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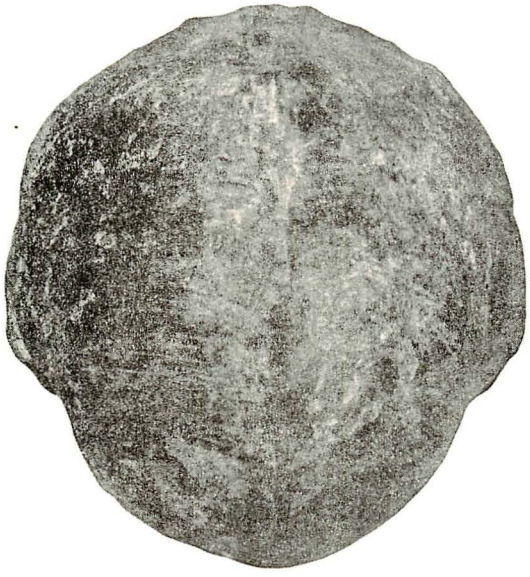

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631. LATE SCYTHIAN AMMONOIDS FROM THE KITAKAMI MASSIF*

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北上山地産 Late Scythian アンモナイト：本アンモナイトは *Subcolumbites* 動物群からなり，海生脊椎動物化石 *Utatsusaurus* と共に産出している。最近産出した *Subcolumbites* と *Columbites* 動物群について記載し，その生層序学的意義について考察した。その結果，大沢層には2化石帯（下位より *Subcolumbites* 帯，*Arnautoceltites* 帯）が認められ，厚さ約 180 m にわたってこれらの動物群を産することが明らかとなった。

坂東祐司・下山正一

Introduction

The stratigraphic position of the Osawa Formation in the Triassic System of the Kitakami Massif is as indicated in the next page, according to BANDO (1964, p. 5).

The Osawa Formation (ICHIKAWA, 1948) consists of alternation of well-bedded, calcareous, fine-grained sandstone and siltstone. Its upper part is composed of laminated, dark blue, calcareous shales which yield Upper Scythian ammonoids such as *Columbites*, *Subcolumbites* and *Leiophyllites*. The formation grades upwards into the Fukkoshi Formation (Middle Trias) which is composed of light green sandstone, banded sandy shales and conglomerates.

The geology of the type area of the Osawa Formation has been studied by many authors. KUROSAWA (1929) included the Osawa Formation in the Isatomae Formation. MABUTI (1932) discovered some pelecypods such as "*Pecten*" *ussuricus* (BITTNER), "*Pecten*" *sichoticus* (BITTNER), "*Pecten*" cf. *discites* (SCHLOTHEIM), and *Pecten alberti virgalensis* (WITTENBURG) from the Lower Triassic beds at Tate near Isatomae, but since then no other fossils have been discovered from the Lower Trias. SHIIDA (1939) surveyed the area of the type locality and subdivided the Triassic beds into H_1 to H_6 members in ascending order and included them in the Hiraiso Formation. Later INAI (1939), ICHIKAWA (1948, 1951), ONUKI and BANDO (1959) and BANDO (1956, 1958 MS) contributed to the stratigraphy and subdivision of the Osawa Formation. ICHIKAWA (1948, 1950) proposed the name of Osawa Formation, and referred it to his Tatean age of the

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	Jurassic System	
	unconformity or fault	
Saragai Group	Chonomori Formation	Karno-Norian
	Shindate Formation	Karnian
	unconformity	
Innai Group	Rifu Formation	Aniso-Ladinian
	Isatomae Formation	Anisian
	Fukkoshi Formation	Anisian
	Osawa Formation	Scythian
	Hiraiso Formation	Scythian
	unconformity	
	Late Permian (Toyama Formation)	

Lower Trias. In 1964, BANDO described *Subcolumbites* cf. *perrinismithi* ARTHABER from the Osawa Formation at Tate near Isatomae, and subsequently he (BANDO, 1970) described some ammonoids, i. e. *Flemingites* sp., *Euflemingites* sp., *Meekoceras* spp., *Xenoceltites*? and *Danubites* sp., from the formation at the type locality based upon the collection of Prof. K. NAKAZAWA. BANDO (1970) also described the *Leiophyllites* fauna, which consists of *Leiophyllites* cf. *pitamaha* (DIENER), *L.* aff. *pradyumna* (DIENER), *L.* sp. and *Danubites* aff. *ambika* DIENER, from the Osawa Formation at Konori near Onagawa-cho, Ojika-gun, Miyagi Prefecture, in the southern part of the Kitakami Massif, on the basis of the collection of Prof. Y. ONUKI. In a previous paper (BANDO, 1970) the writer recognized four ammonoid zones, i. e. *Owenites*, *Anasibirites*, *Subcolumbites* and *Leiophyllites* zones, for the Upper Scythian of Japan, and stressed that the Osawa Formation is represented by two ammonite zones, i. e. *Subcolumbites perrinismithi* zone in the lower and *Leiophyllites* cf. *pitamaha* zone in the up-

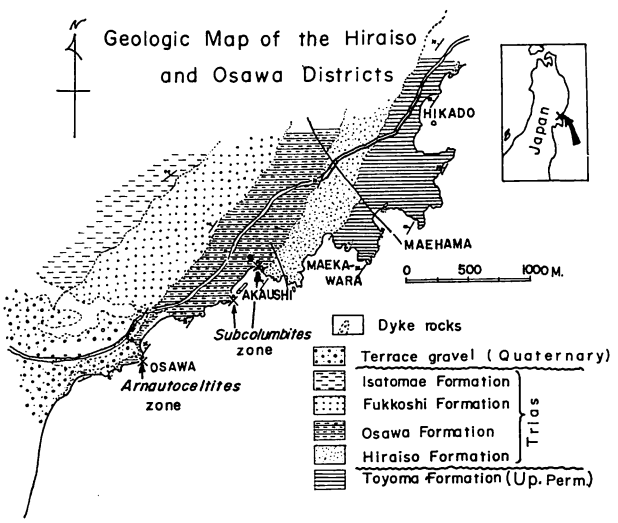


Fig. 1.

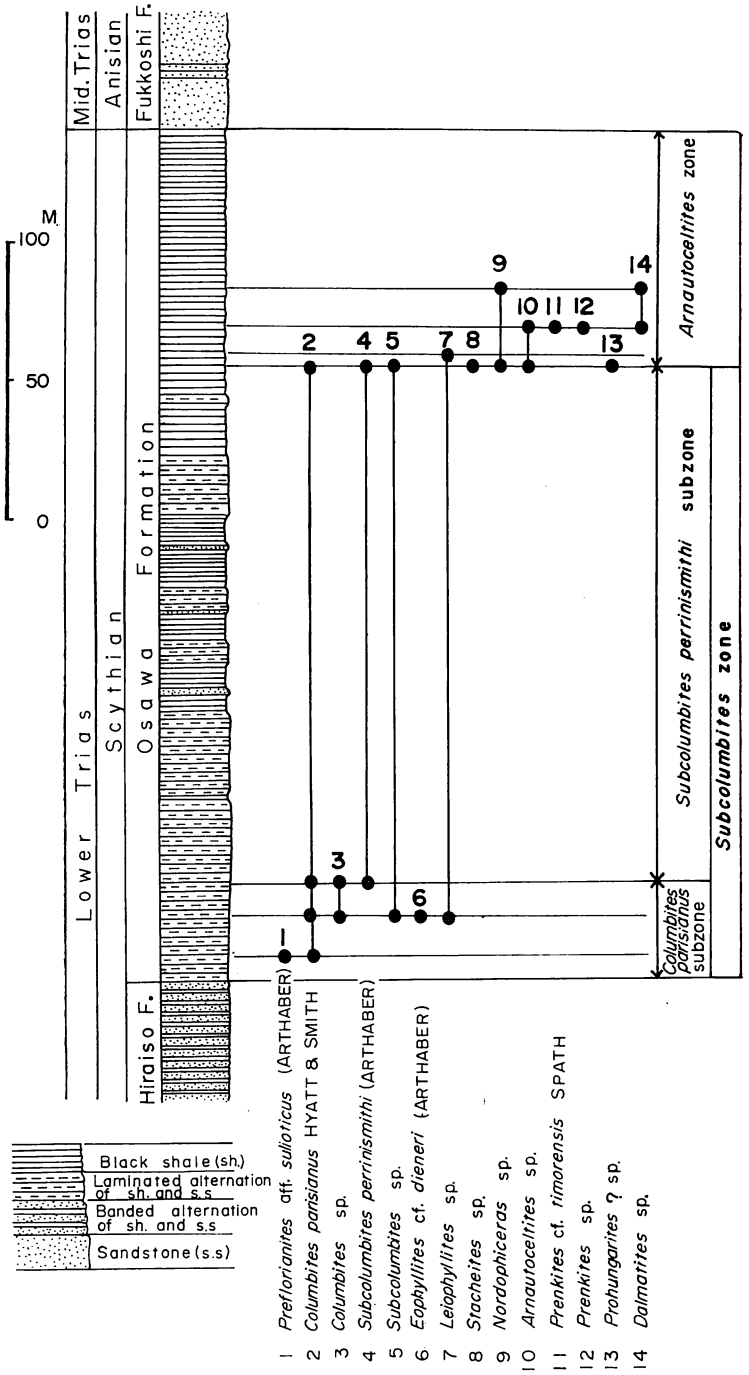


Fig. 2. Geologic column and stratigraphical distribution of the *Subcolumbites* fauna from the type locality of the Osawa Formation in the southern part of the Kitakami Massif.

per, and correlated them with the Late Columbitan to Prohungaritan stages,* Late Olenekian** and with the Late Spathian.***

Recently, geological and biostratigraphical surveys of the Permian-Triassic boundary in the Kitakami Massif were undertaken by NAKAZAWA, ISHII, MURATA and BANDO in the Hiraiso, Tate and Okachi areas in 1971. At that time, they found marine vertebrate fossils in a black shale of the Osawa Formation exposed along the coast of Tate near Isatomae. This vertebrate fossils now being studied by many specialists of vertebrate paleontology of Japan. Subsequently some fossils were described by MURATA (1971, 1973) from the Osawa Formation at the type locality in association with the *Columbites* and *Subcolumbites* faunas. The bed that yielded the vertebrate fossil is dark grey calcareous shale measuring about 30 m in thickness at Tate near Isatomae.

The *Subcolumbites* fauna from the Osawa Formation comprises the following species:

Columbites parisianus HYATT and SMITH, *Columbites* spp., *Subcolumbites perrinismithi* ARTHABER, *Subcolumbites* spp., *Arnautoceltites* sp., *Preflorianites* aff. *sulioticus* (ARTHABER), *Prenkites* cf. *timorensis* SPATH, *Prenkites* sp., *Stacheites* sp., *Eophyllites* cf. *dieneri* (ARTHABER), *Eophyllites* sp., *Leiophyllites* sp., *Dalmatites* sp., *Isculitoides* aff. *originis* (ARTHABER), *Shizophyllites* sp., *Pseudosageceras*? sp., *Prohungarites*? sp.

The beds bearing the *Subcolumbites* fauna in the Osawa Formation at Akaushi, Osawa, Motoyoshi-cho, near Kesennuma City, consist of a laminated alternation of sandstone and black shales. The fossils are found at about 30 m above the top of the subjacent Hiraiso Formation, which consists mainly of light green calcareous sandstone with conglomerate in the basal part.

The ammonoids were collected from two main localities, both of which apparently belong to the same stratigraphic horizon. In the Isatomae district, *Subcolumbites* cf. *perrinismithi* (ARTHABER) was described by BANDO (1964) from the middle part of the Osawa Formation. The horizon with *S. perrinismithi* at Tate near Isatomae is about 30-50 m. below the horizon with *Leiophyllites*. The locality of *Leiophyllites* aff. *pradyumna* (DIENER), *L.* cf. *pitamaha* (DIENER) and *L.* sp. in the calcareous sandy shales of the Osawa Formation at Konori in Onagawa-cho, in the southern part of the Kitakami Massif, is about 30 km south of the Isatomae district, but at the locality these species are not associated with other ammonoids such as seen in the *Subcolumbites* or *Columbites* faunas.

The Osawa Formation that yielded ammonoids of *Columbites*, *Subcolumbites* and *Leiophyllites* is thicker than the Hiraiso Formation, and the main part of the formation may comprise the Prohungaritan-Columbitan ammonoid stages of SPATH (1930, 1934). Judging from the characters of the sediments and faunal sequence, it is considered that the sedimentation of the Osawa Formation progressed rapidly during a short time range of the late Scythian.

Biostratigraphy and Correlation

The biostratigraphical succession (BANDO, 1970, p. 338) of the ammonoids from the Osawa Formation is as follows:

* SPATH (1930, 1934), ** KIPARISOVA and POPOV (1964), *** TOZER (1965b).

3. *Leiophyllites* cf. *pitamaha* zone
2. *Subcolumbites perrinismithi* zone
1. *Meekoceras* and *Euflemingites* zone

These ammonoid zones belong to the Late Scythian, and range from the Owenitan to Prohungaritan of SPATH's stage classification of the ammonoids (SPATH, 1930, 1934). Considering the ammonoid sequence of the Lower Trias in Japan, it is clear that the *Gyronites* and *Flemingites* zones are missing. In the Kitakami Massif the Lower Triassic (Scythian) ammonoids are meager and especially in the Early Scythian ammonoid only one species, *Glyptophiceras* cf. *glacile*, has been described by BANDO (1970) from the type locality of the Hiraiso Formation in the Kitakami Massif, and no other ammonoids have been discovered from the horizon corresponding to the Gyronitan and Flemingitan stages of the Kitakami Massif.

In South China, CHAO (1959) recognized three ammonite zones in the Columbitan stage, namely;

3. *Procarnites-Leiophyllites* zone
2. *Columbites costatus* zone
1. *Tirolites darwini* zone

In South China, these ammonoid zones of CHAO were included in the Columbitan stage of SPATH and correlated with the Late Olenekian. CHAO did not use the name of Prohungaritan, the uppermost ammonoid stage proposed by SPATH (1930, 1934), but followed the classification proposed by KIPARISOVA and POPOV (1956). The present writers are inclined to think that the *Subcolumbites* and *Leiophyllites* faunas of the Osawa Formation have intimate relations with the faunas of South China.

From the Primorye Region, KIPARISOVA (1961) described many species of the *Subcolumbites* faunas, i. e. *Subcolumbites multiformis* KIPARISOVA, *S. solitus* KIPARISOVA, *S. anomalus* KIPARISOVA, *Leiophyllites praematurus* KIPARISOVA, and *Eophyllites amurensis* KIPARISOVA etc. from the Late Scythian. Subsequently ZAKHAROV (1968) contributed to the Triassic stratigraphy and ammonoid paleontology of the Primorye Region. ZAKHAROV (1968) divided the Olenekian stage into two ammonoid zones, i. e. *Owenites koeneni* zone in the lower and *Columbites parisianus* zone in the upper. The latter was subdivided into subzone, i. e. *Neocolumbites insignis* subzone in the lower and *Subcolumbites multiformis* subzone in the upper. The writers think that ZAKHAROV's subdivision is applicable also to the upper Scythian biozone in the Kitakami Massif. However, for the representative species of the *Subcolumbites* zone of the uppermost Olenekian stage in Japan it is more preferable to use *S. perrinismithi* (ARTHABER) instead of *S. multiformis* KIPARISOVA, because *S. multiformis* is not known from the Osawa Formation. *S. multiformis* has a broad venter compared with the other species of *Subcolumbites*.

Acknowledgements

The writers express their sincere thanks to Dr. Kotora HATAI, Professor Emeritus of Tohoku University, and Dr. Yoshio ONUKI of Hase Geological Survey Office, Sendai, for their kind guidance and reading of the manuscript, and to Professor Keiji NAKAZAWA of Kyoto University, Professors Koichiro ICHIKAWA and Ken-ichi ISHII of Osaka City University, Dr. Masafumi MURATA of Tohoku University, Professor Takehiko IWAI and Dr. Tetsuro SHIOBARA of Hirosaki University, for their kind advice and suggestion in many ways. Professor Koichiro ICHIKAWA of Osaka City University kindly offerred to the writers some ammonoid specimens which he

collected from the Hiraiso and Osawa districts in the Kitakami Massif. Dr. Ikuwo OBATA of the National Science Museum in Tokyo commented on the manuscript.

The writers are indebted to Professor Bernhard KUMMEL, Museum of Comparative Zoology of Harvard University, for his kind gift on many useful papers. Thanks are also due to Dr. Yu. ZAKHAROV, Far East Geological Institute, Bradivostok, for donating his ammonoid collection of the *Subcolumbites* fauna from the Olenek River region.

Part of the ammonoid specimens described in the present paper were received from Mr. Niichi NISHIWAKI of Kyoto University, who collected them from the Osawa area during his study on the geology of the area in 1971.

This study was supported in part by grants from the Science Research Fund of the Ministry of Education, Government of Japan. The writers express their sincere thanks to the authorities of the Ministry.

Systematic Description

Class Cephalopoda CUVIER, 1797

Subclass Ammonoidea ZITTEL, 1884

Order Ceratitida HYATT, 1884

Superfamily Noritaceae KARPINSKY, 1889

Family Xenoceltitidae SPATH, 1930

Genus *Preflorianites* SPATH, 1930

Type species: *Danubites strongi* HYATT and SMITH, 1905

Diagnosis:—Shell evolute, with rounded venter, some acute; with radial or prorsiradial ribs. Ribs most distinct on lateral side near umbilicus and diminish on ventral shoulders.

Remarks:—KUMMEL (1969) summed up the species of the genus *Preflorianites* and revised them into five species as follows.

Preflorianites sulioticus (ARTHABER)
Preflorianites garbinus (RENZ and RENZ)
Preflorianites multiplicatus (MOJSISOVICS)
Preflorianites intermedius TOZER
Preflorianites montpelierensis KUMMEL

But KUMMEL did not refer to *Preflorianites strongi* (HYATT and SMITH) which was described as *Danubites* from the *Meekoceras* bed of the Inyo Range, east side of Owens Valley, California. *Preflorianites strongi* has the pronounced ribs on the inner side of the flanks near the umbilicus which almost diminish on the outer side of the flanks and the whorl section is of helmet shape in outer whorl. The writers think that this species is a primitive form of *Preflorianites*, a genus in which the ornamentation is rather variable.

Occurrence and geological horizon:—Late Scythian, *Subcolumbites perrinismithi* zone. Albania; Chios, Greece; Olenek, U.S.S.R.; British Columbia; California and Idaho, U.S.A.; Japan.

Preflorianites aff. *sulioticus* (ARTHABER)

Pl. 40, fig. 7

Compared with:—
Xenodiscus sulioticus ARTHABER, 1911: 229, pl. 19(3), figs. 6a, b, pl. 20(4), figs. 2a, b; DIENER, 1915: 315; C. RENZ, 1928: 155; RENZ and RENZ, 1947: 61; RENZ and RENZ, 1948: 56, pl. 3, figs. 1, 2.
Preflorianites sulioticus, SPATH, 1934: 133, pl. 12, figs. 2a-d.
Preflorianites sulioticus, KUMMEL, 1969: 379, pl. 4, figs. 5, 6, pl. 19, figs. 1, 2, 5-8, text-fig. 9.

Description:—Shell rather laterally

compressed, evolute, with rounded arched venter and strong radial ribs, prominent on sides of inner part of whorls and diminishing near umbilical shoulders. About 12-13 ribs on sides of half outer volution. Sides faintly ornamented with radial or prorsiradiate striations tending to become parallel with ribs.

