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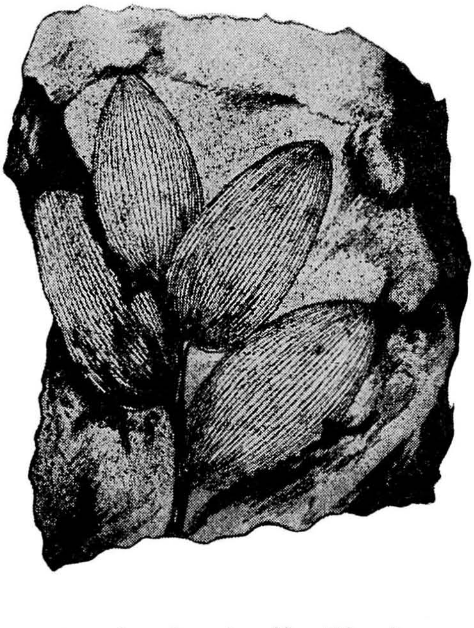

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Palaeontological Society of Japan
April 30, 1978

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The fossil on the cover: Original figure of *Podozamites Reinii* GEYLER, 1877, from the Tetori group. GEYLER's description marked the onset of modern palaeontology in Japan.

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684. *DISCOACTINOCERAS* AND THE DISCOACTINOCERATIDAE, FAM. NOV.*

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Abstract. *Discoactinoceras* used to be placed in either the Huroniidae or the Polydesmiidae is quite distinct from them in the growth of intrasiphuncular stereoplasmic deposits from the actinoceroid to endoceroid type. Because its septal neck is of *Armenoceras* type, it must be a derivative from the common stock with the Armenoceratidae. In longitudinal section the septum looks sigmoidal by an adoral and adapical bent respectively near the conch and septal neck. From these distinctions a new family, Discoactinoceratidae, is proposed for the genus. Here, not only *Discoactinoceras multiplexum*, the type-species of this genus, but also *D.* cf. *multiplexum* and *D. okdongense*, nov. from South Korea are described in detail.

Discoactinoceras known from South Manchuria and North Korea is an interesting genus having shoulderedn nummuli like the Huroniidae, but its siphuncular structure is very complicated. Because the description of its type-species and generic diagnosis written almost fifty years ago is inadequate, they are here redescribed. *Discoactinoceras multiplexum* was monotypic. Five specimens contained in SHIRAKI collection from South Korea represent two forms of this genus for one of which a new name is proposed.

Discoactinoceras has been placed in the Huroniidae or the Polydesmiidae, but either one of them is unable to have it in its domain principally because of the possession of double structural elements of the siphuncle. The family Georginidae recently proposed by WADE from Australia also have double elements in its siphuncle, but these elements are essentially different from those of *Discoactinoceras*. Therefore a new family, Discoactinoceratidae, is here established.

Judging from the siphuncular structure this family indicates an aberrant branch issued from the common stock with the Armenoceratidae in the middle Toufangian or middle Mohawkian age by parallel specialization to the Endoceratida by the benthonic adaptation in the grown stage.

Family Discoactinoceratidae, fam. nov.

Diagnosis:—Actinoceroid with a large marginal siphuncle whose deposits consist of outer annuli and inner tubular or conical sheathes; septa geniculated in proximal and distal parts; septal neck armenoceroid.

Remarks: — Since FOERSTE and TEICHERT's reference (1930) *Discoactinoceras* has long been allocated in the Huroniidae, but as detailed below, it is sufficiently distinguishable from that family. This genus must have been evolved from an

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* Received June 16, 1977 ; read Oct. 16, 1977 at Kumamoto.

unknown common stock with the Armenoceratidae, but the high specialization requires its isolation from that family. Judging from its complexity of the septa and siphuncle it is quite improbable that it is ancestral to the late Ordovician-Silurian Huroniidae. Its siphunucular structure is incomparable with the radially disposed longitudinal lamellae or endosiphuncular blades by TEICHERT and CRICK (1974) in *Huroniella servenense* (FOERSTE and SAVAGE, 1927).

This genus was once located in the Polydesmiidae by CHAO et al. (1965), but as I have already detailed that family in 1940 and 1977, *Discoactinoceras* has inner tubular sheathes on one side and its annuli do not grow in horn-shape as in that family on the other.

In the Georginidae tubular deposits called endocones by WADE (1977) sometimes appear in the central cavity of *Georgina* and well developed in the cavity of *Mesaktoceras* like in *Discoactinoceras.* In the radially lamellate structure of the nummulus and particularly in the so-called engraft by WADE, however, that family is quite distinctive.

Thus, *Discoactinoceras* is isolated from the Huroniidae, Polydesmiidae, Georginidae, or else in the Actino ceratida in its double structure in the inner and outer parts of the siphuncle so far that a new family should be instituted for it.

Distribution:—Middle Ordovician ; Eastern Asia.

Genus *Discoactinoceras* KOBAYASHI, 1929

Diagnosis: — Orthoconic actinoceroid with large marginal siphuncle; septa geniculated near siphuncle and shell wall; septal neck armenoceroid ; siphuncular segment very wide, shouldered near septal neck ; siphuncular deposits beginning with annuli, but becoming later tubular or conical sheathes; central cavity broad primarily, but later narrowing and becoming tubular; radial canals branching off from central cavity or tube and extending laterally through sheathes ; stereoplasmic deposits undeveloped in camerae. Surface of conch, apical end and body chamber unknown.

Type-species: — *Discoactinoceras multiplexum* KOBAYASHI, 1929.

Remarks:—In the large siphuncle with shouldered nummuli and septal geniculation this genus resembles *Huroniella.* It, however, differs essentially from *Huronia* and *Huroniella* in the marginal position of the siphuncle in this genus. The siphuncular deposits are unusually complicated in this family. The genus was allocated in the Polydesmiidae (CHAO et al., 1965), but the siphunclar structure of that family is quite different from that of this family.

The septa of this genus is more or less sigmoidal, although its middle main part is nearly straight. The sigmoidal septa may be comparable to those of *Gonioceras,* but it is no more than a parallelism in the trend of specialization, because *Gonioceras* is quite different in most other characteristics.

Recently CHEN and LIU (1976) described two new species of *Discoactinoceras, platyventrum* and *wuyangshanense,* from the middle part of their Machiakou suite in Shantung. The latter species appears to resemble *D. okdongense,* while the former is quite distinct from *Discoactinoceras* in the *Actinoceras*-type septal neck and especially in the structure in the inner part of the siphuncle.

Distribution:—Toufangian and its correlatives in Korea, North China and Southern Northeast China.

Recently CHEN and LIU (1976) distinguished the *Discoactinoceras-Lophospira* *yentaiensis* zone in the middle part of their Machiakou suite in North China and Northeast China and considered Llanvirnian. Because their Machiakou suite easily confuses the traditional Machiakou limestone, a few words are added here.

Ordovician rocks in North China were first classified in about 1921 into the Yehli formation, Liangchiashan limestone and Machiakou limestone in ascending order, and the Machaikou fauna was correlated with the Black River or Mohawkian of North American by GRABAU (1922). This tripartition has long been in current use in China, but the Machiakou limestone was subdivided into two parts. The lower and upper Machiakou limestone were correlated respectively to the Dawan formation and the Neichiashan series of Central and South China where the series was subdivided into the Kuniutan limestone, Miaopa shale and Pagoda limestone in ascending order (CHANG, 1964). According to LU (1975) the Dawan formation is Llanvirnian plus the *Azygograptus suecicus* zone and the Neichiashan series Llandeilian-middle Caradocian (*Sinoceras sinense* zone) in age.

