoto 京都, Kyushu 九州, Lake Biwa 琵琶湖, Mizuguchi Hill 水口丘陵, Mt. Fujihara-dake 藤原岳, Mt. Gozaisho-dake 御在所岳, Mt. Hiei 比叡山, Mt. Hira 比良山, Mt. Ibuki 伊吹山, Mt. Mikuni-dake 三国岳, Mt. Mikuni-ga-dake 三国ヶ岳, Mt. Nosaka 野坂山, Nagoya 名古屋, Nobi Plain 濃尾平野, Omi Basin 近江盆地, Sayama 佐山, Shiga Hill 滋賀丘陵, Shikoku 四国, Shima-gahara 島ヶ原, Seta 瀬田, Suzuka 鈴鹿, Takashima 高島, Tsu 津, Tsuruga 敦賀, Tōkai region 東海地方, Wakasa Bay 若狭湾, Yanagase 柳瀬, Yōkaichi 八日市.

琵琶湖底 200 m ボーリング・サンプルの花粉学的研究 II: 約 25 万～10 万年前における古植生と古気候の変遷: 日本における第四紀を通じての古植生の変遷とそれに基づく古気候の変化を究明し, 世界における第四紀の気候変化の標準の 1 つを日本で作成することを目的として, 1971 年秋, 琵琶湖の水深 65 m の湖底から約 200 m に及ぶボーリングを実施した。そして, 殆んど完全に連続する過去 60 万年間の湖成層の採集に成功した。このコア・サンプルの 5 m 間隔での試料に基づく過去 60 万年間の古植生と古気候の変遷についての第一報 (藤, 1983) に続いて, 約 25 万～10 万年前の古植生と古気候の変遷を, 200 m コアの 25 cm 間隔で採集したコア・サンプルの花粉分析によって解析した。その結果, この期間約 15 万年間は, 4 花粉帯 6 花粉亜帯に細分され, それぞれの花粉帯と花粉亜帯の詳細な花粉組成とそれに基づく植生と気候を推定した。そして, さらに, この気候変遷を, 現在までに公表されているカリブ海と赤道太平洋からの酸素同位体比による古水温変化, 地中海の Mallorca と南関東, およびニューギニアから得られた海水準変化・海成段丘分布, そして, 中部ヨーロッパで得られたレスのサイクルなどの同時期の変化と比較検討した結果, これらとは全般的にみてよく類似した変化の認められることが判明した。

藤 則雄

823. LOWER PERMIAN CONODONTS FROM THE KAWANORI FORMATION OF THE SOUTHWESTERN KANTO MOUNTAINS, TOKYO

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Abstract. Lower Permian conodont elements are abundantly recovered from the limestone blocks embedded in the Kawanori Formation cropped out in the southwestern part of the Kanto Mountains, Tokyo. These conodonts are *Hindeodus minutus* (Ellison) Pa element, *Diplognathodus* sp. A, *Idiognathodus* sp., *Merrillina* sp. A, *Neogondolella bisselli* (Clark and Behenken), *N. gujoensis* Igo, *N. idahoensis* (Youngquist, Hawley and Miller), *N.* sp. A, *Neostreptognathodus exsculptus* Igo, *N.* ? sp., *Streptognathodus elongatus* Gunnell, *Sweetognathus whitei* (Rhodes) and *Xaniognathus abstractus* (Clark and Ethington).

Most of these conodont elements are indicators of the *Neogondolella bisselli*–*Sweetognathus whitei* Assemblage zone. However, *Streptognathodus elongatus* and *Idiognathodus* sp. seem to be reworked elements from the older formation. Some problems of the Lower Permian conodont zones in Japan and China were briefly discussed herein.

Introduction and acknowledgement

Recently, one of the authors, Hisada (1984) clarified stratigraphy and geologic structure of the Paleozoic and Mesozoic strata in the Ashigakubo-Kamozawa area, southwestern part of the Kanto Mountains. He subdivided these strata into the following three groups, such as the Permo-Carboniferous Hashidate and Jurassic Urayama Groups in the Chichibu Belt, and the Jurasso-Cretaceous Ogouchi Group in the northern Shimanto Belt.

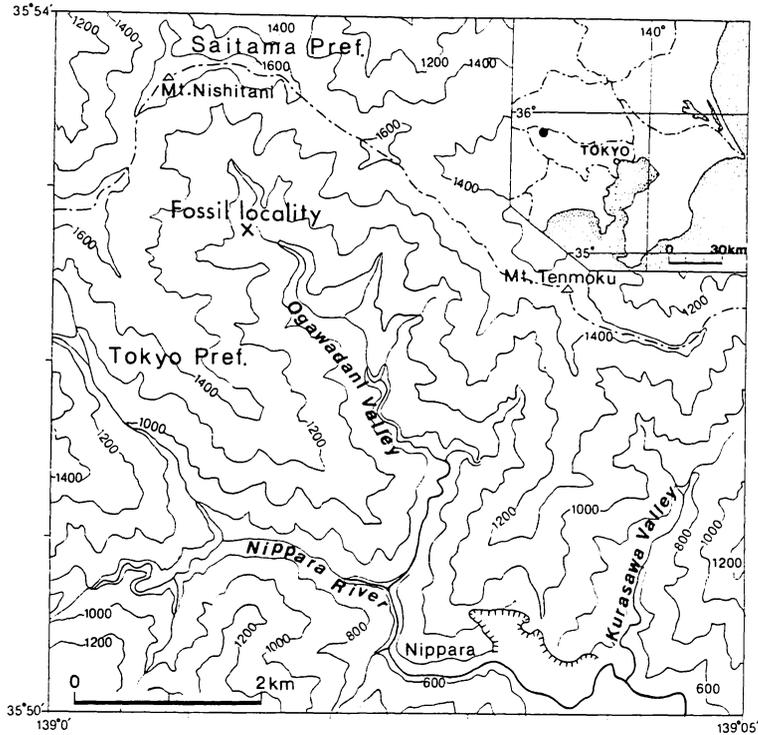
The Urayama Group is composed chiefly of

Received November 9, 1985; revised manuscript received September 10, 1986; read February 3, 1985 at The University of Tokyo.

shale and sandstone containing exotic blocks of chert and limestone. Hisada concluded that the group is an olistostrome and subdivided into the Nenoyama, Takekawadake, Urayama, Kawanori and Nippara Formations based on the lithology of contained exotic blocks.

Gray encrinal limestone block of the Kawanori Formation is exposed in the upstream of the Ogawadani Valley, a tributary of the Nippara River. Hisada (*op. cit.*) marked as F8 in his geologic map and reported the occurrence of Lower Permian fusulinaceans and smaller foraminifers. The limestone block intercalating tuffaceous shale is about 4 m in thickness and more than 10 m in length so far as exposed.

The following conodont elements were abun-



Text-fig. 1. Map showing locality of conodont.

dantly recovered from this limestone, such as *Hindeodus minutus* (Ellison) Pa element, *Diplognathodus* sp. A, *Merrillina* sp. A, *Neogondolella bisselli* (Clark and Behenken), *N. gujiensis* Igo, *N. idahoensis* (Youngquist, Hawley and Miller), *N. sp. A*, *Neostreptognathodus exsculptus* Igo, *N. ? sp.*, *Streptognathodus elongatus* Gunnell, *Sweetognathus whitei* (Rhodes), *Xaniognathus abstractus* (Clark and Ethington), *Idiognathodus* sp., and the following ramiform elements, such as *Enantiognathus* sp., *Lonchodina* spp., *Diplododella* sp., *Hindeodella* sp. and *Hindeodus minutus* Sc element. These conodonts are particularly abundant in the individual numbers but mostly fragmental. They seem to be transported by current and accumulated together with the fragments of crinoid columns. Most of these elements seem to be derived from the assemblage belonging to the *Neogondolella bisselli*–*Sweetognathus whitei* Assemblage zone (Igo, 1981). However, *Streptognathodus elongatus* and *Idiognathodus* sp. are older representatives than the mentioned zone. These conodonts were thought to be reworked from the older forma-

tion.

The authors would like to express their appreciation to Professor Hisayoshi Igo of the University of Tsukuba for his cooperation in the field, valuable suggestion and critical reading of early version of this paper. We acknowledge the comments and suggestions for this study by Professors Tatsuaki Kimura of Tokyo Gakugei University and Nobuo Yamagiwa of Osaka Kyoiku University.

Appraisal of fauna

As already mentioned, conodont elements recovered from limestone exposed at the Ogawadani Valley (Text-fig. 1) are abundant and counted about 500 per 1 Kg, but they are mostly fragmental and more or less abraded. Based upon the occurrence and lithology of limestone, these elements were transported by current and deposited under high energy shallow water. Associated fusulinaceans are mostly *Triticites* and *Pseudofusulina* which also show some attrition. Most of the present conodont elements

were brought from one assemblage, however, the obtained composition may represent a part of the original assemblage.

Hindeodus minutus (Ellison) is now treated as a long-ranging multielement species. Its Pa element is rather commonly obtained in our collection and similar to the forms described as *Anchignathodus minutus* by many authors. This type of discrete element is very common in the Lower Permian limestone in Japan (Igo, *op. cit.*).

Diplognathodus sp. A is not so common in the present collection, but it is identical with *Diplognathodus* sp. A described from the Permian limestone exposed in "Haper Ranch beds" of Kamloops, southern British Columbia, Canada (Orchard, 1984b) and *D. oertlii* Kozur described by Igo (1981) from the upper part of the Lower Permian in the various localities in Central Japan.

Neogondolella bisselli is abundant in the present assemblage. This element is characteristic one in the Lower Permian of North America, Europe and Asia, and is a leading species in the middle part of Lower Permian in Japan. Recently, studies of the Permian conodonts in China have been much progressed (Wang and Wang, 1981a, 1983 and others). This element is characteristic in the lower part of the Chihsia Stage along with *Sweetognathus whitei*. The Chihsia Stage is a classical standard lithogenetic unit of the Permian in South China and was traditionally correlated with the Artinskian of USSR. Recently, however, the lower boundary of the Chihsia has been placed within the Sakmarian and the base of the Permian is settled at the base of the Chihsia in China (Yang *et al.*, 1984 and others). Wang and Wang (1981a) proposed the assemblage zones in the Chinese Lower Permian, such as the *Neogondolella bisselli*-*Sweetognathus whitei* Assemblage zone and *Neogondolella idahoensis* Assemblage zone in ascending order. The same authors (Wang and Wang, 1983) also established the following three assemblage zones in ascending order, such as the *Neogondolella bisselli*-*Sweetognathus whitei*, *Neostreptognathodus pequopensis*-*N. sulcopicatus*, and *Neogondolella idahoensis*-*N. serrata* Assemblage zones. The first mentioned zone is established in the upper half of the Zone of *Pseudoschwagerina* in the Japanese Permian. The *Streptognathodus elongatus* fauna is found in the lower division of the *Pseudo-*

schwagerina zone which is characterized by the occurrence of the primitive species of *Pseudoschwagerina*. This level is correlated with the Asselian of the Russian standard (Igo, 1981). As already pointed out by many Permian conodont specialists, the lowest Permian conodonts are mostly survival elements from the Upper Carboniferous and the occurrence of typical Permian elements are started from above the Asselian. However, it does not indicate that the evidence is suitable to settle the base of the Permian as the international consensus.

Neogondolella gujioensis is common in this assemblage. This species was originally described from the Akuda Formation exposed in the Gujio Hachiman district, Central Japan, and it resembles *Neogondolella bisselli* and *N. idahoensis*. This species is characteristic in the uppermost part of the Zone of *Pseudoschwagerina* associated with *Neogondolella bisselli* and *Sweetognathus whitei* in Japan.

Neogondolella idahoensis is also abundant in the present collection. This species is classical species of the Permian conodonts, and known from the Shimadani Formation of the Gujio Hachiman district, lower part of the Nabeyama Formation of the Kuzuu district and other localities in Japan. *Neostreptognathodus exsculptus* is not so common in our collection but seems to be one of the important composition in this fauna. This species was described from the uppermost part of the Zone of *Pseudoschwagerina* in the lower subgroup of the Yoro Group and others in Central Japan.

Streptognathodus elongatus is not so common in the present fauna. This species was originally described from the Upper Pennsylvanian of U.S.A. Subsequently, this species has been known in the Lower Permian of the various localities in Asia and Europe. In Japan, it is reported from the lowermost Permian Shiraiwa Limestone exposed at west of Ome City, Tokyo Prefecture (Igo, *op. cit.*). Recently, Wang and Li (1984) described this species from the Taiyuan Formation of North China in association with *Pseudoschwagerina*. The Chinese geologists placed the Taiyuan in the uppermost division of Carboniferous.