Measurements (in mm):—

	D	H	W	U	H/D	W/H	U/D
19001-1	35.0(27.3)	9.5(7.9)	7.6?	17.6(12.0)	0.27(0.28)	0.8?	0.50(0.43)

Remarks:—Only one specimen was examined. The present specimen resembles the form of *Preflorianites sulioticus* (ARTHABER) in general characters of the shell, but the ribs are more prominent or stronger than those of *P. sulioticus*. The ribbing form of the present material seems to show more intimate relation with those of *Preflorianites strongi* (HYATT and SMITH), but the present form has the whorl more compressed than that of *P. strongi*. The writers think that the present specimen suggests a form intermediate between *P. sulioticus* and *P. strongi*, but with closer resemblance to *P. sulioticus*.

Occurrence and geological horizon:—*Columbites parisianus* subzone of the *Subcolumbites* zone of the Osawa Formation at Osawa, Motoyoshi-cho, Motoyoshi-gun, Miyagi Prefecture, southern part of the Kitakami Massif. Columbitan stage, Upper Scythian (Early Trias).

Coll. S. SHIMOYAMA. Reg. No. OS-19001-1

Family Paranannitidae SPATH, 1930

Genus *Arnautocestites* DIENER, 1916

Arnautoceltites sp.

Pl. 41, fig. 6

Description:—Shell rather evolute, discoidal, with rounded venter and sharply edged umbilical shoulders. Shell ornamented with obliquely constricted sides; constrictions extending from umbilical margin to venter. Fine striations on shell surface parallel to constrictions of falciradiate form. Venter rounded, outer whorl intended about half height of inner whorl. Width and sutures unknown.

Measurements (in mm):—

	D	H	W	U	H/D	W/H	U/D
802-4	32.0	12.0	—	8.4	0.39	—	0.26

Remarks:—Considering from the shell ornamentation the present specimen surely belongs to the genus *Arnautoceltites*, but specific identification is reserved because of their sutures being not preserved and of the lateral deformation. KUMMEL (1969, p. 397) recognized five species of the genus *Arnautoceltites*, i. e. *A. mediterraneus* (ARTHABER), *A. bajarunasi* (ASTAKHOVA), *A. involutus* CHAO, *A. gracilis* (KIPARISOVA) and *A. teicherti* KUMMEL, and restricted the range of this genus to the Late Scythian *Prohungarites* zone. This genus is character-

ized by considerably strong prorsiradiate constrictions which are arranged irregularly on the outer whorl. In Japan, the horizon that yielded the present specimen is a little above the *Subcolumbites* zone of the Osawa Formation. *Arnautoceltites mediterraneus* (ARTHABER) (ARTHABER, 1911) has stronger constrictions on the outer whorl than the present specimen.

Arnautoceltites mediterraneus as revised by KUMMEL (1969, p. 397) includes the following species: *Paranannites chionensis* RENZ and RENZ (RENZ and RENZ, 1947, p. 66, 67; 1948, p. 70, pl. 1, figs. 10-10c), *Paranannites aspensis* HYATT and SMITH var. *europaea* RENZ and RENZ (RENZ and RENZ, 1947, p. 61; 1948, p. 71, pl. 1, figs. 16-16c), *Paranannites compressus* RENZ and RENZ (RENZ and RENZ, 1947, p. 61, 77, non SMITH, 1932, p. 99, pl. 31, figs. 19-20; RENZ and RENZ, 1948, p. 71, pl. 1, figs. 15-15b), *Paranannites chiosensis* KIPARISOVA (KIPARISOVA, 1961, p. 130), *Celtites arnauticus* ARTHABER (ARTHABER, 1911, p. 267, pl. 24(8), fig. 7; DIENER, 1915, p. 73; SMITH, 1932, p. 37), *Arnautoceltites arnauticus* (ARTHABER) (SPATH, 1934, p. 192, pl. 13, figs. 6a-f), *Paragoceras dukagini* ARTHABER (ARTHABER, 1911, p. 182, 188, 265, pl. 24(8), fig. 6; DIENER, 1915, p. 366; C. RENZ, 1928, p. 155; KUTASSY, 1933, p. 607; SPATH, 1934, p. 199, fig. 60) and *Nannites herberti* ARTHABER (ARTHABER, 1908, p. 274, pl. 11(1), figs. 7a-b; 1911, p. 220).

Occurrence and geological horizon:—*Arnautoceltites* zone of the black shale of the Osawa Formation at Osawa, Motoyoshi-cho, Motoyoshi-gun, Miyagi Prefecture. Late Scythian, *Subcolumbites* zone.

Coll. S. SHIMOYAMA. Reg. No. OS-802-4, GLKU-OS-405(K2)

Genus *Isculitoides* SPATH, 1930

Type species: *Isculitoides originis* ARTHABER, 1911, p. 259, pl. 23, figs. 1a-c.

Occurrence and geological horizon:—*Subcolumbites* zone, Late Scythian. Albania; Chios; South China; British Columbia; Primorye Region, U.S.S.R.; U.S.A.; Afghanistan; Japan.

Isculitoides aff. *originis* (ARTHABER)

Pl. 42, fig. 5

Compared with:—

Isculites originis ARTHABER, 1911: 259, pl. 23 (7), figs. 1-10; DIENER, 1915: 157; C. RENZ, 1928: 155; KUTASSY, 1933: 540; RENZ and RENZ, 1947: 60; RENZ and RENZ, 1948: 33, pl. 13, figs. 7-7a, 9-9a, 11-11b, 12-12b, pl. 14, figs. 6-6a, 9-9a.

Isculitoides originis, SPATH, 1934: 198, pl. 14, figs. 2a-d, text-fig. 59b, c; KUMMEL, 1969: 413, pl, 5, figs. 1-10, pl. 6, figs. 1-6, text-figs. 18-20.

Description:—Conch rather involute, discoidal, with smooth surface and small umbilicus. Umbilicus opening out and umbilical wall indistinct and low. Shell surface ornamented by slight, prorsiradiate striae or faint constrictions, generally projected aperture near venter. Suture line missing.

Measurements (in mm):—

	D	H	W	U	H/D	W/H	U/D
GLKU*-403	33.4	13.2	—	10.5	0.39	—	0.31

* GLKU: Department of Geology, Kagawa University.

Remarks:—The present specimen is too poorly preserved to reveal the form of venter and sutures. Although the umbilicus and the shell ornamentation are rather comparable with *Isculitoides originis* (ARTHABER), the present form is laterally compressed so that the feature of ventral part cannot be observed for comparison. The present material was collected by Dr. M. MURATA from the black shale of the Osawa Formation at Tate, near Isatomae, and the species was associated with *Utatsusaurus*, marine vertebrate fossil.

Occurrence and geological horizon:—*Arnautoceltites* zone ? at Tate near Isatomae, Utatsu-cho, Motoyoshi-gun, Miyagi Prefecture, southern part of the Kitakami Massif. Columbitan-Prohungaritan substage of the Late Scythian (upper Lower Trias).

Coll. M. MURATA. Reg. No. OS-807-1, GLKU-403

Genus *Columbites* HYATT and SMITH, 1905

Type species: *Columbites parisianus* HYATT and SMITH, 1905

Occurrence and geological horizon:—Late Scythian, Columbitan substage or Late Olenekian substage. North America, southern part of Primorye, U. S. S. R. and northern part of Japan.

Columbites parisianus HYATT and SMITH

Pl. 40, figs. 2, 4, 6, 8; Pl. 41, figs. 1, 10; Pl. 42, figs. 1, 3

Columbites parisianus HYATT and SMITH, 1905: 51, pl. 1, figs. 9–14, pl. 61, figs. 1–21, pl. 72, figs. 1–24; FRECH, 1908: pl. 42, fig. 2; DIENER, 1915: 112; 1925, 69, pl. 24, fig. 2; SMITH, 1932: 107, pl. 1, figs. 9–14, pl. 61, figs. 1–21, pl. 72, figs. 1–24; SPATH, 1934: 201, pl. 13, fig. 3, text-fig. 61; KUMMEL, 1957: L140, figs. L141-2a–b; 1969: 424, pl. 39, figs. 1–10, pl. 40, figs. 1–11, pl. 41, figs. 1–7, pl. 41, figs. 1–9, pl. 43, figs. 4–5, text-figs. 22–23.

Columbites cf. *parisianus* HYATT and SMITH, ZAKHAROV, 1968: 106, pl. 20, figs. 5a–b.

Columbites consanquineus SMITH, 1932: 106, pl. 46, figs. 1–13.

Columbites ornatus SMITH, 1932: 107, pl, 46, figs. 14–21.

Columbites ligatus SMITH, 1932: 106, pl. 47, figs. 1–8.

Columbites minimus SMITH, 1932: 106, pl. 47, figs. 9–10.

Columbites spencei SMITH, 1932: 108, pl. 77, figs. 1–21, pl, 78, figs. 1–16; KUTASSY, 1933: 490.

Description:—Shell evolute, discoidal, laterally slightly compressed ? Whorls slightly embracing inner whorls. Sides convex. Height of whorl about 1/3 of diameter of shell, diameter of umbilicus slightly less than half of total diameter of shell. Surface ornamented with radial or prorsiradial ribs and fine striae extending from umbilical shoulders to venter. Fine radial striae parallel with ribs which are prominent on sides of umbilical whorls. Sculptures much weaker on ventral part and forming arc near ventral shoulders.

Remarks:—Eight specimens were examined. *Columbites parisianus* HYATT and SMITH was regarded as the only known species from Southeast Idaho (KUMMEL, 1969, p. 425). Recently a species comparable with the named one was described by ZAKHAROV (1968) from the Primorye Region. The Japanese species from the Osawa Formation lacks the sutures, but the shell form and their ornamentation resemble those of *Columbites parisianus* HYATT and SMITH. *Columbites parisianus* HYATT and SMITH

Measurements (in mm):—

	D	H	W	U	H/D	W/H	U/D
710515-01	24.2	7.6	—	10.7	0.31	—	0.44
1002-1	—	8.6	—	14.9	—	—	—
805-9	—	6.0	—	8.1	—	—	—
1101-7	46.45	12.95	—	22.5	0.27	—	0.48
1101-11	54.4	18.6	—	22.9	0.34	—	0.42
1101-12	30.2	10.8	—	13.2	0.35	—	0.43
1000	35.5	12.3	—	15.5	0.34	—	0.43
19001-24	19.4	6.0	2.4	8.9	0.30	—	0.45

shows slight variation in the shell ornamentation of ribbing form. The ribs are very district on the sides of the umbilical whorls, but feeble on the outer whorls at maturity.

Columbites parisianus was first described by HYATT and SMITH (1905) from the middle Shale Member of the Thayness Formation in Paris Canyon, Southeast Idaho (SMITH, 1932; KUMMEL, 1969). The present species has not been reported from any other countries outside of the United States up to date except for the occurrence of *Columbites* cf. *parisianus* from the Primorye Region (ZAKHAROV, 1968) and the Japanese specimens reported here.

Occurrence and geological horizon:— *Columbites parisianus* subzone of the dark gray to black shale of the Osawa Formation at the type locality, Osawa, Motoyoshi-cho, Motoyoshi-gun, Miyagi Prefecture, southern part of the Kitakami Massif. Late Scythian or Late Olenekian stages.

Coll. S. SHIMOYAMA, N. NISHIWAKI and M. MURATA, 1970-71. Reg. No. OS-710515-1, OS-1002-1, OS-1101-7, OS-1101-11, OS-1101-12, OS-1000, OS-19001-24, OS-805-9.

Genus *Subcolumbites* SPATH, 1930

Type species: *Columbites perrinismithi* ARTHABER, 1908

Subcolumbites perrinismithi (ARTHABER)

Pl. 40, figs. 3, 5; Pl. 41, fig. 9

Columbites perrinismithi ARTHABER, 1908: 277, pl. 12, fig. 1; ARTHABER, 1911: 262, pl. 23(7), figs. 19, 20; DIENER, 1915: 112; C. RENZ, 1928: 155; RENZ and RENZ, 1947: 59; RENZ and RENZ, 1948: 20, pl. 11, figs. 7-7a.

Subcolumbites perrinismithi, SPATH, 1930: 77; SPATH, 1934: 203, pl. 12, figs. 5a, b; KUMMEL, in ARKELL et al., 1957: L140, figs. 172, 15a, b; KUMMEL, 1968: 495, pl. 1, figs. 1-3.

Columbites europaeus ARTHABER, 1908: 278, pl. 12, figs. 2; ARTHABER, 1911, 261, pl. 23(7), figs. 13-18; DIENER, 1915: 112; C. RENZ, 1928: 155; RENZ and RENZ, 1947: 59; RENZ and RENZ, 1948: 19, pl. 11, figs. 3-3a, 4-4a, 6-6a.

Subcolumbites europaeus, SPATH, 1934: 204, pl. 12, figs. 6a, b, text-fig. 62c.

Columbites europaeus-perrinismithi RENZ and RENZ, 1947: 59; RENZ and RENZ, 1948: 20, pl. 11, figs. 1-1b, 2-2b.

Subcolumbites cf. *perrinismithi*, BANDO, 1964: 99, pl. 3, figs. 18, 19, pl. 4, fig. 3.

Subcolumbites perrinismithi, KUMMEL, 1969: 427, pl. 1, figs. 1-9; pl. 2, figs. 5-8; pl. 3, figs. 1-9; pl. 4, figs. 1-4; text-fig. 24.

Remarks:—This species was original-

ly described by ARTHABER (1908) from Arbania as a species of *Columbites*. Later, ARTHABER (1911) and SPATH (1934) recognized three species of *Subcolumbites*, i. e. *Subcolumbites europaeus*, *S. perrinismithi* and *S. mirditensis*, based upon the forms of whorls and sculptures. *Subcolumbites perrinismithi* has more compressed whorls than those of the other species of this genus. RENZ (1928) and RENZ and RENZ (1947, 1948) described *Columbites* (*Subcolumbites*) *perrinismithi* from the Island of Chios in Greece and recognized an intermediate form, *Subcolumbites europaeus-perrinismithi*, between *Subcolumbites perrinismithi* and *Subcolumbites europaeus* from the fauna of Chios.

SPATH (1934) studied the *Subcolumbites* fauna and described the following species: *Subcolumbites perrinismithi* (ARTHABER), *S. europaeus* (ARTHABER), *S. dusmani* (ARTHABER), *S. mirditensis* (ARTHABER).

Recently KUMMEL (1969) revised the genus *Subcolumbites* and included *Columbites europaeus-perrinismithi*, *C.* (*Subcolumbites*) *europaeus* ARTHABER, *Subcolumbites kwangsianus* CHAO (CHAO, 1959) and *Columbites asymmetricus* CHAO (CHAO, 1959), into the synonymy of *Subcolumbites perrinismithi* (ARTHABER).

The Japanese specimens from the Osawa Formation, though poorly preserved, are identified with the present species based upon the characteristic shell ornamentation, which consists of fine, numerous, falciradiate lineations on the shell surface. KUMMEL (1969) stressed that the pattern and intensity of shell ornamentation are quite variable. The writers also think that the sculpture of the genus *Subcolumbites* is very variable and there are many transitional forms between species, for example between *Subcolumbites perrinismithi* and *S. dusmani* (ARTHABER), which were illustrated by ARTHABER (1911, 263, pl. 24(8), figs. 1a-d) as *Columbites*.

One of the present writers (BANDO, 1964) described *Subcolumbites* cf. *perrinismithi* from the Osawa Formation at Tate near Isatomae, Utatsu-cho, about 9 km south of the type locality in the southern part of the Kitakami Massif. Later KUMMEL (1969) pointed out that the Japanese species is conspecific with *S. perrinismithi* from the North America and Chios Island in Greece, after he visited the locality at Tate with BANDO in 1966.

Occurrence and geological horizon:— *Subcolumbites perrinismithi* subzone of the Late Scythian (Columbitan-Prohungaritan). Black shale of the Osawa Formation at Osawa, Motoyoshi-cho, Motoyoshi-gun, Miyagi Prefecture, southern part of the Kitakami Massif.

Coll. S. SHIMOYAMA, M. MURATA and N. NISHIWAKI, 1971. Reg. No. OS-19001-1, OS-50902-2, OS-1002-2, OS-1001.

Genus *Prenkites* ARTHABER, 1911

Type species: *Prenkites malsorensis* ARTHABER, 1911

Occurrence and geological horizon:— Late Scythian (Columbitan-Prohungaritan ?) of the Early Trias. Albania, Chios, Timor, South China ?, Primorye Region and Japan.

Prenkites cf. *timorensis* SPATH

Pl. 41, figs. 4, 5, 8

Compared with:—

Columbites nov. sp. indet., WELTER, 1922: 150, pl. 168, figs. 12-13.

Prenkites timorensis, SPATH, 1930: 77; SPATH, 1934: 208, figs. 62d, e.

Columbites bubulinae RENZ and RENZ, 1947: 59, 73; RENZ and RENZ, 1948: 26, pl. 9,

figs. 7-7a, pl. 10, figs. 1-1b.
Prenkites timorensis, KUMMEL, 1969: 441, text-figs. 17, 26.

Description:—Whorls rather involute, laterally compressed, discoidal, with narrowly rounded venter and sharply edged umbilical shoulders. Umbilical wall almost vertical. Diameter of umbilicus about 1/4 of total diameter of shell. Outer whorl indented, about 4/5 of height of inner whorl. Surface ornamented with prorsiradiate, fine ribs varying in their strength and inserted by fine growth striations parallel with ribs. Their ribs diminish toward inner volutions. Sutures with lateral lobes and saddles, but both ventral and umbilical sutures missing. Lateral lobes denticulated as in Ophiceratids and saddles of spheroidal arch. Umbilical series considerably long.

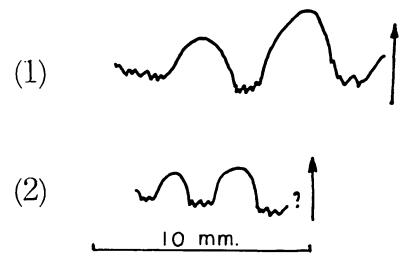


Fig. 3. Suture lines of *Stacheites* sp. (1) and *Prenkites* cf. *timorensis* SPATH (2). Both ammonoids occurred from the black shale of the Osawa Formation at Osawa, Motoyoshi-cho, Motoyoshi-gun, Miyagi Prefecture, southern part of the Kitakami Massif. Late Scythian.

Measurements (in mm):—

	D	H	W	U	H/D	W/H	D/U
802-1	30.0	10.9	4.5?	7.6	0.36	0.41?	0.25

Remarks:—*Prenkites timorensis* was proposed by SPATH (1939, 77) as the type specimen of *Columbites* nov. sp. of WELTER. WELTER's illustrated species is represented by only one specimen from Timor. RENZ and RENZ (1947, 1948) described many species of *Columbites*, e. g. *C. malayanus* RENZ, *C. malayanus crassa* RENZ and RENZ, *C. bublinae* RENZ and RENZ, *C. levantinus* RENZ and RENZ and *C. hellenicus* RENZ and RENZ. But KUMMEL (1969, p. 443) regarded them to be conspecific with *Prenkites timorensis* SPATH, and moreover, included CHAO's species, which consist of *Prenkites kwangsianus* CHAO, *Columbites huangi* CHAO, *C. costatus* CHAO and *C. yaliensis* CHAO, into the synonymy of *Prenkites timorensis* SPATH. *Prenkites timorensis* illustrated by KUMMEL are variable in shell sculpture bearing coarse and strong ribs as seen in *Columbites levantinus* and fine ribs as seen in *Columbites bublinae*. The present writers consider that it is better to distinguish *Prenkites bublinae* from *P. timorensis* because their shell ornamentation is distinctly different from each other.

Occurrence and geological horizon:—*Arnautoceltites* zone of the Osawa Formation at Osawa, Motoyoshi-cho, Motoyoshi-gun, Miyagi Prefecture, southern part of the Kitakami Massif. Late Scythian (Early Trias).

Coll. S. SHIMOYAMA, 1968. Reg. No. OS-802-1, OS-801-5, OS-802-3.

Prenkites sp.