According to CHEN (1976) the post-Liangchiashan rocks of North China, namely the traditional Machiakou limestone, is classifiable into four suites, restricting the Machiakou suite to a part of the limestone and they are correlated to the North American sequence as below.

Suite	Cephalopod zone	North American correlative
Patou	*Gonioceras badonense*	Mohawkian
Kechuang	None	
Machiakou	*Tofangoceras pauciannulatum* *Stereoplasmoceras pseudoseptum*	Chazyan
Peianchuang	*Ordosoceras quasilineatum* *Polydesmia zuezshanensis*	Whiterock

Subsequently, however, the *Discoactinoceras-Lophospira yentaiensis* zone was added at the middle part of the Machiakou suite (LU et al., 1976). Then, what bears *Lophospira yentaiensis* on the zonation is a question. *Lophospira yentaiensis* ENDO is a member of the Kangyao fauna which ENDO (1932) correlated to the early Chazyan or Mosheim fauna of eastern North America. The Mosheim limestone, Alabama is lower Chazyan, but the Stones River group in Tennessee and Kentucky is Black River in age (TWENHOFEL et al., 1954). Therefore, neither *Lophospira yentaiensis* nor abundant *Lophospira* suggests merely Chazyan for the Kangyao correlative. Incidentally, lower Chazyan or Whiterock of today is approximate to Llanvirnian, while Black River is early Caradocian or thereabout in the British sequence.

ENDO (1953) rectified the position of the Kangyao formation as the subjacent unit to the Ssuyen formation, eliminating the Wuting formation from the intercalation between the two other formations and allocating it beneath the Kangyao. This means that the *yentaiensis* horizon is higher than thought before. Likewise, it is probable for the Machiakou suite to extend up into the early Mohawkian or Blackriverian in view of the fact on the hiatus of any fossil in Kechuang suite.

According to CHEN (1976) *Discoactinoceras* occurs in the lower and middle parts of the Machiakou suite but not in the upper part which contains, however, *Armenoceras manchurense,* an associate with *Discoactinoceras multiplexum* in North Korea.

As the result of the above discussion it is concluded that *Discoactinoceras* as a genus ranges through the Machiakou suite whose range is post-Whiterock but probably pre-Trentonian.

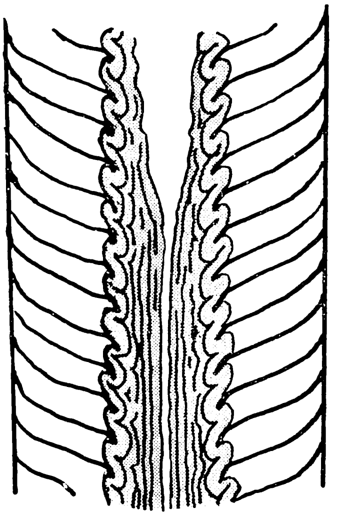
Discoactinoceras multiplexum KOBAYASHI, 1929

Plate 31, Figures 1-5, Text-figures 1-2

1929. *Discoactinoceras multiplexum* KOBAYASHI, *Japan. Jour. Geol. Geogr.*, Vol, 5, no. 4, p. 202, pl. 22, figs. a-d.

1931. *Discoactinoceras multiplexum* KOBAYASHI, *Bull. Geol. Surv. Chosen* (*Korea*), Vol. 11. no. 1, p. 56, pl. 4, figs. la-b.

Description: — Conch large, straight, very slowly tapering, subcircular in cross section. Siphuncle almost circular in cross section, nearly as large as a half of conch's diameter, located marginally or ventrally, distinctly nummuloidal with broad central cavity but becoming narrow, longiconic or tubular where it is surrounded by sheathes. Siphuncular segment distinctly shouldered, but not annulated at the top as often seen in huronioids.



Text-figure 1. Pharagmocone of *Discoactinoceras multiplexum.*

In longitudinal section septa more or less sigmoidal, suddenly bent forward near shell wall and then adnate with shell on distal side, but on the other side they are abruptly bent in- and backward, then sharply recumbent and inserted between nummuli; main part of septum between these two bents long, nearly straight or very slightly convex backward. Connecting ring strongly convex on adoral side and broadly rounded on the other side. Annuli in early stage composed of some concentric layers, but becoming roundly quadrate and separated from neighbouring neck rings by radial canals; subsequent layers less convex and connected with neighbouring ones; at length they become conical or tubular sheathes where, however, they are penetrated by radial canals at places.

Endosiphuncle long, conical in adoral part, but narrow and tubular on the other side. Radial canals extending from it laterally with weak convexity on adapical side and terminating near median part of connecting ring. Septal suture apparently ascending ventrally. Camerae free from stereoplasmic deposit. Surface of conch, apical end and body chamber unknown.

Observation:—In cross section of the holotype specimen it is seen that the siphuncle is in direct contact with the outer shell. Judging from the sinuate septal sutures on the siphuncle exposed on the limestone slab, the sutures are ascending toward the venter.

In the longitudinal section of the specimen the boundary sheath between the outer semicircular and inner tubular layers is particularly well defined. The more inner sheathes are recrystallized, but radial canals penetrate the recrystallized part at some places. In cross section of the siphuncle the boundary sheath is circular but the circle takes zigzag course and radial canals penetrate projections.

In the Cho'san specimen the boundary sheath is clearly defined in the whole length of the siphuncle, but the more inner sheathes are ill-preserved.

Because the septa are thin and the camerae free from stereoplasmic deposits, the camerate part was largely destroyed and the siphuncle exposed. As the result the outer surface of the nummulus was eroded in these specimens in different degrees.

Comparison:—Without seeing the type specimen of this species SHIMIZU and OBATA (1935) expressed their opinion that this species is identical with *Armenoceras submarginale* (GRABAU) in pl. VIII, figs. 5a-b, pl. XI, fig. 3, GRABAU, 1922, but the two species are quite different in all essential characteristics of marginal siphuncular position, septal geniculation, shouldered nummuli and the most complicate siphuncular structure of this species.

Occurrence: — The holotype specimen was collected by K. MITSUISHI from dark gray banded limestone near Chiushukou in the Niuhsintai basin, Liaoning, Northeast China in association with *Ormoceras* (*Paraarmenoceras* ?) *tani* (GRABAU) and *Ormoceras* (?) *submarginale* (KOBAYASHI). The second specimen was procured by Chong-weon KIM from gray spotted limestone at the northern cliff of Changpyong-dong, Nam-myeon, Ch'osan, P'yeongan-bukto, North Korea together with *Armenoceras manchurense* (KOBAYASHI), *Ormoceras* (*Paraarmenoceras* ?) *tani* (GRABAU), *Ormoceras nanum* (GRABAU) and *Stereoplasmoceras* ? *submarginale* (KOBAYASHI). Judging from the cephalopod association the *multiplexum* horizons at the two localities are considered coeval with each other. They are certainly within the Toufangkou limestone.

In the vicinities of P'yongyang, North Korea the Toufangian series consists of four units of strata in descending order as follows:

4. Nanso or Namjang formation, barren of fossils.
3. Unkaku or Unhak formation containing a copious fauna including *Labechia, Lophospira, Ormoceras* and *Armenoceras,* etc.
2. Bantatsusan or Mandalsan formation containing *Stereoplasmoceras* and *Ormoceras* rarely.
1. Maruyama or Hwansan formation yielding *Polydesmia* and cameroceroid.

On the basis of the present knowledge the Toufangian series in North Korea, South Manchuria and North China is tentatively correlated as shown in Table 1.

As discussed already (KOBAYASHI, 1977), the Maruyama, Leichuang and Peianchuang faunas all characterized by *Polydesmia* are approximately coeval with the Whiterock of North America. The Wuting fauna exclusive of Canadian fossils would be about the same age, although neither *Polydesmia* nor *Ordosoceras* is contained in it.