Sweetognathus whitei is also common in the present fauna. This species was originally described from the topmost of the Tensleep Sand-

stone, Wyoming and its geologic age was thought as the Wolfcampian (Rhodes, 1963). *S. whitei* is yielded from the *Pseudoschwagerina* zone associated with *Neogondolella bisselli* in Central Japan.

Xaniognathus abstractus is common representatives in the present fauna. This element is commonly yielded from the upper part of the Lower Permian in Japan. The original specimens were known from the Leonardian Bone Spring Formation, Texas and also from the Wordian in western United States (Clark and Ethington, 1962).

As mentioned above, most of the present conodont elements are known from the *Neogondolella bisselli*—*Sweetognathus whitei* Assemblage zone of Japan which was established in the upper part of the Sakamotozawan and correlated to the lowest part of the Chihhsia Stage in China, and Sakmarian and Wolfcampian of the Russian and American standard divisions, respectively. The present fauna contains slightly older elements as the reworked specimens, such as *Streptognathodus elongatus* and *Idiognathodus* sp.

Although the present conodont elements were recovered from the limestone block which is embedded in the Jurassic strata as an olistolith, but they are additional data to the Lower Permian conodont fauna in Japan.

Systematic description

Genus *Hindeodus* Rexroad and Furnish, 1964

Hindeodus minutus (Ellison, 1941)

Pa element

Pl. 98, Fig. 14.

Spathodus minutus Ellison, 1941, p. 120, pl. 20, figs. 50—52.

Spathognathodus minutus (Ellison); Youngquist and Downs, 1949, p. 169, 170, pl. 30, fig. 4; Sturgeon and Youngquist, 1949, p. 385, pl. 74, figs. 9—11; Rexroad and Burton, 1961, p. 1156, 1157, pl. 141, figs. 10, 11; Hass, 1962, p. 209, pl. 34, fig. 36; Murray and Chronic, 1965, p. 606, pl. 72, figs. 29, 30; Igo and Koike, 1965, p. 88, 89, pl. 9, figs. 16—18; Dunn, 1965, p. 1149, pl. 140, figs. 15, 21, 24; Koike, 1967, p. 311, pl. 3, figs. 39—42;

Webster, 1969, p. 44, pl. 7, fig. 4; Dunn, 1970, p. 339, pl. 61, figs. 27, 30; Merrill, 1973, p. 305, 306, pl. 1, figs. 1—14, pl. 2, figs. 1—28; Lane and Strak, 1974, p. 101, fig. 44: 7, 12; Spassov, 1976, p. 135, pl. 2, fig. 1.

Spathognathodus cfr. *S. minutus* (Ellison); Huckriede, 1958, p. 162, pl. 10, fig. 8; Rhodes, 1963, p. 408, pl. 47, fig. 3.

Anchignathodus minutus (Ellison); von Bitter, 1972, p. 65, 66, pl. 6, figs. 2a-2i; Sweet in Ziegler, 1973, p. 15—17, *Anchignathodus*-pl. 1, figs. 2a, 2b; Behnken, 1975, p. 297, pl. 1, figs. 16—18; Tynan, 1980, p. 1300, pl. 2, figs. 8, 9; Wang and Wang, 1981a, p. 229, pl. 2, figs. 6, 7; Wang and Wang, 1981b, p. 115, 116, pl. 1, fig. 5; Wang and Dai, 1981, pl. 1, figs. 3, 4; Igo, 1981, p. 26, pl. 10, figs. 5, 8, 11; Zhao, Han and Wang, 1984, p. 114, pl. 28, figs. 21, 22, 24, 26, 28; Tian, 1983, p. 338, pl. 77, fig. 4; Wang and Li, 1984, pl. 2, figs. 9, 16, 17.

Anchignathodus minutus (Ellison); Kozur, 1975, p. 5—7, pl. 1, figs. 1—16; Kozur *et al.*, 1975, p. 3, pl. 1, figs. 2, 3, 5, 7—11, pl. 2, figs. 1, 3, 5, 7—9, pl. 7, figs. 2, 10; Kozur, 1977, p. 1118, 1119, pl. 1, figs. 1—16.

Anchignathodus minutus permicus Igo, 1981, p. 26, 27, pl. 10, figs. 1—4.

Anchignathodus typicalis Sweet, 1970a, p. 7, 8, pl. 1, figs. 13, 22; Sweet, 1970b, p. 222, 223, pl. 1, figs. 13, 20; Sweet *et al.*, 1971, pl. 1, fig. 34; Sweet in Ziegler, 1973, p. 19, 20, *Anchignathodus*-pl. 1, fig. 3; Sweet in Teichert *et al.*, 1973, p. 427, pl. 11, figs. 8, 9; Behnken, 1975, p. 297, 298, pl. 2, fig. 12; Sweet, 1976, p. 52, 53, pl. 16, figs. 6—8, 9?; Wang, 1978, p. 215, pl. 1, figs. 26—28; Tian, 1983, pl. 77, fig. 9, pl. 79, fig. 4; Zhao *et al.*, 1984, p. 114, 115, pl. 28, figs. 18—20, 23, 27, 29, 31.

Ozarkodina minutus (Ellison), p element (*Spathognathodonta*), Baesemann, 1973, p. 704, 705, pl. 2, figs. 14, 15, 19, 20; Toomey *et al.*, 1974, pl. 3, fig. 8.

Hindeodus typicalis (Sweet) Pa element, Sweet in Ziegler, 1977, p. 223, 224, *Hindeodus*-pl. 2, figs. 1—6.

Hindeodus ex. gr. *Hindeodus minutus* (Ellison), Bender, 1980, p. 10, pl. 4, fig. 22.

Hindeodus minutus (Ellison) Pa element, Matsuda, 1981, p. 80—84, pl. 1, figs. 1—13; Orchard, 1984b, p. 212, pl. 23.1, figs. 6, 26.

Spathognathodus echigoensis Igo and Koike, 1964, p. 187, 188, pl. 28, figs. 24, 25?

- Spathognathodus cristula* Youngquist and Miller;
Stibane, 1967, p. 335, pl. 35, figs. 21–25.
Spathognathodus rexroadi Webster, 1969, p. 45,
pl. 7, figs. 2, 3 (non fig. 1).

Remarks:—*Anchignathodus typicalis* was distinguished from *Spathognathodus minutus* by its ratio of length to width (Sweet, 1970b). Matsuda (1981) stressed that L/W ratio of *Spathognathodus minutus* from the Pennsylvanian of U.S.A. (Merrill, 1973) and Lower Triassic of Kashmir is overlapping with the range of *Anchignathodus typicalis* (L/W = 2.0–2.5) by Sweet (1970b).

Spathognathodus minutus is a well-known long range element and shows broad variation in external shape. The shape of posterior end and L/W ratio do not have any sufficient criteria to distinguish *Anchignathodus typicalis* from *Spathognathodus minutus* as Pa element of the multielement species, *Hindeodus minutus* (Ellison).

Reg. no. TGU. 1744.

Genus *Diplognathodus* Kozur and Merrill, 1975

Diplognathodus sp. A.

Pl. 98, Figs. 10–13.

- Diplognathodus* sp. A, Orchard, 1984b, p. 210,
pl. 23.1, figs. 7, 9.
Diplognathodus oertlii Kozur; Igo, 1981, p. 32,
pl. 8, figs. 9–12, 14–16 (non fig. 13).

Remarks:—Recently, Orchard (1984b) has described *Diplognathodus* sp. A from “Harper Ranch beds” in Kamloops of southern British Columbia, Canada and discussed the blade and carina profiles of related species. Igo (1981) described the similar forms from the Gujio Hachiman and Samegai districts, Central Japan as *Diplognathodus oertlii* Kozur, but they differ from Kozur’s type specimen in the shape of platform and outline of blade.

Reg. nos. TGU. 1740–1743.

Genus *Merrillina* Kozur, 1975

Merrillina sp. A

Pl. 98, Fig. 22.

Description:—Unit symmetrical and its posterior part expanded laterally and heart-shape in oral view. Unit with three long, sharply pointed and discrete posterior denticles. Cusp large, sharply pointed and steeply inclined posteriorly. Anterior margin of unit anteriorly convex. Anterior denticles inclined posteriorly. Posterior margin of unit concave anteriorly. In aboral view, basal cavity broad, laterally expanded in posterior part.

Remarks:—This unnamed species resembles *Merrillina divergens* (Bender and Stoppel), but the former is distinguished from the latter by larger cusp. *Misikella posthernsteini* Kozur and Mock superficially resembles this species. However, this Upper Triassic species has almost the same denticles and cusp in size.

Reg. no. TGU. 1752.

Genus *Neogondolella* Bender and Stoppel, 1965

Neogondolella bisselli (Clark and Behnken, 1971)

Pl. 97, Figs. 10–15.

- Gondolella bisselli* Clark and Behnken, 1971, p. 429, pl. 1, figs. 12–14.
Neogondolella bisselli (Clark and Behnken); Behnken, 1975, p. 306, pl. 1, figs. 27, 31; Clark *et al.*, 1979, pl. 1, fig. 21; Igo, 1981, p. 37, pl. 1, figs. 1–10, 14, 17–19; Orchard, 1984a, pl. 22.1, fig. 14 (non figs. 16, 17).
Neogondolella cfr. *bisselli* (Clark and Behnken); Malkowski and Szaniawski, 1976, p. 82, pl. 1, figs. 1a, b, c.

Description:—Unit characteristically slender tear-drop in shape. Platform tapers gradually to sharp pointed anterior end and rounded posterior end. Cusp sharply pointed in early growth stage and rounded in mature stage. Carina of mature specimens have 11 to 15 discrete denticles with rounded apex. In gerontic stage, posterior part of platform slightly flat, fused denticles developed in posterior half of carina, a few denticles proj-

ect in anterior half and cusp inconspicuously lowered. Oral surface of platform ornamented by micro-pits.

Remarks:—This species resembles *Neogondolella gujioensis* Igo, particularly in early growth stage, but the former is distinguished from the latter in having long and slender platform. *Neogondolella bisselli* (Clark and Behnken) has more numerous nodes on carina than the latter. *Neogondolella idahoensis* (Youngquist, Hawley and Miller) also resembles this species, but the former has square posterior end, large cusp and square loop.

Recently, this species has been described from the lower part of Chihhsia Formation of Ziyun, Guizhou in China where it is associated with *Neostreptognathodus pequopensis* and *Anchignathodus minutus* (Wang and Wang, 1981a). Based upon the occurrence of this species, they established the *Neogondolella bisselli*–*Sweetognathus whitei* Assemblage zone in the Chihhsia Stage.

Reg. nos. TGU. 1721–1726.

Neogondolella gujioensis Igo, 1981

Pl. 97, Figs. 1–9.

Neogondolella gujioensis Igo, 1981, p. 37, 38, pl. 3, figs. 1–19, pl. 4, figs. 1–6.

Description:—Unit tear-drop in shape, slightly arched, and roundly pointed posterior end. Margin of platform tapers to pointed anterior end and both sides of unit subparallel in central part. Platform extends in full length of unit.

In oral view, both sides of platform inflated upward, and shallow lateral furrows present along carina. Oral surface of platform with small pits.

In aboral view, lower surface bears broad keel. Basal groove connected to small basal cavity surrounded by small loop.

Remarks:—This species resembles *Neogondolella bitteri* (Kozur), but the former is distinguished from the latter in having short platform which is 2/3 posterior of full length of unit.

This species resembles closely *Neogondolella liangshanensis* Wang characterized by deep lateral furrows and sharply pointed higher anterior denticles. *N. liangshanensis* was described from the Upper Permian Wuchiaping Formation, Liangshan area of southern Shanxi in China (Wang, 1978). *N. gujioensis* Igo is probably ancestral form of *N. liangshanensis*.

Reg. nos. TGU. 1712–1720.

Neogondolella idahoensis (Youngquist, Hawley and Miller, 1951)

Pl. 96, Figs. 1–11.

Gondolella idahoensis Youngquist, Hawley and Miller, 1951, p. 361, pl. 54, figs. 1–3, 14, 15; Clark and Ethington, 1962, p. 108, pl. 2, figs. 15, 16; Clark and Mosher, 1966, p. 388, pl. 47, figs. 9–12; Clark and Behnken, 1971, p. 431, pl. 1, fig. 9; Movshovich *et al.*, 1979, pl. 2, figs. 3a, b.

Neogondolella idahoensis (Youngquist, Hawley and Miller); Behnken, 1975, p. 306, 307, pl. 1, figs. 28–30; Wang, 1978, p. 220, 221, pl. 2, figs. 23–26; Szaniawski and Malkowski, 1979, p. 246, 247, pl. 4, figs. 1–8, pl. 5, figs. 5a, b; Clark *et al.*, 1979, pl. 1, fig. 10; Wang and Wang, 1981a, p. 230, pl. 2, figs. 15, 23; Igo, 1981, p. 38, pl. 1, figs. 11–13, 15, 16; Wardlaw and Collinson, 1984, p. 269, pl. 1, figs. 10, 11.