Pl. 41, fig. 11

Description:—Shell discoidal or subglobose, with funnel shaped umbilicus and rounded venter. Umbilical shoulder sharply edged. Ornamentation consists of falciradiate striation which gradually become prominent to body whorl and finer to inner whorl. Ventral part and septa unknown.

Measurements (in mm):—

	D	H	W	U	H/D	W/H	U/D
801-5	30.6	10.8	—	7.8	0.35	—	0.25

Remarks:—The single specimen examined is not of good preservation except for the shell ornamentation and the umbilicus which are both in good condition. In the characters of shell ornamentation and the funnel-shaped umbilicus the present specimen may be belonged to the genus *Prenkites*, which is characteristic in its depressed whorls with the umbilicus abruptly flaring and with the umbilical tubercles on the inner whorls, and also by the constricted body-chamber and aperture as pointed out by SPATH (1934, p. 207).

Occurrence and geological horizon:—*Arnautoceltites* zone of the black shale of the Osawa Formation at Osawa, Motoyoshi-cho, Motoyoshi-gun, Miyagi Prefecture, southern part of the Kitakami Massif. Late Scythian (Early Trias).

Coll. S. SHIMOYAMA, 1968. Reg. No. OS-801-5.

Family Meekoceratidae WAAGEN, 1895

Subfamily Arctoceratinae ARTHABER, 1911

Genus *Stacheites* KITTL, 1903

Type species: *Stacheites prionoides* KITTL, 1903, p. 27, pl. 4, fig. 8.

Stacheites sp.

Pl. 42, fig. 4

Description:—Shell involute, laterally compressed?, discoidal, as in Meekoceratids, with smooth sides or with few radial folds. No growth striations observed on shell surface. Umbilicus narrow, about 3.9 mm in diameter, and about one-fourth of total diameter of shell. Suture incomplete, but with large and entire external saddle and first lateral lobe on external sides of shell. Saddle consist of single first lateral saddle and very long umbilical series.

Remarks:—The single specimen is not well preserved, but the sutures are discernible, and the shell surface and umbilicus are preserved. The whorls and sutures are identified with the genus *Stacheites*. Unfortunately the ventral and umbilical pattern of the sutures are missing in the present material.

Occurrence and geological horizon:—*Subcolumbites perrinismithi* subzone of the Osawa Formation at Osawa, Motoyoshi-cho, Motoyoshi-gun, Miyagi Prefecture. Late Scythian (Early Trias).

Coll. S. SHIMOYAMA, 1971. Reg. No. OS-805-10.

Suborder Phylloceratina ARKELL, 1950

Superfamily Phylloceratacea ZITTEL, 1884

Family Ussuritidae HYATT, 1900

Genus *Eophyllites* SPATH, 1930

Type species: *Monophyllites dieneri* ARTHABER, 1908, p. 288, pl. 13, figs. 3a-c.

Eophyllites cf. *dieneri* (ARTHABER)

Pl. 40, fig. 1

Compared with:—

Monophyllites dieneri ARTHABER, 1908: 288, pl. 13, figs. 3a-c, 4a-c; ARTHABER, 1911: 234, pl. 20, figs. 5-8; DIENER, 1915: 203.

Eophyllites dieneri (ARTHABER), SPATH, 1930: 85, 89; SPATH, 1934: 293-295; KUMMEL, in ARKELL et al., 1957: L186; KUMMEL, 1969: 524, pl. 22, figs. 1-4; pl. 23, figs. 1-7, text-fig. 47.

Monophyllites (*Leiophyllites*) *rosae* RENZ and RENZ, 1947: 61, 77; RENZ and RENZ, 1948: 74, pl. 3, figs. 8-8a.

Monophyllites (*Schizophyllites*) *betilloni* RENZ and RENZ, 1947: 61, 78; RENZ and RENZ, 1948: 74, pl. 4, figs. 8-8b.

Monophyllites (*Schizophyllites*) *betilloni* var. *evoluta* RENZ and RENZ, 1948: 76, pl. 4, figs. 6-6a, pl. 5, figs. 2-2a, 4-4a, 6-6a.

Description:—Specimen evolute, laterally compressed, with serpenticoned umbilicus. Sides of flanks gently convex from umbilical to ventral shoulders. Venter narrowly rounded and umbilical wall shallow. Surface of shell ornamented with fine radial striations extending from umbilical to ventral shoulders. Few comparatively distinct radial ribs or folds on shell surface. Sutures unknown.

Measurements (in mm):—

	D	H	W	U	H/D	W/H	U/D
1101-9	31.4(23.9)	9.4(7.9)	—	15.2(9.1)	0.29	—	0.48

Remarks:—The material at hand from the Osawa Formation are poorly preserved, but the shell ornamentation and whorls are rather well preserved. The present specimens are closest to those of *Eophyllites dieneri* (ARTHABER) in the general shape of shell and surface ornamentation. Unfortunately the sutures are not preserved and the shell is slightly compressed laterally by subsequent deformation. SPATH (1934, p. 293) stated that the ornamentation of the shell is more or less rectiradiate (radial and straight) striae of growth and indistinct. The present material also has numerous radial growth striae and they are straight from the umbilical to the ventral shoulders. The type species, *Eophyllites dieneri*, was originally described by ARTHABER (1908, loc. cit.) from Albania. KUMMEL (1969, p. 524) included SPATH's *Eophyllites refractus* into the synonymy of *E. dieneri*. *E. refractus* SPATH (SPATH, 1934, p. 295, pl. 111, fig. 4) was based upon *Monophyllites hara* ARTHABER (ARTHABER, 1908, p. 216, pl. 12, fig. 4, non DIENER), but according to SPATH (op. cit.) the shell ornamentation has growth striae which are strongly bent back on the peripheral edge. The writers consider that the striae or ribs are rather variable among the species of this genus and, therefore, the identification of species based upon such characters may be difficult. KUMMEL (1969, p. 525) considered that *Eophyllites re-*

fractus is conspecific with *E. dieneri*.

Other species of this genus are *Eophyllites orientalis* SPATH (SPATH, 1934, p. 295, designated as type specimen *Monophyllites* aff. *dieneri* of WELTER, 1922, p. 118, pl. 161, figs. 5-7) from Timor and *E. amurensis* KIPARISOVA, 1961, p. 137, pl. 28, figs. 7, 8, text-fig. 104) from the Primorye Region in eastern part of Siberia.

Occurrence and geological horizon:—*Columbites parisianus* subzone of the Osawa Formation at Osawa, Motoyoshi-cho, Motoyoshi-gun, Miyagi Prefecture. Late Scythian (Early Trias).

Coll. S. SHIMOYAMA, 1970. Reg. No. OS-1101-9.

Eophyllites sp.

Pl. 41, fig. 7

Description:—Shell evolute, whorls compressed laterally, with wide umbilicus and narrowly rounded venter. Surface ornamented with faint and condensed radial striae extending from umbilical margin to ventral margin. Striae on body whorl more prominent than on inner whorl. Three volutions obvious in umbilicus. Suture unknown.

Measurements (in mm):—

	D	H	W	U	H/D	W/H	U/D
GLKU-OS-406	—	15.0?	—	18.6	—	—	—

Remarks:—Considering from the shell ornamentation and the form of umbilicus the present specimen is similar to "*Monophyllites* (*Schizophyllites*)" *betilloni* var. *evoluta* RENZ and RENZ (RENZ and RENZ, 1948, p. 76, pl. 4, figs. 6-6a; pl. 5, figs. 2-2a, 4-4a, 6-6a). KUMMEL placed the species mentioned above in the synonymy of *Eophyllites dieneri* (ARTHABER) (type species: *Monophyllites dieneri* ARTHABER, 1908, p. 288, pl. 13, fig. 3a-c, 4a-c), but the ornamentation of *Eophyllites dieneri* differs from that of *Eophyllites evolutus* (RENZ and RENZ) ((RENZ and RENZ, 1947, 1948, as *Monophyllites* (*Schizophyllites*) *betilloni* var. *evoluta* RENZ and RENZ)). The shell ornamentation and septa of *Eophyllites dieneri* apparently more resemble those of *Leiophyllites* than *Eophyllites evolutus*.

Occurrence and geological horizon:—*Subcolumbites* zone of the Osawa Formation at Osawa, Motoyoshi-cho, Motoyoshi-gun, Miyagi Prefecture. Late Scythian (Early Trias).

Coll. S. SHIMOYAMA, 1970. Reg. No. GLKU-OS-406.

Genus *Leiophyllites* DIENER, 1915

Type species: *Monophyllites suessi* MOJSISOVICS, 1882

Leiophyllites sp.

Pl. 41, fig. 2

Description:—Whorls evolute, laterally compressed, with wide umbilicus, rounded venter and smooth shell surface. Umbilicus composed of three or four inner volutions and shallow and rounded umbilical wall. Outer whorl slightly indented by inner whorl. Sides of shell smooth and flattened without ribs or striations.

Remarks:—In the present material half of the outer volution is missing, but the umbilicus and shell surface are well preserved. The sutures show a *Leiophyllites* form.

Occurrence and geological horizon:—*Subcolumbites* zone of the Osawa Formation at Tate near Isatomae, Utatsu-cho, Motoyoshi-gun, Miyagi Prefecture, southern part of the Kitakami Massif. Late Scythian (Early Trias).

Coll. K. ISHII and Y. BANDO, 1970. Reg. No. GLKU-OS-404.

Family Hungaritidae WAAGEN, 1895

Genus *Dalmatites* KITTL, 1903

Type species: *Dalmatites morlaccus* KITTL, 1903

Dalmatites sp.

Pl. 41, fig. 3

Description:—Laterally much compressed shell with flattened sides and shall umbilicus. Conch involute, discoidal, and sides ornamented with faint radial folds at middle portion of height of flank, there diminish on ventral and umbilical margins, surface ornamented with faint, radial growth striations. Sutures unknown.

Measurements (in mm):—

	D	H	W	U	H/D	W/H	U/D
802-2	25.3	12.2	—	2.8	0.48	—	0.11
801-6	12.2	6.8	—	1.0?	0.55	—	0.08?

Explanation of Plate 40

Fig. 1. *Eophyllites* cf. *dieneri* (ARTHABER)
Reg. no. OS-1101-9, ×1.4, Osawa Formation at Osawa, Motoyoshi-cho. *Columbites parisianus* subzone of the *Subcolumbites* zone, Late Scythian.

Figs. 2, 4, 6, 8, 9. *Columbites parisianus* HYATT and SMITH
2 (Reg. no. OS-1101-4) ×2; 4 (Reg. no. OS-1101-11) ×1.2; 6 (Reg. no. OS-1000) ×1.8; 8 (Reg. no. OS-1108-8) ×1.3; 9 (Reg. no. OS-805-9) ×2.7, Osawa Formation at Osawa, Motoyoshi-cho. *Subcolumbites* zone of the Late Scythian.

Figs. 3, 5. *Subcolumbites perrinismithi* (ARTHABER)
3 (Reg. no. OS-19001) ×1; 5 (Reg. no. OS-50002-2) ×1, Osawa Formation at Tate near Isatomae, Utatsu-cho. *Subcolumbites perrinismithi* subzone of the *Subcolumbites* zone, Late Scythian.

Fig. 7. *Preflorianites* aff. *sulioticus* (ARTHABER)
Reg. no. OS-19001-1, ×1.3, Osawa Formation at Sarusawa, Motoyoshi-cho. *Columbites parisianus* subzone of the *Subcolumbites* zone, Late Scythian.

All specimens illustrated here are preserved at the Department of Geology, Kagawa University, Takamatsu, Kagawa, Japan.


1

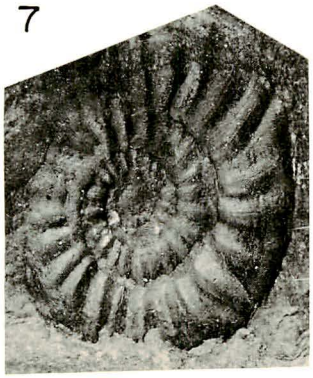

2


3


4


5


6


7


8


9

Remarks:—The ornamentation of the shell of the present specimens resembles that of *Dalmatites morlaccus* KITTL (KITTL, 1903, p. 73, p. 4, figs. 3-7; DIENER, 1915, p. 115; SPATH, 1951, p. 20; KUMMEL, in ARKELL et al., 1957, L156, fig. 187, 7; KUMMEL, 1969, p. 522, pl. 56, fig. 108, text-fig. 46). It is difficult to confirm the specific position of the present specimen because of its poor state of preservation.

Occurrence and geological horizon:—*Arnautoceltites* zone of the Osawa Formation at Osawa, Motoyoshi-cho, Motoyoshi-gun, Miyagi Prefecture, Kitakami Massif. Late Scythian (Early Trias).

Coll. S. SHIMOYAMA, 1968. Reg. No. OS-801-6, OS-802-2.

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Explanation of Plate 41

Figs. 1, 10. *Columbites parisianus* HYATT and SMITH
1 (Reg. no. OS-19001-24) ×2; 10 (Reg. no. OS-1002-1) ×2, Osawa Formation at Osawa, Motoyoshi-cho. *Columbites parisianus* subzone, Late Scythian.

Fig. 2. *Leiophyllites* sp.
Reg. no. GLKU-404, ×1.2, Osawa Formation at Tate near Isatomae, Utatsu-cho. *Subcolumbites* zone.

Fig. 3. *Dalmatites* sp.
Reg. no. OS-802-2, Osawa Formation at Osawa, Motoyoshi-cho. *Arnautoceltites* zone, Late Scythian.

Figs. 4, 5, 8. *Prenkites* cf. *timorensis* SPATH
4 (Reg. no. OS-801-5) ×1.2; 5 (Reg. no. OS-802-3) ×1.3; 8 (Reg. no. OS-802-1) ×1.2, Osawa Formation at Osawa, Motoyoshi-cho. *Arnautoceltites* zone, Late Scythian.

Fig. 6. *Arnautoceltites* sp.
Reg. no. GLKU-OS-405(K2) ×2.5, Osawa Formation at Tate near Isatomae, Utatsu-cho. *Arnautoceltites* zone, Late Scythian.

Fig. 7. *Eophyllites* sp.
Reg. no. GLKU-OS-406, ×1.5, Osawa Formation at Osawa, Motoyoshi-cho. *Subcolumbites* zone.

Fig. 9. *Subcolumbites perrinismithi* (ARTHABER)
Reg. no. OS-1002-2, ×2, Akaushi, Motoyoshi-cho. *Subcolumbites perrinismithi* zone, Late Scythian.

Fig. 11. *Prenkites* sp.
Reg. no. OS-801-5, ×1.9, Osawa Formation at Osawa, Motoyoshi-cho. *Arnautoceltites* zone, Late Scythian.


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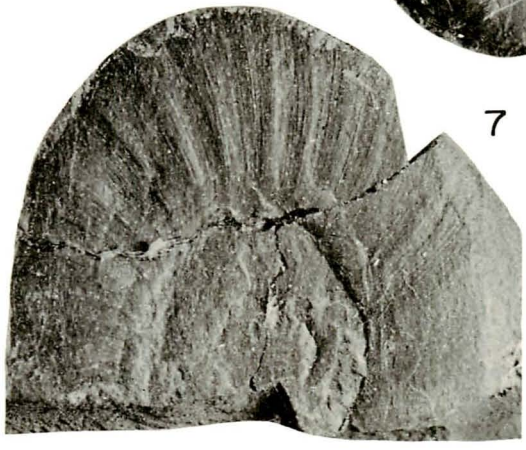
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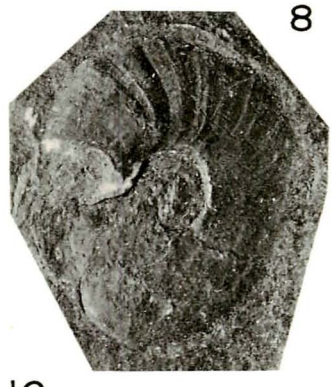
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Akaushi	赤牛
Chonomori	長ノ森
Fukkoshi	風越
Hiraiso	平磯
Isatomae	伊里前
Kesennuma	気仙沼
Konori	小乘
Motoyoshi	本吉
Ojika	牡鹿
Okachi	雄勝
Onagawa	女川
Osawa	大沢
Rifu	利府
Sarusawa	猿沢
Shindate	新館
Tate	館
Toyoma	登米
Utatsu	歌津

Explanation of Plate 42

Figs. 1, 3. *Columbites parisianus* HYATT and SMITH
1 (Reg. no. OS-1101) ×1.9; 3 (Reg. no. OS-1101-8) ×1.9, Osawa Formation at Akaushi, Motoyoshi-cho. *Columbites parisianus* subzone.

Fig. 2. *Subcolumbites perrinismithi* (ARTHABER)
Reg. no. OS-1001, ×2, Osawa Formation at Osawa, Motoyoshi-cho. *Subcolumbites perrinismithi* subzone, Late Scythian.

Fig. 4. *Stacheites* sp. (1), *Prohungarites* ? sp. (2) and *Subcolumbites* sp. (3)
Reg. no. OS-805-8, ×2, Osawa Formation at Osawa, Motoyoshi-cho. *Subcolumbites perrinismithi* subzone, Late Scythian.

Fig. 5. *Isculitoides* aff. *originis* (ARTHABER)
Reg. no. OS-807-1, ×1.6, Osawa Formation at Tate, near Isatomae, Utatsu-cho. *Arnautoceltites* zone ?, Late Scythian.