The Machiakou limestone was primarily named for the post-Liangchiashan limestone, although the superposition of the Machiakou on the Lianchiashan limestone was actually indeterminable, because the former in the Kaiping basin and the latter in the Liukiang coal-field were separate exposures in eastern Hopei (formerly

Table 1.

North Korea KOBAYASHI, 1966b	South Manchuria		North China		
	KOBAYASHI, 1966a	ENDO, 1953	OBATA, 1965	CHEN, 1976	
Nanso	Tapu	Ssuyen	Hsiaofankechuang	Patou	
Unkaku	Toufangkou		Tangshan	upper	Machiakou
		Kangyao	Lincheng	middle	
Bantatsusan			Wushan	lower	
Maruyama	Unnamed	Wuting	Leichuang	Peianchuang	

Chihli). The Machiakou fauna described by GRABAU, however, can safely be correlated to the Toufangkou and Unkaku faunas. Fossils are, however, uncommon in the Bantatsusan formation and apparently absent in the Nanso formation. Similarly, the Tapu formation is almost barren of fossils, although *Stereoplasmoceras* was later reported from the Hsiaofankechuang stage and *Gonioceras* described from the Patou suite recently.

ENDO proposed the Ssuyen formation for the *Armenoceras* rich upper part and the Kangyao for the *Lophospira* rich lower part. *Armenoceras, Lophospira* and other Middle Ordovician fossils are found coexistent in the Toufangkou and Machiakou limestones. OBATA distinguished three stages in this fossiliferous limestone and Chen also made its tripartition. *Armenoceras, Stereoplasmoceras* and *Tofangoceras* are common and persistent genera all through these stages or parts. *Armenoceras coulingi* and *A. resseri,* for example, belong to the lower division by CHEN but to the Lincheng stage by OBATA. Thus the reference of these species disagrees between them.

Ormoceras tani is referred to the lower Machiakou fauna as well as the Wushan fauna in association with *Discoactinoceras multiplexum* in the former. Therefore the *multiplexum* horizon may be located in the lower part of the Machiakou suite. *Ormoceras nudum* and *Armenoceras manchurense,* on the contrary, are considered a Tangshan member by OBATA and a late Machiakou member by CHEN respectively. Although it requires a further investigation to solve the question, it is also probable that the horizon in question lies in the lower Unkaku or the Lincheng stage, if considered the rarity of fossils in the Bantatsusan formation and its equivalents in Koreo-Manchuria.

Discoactinoceras cf. *multiplexum* KOBAYASHI, 1929

Plate 32, Figures 1, 2

Tanggok specimen 9 cm long was cut into three pieces to see its cross section. In the middle 62.5 mm 5 nummuli are countable in longitudinal section in the length of 23 to 24 mm. The siphuncle is there 19 to 21 mm broad at nummulus and 16 to 18 mm broad at septal necks. The septal geniculation and recumbence at the neck are seen clearly near the constriction. The nummulus is distinctly protruded antero-laterally. In the adoral part annuli are only partly lined back by tubular sheathes, while tubular and long conical sheathes are developed on the other part. In the middle part it is seen that radial canals are closed by a few sheathes. The apical angle of the endosiphocone or conical central cavity is about 10 degrees. The central cavity is half as wide as the siphuncle where it is wide open on the adoral side. In cross section the annulus is penetrated by radial canals at a place on the adoral side. In the section of the adapical part sheathes are irregular in outline, but the central part appears more or less crescentic rather than circular or elliptical.

On the eroded surface of this specimen some septa are seen to be extended from the siphuncle laterally and adorally.

Hwangjiri specimen is an adoral part of a phragmocone, 3.5 cm in length and 2 cm in diameter of siphuncle; nummuli 0.5 cm on an average. In longitudinal section septa are seen near the siphuncle on its two sides. They are distinctly geniculated just before insertion between constrictions. Short septal brim adnates with septa. Not only the outer side but also the inner side of the annuli are somewhat dissolved before fossilization, insofar as can be judged from their irregular outline. Nevertheless it is certain that the central cavity of the siphuncle is broader than a half of the siphuncular diameter. No trace of tubular sheathes is seen on this specimen, for this is the adoral part of the phragmocone.

This form agrees fairly well with *Discoactinoceras multiplexum*, but the less developed sheathes in the broad central cavity and lunate cross section of the cavity suggest that this is probably a distinct species, although its denomination is postponed.

Occurrence: — The two specimens in SHIRAKI collection were procured from (1) Tanggok and (2) North of Sinch'on, Hwangji-ri, both in Sangjang-myeon, Samcheok-gun, Kangweon-to, South Korea, probably either from the Tsuibon limestone or limestone lenses intercalated in the Chikunsan shale.

Discoactinoceras okdongense

KOBAYASHI, sp. nov.

Plate 32, Figures 3-5

This species differs from the precedings chiefly in the subovate cross section of the siphuncle and relatively narrow central cavity. It is represented by three specimens as follows:

The largest specimen from Okdong which is the holotype was a siphuncle 17 cm long, but it was cut into three pieces to see cross sections. Its diameter enlarges from 10 mm at narrow end to 20 mm at the other. Ten nummuli are distributed in 40 mm in the adapical part, but in 46.5 mm in the adoral part. In cross section the siphuncle is subovate and its broad flattened venter is in contact with the shell of the conch. In longitudinal section the septum is inserted between two shouldered nummuli and abruptly recumbent at the end. The tubular deposit is seen to line annuli. The central cavity is no more than one-third the siphuncular diameter.

The recumbent septal neck is clearly seen in the second specimen which was contained in the same slab from Okdong with the preceding. Annuli are not yet lined by tubular sheathes. The central cavity is narrower than a half of the siphuncular diameter at the adapical end, but it is expanded more than a half of the diameter at the other end.

The third specimen from Hyeoleom is a phragmocone 55 mm long; 5 camerae found in the length of 20.5 mm. Its cross section shows that the shell is attached to the siphuncle at the broad more or less flattened venter. The central cavity in the section is broad and lunate with convexity on the dorsal side. On the left side of the longitudinal section one can see narrow camerae near the zone of contact. There the septa are gently inclined for some distance, but abruptly geniculate near septal necks. Annuli are well developed, but no tubular lining is as yet deposited in this siphuncle ; central cavity relatively narrow. Episeptal deposits are present on the ventral side in camerae on the outer and posterior sides, while hyposeptal deposits are confined to the middle part of the anterior side. The camerate portion is preserved also on the right side of the observer which is not polished.

In *Discoactinoceras wuyangense* CHEN and LIU the septal neck is of *Armemoceras* type, the nummulus shouldered and annuli are lined with tubular and conical sheathes as in this species, but in comparison with the thickness of the sheathes the annuli are very broad. The siphuncle is marginal but little mention is given of its cross section.

Occurrence:—The first and second specimens were collected from Chinku-ri, Okdong, Sangdong-myeon, Yongweol-gun, Kangweon-to. The third specimen was obtained from 1.5 km southwest of Hyeoleom, Sangjang-myeon, Samcheok-gun, Kangweon-to, South Korea.

Specialization of *Discoactinoceras*

As the result of the preceding description it is emphasized as the most salient point that the siphuncle of *Discoactinoceras* is composed of a series of annuli in the outer side, but invaginated sheathes in the inner side which are conical like-endocones on the adoral side, but tubular on the adapical side. The endosiphuncle in the central part is a conical cavity which, however gradually merges backward with a narrow central tube or endosiphotube. The siphuncle in the adoral side where sheathes are absent, is essentially an actinoceroid siphuncle. On the other hand the siphuncular structure where the sheathes are developed on the inner side reveals an endoceroid-like siphuncle, although the change from the endosiphocone to the endosiphotube is not so sharp as in the Endoceratida. The sheath-development is an example of parallel specialization to the evolution of the Endoceratida which occurred in the Actinoceratida.