Gondolella bisselli Clark and Behnken, Kozur, 1978, pl. 2, figs. 16a–c, pl. 3, figs. 6a–c, 7, 10a, b; Movshovich *et al.*, 1979, pl. 1, fig. 11, pl. 2, figs. 1a–c.

Neogondolella bisselli (Clark and Behnken); Orchard, 1984a, pl. 22.1, figs. 16, 17, (non fig. 14); Orchard, 1984b, pl. 23.1, fig. 10, (non figs. 11, 17).

Description:—Unit slightly arched and asymmetrical. Platform margin tapers to pointed anterior end. Both sides of unit in posterior half subparallel. Anterior half of unit lanceolate. Posterior margin of unit flat. Platform extends in full length of unit. Carina consists of 15 or 16 rounded denticles in mature specimens. Anterior half of carina consists of slightly pointed discrete

denticles and posterior half with low and rounded nodes. Large and stout cusp located posterior end of platform. Flattened posterior margin rimmed by laterally raised carina in some specimens.

Remarks:—This species resembles *Neogondolella bisselli* (Clark and Behnken), but the former is distinguished from the latter in having flattened posterior margin. The range of *Neogondolella idahoensis* is the Leonardian of Texas, Utah and Wyoming in U.S.A. and the Nabeyaman in Japan. This species also reported from the Upper Chihhsia Formation in China. Behnken (1975) pointed out that *Neogondolella bisselli* is ancestral form of *Neogondolella idahoensis*. Igo (1981) followed his opinion and proposed *Neogondolella intermedia* which represents an evolutionary link between *N. bisselli* and *N. idahoensis*.

Reg. nos. TGU. 1701–1711.

Neogondolella sp. A

Pl. 96, Fig. 12.

Neogondolella sp. A; Igo, 1981, p. 39, pl. 4, fig. 12.

Gondolella cfr. *orientalis* Barskov and Koloeva; Suyari, Kuwano and Ishida, 1983, pl. 1, figs. 6a, b.

Description:—In oral view, unit laterally sub-symmetrical, lanceolate with sharply pointed anterior end and roundly pointed posterior terminal. Surface of platform pitted and granular. Shallow lateral furrows present on both sides of carina. Posterior 2/3 of carina composed of node-

like denticles. Discrete and pointed denticles developed in anterior 1/3 of carina. Cusp small and not located at posterior end of platform. Carina not reach at posterior end of platform. Posterior margin of platform rised upward.

Remarks:—This species resembles *Neogondolella gujioensis* Igo, but the former is distinguished from the latter by the position of cusp. Cusp of *Neogondolella gujioensis* is located on the posterior end of platform, but it is located at slightly anterior side from the posterior end of platform in this species.

Reg. no. TGU. 1700.

Genus *Neostreptognathodus* Clark, 1972

Neostreptognathodus exsculptus Igo, 1981

Pl. 98, Figs. 1, 2.

Neostreptognathodus exsculptus Igo, 1981, p. 40, 41, pl. 5, figs. 2, 3a, b, 4a, b.

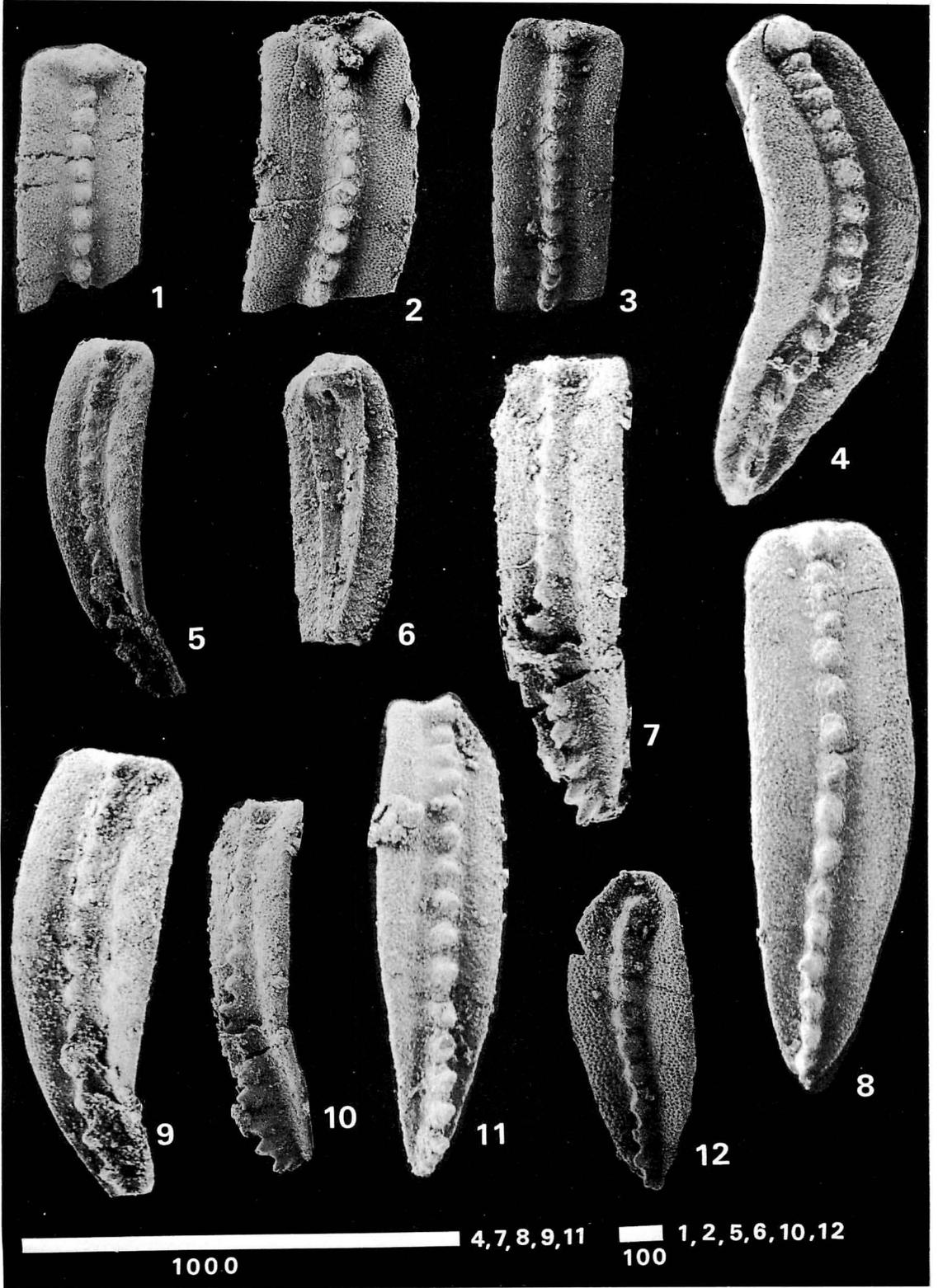
Description:—In oral view, unit elongate with sharply pointed posterior end. Platform provided by 11 transverse ridges. Anterior part of platform pinched laterally. Well developed deep narrow median trough extends throughout platform and transverse section of oral surface deeply V-shaped. Anterior blade joints median part of anterior platform.

In lateral view, unit slightly arched and platform high. In aboral view, expanded basal cavity large, elongate, deepest at center of platform and extends to anterior free blade as narrow groove.

Remarks:—This species resembles *Neostreptognathodus newelli* which was described from

Explanation of Plate 96

- Fig. 1-11. *Neogondolella idahoensis* (Youngquist, Hawley and Miller) Page 521
 Figs. 1-3: Oral views of broken specimens of anterior part. TGU. 1701, 1702, 1703. Fig. 4: Oral view of twisted specimen. TGU. 1704. Figs. 5, 7, 8, 9, 11: Oral views. TGU. 1705, 1707, 1708, 1709, 1711. Fig. 10: Slightly lateral view. TGU. 1710. Fig. 6: Aboral view of broken specimen of anterior part. TGU. 1706.
- Fig. 12. *Neogondolella* sp. A Page 522
 Oral view of mature specimen. TGU. 1700.
 Marker in 4, 7, 8, 9, 11=1000 microns: marker in 1, 2, 3, 5, 6, 10, 12=100 microns.



several localities of Wyoming and the lower part of Meade Peak, Montpelier Canyon section, Idaho, U.S.A. by Wardlow and Collinson (1984). *Neostreptognathodus newelli* Wardlow and Collinson is distinguished from *N. exsculptus* in having more numerous pairs of transverse ridges. On anterior part of platform of *N. newelli*, transverse ridges fused together to make node-like ridges in parallel with median groove.

Reg. nos. TGU. 1731, 1732.

Neostreptognathodus ? sp.

Pl. 98, Figs. 3–6.

Remarks:—The material examined is poorly preserved and anterior blade is lacking. The unit has broadly expanded basal cavity and V-shaped median trough. One rounded node-like ornamentation is developed on the inner side of platform. Many indistinct transverse ridges exist on both sides of median trough.

Reg. nos. TGU. 1733–1736.

Genus *Streptognathodus* Stuffer and

Plummer, 1932

Streptognathodus elongatus Gunnell, 1933

Pl. 98, Figs. 7–9.

Streptognathodus elongatus Gunnell, 1933, p. 283, pl. 33, fig. 30; Ellison, 1941, p. 130, pl. 22, fig. 9; Rhodes, 1963, p. 405, pl. 47, figs. 5, 6, 16–24, 27–34; Sweet in Ziegler, 1975, p. 369, *Streptognathodus*-pl. 1, fig. 6; Igo, 1981, p. 43, 44, pl. 7, figs. 10, 12–15; Ishiga, 1982, pl. 2, figs. 11–13 (non fig. 14); An *et al.*, 1983, p. 179, 180, pl. 32, figs. 3–5; Wan *et al.*, 1983, pl. 1, figs. 1–4; Wang and Li, 1984, p. 200, 201, pl. 1, figs. 1–7; Zhao *et al.*, 1984, p. 133, pl. 25, figs. 11–20.

Gnathodus elongatus (Gunnell), Kozur, 1978, pl. 1, fig. 4.

Streptognathodus cfr. *S. elongatus* Gunnell, Rhodes, 1952, p. 894, pl. 127, figs. 3, 4, 8.

Streptognathodus simplex Gunnell, 1933, p. 285, pl. 33, fig. 40.

Gnathodus simplex (Gunnell), Movshovich *et al.*, 1979, pl. 1, figs. 9, 10.

Remarks:—The material examined has characteristically deep V-shaped median trough and 13 to 15 transverse ridges.

Reg. nos. TGU. 1737–1739.

Genus *Sweetognathus* Clark, 1972

Sweetognathus whitei (Rhodes, 1963)

Pl. 97, Figs. 16–19.

Spathognathodus whitei Rhodes, 1963, p. 404, pl. 47, figs. 4, 9, 25, 26; Clark and Behnken, 1971, pl. 1, figs. 2–6; Merrill, 1973, p. 310, pl. 3, figs. 8, 9.

Sweetognathus whitei (Rhodes); Clark, 1972, p. 155; Clark, 1974, pl. 2, figs. 12–18; Behnken, 1975, p. 312, pl. 1, fig. 26; Sweet in Ziegler, 1977, p. 547, *Neostreptognathodus*-pl. 1, figs. 7a–c; Kozur, 1978, pl. 3, figs. 8, 9a, b; Movshovich *et al.*, 1979, pl. 1, fig. 12; Clark *et al.*, 1979, pl. 1, fig. 4, Wang and Wang, 1981a, p. 231, pl. 1, fig. 20, pl. 2, figs. 8, 10, 11, 22; Igo, 1981, p. 44, pl. 6, figs. 17–22, pl. 7, figs. 1–9; Tian, 1983, p. 334, pl. 77, figs. 3a, b, 11a, b; Zhao *et al.*, 1984, p. 136, pl. 26, figs. 1–16; Orchard, 1984b, p. 213, pl. 23.1, figs. 3–5, 8.

Remarks:—*Sweetognathus behnkeni* Kozur with well developed lateral nodes and *S. whitei* are yielded together in Japan. Both species transitionally change within the same level, therefore, it is very difficult to distinguish as an independent species. Igo (1981) referred *Sweetognathus behnkeni* as a generic form of *S. whitei*.

Reg. nos. TGU. 1727–1730.

Genus *Xaniognathus* Sweet, 1970

Xaniognathus abstractus (Clark and

Ethington, 1962)

Pl. 98, Figs. 15–21.

Subbryantodus abstractus Clark and Ethington, 1962, p. 112, pl. 1, figs. 16, 20 (non fig. 21).

Xaniognathus abstractus (Clark and Ethington), 1973, Sweet in Ziegler, p. 473, *Xaniognathus*-pl. 1, fig. 1; Igo, 1981, p. 44, 45, pl. 11, figs. 9, 10; Wardlow and Collinson, 1984, p. 271, pl. 2, figs. 1-12.