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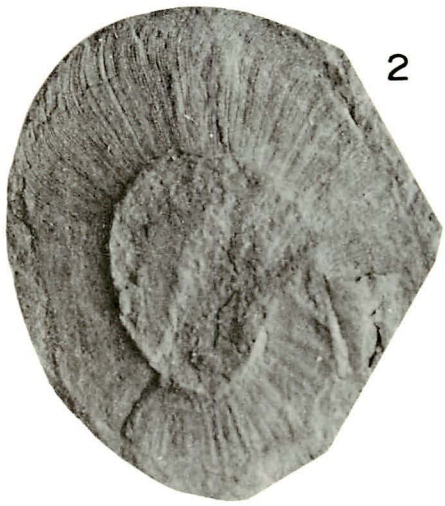
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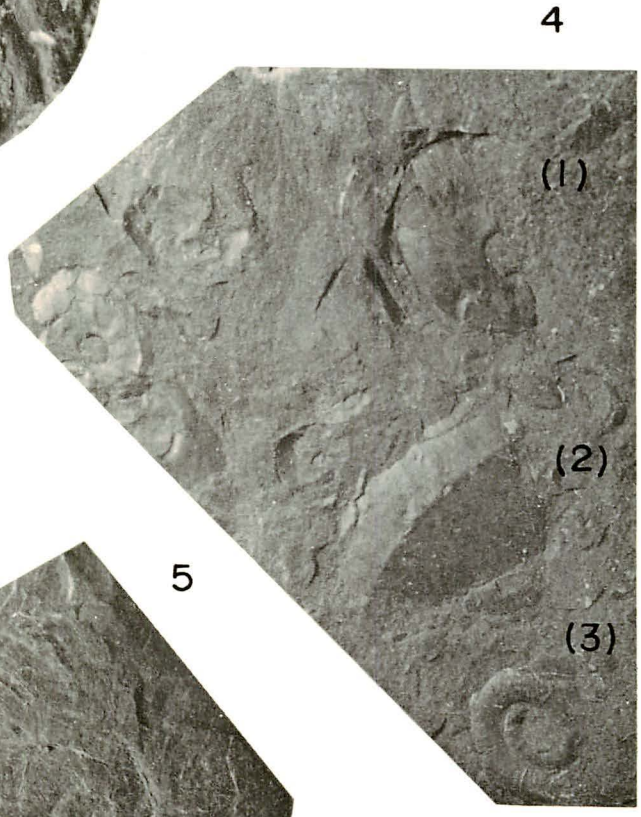
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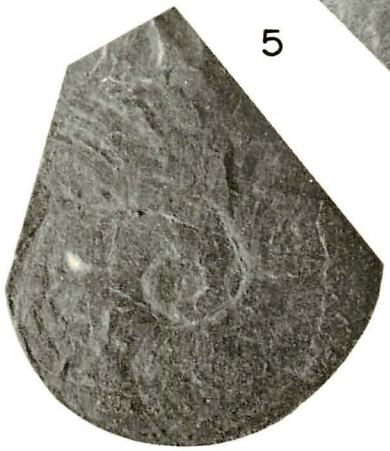
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Trans. Proc. Palaeont. Soc. Japan, N.S., No. 94, pp. 313-318, pl. 43, June 30, 1974

632. TWO SPECIES OF *PERMUNDARIA* FROM THE KITAKAMI MOUNTAINS, NORTHEAST JAPAN*

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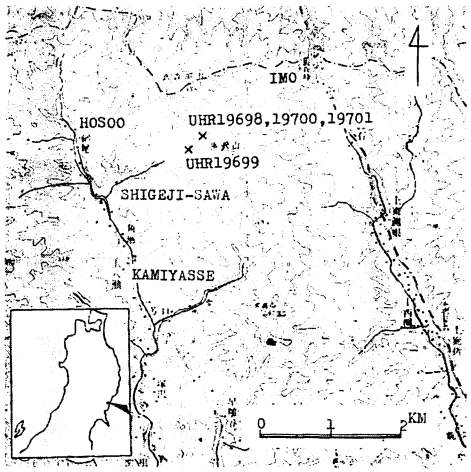
北上山地に産出した2種の *Permundaria* について：*Permundaria*（腕足類）はこれまでに日本，中国南部，カンボジア，カシミールの中～上部二畳系から報告されている。筆者は南部北上山地，宮城県気仙沼市上八瀬地域における叶倉統下部の砂質石灰岩層および細粒砂岩層より多くの腕足類の化石を採集したが，そのなかに4個体，2種の *Permundaria* を認めた。そのうち2個は新種と思われるのでこれを *Permundaria tenuistriata* n. sp. と命名し，記載する。他は *P. asiatica* NAKAMURA, KATO and CHOI に同定された。　田沢純一

Introduction

Recently NAKAMURA, KATO and CHOI (1970) reported the occurrence of some Linoproductid shells from the Lower Kanokura series of the Southern Kitakami Mountains, Northeast Japan and the Upper Permian Sisophon limestone (*Yabeina* zone) of Cambodia. Then they established a new genus *Permundaria* with *P. asiatica* as the type species. According to their description, the present genus is characterized by the surface ornamentation and outline of the shell. Namely conspicuous rugae besides numerous fine costellae are developed on the entire surface of both valves; the shell is semicircular, rectangular or subquadrate in outline and shows weak convexity in pedicle valve. The genus is known to occur from the Middle to Upper Permian of Japan, South China, Cambodia and Kashmir.

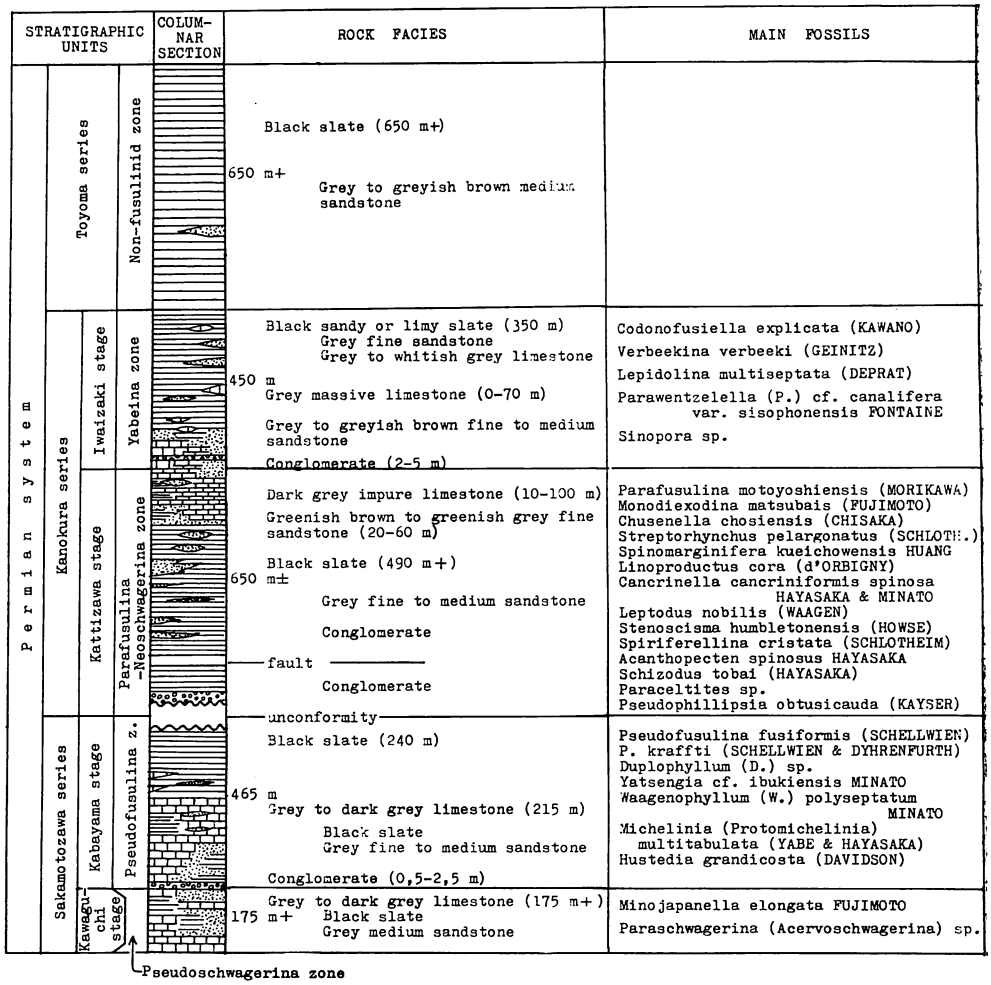
The present author has been engaged in geological and palaeontological studies of the Permian formations developed in the Kamiyasse-Kesennuma area, southern Kitakami Mountains, since 1970. The stratigraphy of this region is summarized as a generalized columnar section shown in Text-fig. 2.



Text-fig. 1. Map showing the fossil locality.

Since the pioneer works of YABE (1900) and HAYASAKA (1922, 23, 25) this area has been known for a long time as a good locality for the Permian invertebrate fossils; in fact a number of papers

* Received July 7, 1973: read June 23, 1973 at Niigata.



Text-fig. 2. Generalized stratigraphic sequence of the Permian System of the Kamiyasse-Kesennuma area, Miyagi Prefecture (After TAZAWA, 1973).

have been published on this fauna. Also the writer, in the course of his field survey, collected a fairly large number of fossils from various horizons.

Brachiopods are extremely rich in the dark grey impure limestone and the greenish brown fine sandstone members belonging to the upper part of the Lower Kanokura Series. Among them four brachiopod specimens seem to be referable to the aforesaid genus. Two of these specimens are assignable to a known species, and the rest represents a new form. And the present article describes two species of *Permundaria*.

Before going into description, the writer wishes to express his sincere thanks to Prof. M. MINATO of Hokkaido University for his kind guidance and encouragement throughout this study. Special thanks are due to Assist. Prof. M. KATO of Hokkaido University and Dr.

K. NAKAMURA of Hokkaido University of Education for their earnest guidance and valuable suggestions given to the author during the course of the present work. The author wishes to extend his hearty thanks to Prof. S. NISHIDA and Assist. Prof. Y. HASEGAWA of Niigata University from whom the author has been received warm encouragement.

Description of species

Family Linoproductidae STEHLI, 1954

Subfamily Linoproductinae STEHLI, 1954

Genus *Permundaria* NAKAMURA, KATO and CHOI, 1970

Permundaria asiatica NAKAMURA, KATO and CHOI, 1970

Pl. 43, figs. 3a-b, 4.

1908. *Productus undatus*, DIENER (non DEFRANCE): pp. 23-25, pl. 1, fig. 10 (excl. fig. 9).
1956. *Striatifera*? sp., HAYASAKA and MINATO: pp. 144-145, pl. 23, figs. 6, 7.
1970. *Permundaria asiatica* NAKAMURA, KATO and CHOI: pp. 296-297, pl. 2, figs. 1, 2.

Type.—NAKAMURA, KATO and CHOI (1970) designated the holotype and the paratype of this species. The Holotype (Pl. 2, figs. 1a-c; Reg. no. UHR 19015) consists of external and internal moulds of a pedicle valve, which was collected at Budo-sawa, a small tributary of Kattisawa, Sumita-cho, Iwate Pref., Japan. The specimen seems to be considerably distorted, although the NAKAMURA and others presumed the degree of deformation to be weak. The paratype (Pl. 2, fig. 2; Reg. no. UHR 19016) is a strongly exfoliated pedicle valve, which was obtained from Phnon Svai, Sisophon, Battambang region, Cambodia.

Material.—The specimens examined by the writer comprise two internal moulds of pedicle valve. The smaller one (pl. 43, fig. 4; Reg. no. UHR 19698) is more or less deformed by pressure, while the another specimen (pl. 43, figs. 3a-b; Reg. no. UHR 19699) represents its original configuration and the calcareous shell materials are partly preserved. Both of them were collected at Nidanosawa, a tributary of Shigejisawa, Kamiyasse, Kesennuma City, Miyagi Pref., Japan (Text-fig. 1).

Description.—Shell of moderate to large in size, wider than long and somewhat rectangular in outline; pedicle valve gently convex in lateral profile; beak small, not projected beyond hinge-line; ears triangular, flattened, obscurely marked off from visceral disc and flanks; interarea and median sulcus absent; shell material fairly thick, and 2.3 mm in thickness near umbo.

The sculpture over the entire surface composed of numerous fine radial costellae and coarse concentric rugae; costellae rounded and interrupted by rugae. Costellae enumerated 9 to 12 in 5 mm at anterior margin and increased in number by intercalations; rugae sharply imbricated, interspaces between them narrow in umbonal region and becoming gradually wider towards the anterior margin, irregularly developed on ears and lateral parts; spine bases not observed.

The conceivable dimensions of the two specimens are as follows: length, 60 mm, width, 96 mm in the larger specimen; length, 51 mm, width, 48 mm in the smaller one.

Remarks.—This species was designated as the type species of the genus *Permundaria* by NAKAMURA, KATO and CHOI (1970). The specific diagnosis

of this form are its transversely rectangular outline, nearly flat or slightly convex pedicle valve and relatively thick, less-numbered costellae. As the holotype appears to be considerably distorted elongately, the pedicle valve must have been originally wider in outline. Based upon the features of the general outline and the surface ornamentation, the specimens from Kamiyasse, now under consideration are safely assignable to the type species.

HAYASAKA and MINATO (1956) described two linoproductid specimens from the Lower Kanokura Series of the southern Kitakami Mountains as a species of *Striatifera* with querry. Although the features of their materials are not clearly observed owing to ill-preservation, they differ from any species of *Striatifera* on account of their straight, conceivably long hinge-line and less-numbered costellae.

DIENER (1908) identified two brachiopod remains derived from the Middle to Upper Permian Zewan bed of Kashmir with *Productus undatus* DEFRANCE. The larger specimen is clearly distinguished from *P. asiatica* by its distinct trail, while the other smaller one may be conspecific with the present species from its rectangular outline and surface ornaments.

In 1883, KAYSER also described two specimens as *Productus undatus* DEFRANCE in his monograph of Loping fauna. The surface sculpture of them consists of concentric rugae and numerous fine costellae. However, their semicircular or rather trigonal outline is quite different from that of the present species. As to the KAYSER's materials, NAKAMURA et al. (1970) gave their opinion as follows; one of them (fig. 13 of KAYSER's plate 26) seemed to be specifically identifiable with *Compressoproductus mongolicus* DIENER, while the other (fig. 12 of the same plate) could be distinguished from the former and referred to the species, *Permundaria sisophonensis*, collected from Sisophon limestone, Cambodia.

CHAO (1927) proposed a new genus *Striatifera* based on the materials from South China and Mongolia, and described some species belonging to the genus at the same time. Judging from the description and the figures illustrated in his monograph, the materials designated as *Striatifera? kayseri* by him appear to be assignable to the genus *Permundaria*. Because of the rather strong convexity of pedicle valve and the numerous very fine costellae, however, this Chinese species is easily distinguished from *P. asiatica*.

Occurrence.—The larger specimen was collected from the bedded, dark grey arenaceous limestone at Nidano-sawa, a tributary of Shigeji-sawa. This limestone contains numerous fossils of fusulinids, bryozoans, brachiopods and others, and is about 25 m in thickness around the fossil locality. Among the brachiopods, *Leptodus nobilis* (WAAGEN) is most dominant. At the upperstream of the same tributary, the smaller one was obtained from the greenish brown fine-grained sandstone member overlying the previous limestone beds, together with so many casts of a fusulinid, *Monodiexodina matsubaishi* (FUJIMOTO). Besides the fusulinid impressions, many brachiopod fossils are contained; *Spinomarginifera kueichowensis* HUANG, *Stenoscisma humbletonensis* (HOWSE) and *Spiriferellina cristata* (SCHLOTHEIM) are the overwhelmingly dominant species. Taking all the above observations into consideration, these limestone and sandstone members may be assigned to the upper part of the Lower Kanokura Series of

the Southern Kitakami Mountains.

Permundaria tenuistriata n. sp.

Pl. 43, figs. 1, 2a-b.

Types.—Two specimens are available for study. The smaller one (holotype: pl. 43, fig. 1; UHR 19700) is preserved as internal mould of a pedicle valve; the larger one (paratype: pl. 43, fig. 2a-b; Reg. no. UHR 19701) is represented by the external mould of a brachial valve. Each of them is only slightly deformed, and the sculptures are somewhat worn and rather ill-preserved. The shell surface of the paratype is covered by fusulinid casts (*Monodiexodina matsubaishi* (FUJIMOTO)). These materials were also collected along the same tributary as seen in the case of *P. asiatica*.

Description.—shell of moderate to large in size, transversely subquadrate or semi-elliptical in outline; hinge-line straight, equal or nearly equal to the greatest width of the shell.

Pedicle valve slightly convex in lateral profile; umbonal region moderately elevated, while lateral and anterior margin nearly flattened; beak small, scarcely projecting beyond hinge-line; ears triangular, flattened, ambiguously demarcated from visceral disc and flanks; cardinal area and median sulcus absent. Brachial valve gently concave as a whole; umbonal region rather strongly excavated; median fold absent.

On each valve, shell surface ornamentation composed of numerous, uniformly developing concentric rugae; fine thread-like costellae rounded, interrupted by rugae, 17 to 20 in 5 mm at anterior margin, increased in number by means of intercalation; rugae sharply imbricated, almost regularly and concentrically arranged; spine bases not observed.

The dimensions are: Length, 30 mm, width, 49 mm, in the holotype specimen; length, 47 mm, width, 105 mm, in the paratype.

Remarks.—The two specimens now in consideration are distinguished from the type species by their transversely wider shell outline, more numerous fine radial costellae and more regularly arranged concentric rugae.

Another Cambodian species, *Permundaria sisophonensis*, differs from the present species in having semicircular-shaped shell and more strongly elevated umbonal region.

In 1927, CHAO proposed a new species called *Striatifera kansuensis* for some gigantic Chinese specimens. These materials also possess concentric rugae and numerous fine costellae. However, its enormously large shell and more strongly convex pedicle valve are much different from those of the present species.

Accordingly, the author wishes to propose a new species, *Permundaria tenuistriata*, for the two specimens described above from the Kitakami Mountains.

Occurrence.—Both materials were collected from the greenish brown fine-grained sandstone member at almost the same locality as that of the smaller specimen of *Permundaria asiatica*.

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YABE, H. (1900): The brachiopoda *Lyttonia* from Rikuzen Province. *Ibid.*, vol. 7, no. 79, pp. 1-4, 2 figs.

Kamiyasse	上八瀬	Sumita-cho	住田町
Kesennuma	気仙沼	Nidano-sawa	ニダノ沢
Budo-sawa	葡萄沢	Shigeji-sawa	茂路沢
Katti-sawa	合地沢		

Explanation of Plate 43

Figs. 1, 2a-b. *Permundaria tenuistriata* n. sp.
1. Internal mould of pedicle valve, holotype, Reg. no. UHR 19700. 2a. External mould of brachial valve, paratype, Reg. no. UHR 19701. 2b. Enlarged portion of fig. 2a, showing numerous fine costellae and some concentric rugae, ×5.

Figs. 3a-b, 4. *Permundaria asiatica* NAKAMURA, KATO and CHOI
3a. Internal mould of Pedicle valve, Reg. no. UHR 19699. 3b. Enlarged portion of fig. 3a, showing rather thick, less-numbered costellae and some concentric rugae, ×5. 4. Internal mould of pedicle valve, Reg. no. UHR 19698.

All figures are natural size, otherwise stated.

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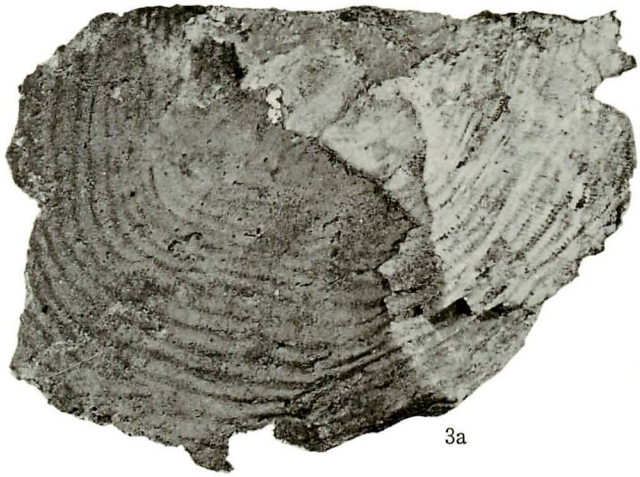

3a

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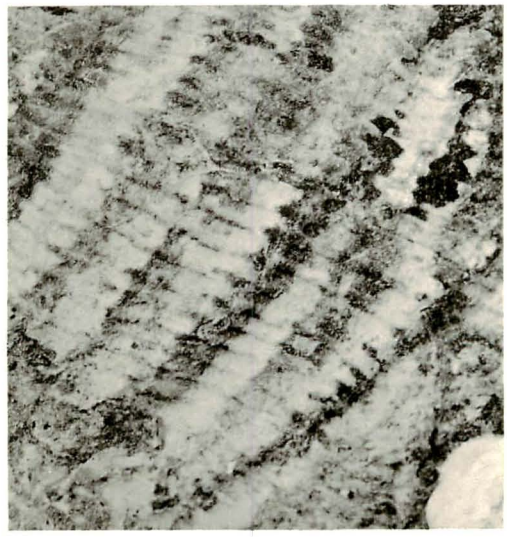

Trans. Proc. Palaeont. Soc. Japan, N.S., No. 94, pp. 319-340, pls. 44-46, June 30, 1974

633. SOME PLANT MICROFOSSILS FROM THE MIOCENE FUJIWARA GROUP, NARA, CENTRAL JAPAN*

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奈良県藤原層群産双鞭毛藻化石とアクリターカ化石：奈良盆地東縁部に分布する中下部中新統の藤原層群から検出された双鞭毛藻化石とアクリターカ化石14属19種（うち4新種，*Diphyes latiusculus*, *Hystrichokolpoma elliptica*, *H. denticulata*, *Tanyosphaerdium fusiform*）を記載・分類した。これらの微化石は藤原層群上部の豊田累層に多産し，その群集組成から2つに区分される。一つは豊田累層下部に認められ，種類数・個体数ともに貧弱である。一方同累層上部では種類も多様になり，また個体数も増加する。また記載された *Areoligera senonensis*, *Diphyes colligerum* (DEFLANDRE & COOKSON) や *Gonyaulacysta* 属, *Tanyosphaeridium* 属, *Schematophora* 属は，これまでヨーロッパ，北アメリカ，オーストラリア地域の上部白亜系から古第三系に普遍的に認められており，中新統よりの報告は，これが最初であろう。

松岡数充

Introduction

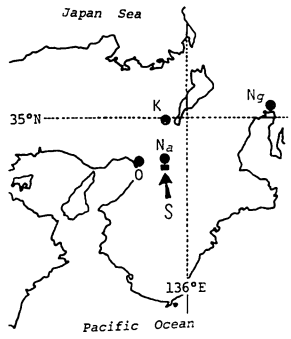
In Japan, there have been only a few studies of the plant microfossils such as dinoflagellates and acritarchs (TAKAHASHI, 1964, 1971; TAKAHASHI & YAO, 1969; SHIMAKURA, NISHIDA & MATSUOKA, 1971). The present paper deals with some descriptions and considerations about the species newly found from the Miocene Fujiwara Group distributed along the eastern margin of the Nara Basin, Kinki district. Following species of the phyto-microplankton are identified; Dinoflagellata—*Areoligera senonensis*, *Achomosphaera* sp., *Cannosphaeropsis* sp., *Cordosphaeridium* sp. cf. *C. uncinispinosum*, *Diphyes colligerum* (DEFLANDRE & COOKSON), *D. latiusculus* n. sp., *Hystrichokolpoma elliptica* n. sp., *H. denticulata* n. sp., *H. rigaudae*, *Hystrichosphaeridium*? sp., *Lingulodinium machaerophorum* (DEFLANDRE & COOKSON), *Operculodinium centrocarpum* (DEFLANDRE & COOKSON), *Spiniferites* sp. aff. *S. buccinus* (DAVEY & WILLIAMS), *S. mirabilis* (ROSSIGNOL), *S. ramosus* (EHRENBERG), *S.* sp. a, *Schematophora* sp. cf. *S. speciosa*, *Tanyosphaeridium fusiform* n. sp., *Tectatodinium* sp.; Acritarcha—*Cymatiosphaera* sp., *Leiosphaeridia* spp.; Chlorophyta—*Pediastrum* sp. cf. *P. boryanum* (TURPIN), Tasmanaceae.