In the Endoceratida the endosiphotube except for the short anterior terminus is closed by diaphragms or endosiphuncular segments in *Nathecoceras crassisiphonatum, Manchuroceras wolungense* and *Penhsioceras* ? sp. (KOBAYASHI, 1935, 1947). In *Cameroceras* cf. *manitobense* the successive lining of the anterior relic portion of the tube through growth yields cone-in-cone structure in its endosiphotube (TEICHERT and CRICK, 1974). In *Discoactinoceras multiplexum,* however, the endosiphocone and endosiphotube are filled up with the same kind of dirt.

In the Endoceratida the camerate portion was scarcely connected with the endosiphuncle where endocones were accumulated sheath after sheath, while in the Actinoceratida any connection could be maintained between the siphuncle and camerae through the connecting rings. In *Discoactinoceras multiplexum* and *D.* cf. *multiplexum* also it is known that radial canals were extended from the central cavity and opened at the perispatium as in other actinoceroids, but sooner or later the canals and annuli were largely lined on their inner side by tubular sheathes which were wavy at first but became straight in longitudinal section. Radial canals penetrated the sheathes at some places, but evidently the control of the camerate portion became difficult for the soft animal through the growth of the sheathes.

In some endoceroids, *Proterocameroceras, Manchuroceras* and *Coreanoceras,* for example, the endosiphuncular blades cross the endocones at definite position. Although their nature and function are not yet well known, they look incomparable with the radial canals of actinoceroids. On the other hand it is interesting to see the lunate cross section of the central tube in *Discoactinoceras* cf. *multiplexum* that it is very much like the crescentic section of the endosiphotube of *Manchuroceras.* Both of them have marginal or submarginal siphuncles whose endosiphuncles are lunate in section with convexity on the dorsal side. Because the development from the actinoceroid siphuncle to endoceroid like siphuncle which occurred in *Discoactinoceras* means the increase of the shell weight and the ventral shifting of the center of gravity and at the same time the devaluation of the air-chamber for its life. Therefore this specialization must have been related to benthonic adaptation.

Because the shell growth of the Nautiloidea advances as a rule from exterior to interior and in each element from apical to oral, the armenoceroid septa of *Discoactinoceras* shows its derivation from the stock of the Armenoceratidae, but in this stage of construction of the septa and camerae the septal geniculation and the shouldered connecting ring show its speciality of evolution. Until the growth stage of neck rings, however, the genus was not far apart from many other actinoceroids. Judging from its camerae and broad central cavity of siphuncle it is presumable that the animal was capable of swimming in this stage as some other actinoceroids. In the full grown stage, however, it became a vagile benthos in view of the facts that the siphucle became so heavy and at the same time the camerae lost their importance.

As discussed already (1977), the Maruyaman or early Toufangian age is approximately the Whiterock in North America and the Llanvirnian in Europe when the first step of radiance has been advanced of the Actinoceratida and *Wutinoceras, Polydesmia* and *Ordosoceras* were brought to birth in Eastern Asia. Then the Armenoceratidae and Ormoceratidae have developed there probably from *Wutinoceras* in the middle Toufangian age when the Toufangkou limestone was deposited in Koreo-Manchuria. Now this limestone is divided into three parts. Therefore I have tried to find out the appearance of *Discoactinoceras* more accurately, but it was in vain for there is still some disagreement in the tripartitions by OBATA and CHEN, although, CHEN (1976) suggested the early Middle Toufangian age for *D. multiplexum.* At any rate it is certain at present that *Discoactinoceras* is one of the most specialized actinoceroids, insofar as the siphuncular structure is concerned, and it appeared sporadically some time during the middle Toufangian age and survived by the end of the age or even a little later.

Finally, I have pointed out long ago (1929) that *Discosorus* resembles *Discoactinoceras* in the possession of endocone-like sheathes, but its conch is quite different as it is a curved brevicone. Since than the order Discosorida was greatly clarified by FLOWER and TEICHERT (1957) and it is known at present that such a structure occurs in certain genera of the Westonoceratidae and Discosoridae, but the actinoceroid structure in the outer part of the siphuncle is always absent in them. Their endocone-like sheathes developed gradually from the lining of the nummuloidal siphuncle. Therefore this is another parallel specialization which took place in the Discosorida intermittently during the prolonged three Palaeozoic periods, from Ordovician to Devonian.

Before closing this article I record here my sincere thanks to Assoc. Professor Itaru HAYAMI of the University of Tokyo for his warm assistance for its preparation.

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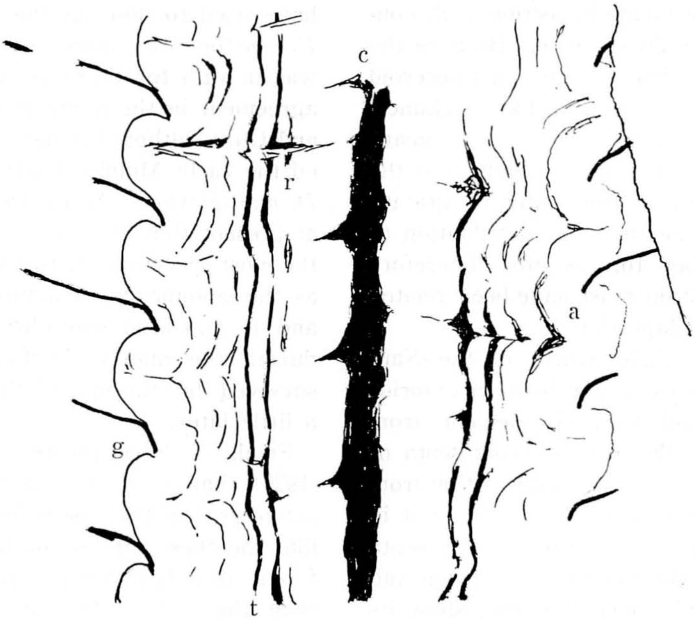
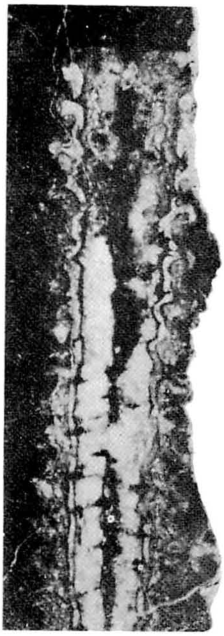


Text-figure 2. Sketch of siphuncle in pl. 31, fig. 5. a : annulus, c : central tube, g : septal geniculation, r : radial canal, t : tubular sheath.

Explanation of Plate 31

Figures 1-4. *Discoactinoceras multiplexum* KOBAYASHI. Two longitudinal sections, weathered surface and transverse section. All reproduced from Plate 22, figures 7a-d, KOBAYASHI, 1929. Natural Size. PM 0051.