Ozarkodina cfr. *O. abstractus* (Clark and Ethington), Zhao *et al.*, 1984, pl. 27, figs. 7, 8.

Description:—In lateral view, anterior process slightly high and with long numerous denticles. Anterior denticles 8 to 11 and posterior denticles 3 or 4. Anterior 1 or 2 denticles small. Denticles long, sharply pointed and discrete one-third of their length. Cusp large, long and sharply pointed. Posterior process slightly curved towards inside.

In aboral view, basal cavity small and extended into both processes as a narrow groove.

Reg. nos. TGU. 1745-1751.

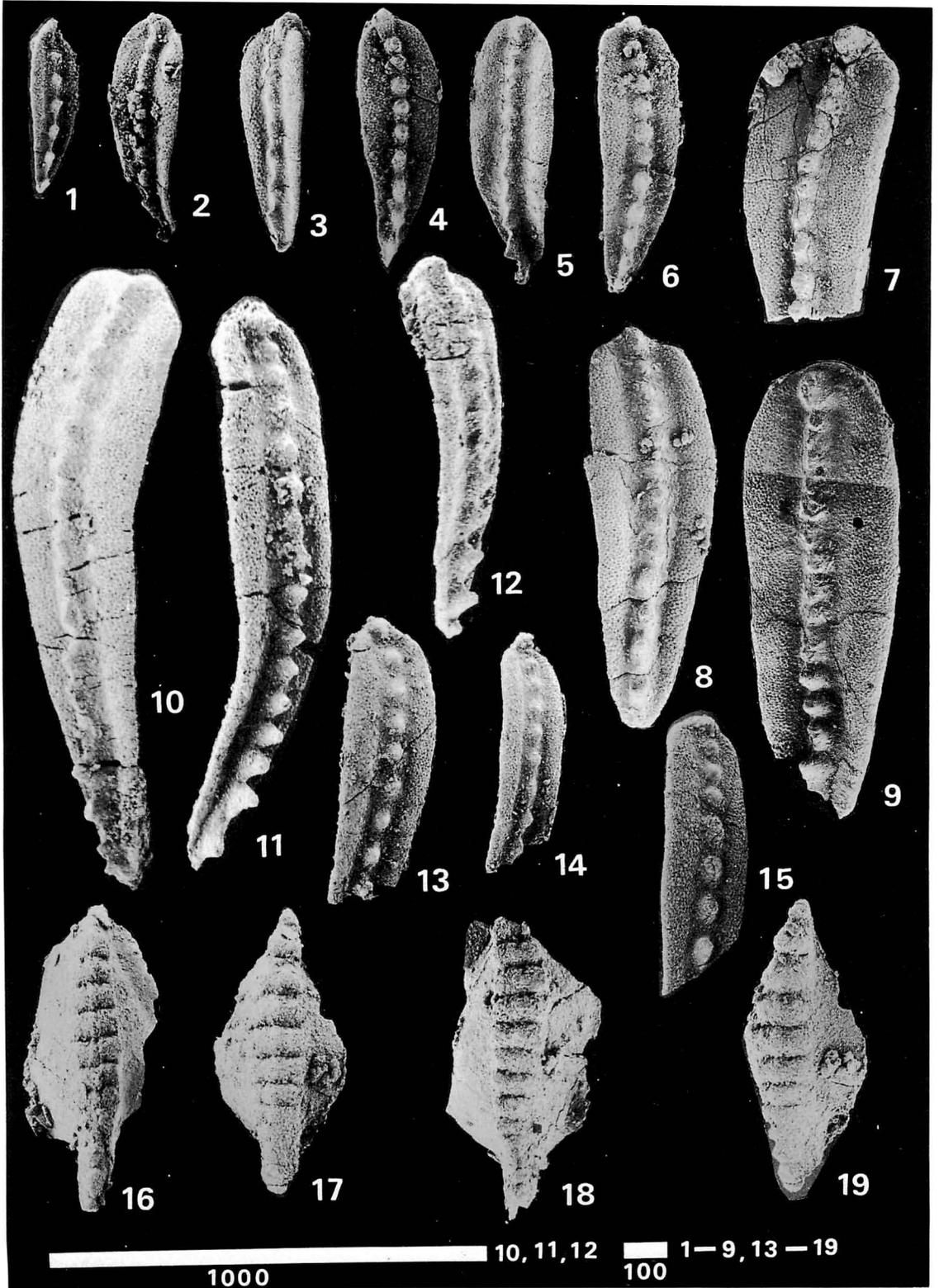
Repository:—All the specimens treated in this paper are preserved in the Department of Astronomy and Earth Sciences, Tokyo Gakugei University.

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Explanation of Plate 97

- Figs. 1-9. *Neogondolella gujioensis* Igo Page 520
 Fig. 1: Slightly lateral view of juvenile specimen. TGU. 1712.
 Figs. 2-6: Oral views of adolescent specimens. TGU. 1713, 1714, 1715, 1716, 1717.
 Figs. 7-9: Oral views of mature specimens. TGU. 1718, 1719, 1720.
- Figs. 10-15. *Neogondolella bisselli* (Clark and Behnken) Page 521
 Figs. 10, 11: Slightly lateral views of mature specimens. TGU. 1721, 1722.
 Fig. 12: Slightly lateral view of adolescent specimen. TGU. 1723.
 Figs. 13-15: Oral views of broken specimens of anterior part. TGU. 1724, 1725, 1726.
- Figs. 16-19 *Sweetognathus whitei* (Rhodes) Page 523
 Oral views of broken specimen of blade. TGU. 1727, 1728, 1729, 1730.
 Marker in 10, 11, 12=1000 microns; marker in 1-9, 13-19=100 microns.

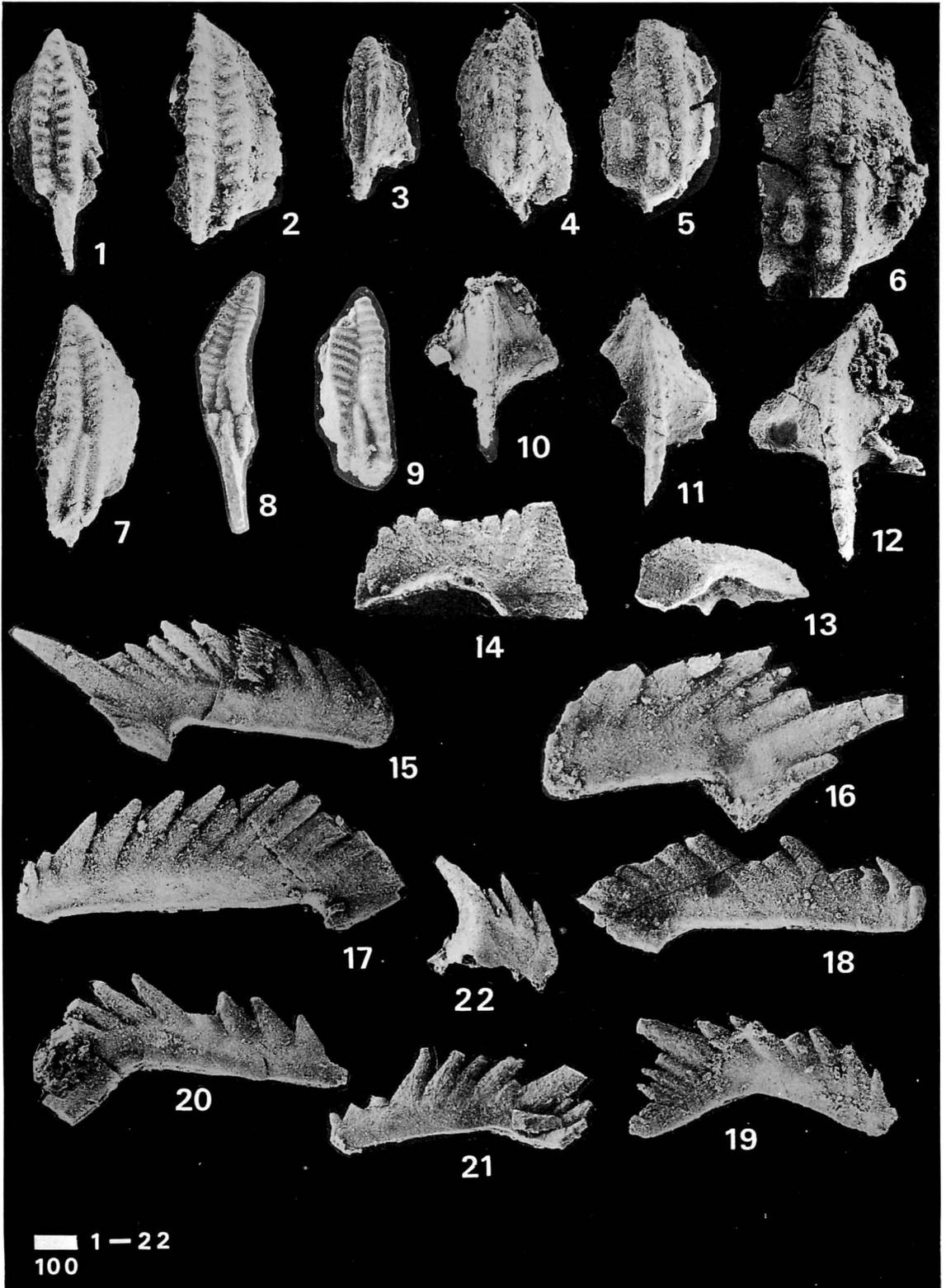


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Explanation of Plate 98

- Figs. 1, 2. *Neostreptognathodus exsculptus* Igo Page 522
Oral views of broken specimens of blade. TGU. 1731, 1732.
- Figs. 3-6. *Neostreptognathodus* ? sp. Page 523
Oral views of broken specimens of anterior part. TGU. 1733, 1734, 1735, 1736.
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- Fig. 14. *Hindeodus minutus* (Ellison) Page 519
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- Fig. 22. *Merrillina* sp. A Page 520
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- Markers of all figures = 100 microns.



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Kawanori 川乗, Ashigakubo 芦ヶ久保, Kamozawa 鴨沢, Hashidate 橋立, Urayama 浦山, Ogouchi 小河内, Nenoyama 子ノ山, Takekawadake 武川岳, Nippara 日原, Ogawadani 小川谷

関東山地南西部川乗層から産出した下部二疊系コノドント: 関東山地南西部の中・古生層は、久田によって、二疊—三疊系の橋立層とジュラ系の浦山層群、ジュラー白亜系の小河内層群に区分された。浦山層群は、頁岩、砂岩、チャート、石灰岩などの外来礫を含むオリストストロームで、子ノ山層、武川岳層、浦山層、川乗層、日原層に細分された。

東京都西部の日原川支流の小川谷上流に分布する川乗層中の石灰岩は多数のコノドントを含み次のような種が識別された。 *Hindeodus minutus* (Ellison) Pa element, *Diplognathodus* sp. A, *Merrillina* sp. A, *Neogondolella bisselli* (Clark and Behnken), *N. gujiensis* Igo, *N. idahoensis* (Youngquist, Hawley and Miller), *N. sp. A*, *Neostreptognathodus exsculptus* Igo, *N.?* sp., *Streptognathodus elongatus* Gunnell, *Sweetognathus whitei* (Rhodes), *Xaniognathus abstractus* (Clark and Ethington), *Idiognathodus* sp., *Enantiognathus* sp., *Lonchodina* spp., *Diplododella* sp., *Hindeodella* sp., *Hindeodus minutus* (Ellison) Sc element. これらのコノドントは *Neogondolella bisselli*—*Sweetognathus whitei* assemblage zone の構成種であるが、*Streptognathodus elongatus* と *Idiognathodus* sp. はそれより古い時代を示し、誘導化石と考えられる。 猪郷久治・久田健一郎

824. EARLY JURASSIC PLANTS IN JAPAN. PART 7.
FOSSIL PLANTS FROM THE NISHINAKAYAMA FORMATION,
TOYORA GROUP, YAMAGUCHI PREFECTURE,
SOUTHWEST JAPAN

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Abstract. This is the seventh of our serial papers on the Early Jurassic plants in Japan. In this paper we describe the following fossil plants obtained from the Nishinakayama Formation of marine origin: *Phlebopteris* sp., *Otozamites micropinatus*, sp. nov., *O.* sp. A, *O.* sp. B, *Zamites toyoraensis* Oishi, *Z.* sp., *Pseudoctenis* sp., *Brachyphyllum* ex gr. *expansum* (Sternberg) Seward, *Cupressinocladus* sp. A, *C.* sp. B, *Elatides* sp. and *Geinitzia* sp.

As our specimens are mostly of poorly preserved impression, it is difficult to give clear specific names but they are all characteristic constitutional elements of this florula.