The morphological affinities between the so-called hystrichospheres and the fossil dinoflagellates have been suggested by several micropalaeontologists. For example, EVITT (1961) pointed out those affinities in the view point of the archeopyle. Furthermore, he (1967) classified the archeopyle of the fossil dinoflagellates and hystrichospheres into four principal archeopyle types based on its morphology and position, that is, apical, intercalary, precingular and combination types.

* Received July 23, 1974: read June 27, 1971 at Nara.

WALL and DALE (1968) carried out some incubation experiments of the living dinoflagellates. One of their results proves that *Spiniferites bentori* (ROSSIGNOL) (one of typical hystrichospheres) is the spore or cyst of *Gonyaulax digitalis*.

Thus the relationship between dinoflagellates and hystrichospheres is being clarified since last decade, and a systematic classification of fossil dinoflagellates and hystrichospheres is being regulated.



Text-fig. 1. Index map of the present studied area: K: Kyoto, O: Osaka, Na: Nara, Ng: Nagoya, S: the present studied area.

Acknowledgement

Acknowledgement for helpful advice and critical reading of the manuscript is due to Professor Emeritus Misaburo SHIMAKURA and Dr. Shiro NISHIDA of Nara University of Education, who suggested this study. The author thanks Professor Kiyoshi TAKAHASHI of Nagasaki University and Professor Kazuo HUZITA and Mr. Akira YAO of Osaka City University for their encouragements and critical reading of the manuscript.

Geological setting

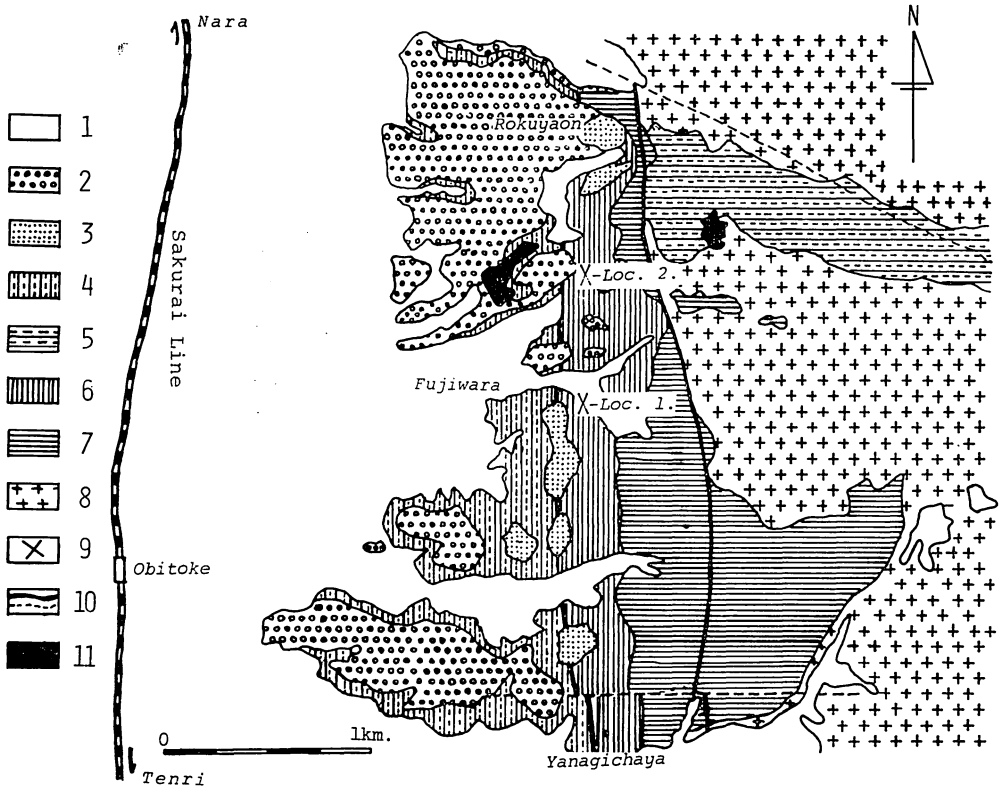
In the eastern part of the Nara Basin, the Neogene stratigraphical succession has been established by SAKAMOTO (1955) and SHIMAKURA *et al.* (1971) as follows in descending order;

Rokuyaon Gravel Bed
Kokuzoyama Gravel Bed
Shirakawa-ike Formation
Jigokudani Group
Fujiwara Group < Toyoda Formation / Iwabuchi Formation
Ryoke Complex

The Ryoke Complex is mostly composed of injection gneiss and gneissic granite, and is widely exposed on the Yamato Highland.

The Fujiwara Group, unconformably underlain by the Ryoke Complex, is divisible into two formations. The lower one named the Iwabuchi Formation consists of basal conglomerate, sandstone, granule conglomerate and mudstone containing a small amount of molluscan fossils. The upper one, the Toyoda Formation, is composed of tuffaceous fine- and coarse-grained sandstone, white medium-grained tuff and mudstone with abundant macro- and microfossils. The fossils reported from this formation are diatoms, benthonic and planktonic foraminifers, molluscs, echinoids, crabs, shark's teeth and fish scales. This group is considered to belong to the early to middle Miocene in age judging from molluscan and benthonic foraminiferal fossils (KONDA, in SHIMAKURA *et al.*, 1971).

The Jigokudani Group lies on the Fujiwara Group with slight clinounconformity. This lacustrine formation is characterized by plenty amount of rhy-



Text-fig. 2. Geologic map of the Southern part of Nara City after SAKAMOTO (1955) and SHIMAKURA *et al.* (1971) with slight modification. 1: Recent deposit, 2: Rokuyaon Gravel Bed, 3: Kokuzoyama Gravel Bed, 4: Shirakawa-ike Formation, 5: Jigokudani Group; Hachibuse Sandstone and Conglomerate Member, 6 and 7: Fujiwara Group; 6, Toyoda Formation, 7, Iwabuchi Formation, 8: Basement rocks; Ryoke Complex, 9: Sampling localities, 10: Faults, 11: Pond.

olitic pyroclastic sediments in the middle part, and can be subdivided into six members as follows in ascending order; the Hachibuse Sandstone and Conglomerate, Higashiyama Conglomerate, Onigatsuji Sandstone and Mudstone, Sekibutsu Tuff, Yadahara Conglomerate, and Nakanokawa Tuffaceous Sandstone Members. The Hachibuse and Onigatsuji Members yield abundant macro- and microfossils of plants (KOKAWA, 1954; SHIMAKURA, 1963; SHIMAKURA *et al.*, 1971). This group may belong to late Miocene in age.

The Shirakawa-ike Formation consists of gravel, sand and mud intercalated by several volcanic ash beds, and is characterized by abundant plant remains belonging to the *Metasequoia* flora (KOKAWA, 1954). Therefore, this formation is correlatable with the lower part of the Osaka Group.

The Kokuzoyama and the Ryuyaon Gravel Beds seem to be terrace deposits, although they are somewhat deformed. They consist mainly of poorly sorted cobbles derived from the Ryoke Complex. No fossils have been found from

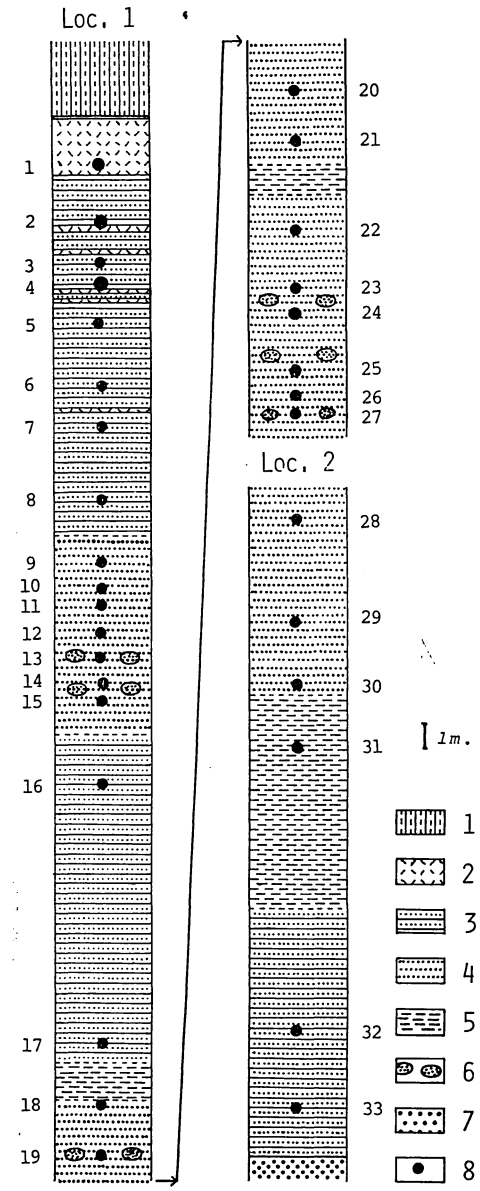
them. The former bed is more deeply weathered than the latter bed and is partially reddish in color.

Sample localities and preparation method

Samples examined in the present study were collected from two localities near the type locality of the Fujiwara Group at Fujiwara-cho in Nara City; namely six samples from Locality 2 and twenty-seven samples from Locality 1 (text-fig. 3). These samples except for Nos. 1, 29, 31, 32 and 33 contained abundant plant microfossils.

The palynological preparation method used for this study is generally based on SHIMAKURA's method (1963). In order to remove the colloidal particles, water was added to the crushed rock sample in a large breaker and was well stirred. The sample was kept at a stable state from six to twelve hours. Then the muddy water in the upper part of the beaker was decanted. These operations were carried out repeatedly for about a week. And the smaller fraction of the precipitates was used for the analysis. The material was treated with the mixed solution of nitric and hydrochloric acids (HNO_3: HCl: H_2O=1:1:1), and then with 10 per cent potassium hydroxide solution. Furthermore, the 30 per cent hydrofluoric acid was used in purpose to dissolve the fine mineral grains. When a number of plant fragments were found, the ERDTMAN's acetolysis method was adopted to take off them. The plant microfossils obtained were stained with Safranin or Gentian violet. They were mounted in glycerine jelly on slide and sealed with nail enamel.

The specimens described in this paper



Text-fig. 3. Columnar sections of the Toyoda Formation at Localities 1 and 2 at Fujiwara-cho in Nara City. 1: Shirakawa-ike Formation composed of sand, mud and gravel, 2-6: Toyoda Formation, 2: White medium grained sandstone, 3: Tuffaceous fine-grained to silty sandstone, 4: Medium-grained sandstone, 5: Siltstone, 6: Calcareous nodules, 7: Iwabuchi Formation composed of granule conglomerate, 8: Positions of samples collected.

are deposited in the Department of Geosciences, Osaka City University.

Comments on plant microfossils

As seen in Table 1, *Areoligera senonensis*, *Cordosphaeridium* sp. cf. *C. uncinispinosum*, *Lingulodinium machaerophorum* (DEFLANDRE & COOKSON), *Spiniferites* sp. aff. *S. buccinus* (DAVEY & WILLIAMS), *S. ramosus* (EHRENBERG), and *Operculodinium centrocarpum* (DEFLANDRE & COOKSON) are common or abundant in Locality 1. *Diphyes colligerum* (DEFLANDRE & COOKSON), *D. latiusculus* n. sp., *Hystrichokolpoma elliptica* n. sp., *H. denticulata* n. sp., *H. rigaudae*, *Tanyosphaeridium fusiform* n. sp., *Cannosphaeropsis* sp., and *Gonyaulacysta* spp. are a few or rare. From Locality 2, only *Cordosphaeridium* sp. cf. *C. uncinispinosum*, *Diphyes colligerum* (DEFLANDRE & COOKSON), *Operculodinium centrocarpum* (DEFLANDRE & COOKSON), *Spiniferites* sp. aff. *S. buccinus* (DAVEY & WILLIAMS), and *S. ramosus* (EHRENBERG) are rarely found.

TAI (1957) and KONDA (in SHIMAKURA *et al.*, 1971), who studied the fossil benthonic foraminifers in the Toyoda Formation of the Fujiwara Group, recognized two benthonic foraminiferal faunules. According to KONDA, the lower assemblage, the *Lenticulina* assemblage, consists of only a few species and specimens, which are poor in preservation. The upper assemblage, the *Lenticulina-Cibicides-Uvigerina* assemblage, is characterized by many species and specimens of both planktonic and benthonic foraminifers. As mentioned above, the dinoflagellates and acritarchs from the upper part of the Toyoda Formation which mostly includes Locality 1 are very abundant in number of species and specimens. On the other hand, the lower part mostly including Locality 2 contains only poor assemblage. Accordingly, the tendency of the number of species and the occurrence of individuals in both dinoflagellates and acritarchs is similar to that of foraminiferal assemblages each other.

Areoligera senonensis and *Diphyes colligerum* (DEFLANDRE & COOKSON) have been commonly found from the Upper Cretaceous to Palaeogene strata in Europe, Australia and North America. Also, the genera of *Gonyaulacysta*, *Tanyosphaeridium* and *Schematophora* have been known from late Cretaceous to Palaeogene (SARJEANT, 1967a, b). On the other hand, *Lingulodinium machaerophorum* (DEFLANDRE & COOKSON) and *Operculodinium centrocarpum* (DEFLANDRE & COOKSON) are common species from the Miocene to Recent sediments. As mentioned above, the geological age of the Fujiwara Group is considered to be early to middle Miocene based on benthonic foraminiferal and molluscan fossils. Therefore, the stratigraphical ranges of *Areoligera senonensis*, *Diphyes colligerum* (DEFLANDRE & COOKSON) and of the genera of *Gonyaulacysta*, *Tanyosphaeridium* and *Schematophora* seem to be extended to early to middle Miocene.

Systematic description

Recently, the classification of fossil dinoflagellate cysts including the hystrichospheres becomes to be confused with increase of reports concerning the life cycle of the living, motile and thecate dinoflagellates (EVITT & DAVIDSON, 1964 and WALL & DALE, 1968). For example, WALL and DALE (1968) reported the result of single cell incubation of *Gonyaulax spinifera* (CLAPAREDE & LACH-

Table 1. Occurrence of some dinoflagellates, acritarchs and chlorophytes from the Toyoda Formation.

Species \ Localities / Samples	Loc. 1																									Loc. 2	
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	30
Dinoflagellata																												
Achomosphaera sp.	+	+	+	+	+		++		+		+						+	+		+					+	+		
Areoligera senonensis	+	++	+		++	+		+	+	+	++	+	+	+	+	+		++	+	+	+			+		+		
Cannosphaeropsis sp.	+		+	+																								
Cordosphaeridium sp. cf. *C. uncinispinosum*	+	+	+		++					+	+	++	+	+	+			+					+			+	+	
Diphyes colligerum		+	+	+	+		+	+											+							+	+	
Diphyes latiusculus n. sp.				+	+																					+		
Hystrichokolpoma elliptica n. sp.																										++		
Hystrichokolpoma denticulata n. sp.		+			+		+												+							++		
Hystrichokolpoma rigaudae																										++		
Lingulodinium machaerophorum	++	++	++	++	++	+	+	+	+	+	+	+		+	+	+		+	+	+	+	+		+		+		
Operculodinium centrocarpum	++	++	++	+	+		+	+	+	+	+	+	+	+		+		+	+	+		+	+			++	+	+
Schematophora sp. cf. *S. speciosa*														+	+													
Spiniferites sp. aff. *S. buccinus*	+	+	++	+	+	+	+	+	+	+	++	+			+			+++	+	+	+	++	+++	++	++	+++	+	+
Spiniferites mirabilis																										+		
Spiniterites ramosus	+	+	++	+	++	+	+	+	+	+	++	+			+		+	++	+	+	+	+	++	++	++	++	+	
Spiniferites sp. a																									+	+		
Tanyosphaeridium fusiform n. sp.												+													+	+		
Gonyaulacysta spp.				+			+				+				+													
Spiniferites spp.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Acritarcha																												
Cymatiosphaera sp.																										+		
Leiosphaeridia spp.				+			++		+		++	+																
Chlorophyta																												
Pediastrum sp. cf. *P. boryanum*			+														+									+		
Tasmanaceae		++	++		+	+	+	+	+	+	+	+	+	+	+	+	+								++	+		

\+ Rare ++ A few +++ Common +++ Abundant

MANN), i.e. one of living, motile and thecate species. This living species produces three types of the cyst or spore belonging to three genera in palaeontological sense such as *Nematosphaeropsis balcombiana*, *Spiniferites mirabilis* (ROSSIGNOL) and *Tectatodinium pellitum*. Therefore, on the classification of the fossil dinoflagellate cysts, several opinions have been published.

In this paper, the author follows to SARJEANT and DOWNIE's classification (1966) and uses the terminology proposed by EVITT (1961, 1967) and DOWNIE and SARJEANT (in DAVEY *et al.*, 1966).

Class Dinophyceae PASCHER, 1914

Subclass Dinoferopfycidas BERGH

Cyst-Family Gonyaulacystaceae SARJEANT & DOWNIE, 1966

Genus *Gonyaulacysta* DEFLANDRE emend. SARJEANT, 1969

Gonyaulacysta sp. a

Pl. 46, fig. 8.