Figure 5. Same species. Posterior part of longitudinal section in fig. 1, four times magnified from the holotype specimen to show septal geniculation near siphnucle and growth of annuli and tubular sheathes in the siphuncle.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2


3


5

4

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Place Names

C : China, K : Korea

Bantatsusan, Mandalsan 晩達山 (K), Changp'yong-dong 倉坪洞 (K), Chihli 直隷 (C), Chinku-ni 津邱里 (K), Chiushukou 秋樹溝 (C), Ch'osan 楚山 (K), Dawan 大湾 (C), Dongjeom-ni 銅店里 (K), Hopei 河北 (C), Hwangji-ri 黄池里 (K), Hyeoleom 穴巖 (K), Kangweon-do 江原道 (K), Kangyao 缸窑 (C), Kechuang 閣庄 (C), Kuniutan 牯牛潭 (C), Hsiaofankechuang 小礬各庄 (C), Leichuang 雷莊 (C), Liangchiashan 亮家山 (C), Liaoning 遼寧 (C), Lincheng 臨城 (C), Machiakou 馬家溝 (C), Maruyama, Hwansan 丸山 (K), Miaopa 庙坡 (C), Nam-myeon 南面 (K), Nanso, Namjang 南莊 (K), Neichiashan 艾家山 (C), Okdong 玉洞 (K), Niuhsintai 牛心台 (C), Patou 八陡 (C), Peianchuang 北庵庄 (C), Samcheok 三陟(K), Sangdong-myeon 上東面 (K), Sangjang-myeon 上長面 (K), Sinch'on 新村 (K), Ssuyen 四眼 (C), Tanggok 堂谷 (K), Tangshan 唐山 (C), Tapu 大堡 (C), Toufangkou 豆房溝 (C), P'yeongan-bukto 平安北道 (K), Unkaku, Unhak 雲鶴 (K), Wushan 武山 (C), Wuting 五頂 (C), Yehli 冶里 (C)

Discoactinoceras と新科 Discoactinoceratidae — *Discoactinoceras* は Huroniidae や Polydesmiidae に入れられていたが，体管内に初めは珠角石型で，後には内角石類と類似する堆積物を生ずる点で上記二科とは全く異っている。その隔壁頸は *Armenoceras* 型で Armenoceratidae と同一祖先から分化して来たと考えられるが，隔壁は縦断面で直線的で，両端部で急に折れ曲って，やゝ S字状を呈している。これらの特性からも新科は他の諸科と異り，珠角石類中の1科をなしている。南朝鮮産の素木コレクション中には *Discoactinoceras* cf. *multiplexum* と *D. okdongense*, sp. nov. とがあり，本属模式種の *Discoactinoceras multiplexum* と共にこれらをここに詳しく記載した。

小　林　貞　一

Explanation of Plate 32

Figures 1a-b. *Discoactinoceras* cf. *multiplexum* KOBAYASHI. Longitudinal and transverse sections of adoral part of a phragmocone. ×$1^1/_2$ Hwanji-ri specimen. PM 4296.

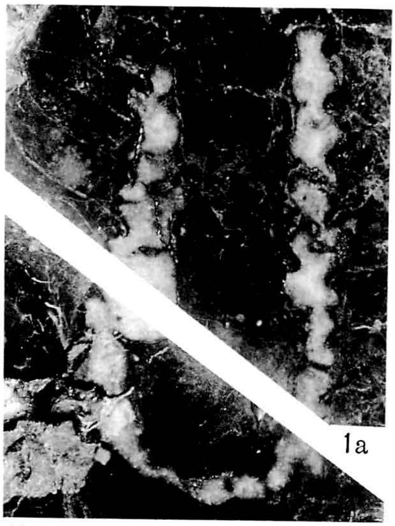
Figures 2a-c. Same species. One longitudinal and two transverse sections from 13 mm and 12 mm respectively from anterior and posterior ends of a siphuncle. ×1. Tanggok specimen. PM 4297.

Figure 3. *Discoactinoceras okdongense* KOBAYASHI, sp. nov. Longitudinal section of siphnucle. Natural size. Second specimen of Okdong. PM 4298.

Figures 4a-c. Same species. Two longitudinal and one transverse sections. Natural size. Hyeoleom specimen. PM 4299.

Figures 5a-e. Same species. Two longitudinal and three transverse sections of the holotype siphuncle. Natural size. Okdong specimen. PM 4300.

Repository: University Museum, University of Tokyo.

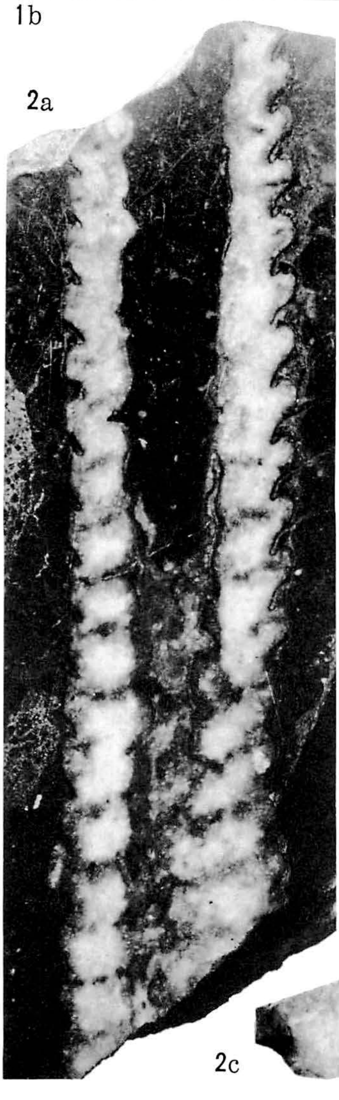

1a

1b


3


4a


4b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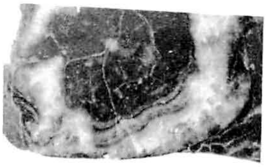
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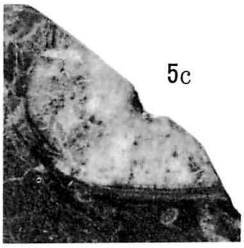
4c


5a


5b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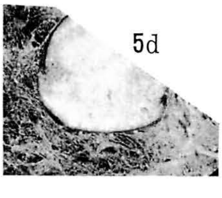
5d


5e


2c

Trans. Proc. Palaeont. Soc. Japan, N. S., No. 109, pp. 235-258, pls. 33-35, April 30, 1978

685. PHENOTYPIC SUBSTITUTION OF *GAUDRYCERAS* (A CRETACEOUS AMMONITE)*

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Waseda University, Shinjuku, Tokyo 160

Abstract. The mutual relations among three nominal species, *Gaudryceras denseplicatum*, *G. intermedium* and *G. tenuiliratum* from Japan and Sakhalien are examined. *G. denseplicatum* and *G. intermedium* are here explained as a sexual dimorphic pair from the facts that they coexist, they occur in the same stratigraphic range and a constant numerical ratio of the specimens is kept for the duration in addition to their morphogenetical resemblance. They should be degraded to *G. denseplicatum* var. *denseplicatum* and *G. d.* var. *intermedium* respectively.

Some main characters of *G. tenuiliratum* are common to those of var. *denseplicatum* and var. *intermedium*. The numerical ratio of the specimens of *G. tenuiliratum* to those of *G. denseplicatum* var. *deseplicatum*+ *G. d.* var. *intermedium* historically changes in the same pattern in Obira, Hokkaido and Naibuchi, Sakhalin. Three possible explanations on the relations of *G. tenuiliratum* with *G. d.* var. *denseplicatum* and *G. d.* var. *intermedium* are discussed and transient polymorphism seems to be the most reasonable. Then *G. tenuiliratum* is degraded to *G. denseplicatum* var. *tenuiliratum*.

Introduction

Ammonites have been looked upon as interesting and favourable material for evolutionary study, but the detailed evolutionary mode has not always been established. The material which I deal with is a species of *Gaudryceras* which flourished from the Turonian to Maastrichtian of the late Cretaceous. It includes three nominal species, *G. denseplicatum* (JIMBO, 1894), *G. intermedium* YABE, 1903 (emend. SHIMIZU, 1935) and *G. tenuiliratum* YABE, 1903, but I here regard them as conspecific for the reasons which mentioned later. In the present paper they are called var. *denseplicatum*, var. *intermedium* and var. *tenuiliratum* respectively. No character was significantly changed in each variety during the life period of the species. They are very similar to one another, although a few characters are different as mentioned by MATSUMOTO (1941). The species occurs fairly commonly in Sakhalien, Japan, Madagascar and some other areas.