This florula is quite different in floristic composition from the coeval floras of the Kuruma Group and Iwamuro Formation in Japan and of the Xiangxi Formation in West Hubei, China.

Introduction

The Toyora Group of marine origin consists of the Higashinagano, Nishinakayama and Utano Formations in upward sequence distributed in western part of Yamaguchi Prefecture, Southwest Japan. Invertebrate fossils are very abundant but fossil plants are rather rare except the

Utano Formation. From the Higashinagano Formation only *Nilssonina brevis* Brongniart was described by Oishi (1940). The Nishinakayama Formation is divided by Hirano (1971, '73) into Nf-, Np-, Nd- and Na-ammonite Zones in upward sequence. According to Hirano (1971, '73), the geological age of the Nishinakayama Formation ranges from Pliensbachian to early Toarcian based on its rich ammonite-fauna.

The following fossil plants were described by

* Received December 9, 1985; Read February 1, 1986 at Tohoku University.

Yabe (1922), Oishi (1935, '40) and Huzioka (1938) from the Nishinakayama Formation: *Phlebopteris takahashii* Huzioka, 1938; *Zamites toyoraensis* Oishi, 1935; *Z. yabei* Oishi, 1940 (= Cf. *Zamiophyllum buchianum* by Yabe, 1922); *Brachyphyllum expansum* (Sternberg) Seward (Oishi, 1940, but not illustrated).

We recognized the following plant-taxa among the collection made by one of us (Naito), Y. Kurihara, H. Ishida, T. Fukutomi and others: *Phlebopteris* sp., *Otozamites micropinnatus* Kimura, Naito et Ohana, sp. nov., *O.* sp. A, *O.* sp. B, *Zamites toyoraensis* Oishi, *Z.* sp., *Pseudoctenis* sp., *Brachyphyllum* ex gr. *expansum* (Sternberg) Seward, *Cupressinocladus* sp. A, *C.* sp. B, *Elatides* sp. and *Geinitzia* sp.

Although the number of plant-taxa is small, it is worth mentioning that this florula is quite different in floristic composition from the coeval floras from the Kuruma Group and Iwamuro Formation in Japan (Kimura and

Tsujii, 1980a, b, '81, '82, '83, '84) and from the Xiangxi Formation (s. str.) in West Hubei, China (Wu, S. Q. et al., 1980).

The floristic features of the Nishinakayama Formation will be discussed in the last of our serial papers (Early Jurassic plants in Japan. Part 8) together with the concluding remarks of the Early Jurassic floras in Japan and its adjacent areas. Accordingly this paper deals only with the description of fossil plants newly obtained from the Nishinakayama Formation.

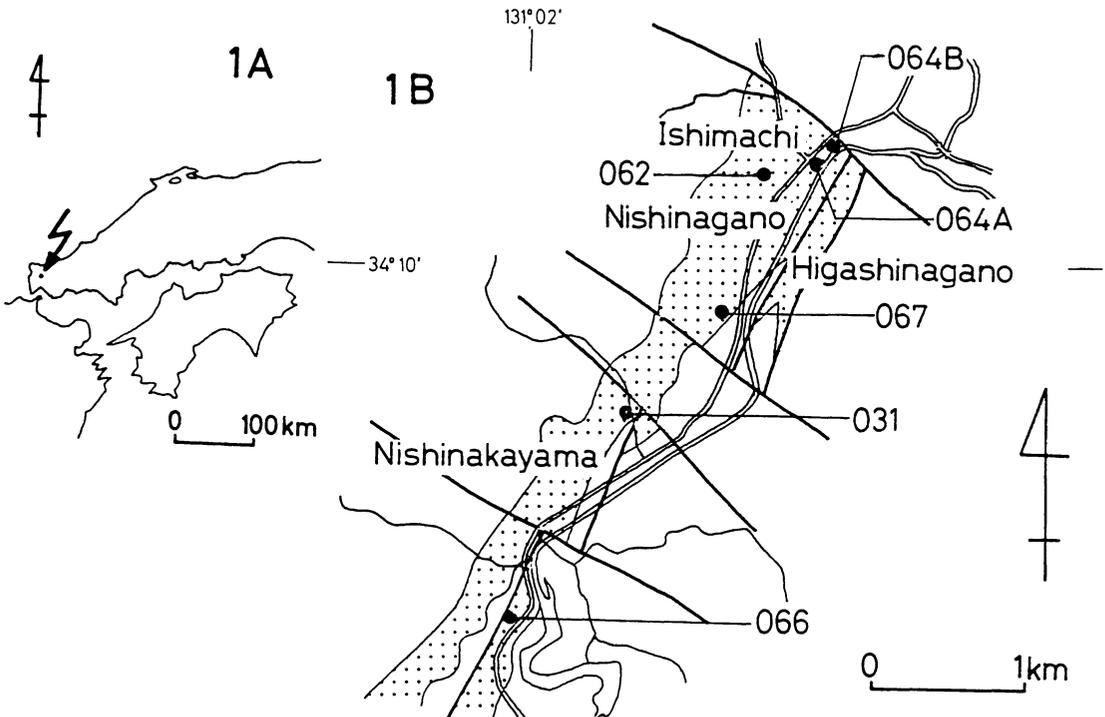
Figs. 1A, B show the distribution of the Nishinakayama Formation and the main localities of fossil plants described herein.

Systematic description

Filicales: Family Matoniaceae

Genus *Phlebopteris* Brongniart, 1836: 371

Phlebopteris sp.



Figs. 1A, B Distribution of the Nishinakayama Formation and localities of fossil plants. 1A; an arrow indicates the location of the Nishinakayama Formation (after Hirano, 1971). 1B; solid circles show the main localities of fossil plants.

Text-figs. 1a—d

Material: N1984. *Locality:* Ishimachi (Loc. no. 062). *Horizon:* Nd-Zone. *Occurrence:* Rare.

Description: Obtained is a single sterile pinna fragment, 3 cm long and 1.7 cm wide at its basal part, narrowing gradually towards its distal part. The pinna axis is slender, 0.8 mm wide, giving oppositely off closely set pinnules at nearly right angle. The pinnules are elongate-triangular in form; the largest one preserved is 8 mm long and 3 mm wide near the base; adjacent pinnules are connected by a web, 0.5 mm wide. Apices of pinnules are obtusely pointed; margins are entire, but most of them are markedly recurved. Veins are partly visible; midnerve is prominent, giving off lateral veins forking at once into forward and backward branches which join those of adjacent branches to form the 'arches'. The 'arches' are usually wider than high, rather flat and never including any branch veins. The 'arches' give off 2—3 outer veins running nearly perpendicularly to the margins. The outer veins are forking once near the 'arch' or near the margin, and sometimes anastomosing with adjacent branches to form elongate meshes. In the web region, the 'arches' are along the pinna axis, small, semi-circular and each giving off simple or once forked outer veins directed forwards in the acroscopic base of pinnule and directed backwards in the basiscopic base of pinnule.

Remarks: Judging from the characteristic venation observed in our sterile pinna, it is certain that our pinna is referable to *Phlebopteris*. But it is difficult to make its specific identity because of the insufficiency of our material.

Huzioka (1938) described *Phlebopteris takahasii* as a new species from Ishimachi (the same locality as ours) based on a single large-sized sterile pinna fragment. Huzioka's pinnules are long and narrow, linear, more than 3 cm long and 5 mm wide, and attached to the thick pinna axis, 4 mm wide at a wide angle. If the venation of Huzioka's pinnules is properly drawn, *Phlebopteris takahasii* may be distinct from ours, because in Huzioka's drawing, there are no 'arches' but

crowded lateral veins directly from the midnerve.

Our *Phlebopteris* sp. differs from other *Phlebopteris* species hitherto described in its rather flat 'arches' along the both sides of midnerve, instead of angular (as shown by Harris, 1961, figs. 33, 35) in others.

Bennettitales

Genus *Otozamites* Braun, 1842

Otozamites micropinnatus Kimura,
Naito et Ohana, sp. nov.

Pl. 99, Figs. 1—3; Pl. 100, Figs. 1—2;
Text-figs. 2a—c

Material: Holotype; N1983 (Narusebashi; Loc. no. 064). Paratype; N3648 (ditto). Other specimens: 1983A, 3644, 3685, 3687 (ditto). *Stratum typicum:* Nishinakayama Formation (Upper Np- and Lower Nd-Zones). *Locus typicus:* Ishimachi, Toyora-cho, Toyora-gun, Yamaguchi Prefecture (Loc. no. 064). *Derivatio nominis:* According to small-sized pinnae. *Occurrence:* Not rare.

Diagnosis: Typical leaf elongate-oblongate in outline, more than 10.5 cm long, up to 2 cm wide. (apex and petiole not known.) Rachis comparatively thick, 2 mm wide measured on impression, sending off more than 50 alternate pairs of small-sized pinnae at a wide angle (70—75 degrees). Pinnae attached to the upper surface of rachis by the middle of base or by the lower half of semi-amplexicaul base and often imbricate. Pinnae on the apical half of a leaf elongated, 1 cm long and 2.5 mm wide near auricle; those on the proximal half short-rectangular and those on the proximal part semi-circular or triangular, 2 mm long and 1.2 mm wide at base, sometimes falcate; apex obtuse; pinna base asymmetrical and auriculated. Auricle free and developed near acroscopic basal angle; auricle of the opposite pinna lying below partly covering basiscopic basal margin of the pinna lying above; then upper surface of rachis usually concealed. Veins emerging from the point of attachment of pinna and radiating into auricle and the rest of pinna, 10-12 in number near the base; a few forking dichotomously near the base. (Cuticle

not preserved and reproductive organs not known.)

Description: Pl. 99, Fig. 2 (Text-fig. 2a, c) shows the holotype of *Otozamites micropinnatus* represented by its under surface. But fortunately its rachis was partly stripped off, then we could recognize both the whole shape and the mode of attachment of pinnae.

The general leaf-form is shown in Pl. 99, Fig. 1 (paratype), although its apex and petiole are missing. This is under surface view of leaf, then characteristic pinna bases including developed auricles are all concealed by the crushed rachis. Such leaf as mentioned above can be confused with the small-sized leaves of *Ptilophyllum*.

Pl. 100, Fig. 1 shows also under surface view of an apical half of the largest leaf in our hand; its preserved part with 40 alternate pairs of pinnae is 11 cm long, but its apex is missing.

Pl. 99, Fig. 3 and Pl. 100, Fig. 2 show two proximal parts of leaves in under surface view, the former is smaller and the latter is larger in size both with marked petiole.

Discussion and comparison: *Otozamites micropinnatus* is characterized by its elongate-ob lanceolate leaf bearing small-sized and closely set pinnae with well developed auricles.

Most *Otozamites* species hitherto known have far larger leaves than *O. micropinnatus*. So far as we know, *Otozamites* species bearing small-sized pinnae are; *O. bengalensis* (Oldham et Morris), *O. bunburyanus* Zigno var. *indica* Seward et Sahni, *O. chuensis* Zhou, *O. kilpperiana* Barnard et Miller, *O. margaritaceus* Zhou, *O. mattiellianus* Zigno, *O. mixomorphus* Ye, *O. parvus* Zhou, *O. tenellus* Zhou.

Among them *Otozamites bengalensis*, *O. bunburyanus* var. *indica*, *O. kilpperiana*, *O. parvus* and *O. tenellus* are clearly distinguished from *O. micropinnatus* by their leaves all with semi-circular or nearly circular pinnae and also *O. margaritaceus* is distinguished by its leaf with triangular pinnae.

In *Otozamites chuensis* originally described by Zhou (1984) from the early Lower Jurassic Guanyintan Formation, Southwest Hunan, China,

its pinnae are similar in form to those on the distal half of leaf of *O. micropinnatus*, but it is difficult to make full comparison of Zhou's species with our species because Zhou's original specimen is only represented by 7 pairs of elongated pinnae.

In *Otozamites mattiellianus* Zigno (Zigno, 1873–1885; Wesley, 1974) described by Zhou (1984) from the Guanyintan Formation, its pinnae are similar in form to those of our elongated ones, but are larger in size and with submucronate (or submucronulate) apex.

Ye (in Wu, S. Q. *et al.*, 1980) proposed *Otozamites mixomorphus* as a new species based on Sze's *O. bengalensis* (Oldham et Morris) (Sze, 1949, p. 17, pl. 4, fig. 3b; pl. 11, fig. 4) from the late Lower Jurassic Xiangxi Formation (*s. str.*), Western Hubei, China. *Otozamites mixomorphus* is most close in size and pinna form to our *O. micropinnatus*, but it is difficult to make full comparison of Ye's species with ours because Ye's species is represented only by broken parts of leaves.

Under the circumstances, we here propose *Otozamites micropinnatus* as a new species.