Description:—The present specimens of *Gonyaulacysta* have a conical epitract and a hemispherical hypotract with microgranular surface. There are no apical and antapical horns. Conceivable tabulation is 4′, 6″, 6g, 6‴ (?), 1p and 1⁗. The boundaries of each plate bear microgranular membraneous crests. Among four apical plates, plate 3′ is smaller than the others. All of precingular plates except for plate 1″ become relatively long in longitudinal direction. The hypotract has six postcingular plates, one posterior intercalary plate and one antapical plate. Plates 5‴ and 6‴ are longer in length than in width. Posterior intercalary plate is quadrate in shape, and its length and width are nearly equivalent to those of plate 1‴. The sulcal region is narrow in its anterior portion. The cingulum appears to have six plates and each cingular plate is surrounded by relatively high membraneous crests. It is of moderate breadth and forms a feebly laevorotatory spiral, and its two ends scarcely differ in antero-posterior positions. The archeopyle formed by loss of plate 3″ is a large precingular type.

Dimensions:—Diameter of central body 85μ×75μ, width of cingulum ca. 7μ.

Remarks:—Only one specimen obtained from the Toyoda Formation is characterized in having no apical and antapical horns. Hitherto, five species of *Gonyaulacysta* without apical and antapical horns are known; namely *G. ambigua*, *G. aceras*, *G. amabilis*, *G. corginera* and *G. porosa* (in EISENACK, 1964). Among them *G. amabilis* is similar to the present species in shape, but differs in diameter of the central body; the former is ca. 38μ×32μ.

Specimen slide:—KM-1234 (20.7/2.4).*

Cyst-Family Hystrichosphaeraceae O. WETZEL 1933 emend. SARJEANT & DOWNIE, 1966

Genus *Spiniferites* MANTELL, 1850

Spiniferites sp. aff. *S. buccinus* (DAVEY & WILLIAMS, 1966)

Pl. 45, figs. 1, 2.

Aff. 1966. *Hystrichosphaera buccina* DAVEY & WILLIAMS; *Bull. Brit. Mus.* (*Nat. Hist.*) *Geol.* Suppl. 3, p. 42-43, pl. 4, fig. 1, text-figs. 10, 11.

Description:—The present specimens are ovoid on lateral view, and subsph-

* Position of the specimen on slide.

erical on apical and antapical views. Its central body is delicately reticulate and the surface of processes is fine reticulate with irregularly shaped perforation in various size. There are two sorts of processes; one is gonal and triangular in optical section and the other is sutural and taeniate. Distally these processes are mostly foliate or digitate, tapering to subconical in shape and short fibriform or bifurcate. Gonal process are usually connected by well developed membrane at the bases. The tabulation is 3′, 6″, 6g, 5‴, 1p, 1pv and 1⁗. The sixth precingular plate is reduced, but its existence is indicated by the shape of plate 5″ and of the longitudinal fullow. The plates of the cingulum are not clear, but in well preserved specimens, these plates are elongate and hexagonal in shape expanding to the equatorial direction. Sometimes in the longitudinal fullow, plate 1pv is distinctively observed. The archeopyle is a precingular type formed by loss of plate 3″ and occasionally reduced.

Dimensions:—Diameter of central body 79μ-63μ, length of processes 25μ-35μ, diameter of archeopyle 18μ-30μ.

Remarks:—The present specimens of *Spiniferites* resemble to *S. buccinus* (DAVEY & WILLIAMS) in the shape of the central body, but differ from the latter species in characters of distal parts and of stalks, and the tabulation. In *S.* sp. aff. *S. buccinus* (DAVEY & WILLIAMS) one posterior intercalary plate is always observed on ventral side, but *S. buccinus* (DAVEY & WILLIAMS) does not have this plate. Also, *S.* sp. aff. *S. buccinus* (DAVEY & WILLIAMS) is larger than *S. buccinus* (DAVEY & WILLIAMS) in the diameter of the central body.

Specimen slides:—KM-5123 (9.0/12.6) and KM-5124 (23.3/0.7).

Spiniferites mirabilis (ROSSIGNOL)

Pl. 45, fig. 3.

1962. *Hystrichosphaera mirabilis* ROSSIGNOL; *Pollen et Spores*, vol. 4, no. 1, p. 132.
1967. *Hystrichosphaera mirabilis* ROSSIGNOL, WALL; *Palaeontology*, vol. 10, pt. 1, p. 101, pl. 14, figs. 5, 6, text-fig. 2.
1968. *Hystrichosphaera mirabilis* ROSSIGNOL, WALL & DALE; *Micropaleontology*, vol. 14, no. 3, p. 270, pl. 10, text-fig. 4.

Description:—The present specimens of *Spiniferites* have a subsphaerical central body, of which surface is microgranular, and are characterized by well developed tapering hollow process corresponded to the antapical plate. This process is elliptical in optical section and is covered with micro-grains. The other processes are formed from thin outer wall, densely set along the sutures and distally bifurcate or trifurcate with two or three branched tips. Its tabulation appears to be 4′, 6″, 6g(?), 6‴, 1pv (?) and 1⁗. The archeopyle is precingular type formed by loss of plate 3″.

Dimensions:—Diameter of central body 43μ-46μ, length of processes 10μ-15μ, diameter of archeopyle ca. 18μ-22μ.

Remarks:—*Spiniferites mirabilis* (ROSSIGNOL) described by WALL (1967) is slightly larger than the present specimens. This species is common in the Pleistocene sediments from the Caribbean Sea (WALL, 1967). This hystrichosphere is the cyst or spore of living, motile and thecate species *Gonyaulax spinifera* as shown by WALL and DALE (1968).

Specimen slide:—KM-5033 (18.1/4.8).

Spiniferites ramosus (EHRENBERG) MANTELL, 1850

Pl. 45, fig. 4.

1955. *Hystrichosphaera ramosa* (EHR.) O. WETZEL, 1933; DEFLANDRE & COOKSON; *Aust. J. Mar. Freshw. Res.*, vol. 6, no. 2, p. 263-264, pl. 2, fig. 1, pl. 5, fig. 6, pl. 6, fig. 1.
1959. *Hystrichosphaera ramosa* (EHR.) O. WETZEL, MAIER; *N. Jb. Geol. Paläont.*, Abh., vol. 107, no. 3, p. 301-302, pl. 28, fig. 5.
1963. *Hystrichosphaera ramosa* (EHR.) O. WETZEL, BROSIUS; *Z. dts. geol. Ges.*, vol. 114, p. 49, pl. 3, fig. 5.
1964. *Hystrichosphaera ramosa* (EHR.) O. WETZEL, MORGENROTH; *Palaeontographica*, Abt. B, vol. 119, no. 1, p. 14, pl. 7, figs. 5, 6.
1964. *Hystrichosphaera furcata* (EHR.) O. WETZEL, 1933; COOKSON & HUGHES; *Palaeontology*, vol. 7, pt. 1, p. 45, pl. 9, figs. 1, 2.
1966. *Hystrichosphaera ramosa* (EHR.) emend. DAVEY & WILLIAMS; *Bull. Brit. Mus. (Nat. Hist.) Geol.* Suppl. 3, p. 32, pl 1, figs. 1, 6, text-fig. 8.
1967. *Hystrichosphaera ramosa* (EHR.) DAVEY & WILLIAMS, GOCHT; *Palaeontographica*, Abt. B, vol. 126, no. 1, p. 30-31, pl. 4, figs. 10, 11, text-fig. 21.
1970. *Spiniferites ramosus* (EHR.) MANTELL, 1850; WALL & DALE; *Micropaleontology*, vol. 16, no. 1, p. 49-52, pl. 1, figs. 1-5, text-figs. 1-9.
1971. *Spiniferites ramosus* (EHR.) MANTELL, TAKAHASHI; *Trans. Proc. Palaeont. Soc. Japan, N.S.* no. 81, p. 16-17, pl. 2, figs. 1-3.

Description:—The present specimens of *Spiniferites* have a subsphaerical to ovoid central body with fine reticulate surface. Processes are gonal, solid and bifurcate or trifurcate occasionally with bifid branches. Conceivable tabulation is 4′, 6″, 6g, 5‴, 1p and 1⁗. On dorsal side, a precingular archeopyle corresponded to plate 3″ is observed.

Dimensions:—Diameter of central body 30μ-50μ, length of processes 10μ-15μ.

Remarks:—As a results re-investigation of *Spiniferites ramosus* (EHRENBERG) and *S. furcatus* (EHRENBERG), DAVEY and WILLIAMS (DAVEY *et al.*, 1966) concluded that *S. furcatus* (EHRENBERG) is a synonym of *S. ramosus* (EHRENBERG), and *S. ramosus* (EHRENBERG) is classified in many varieties based on the nature of processes and central bodies. This species differs from the species designated as *S.* sp. aff. *S. buccinus* (DAVEY & WILLIAMS) in this paper in having only gonal processes and reticulate surface of the central body.

Specimen slide:—KM-5124 (4.3/4.3).

Spiniferites sp. a

Pl. 45, fig. 7.

Description:—The present specimens of *Spiniferites* have a subpentagonal to ovoid central body with delicately reticulate or smooth body surface, and moderate thick wall ca. 2μ. Processes are much reduced and occasionally form small pads or sclerotes at the corners of plates. These processes have fine reticulate or smooth stalk surface and are distally digitate or bifurcate. Intergonal processes are not observed or very rare. Its tabulation may be 3-4′, 6″, 6g, 6‴, 1p and 1⁗. The sixth precingular plate is subtriangular in shape. The cingular plates are not distinctive, but in well preserved specimens, the shapes of them are elongated. On dorsal side, there is a precingular archeopyle formed by loss of plate 3″.

Dimensions:—Diameter of central body 70μ-78μ, length of reduced processes ca. 10μ.

Remarks:—The present specimens have characteristically much reduced processes, but distal parts of these processes are similar to those of abovementioned *Spiniferites* sp. aff. *S. buccinus*

(DAVEY & WILLIAMS). In *Spiniferites nodosa* described by WALL (1967) from deep sea cores of the Caribbean Sea, its processes are also much reduced as seen in the present specimens. The latter species, however, is different from the former in having slender stalks of processes.

Specimen slide:—KM-5043 (3.6/4.2).

Genus *Achomosphaera* EVITT, 1963

Achomosphaera sp.

Pl. 45, fig. 6.

Description:—The present specimens of *Achomosphaera* have a subspherical to ellipsoidal central body with smooth or microgranular surface. Processes are solid and bifurcate or trifurcate as those of *Spiniferites ramosus* (EHRENBERG). At the bases, processes are semicircular in optical section. The archeopyle may be a precingular type. Its tabulation is not determinable.

Dimensions:—Diameter of central body 42μ-52μ, length of processes 12μ-20μ.

Remarks:—The present specimens of *Achomosphaera* are similar to *Spiniferites ramosus* (EHRENBERG) in the nature of processes, but distinguished from the latter species by poorly developed sutural ridges or septa.

Specimen slide:—KM-1163 (3.3/5.3).

Cyst-Family Hystrichosphaeridiaceae EVITT, 1963 emend. SARJEANT & DOWNIE, 1966

Genus *Cordosphaeridium* EISENACK, 1963 emend. DAVEY & WILLIAMS, 1966

Cordosphaeridium sp. cf. *C. uncinispinosum* DE CONINK, 1967

Pl. 45, fig. 12.

Cf. 1970. *Cordosphaeridium uncinispinosum* DE CONINK, 1967; GRUAS-GAVAGNETTO; *Rev. Micropaléontologie*, vol. 13, no. 2, p. 70, pl. 1, fig. 13.

Description:—The present specimens of *Cordosphaeridium* have a subspherical to elongate central body with microgranular surface. Processes have relatively slender and smooth stalks with furcate or simple tips. Its archeopyle appears to be an apical type with several accessory archeopyle sutures. These specimens posses intratabular processes, so the tabulation is not determinable. The cingular region is indicated by the parallel arrangement of slender processes.

Dimensions:—Diameter of central body 38μ-68μ, length of processes 16μ-25μ, width of cingulum ca. 7μ.

Remarks:—The present specimens resemble to *Cordosphaeridium uncinispinosum* in the nature of processes. But the archeopyle of the latter species is not distinctive in the specimen figured by GRUAS-GAVAGNETTO (1970).

Specimen slide:—KM-5032 (1.3/6.1).

Genus *Diphyes* COOKSON, 1965 emend. DAVEY & WILLIAMS, 1966

Diphyes colligerum (DEFLANDRE & COOKSON, 1955) emend. DAVEY & WILLIAMS, 1966

Pl. 44, fig. 7.

1955. *Hystrichosphaeridium colligerum* DEFLANDRE & COOKSON; *Aust. J. Mar. Freshw. Res.*, vol. 6, no. 2, p. 278, pl. 7, fig. 3.

1965. *Hystrichosphaeridium colligerum* DEFLANDRE & COOKSON, STANLEY; *Bull. Amer. Paleont.*, vol. 49, no. 222, p. 231, pl. 24, figs. 7, 8.

1966. *Diphyes colligerum* (DEFLANDRE & COOKSON) DAVEY & WILLIAMS; *Bull.*

Brit. Mus. (Nat. Hist.) Geol. Suppl. 3, p. 96, pl. 4, figs. 2, 3.

Description:—The present specimens of *Diphyes* have a ovoid to subspherical central body with fine reticulate or microgranular surface. Processes are formed from outer wall and of two types. The single large process which is hollow cylindro-conical and occasionally closed distally marks a position of the antapical plate. A number of slender processes are commonly slightly curved, sometimes bifid, and open or closed distally. Total number of these processes exceeds fifty.

Dimensions:—Diameter of central body 35μ-45μ, length of large antapical processes 25μ-32μ, width of those processes 12μ-18μ, length of slender processes 12μ-20μ.

Remarks:—*Diphyes colligerum* (DEFLANDRE & COOKSON) is known from the lower Eocene Princeton Member of Dilwyn Clay in Australia (DEFLANDRE & COOKSON, 1955), the Eocene London Clay in England (DAVEY & WILLIAMS, 1966) and the Paleocene Fort Union Formation in North America (STANLEY, 1965). *Hystrichosphaeridium colligerum* shown by MORGENROTH (1966) is differentiated from the present species in having its ovoid antapical process and hemispherical outline of its central body in optical section.

Specimen slide:—KM-021 (22.4/4.6).

Diphyes latiusculus MATSUOKA, n. sp.

Pl. 44, fig. 6.

Diagnosis:—Ovoid to elongate central body with thin, microgranular surface and microgranular surface of the large antapical process. Processes formed from outer wall and of two types. One single broad antapical process, and slender, bifid or oblate processes. Total number of processes exceeding fifty.

Holotype:—Specimen slide KM-1162 (16.3/8.4), sample No. 6, Toyoda Formation, Fujiwara Group, early to middle Miocene, Fujiwara-cho, Nara City, Nara Prefecture. Pl. 44, fig. 6a, 6b.

Paratype:—Specimen slide KM-1132 (23.4/5.6), sample No. 5, Toyoda Formation, Fujiwara Group, early to middle Miocene, Fujiwara-cho, Nara City, Nara Prefecture.

Dimensions:—Holotype: Diameter of central body 45μ×52μ, length of antapical process 22μ, width of this process 14μ, length of slender processes 12μ-22μ, diameter of archeopyle ca. 33μ. Ranging dimensions: Diameter of central body 40μ-56μ×30μ-55μ, length of antapical processes 22μ-28μ, width of these processes 13μ-18μ, length of slender processes 12μ-22μ, diameter of archeopyle 25μ-40μ.

Description:—The present specimens of *Diphyes* have a characteristic apical archeopyle and single large antapical process. The antapical process is hollow, cylindro-subconical and open distally. The tips of the antapical process are irregularly denticulate or fibroid. The slender processes are commonly single, sometimes connect with adjacent ones at the base. They are ordinarily bifid, sometimes oblate and closed distally, and the both types do not connected with interior of the central cavity. The parallel arrangement of these slender processes indicates the cingular and sulcal regions.

Remarks:—The present species differs from *Diphyes colligerum* (DEFLANDRE & COOKSON) in the shape of the central body and the distal parts of the slender processes.

Genus *Hystrichokolpoma* KLUMPP, 1953 emend. WILLIAMS & DOWNIE, 1966

Hystrichokolpoma elliptica MATSUOKA, n. sp.

Pl. 44, fig. 2.

Diagnosis:—Ellipsoidal central body with granular surface, continual beneath processes and thin microgranular outer wall. Processes formed from outer wall and of two types: large ones with trapezoid bases, infundibular to buccinate with slightly denticulate open end, and small slender processes with furcate or bifid diftal parts. Tabulation refrected by these processes and shape of small archeopyle typical for this genus; 4′, 6″, 6g, 5‴, 1p and 1⁗. Small apical archeopyle with several archeopyle sutures and sulcal notch.

Holotype:—Specimen slide KM-022 (18.6/7.2), sample No. 27, Toyoda Formation, Fujiwara Group, early to middle Miocene, Fujiwara-cho, Nara City, Nara Prefecture. Pl. 44, fig. 2a, 2b.

Paratype:—Specimen slide KM-022 (19.5/12.7), sample No. 27, Toyoda Formation, Fujiwara Group, early to middle Miocene, Fujiwara-cho, Nara City, Nara Prefecture.

Dimensions:—Holotype: Diameter of central body 42μ×50μ, length of large processes 16μ-26μ, width of these processes 10μ-15μ, length of small slender processes 10μ-14μ, diameter of archeopyle 11μ×14μ. Ranging dimensions: diameter of central body 42μ-40μ×50μ-48μ, length of large processes 16μ-26μ, width of these processes 8μ-15μ, length of small slender processes 10μ-14μ, diameter of archeopyle ca. 20μ.

Description:—The present specimens of *Hystrichokolpoma elliptica* n. sp. are characterized by infundibular to buccinate large hollow processes and ellipsoidal central body with granular surface. Distal ends of large processes are slightly denticulate and somewhat recurved. The plate 6″ is smaller than the other precingular processes. The posterior intercalary process is also small, incompletely hollow and distally bifid, and occupies a position between plates 1‴ and 1⁗. The original sulcal and cingular regions are reflected by small slender processes which are distally furcate or bifid. The cingular region has about twelve small slender processes and the sulcal region has about six small ones. Its small apical archeopyle is polygonal with a sulcal notch.

Remarks:—This species is similar to *Hystrichokolpoma denticulata* n. sp. in having slightly denticulate distal margin of large hollow processes, but different from the latter in the shape of large hollow ones. Also, this species is distinguished from the other species of *Hystrichokolpoma* in having infundibular to buccinate large hollow processes, characteristic ellipsoidal central body and small polygonal apical archeopyle.

Hystrichokolpoma denticulata MATSUOKA n. sp.

Pl. 44, figs. 3-5.

Diagnosis:—Hemispherical central body with thin wall of granular surface, and thin smooth outer wall. Processes formed from outer wall and of two types; large ones with quadrate bases, cylindrical to tubiform with slightly denticulate open end, and small slender processes with slightly bifid distal parts. Tabulation reflected by these processes and shape of archeopyle typical for this genus; 4′, 6″, 6g, 5‴, 1p and 1⁗. Each cingular plate indicated by two adjacent

slender processes combined at basal parts.

Holotype:—Specimen slide KM-045 (13.8/1.5); sample No. 27, Toyoda Formation, Fujiwara Group, early to middle Miocene, Fujiwara-cho, Nara City, Nara Prefecture. Pl. 44, fig. 3a, 3b.

Paratype:—Specimen slide KM-023 (13.0/4.9) and KM-045 (3.1/13.9), sample No. 27, Toyoda Formation, Fujiwara Group, early to middle Miocene, Fujiwara-cho, Nara City, Nara Prefecture. Pl. 44, figs. 4a, 4b, 5.

Dimensions:—Holotype: Diameter of central body 38μ×42μ, length of large processes 14μ-21μ, width of these processes 8μ-12μ, length of small slender processes 11μ-17μ, diameter of archeopyle ca. 20μ. Ranging dimensions: Diameter of central body 40μ-50μ×42μ-60μ, length of large processes 16μ-22μ, width of these processes 8μ-12μ, length of small slender processes 11μ-17μ, diameter of archeopyle 20μ-30μ.