The purpose of this paper is firstly to clarify the mutual relations of these three varieties and secondly to obtain an information about the adaptive strategy of ammonites which flourished in the Cretaceous.

I express my gratitude to Prof. Tatsuro MATSUMOTO, Dr. Itaru HAYAMI and Dr. Kazushige TANABE for their discussion and criticism. Prof. Terumi MUKAI, Dr. Tsuneyuki YAMAZAKI and Dr. Osamu YAMAGUCHI gave me instructive advice

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on genetics. Prof. Anthony HALLAM kindly read the manuscript and gave me some suggestions. Prof. Tokio SHIKAMA, Prof. Tetsuro HANAI, Dr. Ikuwo OBATA, Dr. Takashi HAMADA, Dr. Kiyotaka CHINZEI and Dr. Noriyuki IKEYA gave many helpful suggestions. Among the studied samples, those from Sakhalien and part of Hokkaido were obtained by Prof. MATSUMOTO and have been generously loaned for this study. These and several other specimens kept in the University Museum of the University of Tokyo have been on loan by courtesy of Prof. HANAI. This study was financially supported partly by the Science Research Fund of the Ministry of Education, Science and Culture (No. 074202 for 1975, No. 174269 for 1976), the Matsunaga Research Grant and Prof. MATSUMOTO's Grant. Miss Mutsuko HAYASHIDA and Mrs. Yukiko HIRANO assisted me in various ways.

Material and method

The samples studied in this work were obtained from the Naibuchi area in Sakhalien and the Obira, Ashibets and Tomiuchi (=Hetonai) areas in Hokkaido (Fig. 1). Those from the Naibuchi and Obira areas are large in size and were obtained in stratigraphic order. Therefore they are suitable for the statistical examination. The samples are well preserved in hard calcareous nodules (with diameter about 30 cm), though the body chambers are not always complete. Here specimens derived from one nodule are considered as one sample. For the geology of these areas and the locality records including associated fossils see MATSUMOTO (1942, 43), MATSUMOTO ed. (1954), MATSUMOTO and OKADA (1973), MATSUMOTO et al. (in press), TANABE et al. (1977) and HIRANO et al. (1977).

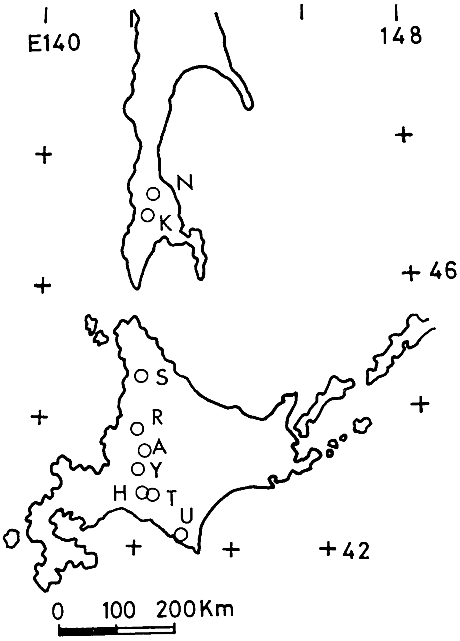

Fig. 1. Map showing the fossil localities. N: Naibuchi, K: Kawakami, S: Saku, R: Obira, A: Ashibets and Ikushumbets, Y: Yubari and Oyubari H: Hobets, T: Tomiuchi, U: Urakawa.

Besides the material from the areas mentioned above I examined some specimens obtained from the Kawakami area in Sakhalien, the Saku, Oyubari, Ikushumbets, Hobets and Urakawa areas in Hokkaido and the Uwajima area in Shikoku which are kept in the University Museum of the University of Tokyo and Kyushu University, although they are not directly quoted. For the specimens from overseas areas I depended on the published papers.

The whorl of *Gaudryceras* is planispiral. The morphology can be expressed graphically by projection of two planes which cross perpendicularly to each other. Because the mode of coiling and the relief of surface sculpture are often considered as the specific criteria in *Gaudryceras* and the tangential section enables us to measure these two characters, the tangential section was employed for the study of relative growth. The mensuration was done under Nikon profile projector V-16 and the suture lines were drawn using Wild stereoscope.

Distribution of *Gaudryceras*

So far as available literature is concerned, about thirty species of *Gaudryceras* have been reported from various localities of the world. The first appearance of this genus is in the Cenomanian of India (KOSSMAT, 1895; COLLIGNON, 1956) and Japan-Saghalien (MATSUMOTO, 1942), though a precise record in the former region is not available. Concerning the latter, although the stratigraphy is very well established, the occurrence is not frequent.

Only three nominal species have been confirmed from the Turonian, *G. denseplicatum*, *G. intermedium* and *G. varagurense*. The first and second occur in the Lower Turonian of Japan-Sakhalien (JIMBO, 1894; SHIMIZU, 1935; MATSUMOTO, 1941, 43, 59b) and the third was reported from the Turonian of India (KOSSMAT, 1895) and Angola (HOWARTH, 1965), with little stratigraphic information. A species comparable with *G. intermedium* is known from the Turonian of Angola (HOWARTH, 1965). In the Coniacian and Santonian *Gaudryceras* is widely distributed. The extinction of *Gaudryceras* occurred in the Maastrichtian.

Through this specified time *Gaudryceras* may be most abundant in the Japan-Sakhalien area. The biostratigraphical distribution and the mode of occurrence have been preliminarily reported by MATSUMOTO (e.g., 1942, 43, 59b; ed., 1954). The specific diversity of *Gaudryceras*, however, is not high there. This phenomenon is interesting in view of the phylogeny of *Gaudryceras*, and its analysis is the future problem with the revision of classically described species in the world. Here I show the stratigraphic distribution and the number of specimens in each zone of the sequences of the Naibuchi and the Obira areas (Table 1). Var. *denseplicatum* and var. *intermedium* appeared in the *Inoceramus labiatus* zone of the Turonian and continue to the *I. amakusensis* zone of the Santonian (Obira) and the *I. japonicus* zone of the Santonian (Naibuchi), and their extinction occurred in the early Campanian (MATSUMOTO, 1942, 59a). On the other hand, var. *tenuiliratum* appeared in the *I. uwajimensis* zone of the Coniacian, continuing at least to the *I. japonicus* zone of the Santonian. The upper limit of this variety is early or middle Campanian (MATSUMOTO, 1959a), and the number of specimens seems to increase with time.

I examined the change of then umerical ratio of var. *intermedium* to var. *denseplicatum* in the sequences of Naibuchi and Obira (Fig. 2). The numerical ratios of the specimens of these two varieties do not show any significant differences (Table 2): the hypothesis of uniform ratio is not rejected.

The numerical ratio of var. *tenuiliratum* to var. *denseplicatum*+var. *intermedium* seems to increase gradually with time (Fig. 3). The ratios in the two sequences, Naibuchi and Obira, are examined by chi-square test (2×2 contingency table) to know whether the zone by zone ratios equal to each other or not. The results show that there are no significant differences between the two sequences (Table 3) and that the patterns of the transition of the ratios in these two areas are equal to each other.

Furthermore, in the field these three varieties are commonly found in the same nodule or one exposure. Although the

Table 1. Stratigraphic distribution of *G. denseplicatum* var. *denseplicatum*, var. *intermedium* and var. *tenuiliratum* in Obira, Hokkaido and Naibuchi, Sakhalien.