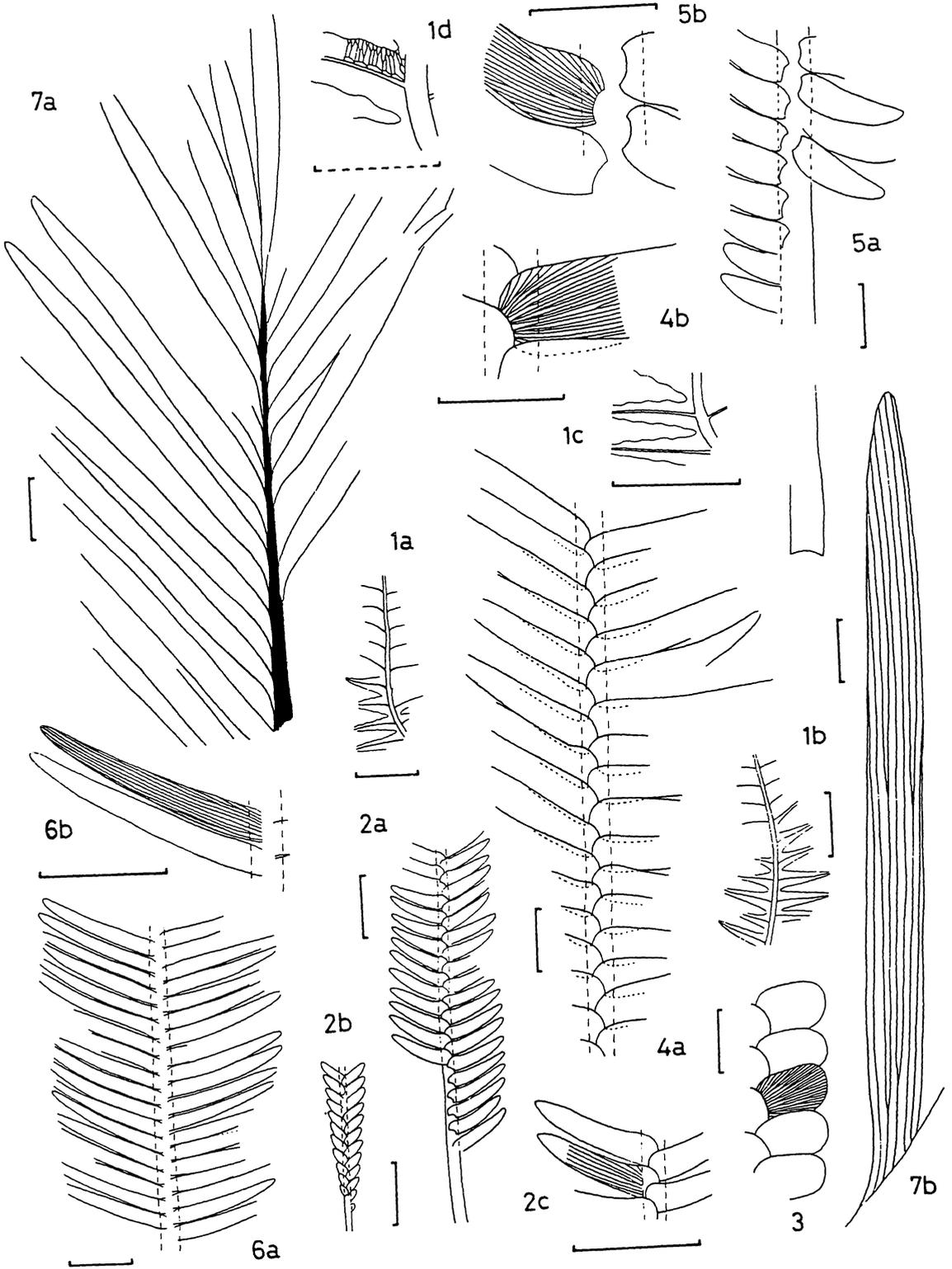
Otozamites sp. A

Text-fig. 3

Material: NI-1004, 1008. *Locality:* Nishinakayama Quarry (Loc. no. 066). *Horizon:* Nd-Zone. *Occurrence:* Rare.

Description: Leaf is pinnate. Pinnae are set closely, alternate, imbricated, elliptic in form, 1.2 cm long and 0.8 cm wide and attached to the upper sides of rachis at a wide angle and concealed the rachis completely; basiscopic base of pinna is entirely concealed by the acroscopic base of opposite pinna. Acroscopic basal angle is not auriculated; upper surface of pinnae is usually convex. Veins are divergent, dichotomously forking once or twice as shown in Text-fig. 3; 26 per cm in density.

Remarks: In general, form and size of *Otozamites* pinnae are different according to the position of a leaf. Thus it is difficult to make the specific identity for such leaf-fragments



as ours represented only by 7 alternate pairs of pinnae.

Our pinnae somewhat resemble proximal pinnae of *Otozamites hsiangchiensis* Sze (e. g. Wu, S. Q. *et al.*, 1980, pl. 17, fig. 6) from the late Lower Jurassic Xiangxi Formation (s. str.), Western Hubei, China.

Leaves with similar pinnae are represented by *Otozamites walkamotaensis* Bose et Zaba-Bano and *O. kachchhensis* Bose et Banerji known from the Middle-Upper Jurassic plantbeds in Kachchh (Bose and Banerji, 1984). But these pinnae are characterized by more or less developed acroscopic angles.

Most of all, *Otozamites* sp. A resembles macroscopically *O. bunburyanus* Zigno (Wesley, 1974, pl. 2, fig. 4) from the Lower Jurassic of Italy.

Otozamites sp. B

Pl. 100 Fig. 3; Text-fig. 4a—b

Material: N3684, IC-2011 (2014; counterpart). *Localities*: Narusebashi (Np-Zone) and Ishimachi (Nd-Zone). *Occurrence*: Rare.

Description: Obtained are two broken leaves of which pinnae are closely set, imbricated and are attached alternately to the upper surface of thick rachis (4 mm wide) at a wide angle, concealing the rachis completely. Pinnae are elongate-triangular in form, sometimes falcate with obtusely pointed apex and with asymmetrical and contracted base possibly with the small area of attachment near the basicopic margin; acroscopic angle is not so prominent.

Basicopic base and margin are usually concealed by the acroscopic base of an opposite pinna and the acroscopic margin of pinna of subordinate position respectively. Veins are typical *Otozamites*-type. Although their origin is concealed, judging from our observation as shown in Text-fig. 4b, veins are small in number (5—6) at the base, then repeatedly forking dichotomously near the base; more than 20 in number at the middle of pinna. Cuticle is not preserved.

Remarks: Although very base of pinnae is usually concealed and acroscopic angle of pinna is not well developed, it is highly probable that our leaves fall under the category of *Otozamites*, because our pinna base is asymmetrical, contracted, attached to the upper surface of rachis and the pinnae with typical *Otozamites*-type venation.

Our leaf is characterized by its closely imbricated pinnae, but at present we reserve to make its specific identity and regard it as *Otozamites* sp. B. until more satisfactory leaves are available.

The leaves of *Otozamites* sp. B resemble in form some leaves of *O. hsiangchiensis* Sze (Wu, S. Q. *et al.*, 1980) known from the late Lower Jurassic Xiangxi Formation (s. str.), Western Hubei, China, but is distinguished by its closely imbricated pinnae and undeveloped acroscopic pinna angle.

Genus *Zamites* Brongniart, 1828

Zamites toyoraensis Oishi

Pl. 100, Fig. 4; Text-fig. 5a—b

Zamites toyoraensis Oishi: Oishi, 1935,

Text-figs. 1—7 (length of solid bar indicates 1 cm, and length of broken bar indicates 0.5 cm).

1. *Phlebopteris* sp.: 1a, b; pinna fragments (N1984). 1c; enlarged partly from 1a. 1d; ditto, showing the venation of pinnule. 2. *Otozamites micropinnatus* Kimura, Naito et Ohana, sp. nov.: 2a; middle part of a leaf (holotype; N1983) (Pl. 99, Fig. 2). 2b; basal part of a leaf (N3685) (Pl. 99, Fig. 3). 2c; enlarged from 2a, showing the venation of pinna. 3. *Otozamites* sp. A (NI-1004), showing the pinna-form and venation. 4. *Otozamites* sp. B: 4a; middle part of a leaf (IC-2011). 4b; enlarged from 4a, showing the venation of pinna. 5. *Zamites toyoraensis* Oishi: 5a; proximal part of a leaf (N1990) (Pl. 100, Fig. 4). 5b; enlarged from 5a, showing the basal part of pinnae and venation of pinna. 6. *Zamites* sp.: 6a; a part of leaf (IC-1001). 6b; enlarged partly from 6a, showing the venation of pinna. 7. *Pseudoctenis* sp.: 7a; distal part of a leaf (N1988) (Pl. 100, Fig. 5). 7b; enlarged from 7a, showing the venation.

p. 98, text-fig. 1 (Tarai); 1940, p. 358 (remarks); Takahashi, 1973a, pl. 1, fig. 1 (Ishimachi).

Material: N1990, 3684, 3718. *Localities*: Narusebashi (Loc. no. 064; Np-Zone) and Sakuraguchidani (Loc. no. 067; Upper Np- and Lower Nd-Zones). *Occurrence*: Not rare.

Description: Among three specimens in our hand one (Pl. 100, Fig. 4; Text-fig. 5a–b) is represented by the proximal portion of a leaf. The pinnae are elongate-deltoid or short-rectangular in form below, 1.2 cm long and 0.4 cm wide near the base, and more elongate-deltoid above, 1.7 cm long and 0.5 cm wide near the base, slightly falcate and all with obtusely pointed apex; attached to the upper surface of thick rachis (0.5 cm wide measured on impression) by a rounded symmetrical and non-auriculate base with ‘callosity’ at a wide angle. The veins are slender and densely crowded; some forking dichotomously near the base, mostly parallel to each other except at the base where they are divergent, not converging at apex; about 16 in number near the base (Text-fig. 5b). Cuticle is not preserved.

Remarks: *Zamites toyoraensis* was first described by Oishi (1935) based on a single broken leaf representing the middle-distal part. Takahasi’s illustration (Takahasi, 1973a) showed also the same part of a leaf. According to Oishi (1935), in the original leaf, pinna apices are usually acuminate instead of obtusely pointed in ours and veins are 25–30 in number at the basal broadest portion of each pinna instead of 16 in ours. We now think, however, that our leaf shown in Pl. 100, Fig. 4 represents the proximal portion of a leaf belonging to *Zamites toyoraensis*, because in other bennettitalean leaves, such morphological differences as mentioned above are usually recognized according to the position of pinnae in a leaf.

Zamites sp.

Pl. 99, Fig. 4; Text-fig. 6a–b

Material: N3676, IC-1001, IC-1002 (?), N3647 (?). *Locality*: Narusebashi (Loc. no. 064; Np-Zone). *Occurrence*: Rare.

Description: Obtained are four ill-preserved leaf-fragments. Thus whole leaf is unknown. In Text-fig. 6a, leaf is more than 6.5 cm long and up to 4 cm wide with rather thick rachis (3 mm wide). Pinnae are set closely and attached alternately to the upper sides of rachis at a wide angle, but not concealed it completely. Pinnae are linear, nearly parallel-sided for the most part, typically 2 cm long and 2.5 mm wide; pinna base slightly contracted and nearly symmetrical, but its very base and mode of attachment to the rachis are obscure; pinna apex is obtusely pointed. Veins are 9 in number at base, acroscopic and basisopic one or two veins are slightly divergent and forking once near the base; other veins are parallel, not converging at apex. Pl. 99, Fig. 4 may represent the apical part of a leaf; its pinnae are small-sized and attached to the rachis at an angle of 45 degrees. Cuticle is not preserved.

Remarks: Although very base of pinnae is obscure, it is highly probable that our leaves fall under the category of *Zamites* because our pinna base is contracted, symmetrical and attached to the upper sides of rachis and the veins of acroscopic side curving basipetally and the veins of basisopic side acropetally.

Our leaf is characterized by its small-size and closely set pinnae, but we here reserve its specific identity and regard it as *Zamites* sp. until more satisfactory leaves are available.

At first glance, the leaves of *Zamites* sp. resemble in external form large-sized leaves of *Pterophyllum nathorsti* Schenk (or *Tyrmia latior* Ye) and those of *Ptilophyllum contiguum* Sze both described by Wu, S. Q. *et al.* (1980) from the late Lower Jurassic Xiangxi Formation, Western Hubei, China. But *Zamites* sp. is distinguished from *Pterophyllum nathorsti* of which pinnae are attached to the lateral sides of rachis and from *Ptilophyllum contiguum* of which pinnae are with asymmetrical base.