Description:—*Hystrichokolpoma denticulata* n. sp. is characterized by cylindrical to tubiform large hollow processes with quadrate to trapezoid bases and having a large apical archeopyle. Distal parts of large processes are slightly denticulate. The original apical, precingular, postcingular, posterior intercalary and antapical plates are reflected by these large processes. The first posterior intercalary plate has a small cylindrical to tubiform process, and occupies a position between plates 1‴ and 1⁗. The original cingular region is indicated by small slender bifid processes. Adjacent two of these slender processes are always connected at the bases. There are about six sulcal processes with distally open or bifid, which occupy a position between plates 1‴ and 5‴. Its large apical archeopyle has a zig-zag margin and may be formed by loss of four apical plates.

Remarks:—The present species is differentiated from *Hystrichokolpoma poculum*, *H. rigaudae*, *H. unispinum* and *H. elliptica* in having cylindrical to tubiform large hollw processes with quadrate to trapezoid bases, slightly denticulate distal margin of them and a two connected slender processes in the cingular region.

Hystrichokolpoma rigaudae DEFLANDRE & COOKSON, 1955.

Pl. 44, fig. 1.

1955. *Hystrichokolpoma rigaudae* DEFLANDRE & COOKSON; *Aust. J. Mar. Freshw. Res.*, vol. 6, no. 2, p. 279-281, pl. 6, figs. 6, 10, text-fig. 42.

1959. *Hystrichokolpoma rigaudae* DEFL. & COOK., MAIER; *N. Jb. Geol. Paläont.*, Abh., vol. 107, no. 3, p. 311, pl. 31, fig. 2.

1961. *Hystrichokolpoma rigaudae* DEFL. & COOK., GERLACH: *N. Jb. Geol. Paläont.*, Abh., vol. 112, no. 2, p. 183, pl. 27, figs. 7, 8.

1962. *Hystrichokolpoma rigaudae* DEFL. & COOK., ROSSIGNOL; *Pollen et Spores*, vol. 4, no. 1, p. 134, pl. 2, fig. 7.

1963. *Hystrichokolpoma rigaudae* DEFL. & COOK., BROSIUS; *Z. dts. geol. Ges.*, vol. 114, p. 43, pl. 2, fig. 6.

1966. *Hystrichokolpoma rigaudae* DEFL. & COOK., WILLIAMS & DOWNIE; *Bull. Brit. Mus. (Nat. Hist.) Geol.* Supl. 3, p. 180, pl. 17, fig. 4.

Description:—*Hystrichokolpoma rigaudae* from the Fujiwara Group possesses tubiform to buccinate large hollow processes with secate to slightly recurved distal parts. A central body with granular surface is ellipsoidal to ovium. The antapical process is the largest among the other hollow processes, and characteristic pen point-like in

shape with open distal end. All of the present specimens have been lost apical plates, but the apical archeopyle with several accessory archeopyle sutures indicates that these specimens might have four apical plates. Therefore, its tabulation may be typical for the present genus; 4′, 6″, 6 g, 5‴, 1p and 1⁗.

Dimensions:—Diameter of central body 40μ-48μ×38μ-56μ, length of large hollow processes 18μ-36μ, width of these processes 12μ-18μ, length of small slender processes 10μ-18μ, diameter of archeopyle 46μ-54μ.

Remarks:—The occurrence of the present species of *Hystrichokolpoma* has been reported from several areas; the Eocene London Clay in England (WILLIAMS & DOWNIE, in Davey et al., 1966) the Eocene and Miocene (or older) in Australia (DEFLANDRE & COOKSON, 1955), the middle Oligocene to middle Miocene in Germany (GERLACH, 1961 and BROSIUS, 1963) and the Pleistocene marine sediments in Israel (ROSSIGNOL, 1962).

Specimen slide:—KM-023 (18.1/3.9).

Genus *Hystrichosphaeridium* DEFLANDRE, 1937 emend. EVITT, 1963 emend. DAVEY & WILLIAMS, 1966.

Hystrichosphaeridium ? sp.

Pl. 45, fig. 5.

Description:—The present specimens have a spherical to ovoid central body ornamented with two kinds of processes and moderate thick wall without polar structures. There are very short spines and mostly asymmetrically bifurcate, but sometimes trifurcate processes with bifid or acuminate tips. The bases of furcate processes are occasionally semicircular or subtriangular in optical section, and are partly connected with adjacent processes by sutures. Its archeopyle is an apical type with several accessory archeopyle sutures. The number of processes is about thirty.

Dimensions:—Diameter of central body 44μ-56μ, length of very short processes ca. 2μ, length of furcate processes 10μ-18μ, diameter of archeopyle ca. 40μ.

Remarks:—According to DAVEY and WILLIAMS (in DAVEY *et al.*, 1966), the genus *Hystrichosphaeridium* has charactristic hollow processes and an apical archeopyle. The present specimens have solid furcate processes, so they may be belonged to the genus *Achomosphaera* judging from the solid and furcate processes. But these specimens differ from the genus *Achomosphaera* in having an apical archeopyle.

Specimen slide:—KM-1233 (14.0/9.8)

Genus *Tanyosphaeridium* DAVEY & WILLIAMS, 1966.

Tanyosphaeridium fusiform MATSUOKA n. sp.

Pl. 46, figs. 4, 9, 10.

Diagnosis:—Very elongate central body with irregularly reticulate inner wall surface. Processes tubiform, open distal parts with aculeate or orthogonal margin, and similar length. The number of processes about fifteen. Conceivable tabulation 3′, 6″, ?g, 6‴ and 2-3⁗.

Holotype:—Specimen slide KM-045 (5.0/17.7), sample No. 27, Toyoda Formation, Fujiwara Group, early to middle Miocene. Fujiwara-cho, Nara City, Nara Prefecture. Pl. 46, fig. 4.

Paratypes:—Specimen slide KM-045 (23.1/1.0) and KM-023 (10.3/3.5), sample No. 27, Toyoda Formation, Fujiwara Group, early to middle Miocene, Fuji-

wara-cho, Nara City, Nara Prefecture. Pl. 46, figs. 9, 10.

Dimensions:—Holotype: Length of central body 50μ, width of central body 24μ, length of processes 14μ-16μ, diameter of archeopyle ca. 20μ. Ranging dimensions: Length of central body 48μ-60μ, width of central body 25μ-30μ, length of processes 12μ-24μ, diameter of archeopyle ca. 20μ-26μ.

Description:—The present specimens have a very elongate central body with irregularly reticulate inner wall surface. Processes are composed of thin smooth outer wall and have broad bases and taper tips. The processes are distally aculeate or orthogonal with irregularly long tips. The bases of these processes are quadrate, but always not clear. The number of these processes is about fifteen. In the specimens attached the operculum, three hollow and tubiform processes are observed in the apical area. The six processes corresponding to each precingular plates are around the apical archeopyle. Any ornamentation is not observed in the cingular and sulcal regions. But relatively broad span between precingular and postcingular processes may reflect the cingular region. The postcingular region has six tubiform processes, and each one indicates to each original postcingular plate. The antapical area has three or sometimes two processes. Its archeopyle is an apical type with several archeopyle sutures.

Remarks:—The present new species of *Tanyosphaeridium* resembles to *T. paradoxum* (BROSIUS) shown by GOCHT (1969) in the shape of the central body, but differs from the latter species in the number of processes and the nature of these distal parts. Also, this species has a smaller number of processes than that of the other species described by DAVEY and WILLIAMS (in DAVEY *et al.*, 1966), such as *T. variecalamum* and *T. regulare*.

Cyst-Family Areoligeraceae EVITT, 1963 emend. SARJEANT & DOWNIE, 1966

Genus *Areoligera* LEJEUNE-CARPENTIER, 1938

Areoligera senonensis LEJEUNE-CARPENTIER, 1938

Pl. 46, figs. 1, 2.

1965. *Areoligera* sp. aff. *A. senonensis* LEJEUNE-CARPENTIER, STANLEY; *Bull. Amer. Paleont.*, vol. 49, no. 222, p. 228, pl. 26, figs. 1-8.

1969. *Areoligera senonensis* LEJEUNE-CARPENTIER, GOCHT; *Palaeontgraphica*, vol. 126, no. 1, Abt. B, p. 56, pl. 8, figs. 4-9, text-figs. 40-41.

Description:—A hemispherical to ovoid central body with microgranular surface has a large characteristic apical archeopyle, and six precingular, five postcingular, one posterior intercalary and one antapical annular or soliate complex processes. Judging from the shape of some free operculums, the apical area appears to have four plates. Therefore, conceivable tabulation is 4′, 6″, ?g, 5‴, 1p and 1⁗. All precingular plates bear soliate complex processes and plate 5″ is larger than the others. Several accessory archeopyle sutures are observed between plates 1″ and 2″, 3″ and 4″, 4″ and 5″, and 5″ and 6″. Plates 2‴, 3‴, 4‴, and 5‴ posess annulate complex processes, but plate 1‴ is not obvious in detail. One posterior intercalary plate, 1p, is represented by incomplete soliate complex processes, and occupies a position between plates 1‴ and 1⁗. The largest complex process is an ant-

apical plate and charactristically comma-like in shape. The small sulcal notch is observed on dorsal side between plates 1″ and 6″. The sulcal region is probably indicated by reduced linear complex processes. These processes are formed from smooth membrane and incompletely conected with two or more adjacent processes at the bases and occasionally at the distal parts.

Dimensions:—Diameter of central body 42μ-50μ×48μ-70μ, length of complex processes 10μ-26μ, diameter of archeopyle 38μ-52μ.

Remarks:—The present occurrence of *Areoligera senonensis* from the Fujwara Group is the first report from the Miocene sediments.

Specimen slides:—KM-3153 (6.7/1.9) and KM-5333 (2.0/9.3).

Cyst-Family Cannosphaeropsitaceae SARJEANT & DOWNIE, 1966

Genus *Cannosphaeropsis* O. WETZEL, 1933 emend. WILLIAMS & DOWNIE, 1966

Cannosphaeropsis sp.

Pl. 45, figs. 10, 11.

Description:—The present specimens of *Cannosphaeropsis* have a ellipsoidal central body with thin smooth surface. Processes are gonal and intergonal with smooth stalk, and have solid and furcate ends connecting distally. The diameter of these processes is larger than that of the ornamental network. Its tabulation is not determinable but an archeopyle is a precingular type. The cingular region is indicated by a parallel arrangement of gonal and intergonal processes.

Dimensions:—Diameter of central body 22μ-33μ, length of processes 14μ-22μ.

Remarks:—The present specimens are similar to *Cannosphaeropsis reticulensis* described by WILLIAMS and DOWNIE (in DAVEY *et al.*, 1966) in the shape of the central body, but differ from it in the nature of distal parts, the number, and arrangement of processes.

Specimen slides:—KM-1132 (1.4/5.1) and KM-(4.6/15.6)

Cyst-Family Incertae Sedis

Genus *Schematophora* DEFLANDRE & COOKSON, 1955

Schematophora sp. cf. *S. speciosa* DEFLANDRE & COOKSON, 1955

Pl. 46, fig. 3.

Cf. 1955. *Schematophora speciosa* DEFLANDRE & COOKSON; *Aust. J. Mar. Freshw. Res.*, vol. 6, no. 2, p. 262-263, pl. 6, figs. 11-13.

Description:—The present specimens have a hemispherical central body with fine reticulate surface, and six precingular, four or five cingular, five postcingular, one posterior intercalary and one antapical annular, soliate or linear complex processes. Its archeopyle is a large apical type with a free operculum, so that the number of apical plate is uncounted. Conceivable tabulation except for the apical region is 6″, 4-5 g, 5‴, 1p and 1⁗. Plates 1″ and 6″ are annular complex processes but the other precingular plates are mostly soliate complex processes. Most of these complex processes connect with two adjacent tips and become circular or incomplete circular in optical section. Furthermore, plate 6″ is smaller than the other precingular plates. The cingular region posesses four or five linear complex processes on dorsal side. The hypotract has five annular complex post-

cingular, one annular complex posterior intercalary, and one large annular complex antapical processes. The one small posterior intercalary process occupies a position between plates 1‴ and 5‴. The annular complex antapical process is the largest of all processes. The sulcal notch is observed between plates 1″ and 6″ on dorsal side. Around the zigzag margin of its apical archeopyle, there are a few accessory archeopyle sutures.

Dimensions:—Diameter of central body ca. 50μ, length of complex processes 4μ-8μ, diameter of archeopyle ca. 34μ.

Remarks:—Only two specimens were obtained from the Fujiwara Group. These specimens differ from *Areoligera senonensis* in the nature of those complex processes. The present specimens of *Schematophora* have charactristically annular or soliate complex processes connecting with two adjacent tips.

Specimen slide:—KM-3145 (6.9/10.6).

Genus *Lingulodinium* WALL, 1967

Lingulodinium machaerophorum (DEFLANDRE & COOKSON, 1955) emend. WALL, 1967

Pl. 46, figs. 5, 6.

1955. *Hystrichosphaeridium machaerophorum* DEFLANDRE & COOKSON; *Aust. J. Mar. Freshw. Res.*, vol. 6, no. 2, p. 274, pl. 9, figs. 4, 8.

1959. *Hystrichosphaeridium machaerophorum* DEFL. & COOK., MAIER; *N. Jb. Geol. Paläont.*, Abh., vol. 107, no. 3, p. 315, pl. 31, fig. 8.

1962. *Hystrichosphaeridium ashdonense* ROSSIGNOL; *Pollen et Spores*, vol. 4, no. 1, p. 132, pl. 2, fig. 2.

1967. *Lingulodinium machaerophorum* (DEFL. & COOK.) emend. WALL; *Palaeontology*, vol. 10, pt. 1, p. 109, pl. 15, figs. 16, 17, text-fig. 6.

Description:—The present specimens have a spherical central body with moderate thick wall and microgranular surface. Processes are mostly curved and acuminate distally. The bases of processes are nearly circular in optical section. These specimens have a characteristic compound precingular archeopyle with the compound operculum which appears to be corresponded to plate 2″-5″.

Dimensions:—Diameter of central body 54μ-58μ, length of processes 12μ-18μ, diameter of processes in optical section ca. 2μ.

Remarks:—The present species is very similar to *Cleistosphaeridium* ? *flexuosum* described by DAVEY *et al.*, (1966) in the nature of the processes and the size of the central body. The archeopyle, however, is an apical type in *Cleistosphaeridium* ? *flexuosum*, while *Lingulodinium machaerophorum* (DEFLANDRE & COOKSON) has a large compound precingular archeopyle. According to DAVEY *et al.* (1966), this species is belonged to the genus *Cleistosphaeridium*. But *Lingulodinium machaerophorum* (DEFLANDRE & COOKSON) is differentiated from the genus *Cleistosphaeridium* based on having a compound precingular archeopyle.

Furthermore, this species has been regarded as a cyst stage of living motile and thecate species, *Gonyaulax polyedra*, by EVITT and DAVIDSON (1964) and WALL (1967). Recently, this interpretation is proved by an experiment of a single cell incubation carried out by WALL and DALE (1968).

The oldest occurrence of this species is known from the Miocene sediments in Australia (DEFLANDRE & COOKSON, 1955).

Specimen slides:—KM-5031 (2.9/0.6) and KM-5332 (10.5/5.2).

Genus *Operculodinium* WALL, 1967

Operculodinium centrocarpum (DEFLANDRE & COOKSON, 1955) emend WALL, 1967

Pl. 45, fig. 9.

1955. *Hystrichosphaeridium centrocarpum* DEFLANDRE & COOKSON; *Aust. J. Mar. Freshw. Res.*, vol. 6, no. 2, p. 272-273, pl. 8, figs. 3, 4.
1959. *Hystrichosphaeridium centrocarpum* DEFL. & COOK., MAIER; *N. Jb. Geol. Paläont.*, Abh., vol. 107, no. 3, p. 314, pl. 25, fig. 9.
1961. *Baltisphaeridium centrocarpum* (DEFL. & COOK.), GERLACH; *N. Jb. Geol. Paläont.*, Abh., vol. 112, no. 2, p. 193, pl. 28, fig. 9.
1963. *Baltisphaeridium centrocarpum* (DEFL. & COOK.), BROSIUS; *Z. dts. geol. Ges.*, vol. 114, p. 44, pl. 6, fig. 6, text-fig. 8a, b.
1967. *Operculodnium centrocarpum* (DEFL. & COOK.) emend. WALL; *Palaeontology*, vol. 10, pt. 1, p. 111, pl. 16, figs. 1, 2, 5.

Description:—The present specimens have a spherical central body with granular surface. The thickness of the wall is about 3μ. Processes are often strongly curved and distally pin's head-shaped. The tips of these processes are usually bifid or sometimes acuminate. The bases of processes are conical and fine striations are observed. Its archeopyle is formed on dorsal side by loss of the precingular plate corresponded to plate 3″, and is subtrapezoid to triangular in shape. Arrangement of spinous processes is intratabular, so the number of them is uncountable.

Dimensions:—Diameter of central body 40μ-52μ, length of processes 8μ-12μ, diameter of archeopyle in figured specimen 20μ×24μ.

Remarks:—The occurrence of *Operculodinium centrocarpum* (DEFLANDRE & COOKSON) has been reported from the Oligocene in Germany (GERLACH, 1961 and BROSIUS, 1963), the Miocene in Australia (DEFLANDRE & COOKSON, 1955) and the Pleistocene deep sea cores from the Caribbean Sea (WALL, 1967) and the Recent (WALL & DALE, 1968). WALL (1967) stated that *Operculodinium centrocarpum* (DEFLANDRE & COOKSON) is classified into two types based on the diameter of the central body. According to him, the larger one is 70μ-90μ, and the smaller one 40μ-50μ. In the

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Explanation of Plate 44

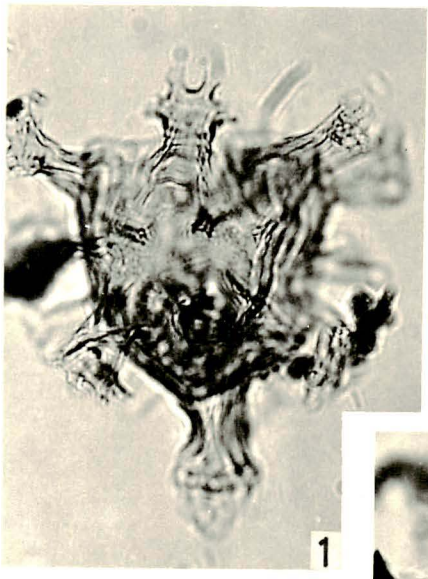
Fig. 1. *Hystrichokolpoma rigaudae* DEFLANDRE & COOKSON. × ca. 650, slide no. KM-023 (18.1/3.9), dorsal view.

Fig. 2. *Hystrichokolpoma elliptica* n. sp. × ca. 650: Holotype, slide no. KM-022 (18.6/7.2), a; optical section, showing the archeopyle with several archeopyle sutures. b; ventral view, showing the sulcal region.

Figs. 3-5. *Hystrichokolpoma denticulata* n. sp. × ca. 650. 3. Holotype; slide no. KM-045 (13.8/1.5), a; dorsal view, b; ventral view. 4. Paratype; slide no. KM-023 (13.0/4.9), a; oblique dorsal view, b; optical section. 5. Paratype; slide no. KM-045 (3.1/13.9), oblique antapical view.

Fig. 6. *Diphyes latiusculus* n. sp. × ca. 650; Holotype; slide no. KM-1162 (16.3/8.4), a; optical section, b; surface view.