Geological age	Zone of Inoceramus		m. y.	Number of specimens										Local stratigraphic division
				Obira					Naibuchi					
				a	b	c	d	e	a	b	c	d	e	
Campanian	orientalis			0	0	0	0	0	0	0	0	0	0	Mh7
Santonian	japonicus	n	—76—	0	0	0	0	19	9	8	19	36	100	Mh6β
									1	0	16	17	11	Mh6α-β
	amakusensis			0	1	21	22	19	4	4	11	19	34	Mh6α2
									0	1	8	9	1	Mh6α1
Coniacian	mihoensis	y	—82—	0	0	40	40	3	2	0	2	4	0	Mh5
	uwajimensis			6	1	3	10	1	1	3	3	7	1	Mh4
Turonian	teshioensis		—88—	3	1	31	35		1	0	0	1		Mh3
	hobetsensis			9	2	49	60		0	0	1	1		Mh2
	labiatus			0	0	5	5		1	0	0	1		Mh1
Cenomanian	concentricus		—94—											Mh0

a: var. *denseplicatum*, b: var. *intermedium*, c: immature specimens of var. *denseplicatum* and/or var. *intermedium*, d: a+b+c, e: var. *tenuiliratum*.
n: naumanni, y: yokoyamai

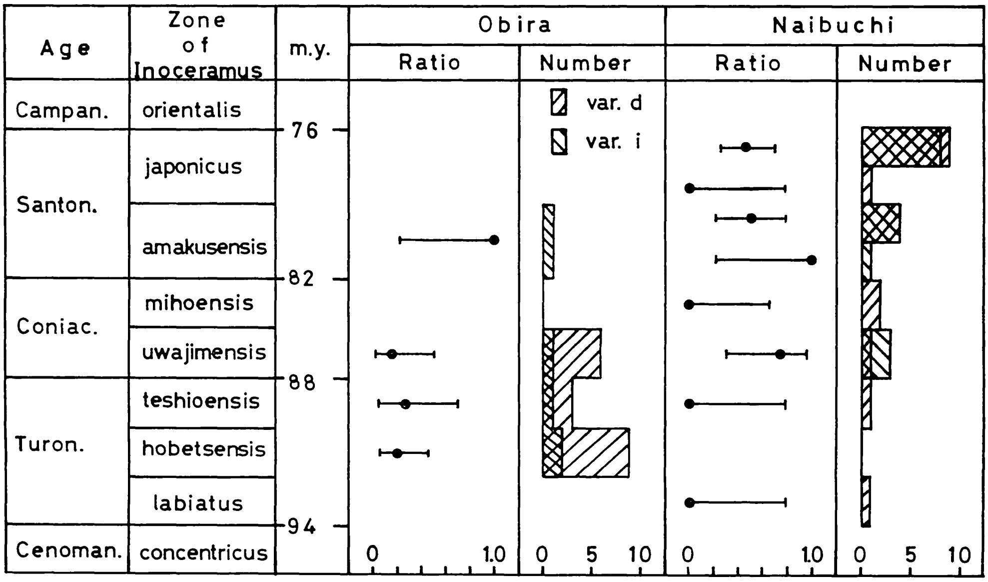

Fig. 2. Chronological changes of the numbers of the specimens of var. *denseplicatum* and var. *intermedium* and the numerical ratios of the latter to the former (95% confidence interval is shown by a bar).

Table 2. Chi-square matrix with Yate's correction (2×2 contingency table) on the ratio of the number of the specimens of var. *intermedium* to that of var. *denseplicatum*, from the Upper Cretaceous of Naibuchi (upper) and Obira (lower). Data same as Table 1.

	Mh6 8 : 9	Mh6 0 : 1	Mh6 4 : 4	Mh6 1 : 0	Mh5 0 : 2	Mh4 3 : 1	Mh3-1 0 : 2
Mh6							
Mh6	0.01						
Mh6	0.09	0.01					
Mh6	0.00	0.00	0.01				
Mh5	0.27	—	0.23	0.19			
Mh4	0.20	0.05	0.04	0.70	0.75		
Mh3-1	0.27	—	0.23	0.19	—	0.75	

$\chi^2_{0.05(\nu=1)}=3.84$

	amak. 1 : 0	miho. 0 : 0	uwaj. 1 : 6	teshio. 1 : 3	hobets. 2 : 9	labia. 0 : 0
amak.						
miho.	—					
uwaj.	0.38	—				
teshio.	0.05	—	0.14			
hobets.	0.36	—	0.19	0.19		
labi.	—	—	—	—	—	

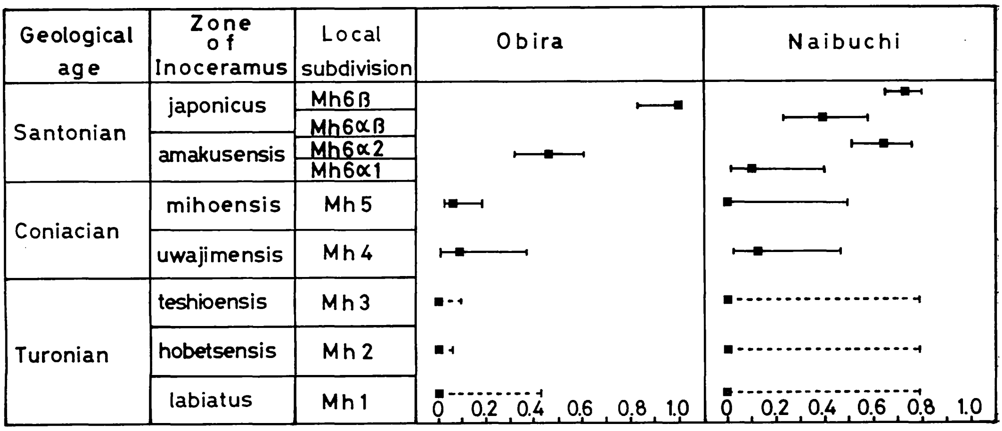

Fig. 3. Chronological change of the numerical ratio of var. *tenuiliratum* to the three varieties in the number of specimens (95% confidence interval is shown by a bar or a dashed line).

Table 3. Chi-square matrix with Yate's correction (2×2 contingency table) on the ratio of the number of var. *tenuiliratum* to that of the pair of var. *denseplicatum* and var. *intermedium* between the samples from Obira and Naibuchi. Data same as Table 1.

Naibuchi Obira	Mh6β 100 : 36	Mh6α-β 11 : 17	Mh6α1+α2 35 : 28	Mh6α2 34 : 19	Mh6α1 1 : 9	Mh5 0 : 4	Mh4 1 : 7
japonicus 19 : 0	5.15	15.0					
amakusensis 19 : 22	0.87	0.19	0.52	2.30	3.06		
mihoensis 3 : 40	$\chi^2_{0.05(\nu=1)}=3.84$					0.27	
uwajimensis 1 : 10	$\chi^2_{0.01(\nu=1)}=6.63$						0.27

clear distinction between var. *denseplicatum* and var. *intermedium* in the immature stages is impossible, as will be mentioned later, some of the immature specimens which have hitherto been regarded as *G. denseplicatum* are assumed to be var. *intermedium* and the rest are var. *denseplicatum* from the examination of the position of the nepionic constriction. Thus, var. *denseplicatum* and immature var. *intermedium* are coexistent. Adult individuals of var. *intermedium* sometimes occur exclusively and therefore the habitat may be somewhat different from those of the immature var. *intermedium* and other varieties. A fully grown up and large specimens of var. *intermedium*, however, independently forms one nodule (the size of a fully grown up specimen is nearly the same as that of a common nodule) and therefore the associated fossils with the adult variety in a nodule are rare. It is uncertain whether this mode of occurrence depends on physical and/or chemical or biological reasons. Var. *tenuiliratum* often coexists with var. *denseplicatum* and assumed immature var. *intermedium*.