Oishi (1940, p. 358, pl. 37, fig. 6) described *Zamites yabei* based on Yabe’s Cf. *Zamiophyllum buchianum* (Yabe, 1922) collected possibly from Nd-Zone of the Nishinakayama Formation (Takahasi, 1973b). According to Oishi (1940),

Zamites yabei is characterized by the large leaf bearing long, narrow and parallel-sided pinnae attached to the upper surface of the rachis and each with 15 (?) parallel veins. There is a possibility that *Zamites* sp. A represents the apical portion of a leaf of *Zamites yabei*.

Cycadales

Genus *Pseudoctenis* Seward, 1911: 19*Pseudoctenis* sp.

Pl. 100, Fig. 5; Text-fig. 7a—b

Material: N1988. **Locality:** Narusebashi (Loc. no. 064; Np-Zone).

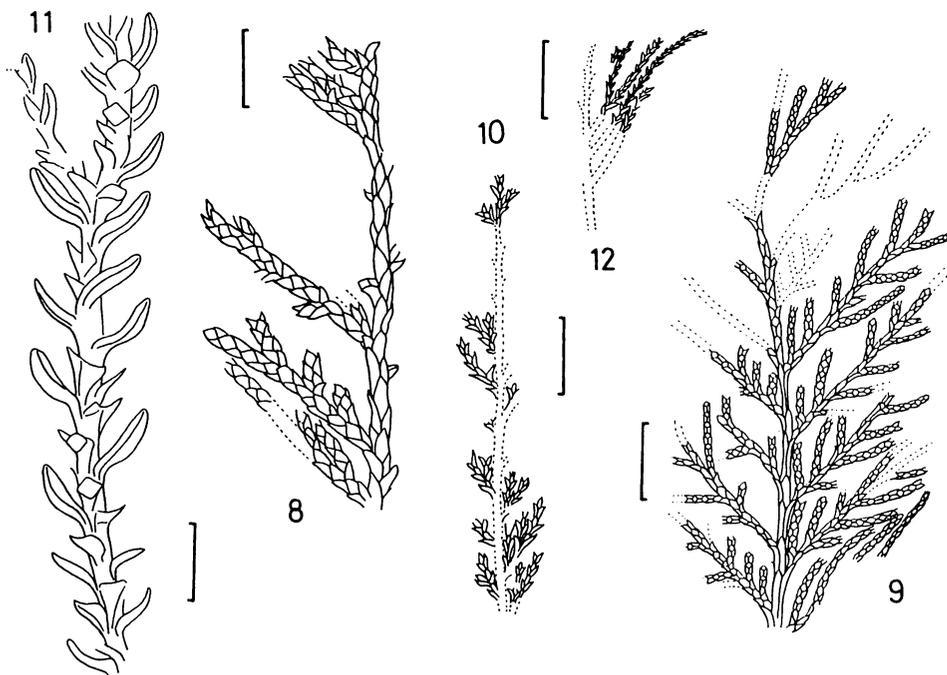
Occurrence: Rare.

Description: The leaf is imparipinnate with rather stout rachis, 4 mm wide. The whole leaf is unknown. The pinnae are long and narrow,

typically 6.5 cm long, nearly parallel-sided for the most part, 4.5 mm wide, gradually narrowing to the obtusely pointed apex, constricted near the base then expanded and decurrent at the base, and attached remotely to the lateral sides of rachis at an angle of 40 degrees; angles reducing distally. The veins are typically 5 in number at base; some of them are forking once or twice dichotomously, then running parallel to the margins and ending at the distal margins of pinna; 9 in number (10—11 per cm) at the middle. Cuticle is not preserved.

Remarks: A single broken leaf was obtained (collected by T. Utamura in 1976). According to its pinna-form the present leaf has led us to regard it as belonging to the cycadean genus *Pseudoctenis*.

Pseudoctenis sp. closely resembles in external form *P.* sp. described by Oishi (1940, p. 324,



Text-figs. 8—11 (length of solid bar indicates 1 cm).

8. *Brachyphyllum* ex gr. *expansum* (Sternberg) Seward; a part of branching twig (IC-3003) (Pl. 99, Fig. 7). 9. *Cupressinocladus* sp. A; a pinnately branched shoot (IC-5010) (Pl. 99, Fig. 6; Pl. 100, Fig. 7). 10. *Cupressinocladus* sp. B; a branching twig (IC-5003). 11. *Elatides* sp.; a branching twig (IC-5012) (Pl. 99, Fig. 5). 12. *Geinitzia* sp.; an ill-preserved branching twig (IC-2002).

pl. 29, fig. 6) from Takaji (Middle Jurassic Utano Formation). But Oishi's leaf is distinguishable by its small-size (about one-half of ours) and more crowded veins (13 in each pinna).

The leaves described by Oishi (1940, p. 322, pl. 29, figs. 1–3) as *Pseudoctenis lanei* Thomas from the Upper Jurassic Oginohama Formation, Northeast Japan are also distinguishable from that of ours by its pinnae each with acuminate apex and with 13 veins.

Pseudoctenis nipponica originally described by Kimura and Tsujii (1983) from the Negoya Formation, Kuruma Group is distinguished by its pinnae each with acutely pointed apex and with crowded veins (typically 13 in number).

A Wealden species, *Pseudoctenis eathiensis* (Richards) Seward (1885, 1917) is one of the comparable species in size with the present *P. sp.*, but is distinguished by its pinnae which are sometimes longer (the longest is 17 cm) and are more contracted near the base.

Thus, *Pseudoctenis sp.* is considered to be distinct, but we at present reserve to give it a new specific name until the subsequent supply of material.

Coniferales

Form-genus *Brachyphyllum* Lindley et Hutton

1836 ex Brongniart, 1828

Brachyphyllum ex gr. *expansum*
(Sternberg) Seward

Pl. 99, Fig. 7; Pl. 100, Fig. 8; Text-fig. 8

Comparable Japanese specimens:

Brachyphyllum expansum (Sternberg) Seward: Oishi, 1940, p. 391, pl. 39, figs. 10–11; pl. 40, fig. 9 (Takaji, Utano Formation).

Material: IC3003 (3004), N3636, 3638, 3718, 3719. *Locality:* Andadani (Loc. no. 031; Np-Zone). *Occurrence:* Not rare.

Description: The branching-twig shown in Pl. 99, Fig. 7 (Text-fig. 8) is the largest one in our collection. In this twig, branches are nearly straight and main branch is more than 6 cm long and 2 mm wide, giving alternately off closely set secondary branches in one plane; the secondary branches are more than 2.8 cm long and giving alternately off short third ones. Leaves are arranged spirally and mostly appressed to the stem. Leaf is arising from a leaf-base cushion which may be elongated. Leaf with leaf-base cushion varies from 0.5 cm long and 2 mm wide on the main branch to 2 mm long and 1.5 mm wide on the ultimate branch. Cuticle is not preserved.

Remarks: In the case of such twigs without cuticle and reproductive organs as ours, it is difficult to make precise specific identity, but our twigs resemble in external form those illustrated by Oishi (1940) as *Brachyphyllum expansum* from Takaji. Under the circumstances, we regard our twigs provisionally as *Brachyphyllum* ex gr. *expansum*.

So far as we know, such branching twig as ours has not been recorded from the Upper Triassic plant-beds in Japan, Korea and from the late Lower Jurassic Kuruma Group and its equivalents in Japan. However, Z. Y. Zhou (1984) illustrated two small twigs as *Brachyphyllum*

Explanation of Plate 99

(Natural size unless otherwise indicated)

Fig. 1. *Otozamites micropinnatus* Kimura, Naito et Ohana, sp. nov.: Paratype (N3648).

Fig. 2. *Otozamites micropinnatus* Kimura, Naito et Ohana, sp. nov.: Holotype (N1983) (Text-figs. 2a, c).

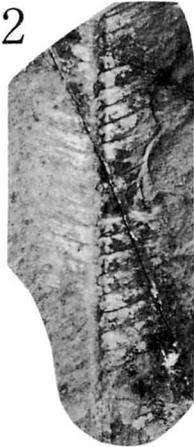
Fig. 3. *Otozamites micropinnatus* Kimura, Naito et Ohana, sp. nov.: N3685 (Text-fig. 2b).

Fig. 4. *Zamites* sp.: N3676.

Fig. 5. *Elatides* sp.: IC-5012 (Text-fig. 11).

Fig. 6. *Cupressinocladus* sp. A: IC-5012 (Text-fig. 9).

Fig. 7. *Brachyphyllum* ex gr. *expansum* (Sternberg) Seward: IC-3003 (Text-fig. 8).



sp. from the early Lower Jurassic Guanyintan Formation, Southwest Hunan, China. So this would be the oldest record of such-like plants in East Asia.

Takahasi (1973b) recorded the occurrence of *Brachyphyllum expansum* from the uppermost zone (Sinemurian) of Higashinagano Formation and the Np-Zone of Nishinakayama Formation and of *Brachyphyllum* sp. from the Nd-Zone of Nishinakayama Formation. But they were neither described nor illustrated.

Form-genus *Cupressinocladus* Seward, 1919:307

Cupressinocladus sp. A

Pl. 99, Fig. 6; Pl. 100, Fig. 7; Text-fig. 9

Material: IC5010, 5011 (5012, counterpart).
Locality: Narusebashi (Loc. no. 064; Np-Zone).
Occurrence: Rare.

Description: Pl. 99, Fig. 6 (Pl. 100, Fig. 7 enlarged from Pl. 99, Fig. 6; Text-fig. 9) shows a pinnately branched shoot with scaly leaves in decussate pairs, more than 12 cm long. The second branches (in this figure) are alternate, about 1.5 cm distant; the longest one is 3.5 cm long. The ultimate branches are nearly the same wide as the secondaries, up to 1.3 cm long and opposite proximally but alternate distally. The leaves are small-sized, rhomboidal in outline, all appressed to the axis, weakly keeled dorsally with acutely pointed apex. Cuticle is not preserved.

Remarks: Among two branched leafy shoots now in our hand, the illustrated one is well preserved. Our branched leafy shoots can not be referable to Form-genus *Brachyphyllum* because *Brachyphyllum* is defined as its leaves are spirally arranged (Harris, 1979). Our branched leafy shoots agree well with the definition of *Cupressinocladus* given by Seward (1919), Chaloner and Lorch (1960) and Harris (1969).

Cupressinocladus koyatoriensis originally described by Oishi (1940) from the Upper Jurassic Oginohama Formation, Northeast Japan differs from our *C. sp. A* in that in Oishi's decussate leaves, one pair is appressed to the axis but the

other pair is free except the basal halves and free part is at a right angle to the axis, instead of all appressed and not radiated in ours.

Similar branched leafy shoots to ours have so far been described under various generic names, but at present it is difficult to make specific identity and to mention their botanical affinity for such sterile impressions as ours.

Cupressinocladus sp. B

Text-fig. 10

Material: IC5003. *Locality*: Ishimachi (Loc. no. 062; Nd-Zone).

Occurrence: Rare.

Description: Obtained is a single ill-preserved branching twig of which main axis is more than 5.7 cm long sending alternately off shorter secondaries at an angle of 40 degrees in one plane; secondary branch is 1.2 cm long sending off very short third branches. Leaves are rhomboidal in outline with acutely pointed apex and decussate in arrangement; dorsal and ventral pairs are usually appressed to the axis but lateral pairs are free, diverging from axis typically at 40 degrees but decurrent proximally. Cuticle is not preserved.

Remarks: *Cupressinocladus* sp. B differs from *C. sp. A* in its free lateral leaves. Our twig is too incomplete to compare with other twigs with decussate leaves hitherto known.

Form-genus *Elatides* Heer, 1876 em. Harris,
1976: 66

Elatides sp.

Pl. 99, Fig. 5; Pl. 100, Fig. 6; Text-fig. 11

Material: N1981, 1982, 3638, 3689, IC5012.
Localities: Narusebashi (Loc. no. 064; Np-Zone) and Sakuraguchidani (Loc. no. 067; Upper Np- and Lower Nd-Zones). *Occurrence*: Not rare.

Description: Obtained are five broken leafy shoots. The leaves are persistent, spirally and closely set, diverging radially and arising from decurrent cushion. Free part of leaves is falcate

and rhomboidal in section each with obtusely pointed apex and a single keel (vascular bundle?). Cuticle is not preserved.

Remarks: The above description agrees well with the emended diagnosis of *Elatides* given by Harris (1979).

In Pl. 99, Fig. 5 (Text-fig. 11), only parallel or nearly parallel leaves to the bedding plane were preserved completely but other leaves were broken during the collection leaving their crossing rhomboidal section.

The leafy shoots of our *Elatides* sp. resemble in leaf-form those of other *Elatides* species such as *E. asiatica* (Yokoyama) Krassilov, *E. curvifolia* (Dunker) Nathorst and those regarded as *Araucarites* hitherto described.