Fig. 7. *Diphyes colligerum* (DEFLANDRE & COOKSON) DAVEY & WILLIAMS. × ca. 650, slide no. KM-021 (22.2/4.6), showing the large apical archeopyle.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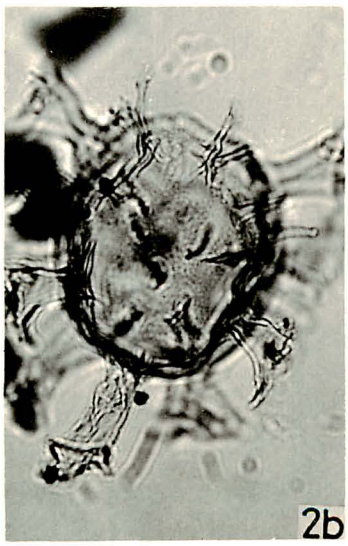
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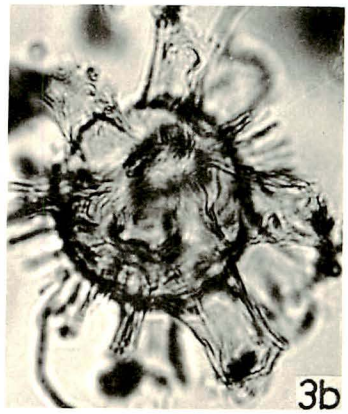
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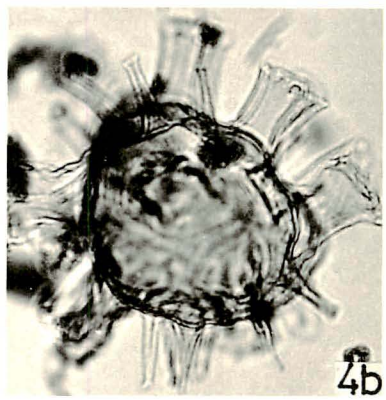
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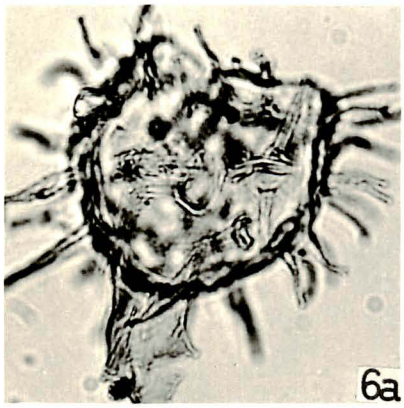
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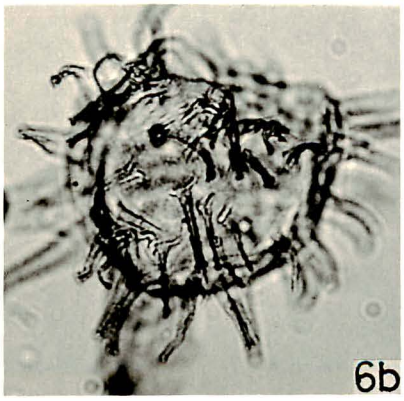
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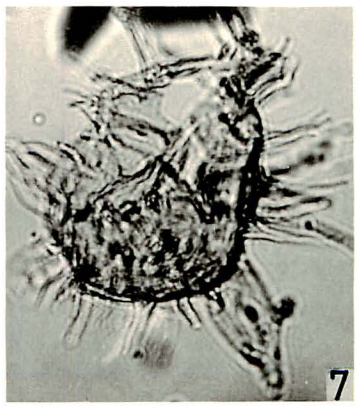
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stratigraphical distribution, the larger one is obtained mainly from Oligocene to Miocene, while the smaller one is mostly observed in Pleistocene to Recent sediments.

This species is said to be a cyst stage of living, motile and thecate species *Protoceratium reticulatum* (WALL & DALE, 1968).

Specimen slide:—KM-045 (18.3/2.9).

Genus *Tectatodinium* WALL, 1967

Tectatodinium sp.

Pl. 45, fig. 8.

Description:—The present specimens of *Tectatodinium* are characterized by a spherical central body ornamented with numerous very short spines. Its archeopyle is a precingular type and trapezoid in shape. These specimens have no distinctive features of the dinoflagellate cyst with exception of its precingular archeopyle. Therefore, its tabulation is not determinable.

Dimensions:—Diameter of central body 28μ-33μ, length of short spines ca. 1μ, diameter of archeopyle 8μ-15μ.

Remarks:—No characters of the dinoflagellate cyst except for the archeopyle are observed in the both genera *Chytroeisphaeridia* and *Tectatodinium*. The genus *Chytroeisphaeridia* has an apical archeopyle according to its generic description by NORRIS and SARJEANT (1965). The genus *Tectatodinium* differs from the genus *Chytroeisphaeridia* in having a precingular archeopyle.

Specimen slide:—KM-1221 (3.2/11.2).

Class Incertae Sedis

Group Acritarcha EVITT, 1963

Subgroup Herkomorphitae DOWNIE, EVITT & SARJEANT, 1963

Genus *Cymatiosphaera* O. WETZEL, 1933 emend. DEFLANDRE, 1954

Cymatiosphaera sp.

Pl. 46, fig. 7.

Description:—The present specimens have a strongly ellipsoidal shell with microgranular surface divided into many polygonal fields. The boundaries of these polygonal fields are formed from well developed crests of thin microgranular membrane. The number of polygonal fields is about twenty.

Dimensions:—Shell diameter 47$\mu\times$22μ, height of crests ca. 5μ, diameter of the largest polygonal field 13$\mu\times$12μ.

Remarks:—Only two specimens were obtained from the Fujiwara Group. These specimens differ from two Japanese Oligocene species, which are *Cymatiosphaera globulosa* and *C. reticulosa* described by TAKAHASHI (1964) from the Asagai Formation, in shell diameter, shell shape and the number of polygonal fields.

Specimen slide:—KM-042 (15.5/6.7).

The other plant microfossils

Besides these species described above belonging to dinoflagellates and acritarchs, several plant microfossils occurred from the Fujiwara Group. Obtained species are *Leiosphaeridia* spp., *Pediastrum* sp. cf. *P. boryanum* (TURPIN) and Tasmanaceae.

Leiosphaeridia spp. belonging to Acritarcha were found from the Toyoda Formation in Fujiwara-cho and the Iwabuchi Formation exposed in Rokuyaoncho of Nara City.

The genus *Pediastrum* is a delicate

freshwater green algae. The Toyoda Formation occurring *Pediastrum* sp. cf. *P. boryanum* (TURPIN) is marine sediments. Hitherto, several reports, however, have been dealt with occurrence of Pediastrum from marine sediments (EVITT, 1963, STANLEY, 1965, SHIMAKURA 1970 and MATSUOKA, 1971).

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Explanation of Plate 45

Figs. 1, 2. *Spiniferites* sp. aff. *S. buccinus* (DAVEY & WILLIAMS) × ca. 470.
1. Slide no. KM-5123 (9.0/12.6), ventral view; showing the precingular archeopyle. 2. Slide no. KM-5124 (23.3/0.7), ventral view.

Fig. 3. *Spiniferites mirabilis* (ROSSIGNOL) × ca. 760, slide no. KM-5033 (18.1/4.8), oblique ventral view.

Fig. 4. *Spiniferites ramosus* (EHRENBERG) MANTELL × ca. 650, slide no. KM-5124 (4.3/4.3), antapical view.

Fig. 5. *Hystrichosphaeridium* ? sp. × ca. 760, slide no. KM-1233 (14.0/9.8), showing the large apical archeopyle with several archeopyle sutures.

Fig. 6. *Achomosphaera* sp. × ca. 760, slide no. KM-1163 (3.3/5.3), ventral view (?).

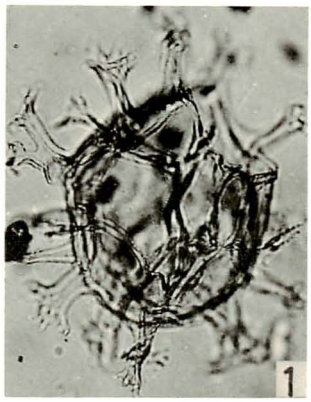
Fig. 7. *Spiniferites* sp. a × ca. 470, slide no. KM-5043 (3.6/4.2), ventral view (?).

Fig. 8. *Tectatodinium* sp. × ca. 500, slide no. KM-1221 (3.2/11.2), showing the precingular archeopyle.

Fig. 9. *Operculodinium centrocarpum* (DEFLANDRE & COOKSON) WALL × ca. 650, slide no. KM-045 (18.3/2.9), showing the trapezoid precingular archeopyle.

Figs. 10, 11. *Cannosphaeropsis* sp. × ca. 650.
10. Slide no. KM-1132 (1.4/5.1), free operculum corresponded with parts of apical and precingular plates (?). 11. Slide no. KM-1114 (4.6/15.6), optical section.

Fig. 12. *Cordosphaeridium* sp. cf. *C. uncinispinosum* DE CONINK × ca. 650, slide no. KM-5032 (1.3/6.1), showing the apical archeopyle within the central body.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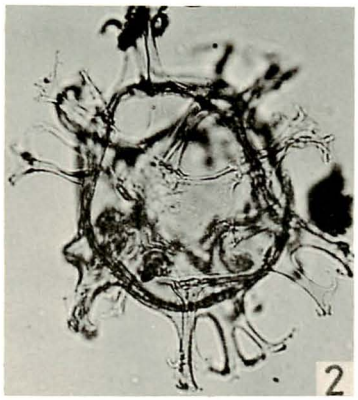
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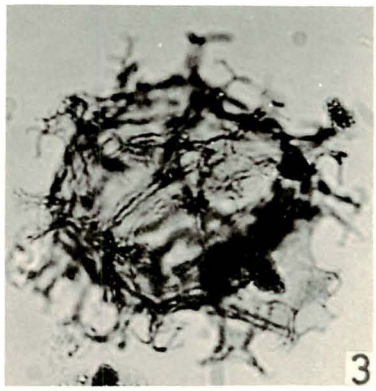
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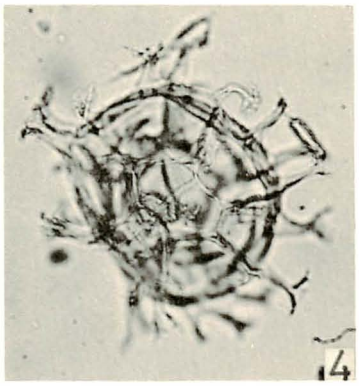
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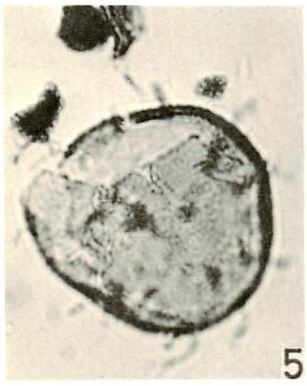
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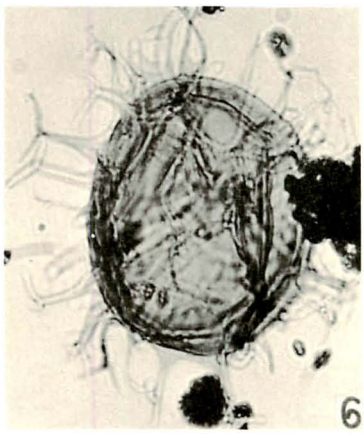
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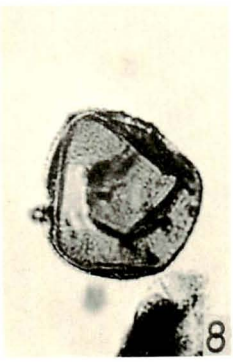
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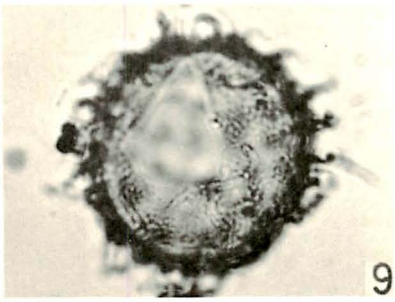
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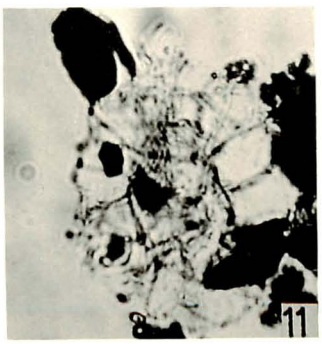
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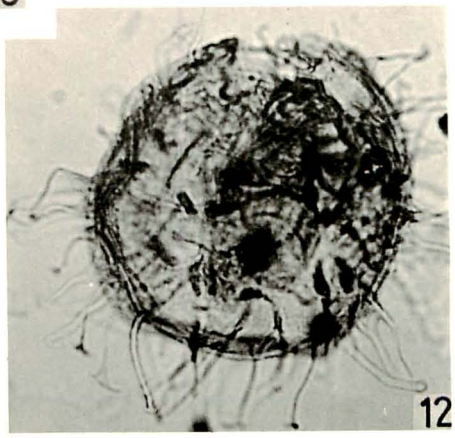
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Fujiwara	藤原	Osaka	大阪
Hachibuse	鉢伏	Rokuyaon	鹿野園
Higashiyama	東山	Ryoke	領家
Iwabuchi	岩淵	Sekibutsu	石仏
Jigokudani	地獄谷	Shirakawa-ike	白川池
Kinki	近畿	Tenri	天理
Kokuzoyama	虚空蔵山	Toyoda	豊田
Nakanokawa	中ノ川	Yadahara	矢田原
Nara	奈良	Yamato	大和
Obitoke	帯解	Yanagichaya	柳茶屋
Onigatsuji	鬼ケ辻		

Explanation of Plate 46

Figs. 1, 2. *Areoligera senonensis* LEJEUNE-CARPENTIER × ca. 700
1. Slide no. KM-3153 (6.7/1.9), a; oblique apical-ventral view; showing the large apical archeopyle with several archeopyle sutures, b; oblique antapical-dorsal view. 2. Slide no. KM-5333 (2.0/9.3), oblique apical view.

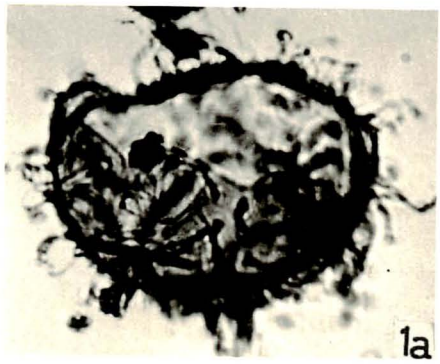
Fig. 3. *Schematophora* sp. cf. *S. speciosa* DEFLANDRE & COOKSON × ca. 700, slide no. KM-3145 (6.9/10.6), a; dorsal view, b; ventral view.

Figs. 4, 9, 10. *Tanyosphaeridium fusiform* n. sp. × ca. 1000
4. Holotype; slide no. KM-045 (5.0/17.7), showing the apical archeopyle. 9. Paratype, slide no. KM-045 (23.1/1.0). 10. Paratype, slide no. KM-023 (10.3/3.5).

Figs. 5, 6. *Lingulodinium machaerophorum* (DEFLANDRE & COOKSON) WALL × ca. 700.
5. Slide no. KM-5031 (2.9/0.6), free operculum (?). 6. Slide no. KM-5332 (10.5/5.2), dorsal view, showing the compound precingular archeopyle corresponded with plates 2″ to 5″.

Fig. 7. *Cymatiosphaera* sp. × ca. 760, slide no. KM-042 (15.5/6.7).

Fig. 8. *Gonyaulacysta* sp. a × ca. 760, slide no. KM-1234 (20.7/2.4); showing the precingular archeopyle; dorso-ventral view.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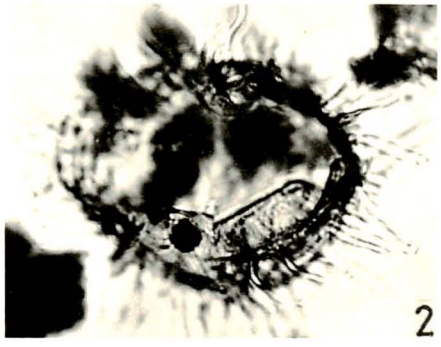
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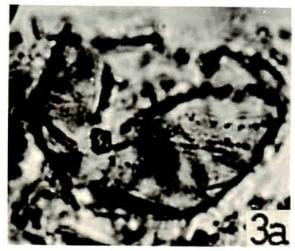
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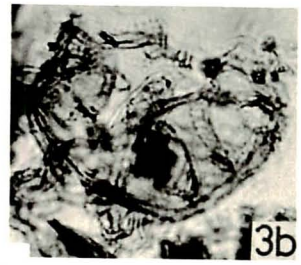
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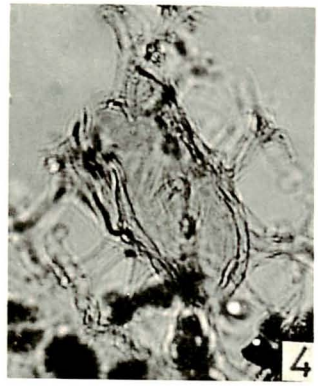
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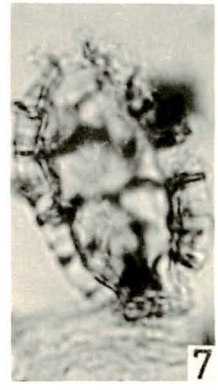
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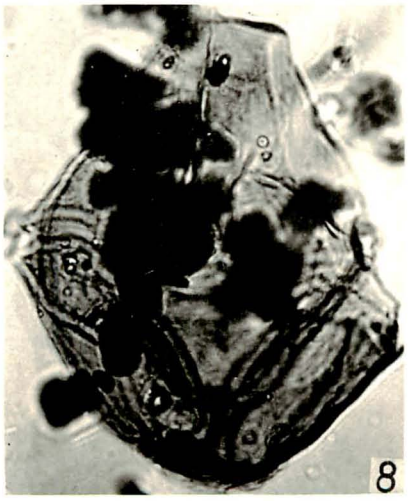
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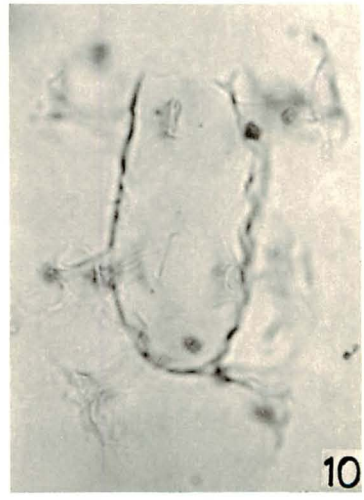
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例会等の通知

	開催地	開催日	講演申込締切日
114回例会	名古屋大学	1974年10月19-20日	1974年8月20日
1975年 総会・年会	国立科学博物館	1975年1月25-26日	1974年11月10日

◎ 114回例会では，20日に瑞浪地方巡検（ガイド・森下　晶）が予定されている。

◎ 1975年総会・年会には，シンポジウム「走査型電子顕微鏡と古生物学」（世話人・岩崎泰頴）が予定されている。

お知らせ

◎ 地球化学研究協会三宅賞受賞候補者の推薦依頼が，地球化学研究協会理事長から本会会長宛につきました。本会の推薦を希望される方は8月20日迄に賞の委員会宛お申出下さい。自薦・他薦を問いません。

この賞は地球化学の研究に顕著な業績をあげた研究者に年1件あて贈られ，賞状のほか賞牌，賞金（30万円）を含みます。なお第1回（1973年度）は名古屋大学教授北野康博士（炭酸塩堆積物の化学的研究）が受賞しました。　（賞の委員会）

◎ 科学研究費配分に関する公聴会が9月16日（月曜日）午後1時30分から東京教育大学で開かれます。

◎ 本会誌の出版費の一部は文部省研究成果刊行費による。

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