The original specimen of *Elatides asiatica* was first described by Yokoyama (1906) from the Lower Jurassic (?) of Liaoning, China as *Palissya manchurica*. Since then similar leafy shoots have been described by many authors from the Lower Jurassic to Lower Cretaceous plant beds in North and Northeast China and Central Asia as *Elatocladus manchuricus*, *E. subzamioides* and *E. asiatica*. Obviously there are some morphological differences among these leafy shoots but it is difficult to separate them specifically based only on their external form.

Then it is appropriate to regard *Elatides asiatica* as a comprehensive 'species' ranging in age from Early Jurassic to Early Cretaceous.

Elatides sp. is somewhat different in leaf-form from *E. asiatica* in its more falcate leaves. The leafy shoots of *Elatides* sp. is most close in leaf-form to those regarded as the other comprehensive species *E. curvifolia* first de-

scribed from the Wealden of Germany, especially in its stout and markedly falcate leaves.

The leafy shoots of *Araucarites vassilevskiae* Turtanova-Ketova known from the Lower-Upper Jurassic of Central Asia somewhat resemble in leaf-form those of *Elatides* sp., but the former leaves are more delicate and more markedly curved adaxially than the latter.

The occurrence of leafy shoots of *Elatides*-type is the first record in the Mesozoic of Japan.

Form-genus *Geinitzia* Endlicher, 1847: 280

Geinitzia sp.

Text-fig. 12

Material: IC2002. *Locality:* Ishimachi (Loc. no. 062; Nd-Zone).

Occurrence: Rare.

Description: Obtained is a single small-sized branching twig of which secondary branches are long and narrow, 2.3 cm long and 1 mm wide, sending off occasional third branches. Leaves are spirally arranged; free part of leaf is spreading, 1–2 mm long, elongate-triangular in form, possibly equally thick in vertical and horizontal directions and merging into basal cushion on stem without contracting. Cuticle is not preserved.

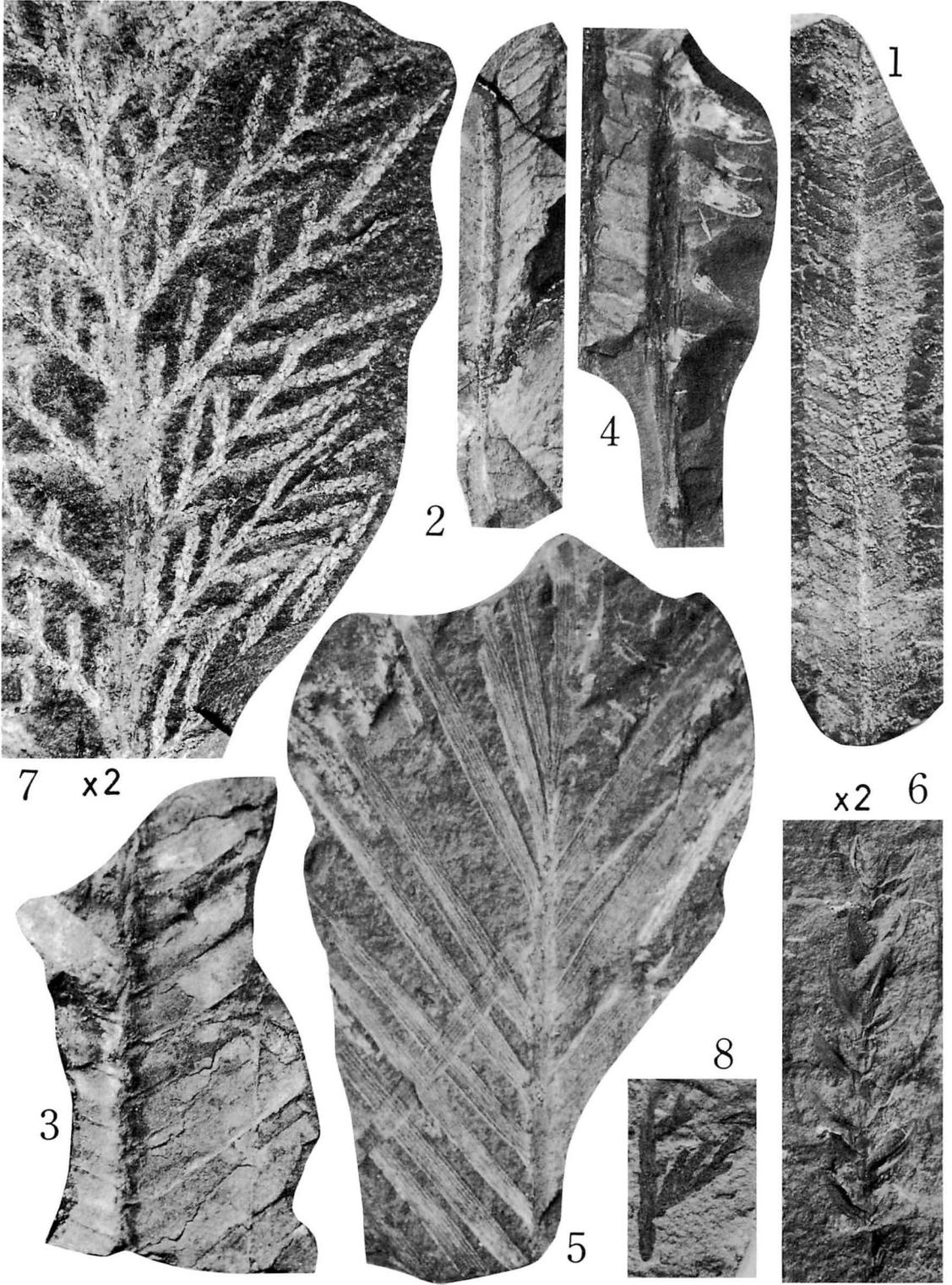
Remarks: The features of the present leafy twig, though small fragment, agrees with the emended diagnosis of *Geinitzia* given by Harris (1979). But it is difficult to make further argument about this twig because of its ill-preservation.

Harris (1979) noticed that the elongated

Explanation of Plate 100

(Natural size unless otherwise indicated)

- Fig. 1. *Otozamites micropinnatus* Kimura, Naito et Ohana, sp. nov.: N3644.
 Fig. 2. *Otozamites micropinnatus* Kimura, Naito et Ohana, sp. nov.: N3687.
 Fig. 3. *Otozamites* sp. B: N3684.
 Fig. 4. *Zamites toyoraensis* Oishi: N1990 (Text-fig. 5a, b).
 Fig. 5. *Pseudoctenis* sp.: N1988 (Text-fig. 7a, b).
 Fig. 6. *Elatides* sp.: N3689.
 Fig. 7. *Cupressinocladus* sp. A: N5010; enlarged from Pl. 99, Fig. 6 (Text-fig. 9).
 Fig. 8. *Brachyphyllum* ex gr. *expansum* (Sternberg) Seward: IC-3004.



juvenile leaves of some *Brachyphyllum* had the *Geinitzia*-form.

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Andadani 安田谷, Guanyintan* 観音灘, Higashinagano 東長野, Hubei* 湖北, Hunan* 湖南, Ishimachi 石町, Iwamuro 岩室, Kuruma 来馬, Liaoning* 遼寧, Narusebashi 鳴瀬橋, Negoya 似虎谷, Nishinakayama 西中山, Oginohama 荻ノ浜, Sakuraguchidani 桜口谷, Takaji 高地, Toyora 豊浦, Utano 歌野, Yamaguchi 山口, Xiangxi (Hsiangchi)* 香溪

* Chinese name

日本のジュラ紀前期植物化石—その7, 山口県豊浦層群西中山層の植物化石: 山口県豊浦郡菊川町田部盆地以北に分布する豊浦層群中位の西中山層群の時代は, おもに豊富に産するアンモナイト化石によって, Pliensbachian から Toarcian 初期にわたると考えられている。このたび, 内藤源太朗, 石田英夫, 福富孝義および栗原 豊らによって西中山層から採集された標本の中から, つぎの分類群を識別した。 *Phlebopteris* sp., *Otozamites micropinnatus*, n. sp., *O.* sp. A, *O.* sp. B, *Zamites toyoraensis* Oishi, *Z.* sp., *Pseudoctenis* sp., *Brachyphyllum* ex gr. *expansum* (Sternberg) Seward, *Cupressinocladus* sp. A, *C.* sp. B, *Elatides* sp., *Geinitzia* sp.

識別された分類群の数は多いとはいえないが, 西中山層植物群は, ベネチテス類および鱗片葉をつける球果類の多様性によって特徴づけられ, 同時代の来馬層群, 岩室累層および山奥層植物群とはその組成が完全に異なる。また, 同時期の中国湖北省西部に知られている香溪 (Xiangxi) 植物群のそれとも一致しない。

木村達明・内藤源太朗・大花民子

日本古生物学会特別号の原稿募集

PALAEONTOLOGICAL SOCIETY OF JAPAN, SPECIAL PAPERS, NUMBER 30 を 1988 年度に刊行したく、その原稿を公募します。適当な原稿をお持ちの方は、次の事項に合わせて申込書を作成し、原稿の写しを添えて、〒812 福岡市東区箱崎 九州大学理学部地質学教室気付、日本古生物学会特別号編集委員会（代表者柳田寿一）宛に申し込んで下さい。

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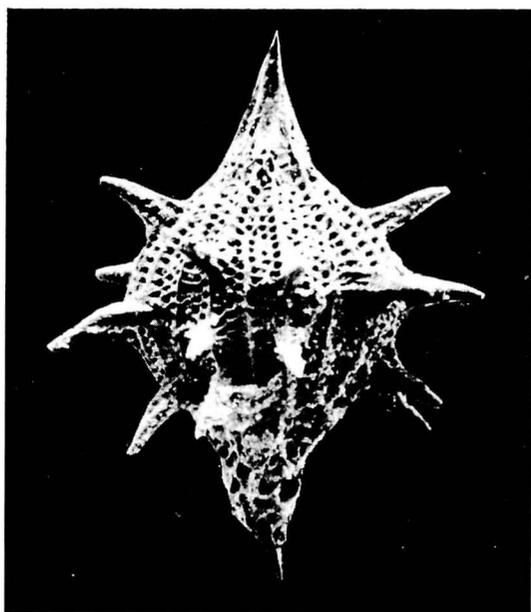
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日本古生物学会 報告・紀事

Transactions and Proceedings
of the
Palaeontological Society of Japan

New Series
No. 137~No. 144
1985—1986



日本古生物学会

Palaeontological Society of Japan

The heading in Japanese commemorates the handwriting of Prof. Matajiro YOKOYAMA, father of Japanese palaeontology, who was a professor of stratigraphy and palaeontology at the Geological Institute, Imperial University of Tokyo.

The fossil on the cover is *Unuma (Spinunuma) echinatus* ICHIKAWA and YAO, a Middle Jurassic multisegmented radiolaria from Unuma, Gifu Prefecture, central Japan (photo by A. YAO, × 260).

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行事予定

	開催地	開催日	講演申込締切日
1987年 年会・総会	静岡大学	1987年1月30日～2月2日	1986年11月15日
1987年 136回 例会	福井県立博物館	1987年 6月20日～21日	1987年 4月 5日

講演申込先： 〒113 東京都文京区弥生 2-4-16 日本学会事務センター
日本古生物学会 行事係 (葉書で申し込んでください)

お知らせ

東京地学協会から本会あて下記のような案内を頂いています。

昭和61年 9月 4日

日本古生物学会殿

東京都千代田区二番町 12-2
社団法人 東京地学協会
会長 和達清夫

拝啓 当協会は今年度に引き続き、昭和62年度も下記により地学に関する研究調査を助成することに致しました。つきましては貴学会機関誌にこの旨御掲載願えれば幸いです。

記

1. 助成対象：本協会会員又は会員が加わっている研究グループ、あるいは会員の推薦する研究グループによって行われる地学に関する研究調査
2. 申請締切：昭和62年 1月末日
3. 助成金総額：約 300 万円
4. 1件当たりの助成額：50 万円以内
5. 助成を受けたものの義務：研究成果を本協会において講演し、かつその要旨を地学雑誌に発表すること。
6. 審査決定：昭和 62 年 4 月中旬の予定
7. その他：申請についての御問い合わせ、申請用紙の請求などは協会事務局 (電話 03-261-0809) まで願います。以上

○文部省科学研究費補助金 (研究成果刊行費) による。

1986年 12月 25日 印刷

1986年 12月 30日 発行

ISSN 0031-0204

日本古生物学会報告・紀事

新 篇 144 号

2,500 円

発行者 日本古生物学会
文京区弥生 2-4-16
日本学会事務センター内
(振替口座東京 84780 番)
(電話 03-817-5801)

編集者 猪郷久義・浜田隆士
編集幹事 野田浩司

印刷者 東京都練馬区豊玉北 2ノ13
学術図書印刷株式会社 富田 潔
(電話 03-991-3754)

Transactions and Proceedings of the Palaeontological
Society of Japan

New Series No. 144

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