Characteristics of var. *denseplicatum* and var. *intermedium*

Ontogeny: Generally, the growth of parts of the body relative to that of the body is in a certain functional relation, called allometry, and is expressed as $y=\beta x^{\alpha}$ (where y represents the size of a particular organ or a part of the body; β the relative size of the organ at its first appearance; x that of the total body or a part of the body; and α the rate of growth of the organ y) (NOMURA, 1926; HUXLEY, 1932). GOULD (1966) designated the term allometry as the differences in proportions correlated with changes in absolute magnitude of the total organism or of the specific parts under consideration. Ideally, the growth pattern of an ammonite is isometric and the pattern is recognized as a logarithmic spiral (THOMPSON, 1917; HUXLEY, 1932; OBATA, 1959, 60, 61, 65). The method of mesnuration is the same as that described in HIRANO (1975).

The growth pattern of the whorl of var. *denseplicatum* is characterized by the high rate of the growth of radius length to the spiral in comparatively later stages as shown in Fig. 4 (Compare it with that of var. *tenuiliratum* in Fig. 10 of this paper and fig. 3 in HIRANO, 1975). The suture line shows little variation and is expressed as ELU_2U_1Is in terms of the formula by KULLMAN and WIEDMANN (1970) (Fig. 5). The surface of shell is covered by widely interspaced thin and

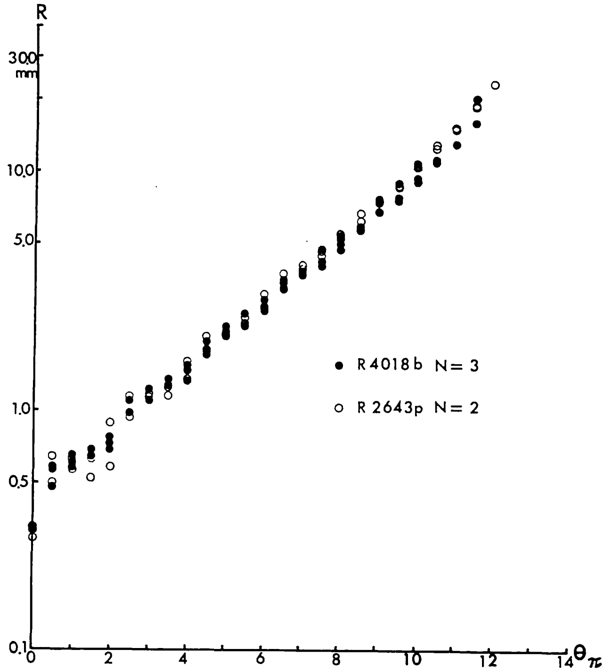

Fig. 4. Example of the growth pattern of the radius length (R) to the spiral (θ). Samples are from the *teshioensis* zone of Obira (R2643p: var. *denseplicatum*; R4018b: var. *denseplicatum* and/or var. *intermedium*).

comparatively high radial subcostae from the first whorl to the early half of the third whorl. After the stage, numerous coarse and weakly sinuous subcostae (Tables 4, 5; See table 11 of *tenuiliratum* in HIRANO, 1975) appear, and branching and insertion of these subcostae arise on the lateral to the ventro-lateral side of the fourth to the fifth whorl. At about the sixth whorl the costae appear and continue later. They describe a sine curve in cross section and the interspaces become narrower with growth. The body chamber occupies a little less than 360° in spiral angle, although the estimation is approximate owing to the difficulty in recognizing the peristome. The ventral shell is composed of three layers and the dorsal shell is of two layers as the outer layer wedges out at the umbilical seam. This variety has a constriction like var. *tenuiliratum* (HIRANO, 1975), and especially the first, nepionic constriction, is situated at a constant position (Table 6).

G. denseplicatum var. *intermedium* was at first described by YABE (1903) as a variety of *G. tenuiliratum* and regarded by SHIMIZU (1935) as a distinct species. After that it was treated by MATSUMOTO (1959b) as a subspecies of *G. denseplicatum*. As mentioned in the previous chapter, the variety under consideration is coexistent with var. *denseplicatum* and therefore the subspecific relation between them is unlikely.

The morphological characteristics of var. *intermedium* are the same as those of var. *denseplicatum* to the 5th or 6th whorl and the differences between them are not detected by the observation and the biostatistic examination(Figs. 6, 7). The growth ratio of the radius length to the

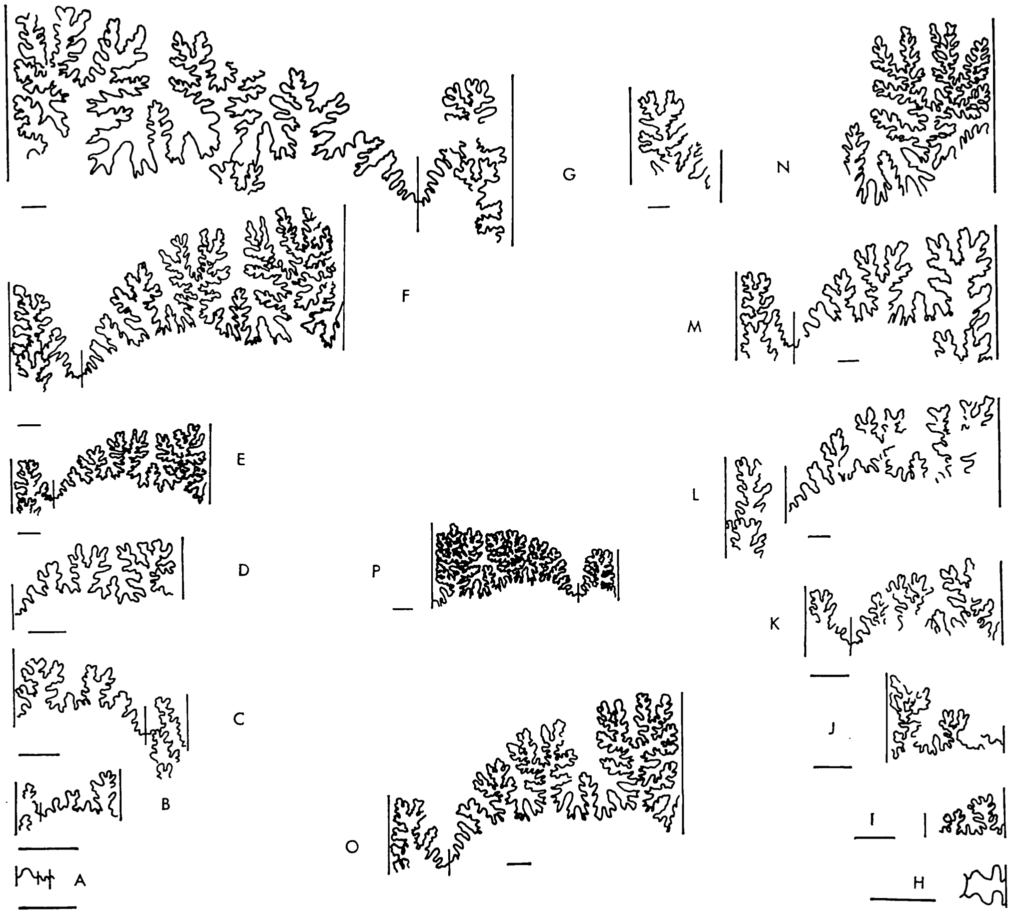

Fig. 5. Sutural ontogeny of var. *denseplicatum*. A-G: H2157, from Mh6 β, Naibuchi, Sakhalien. A: 180° from the protoconch. B: 2.5 th whorl. C: 3.5th whorl. D: 4.5th whorl. E: Just 5th whorl. G: Just before 6th whorl. H-N: H2153, from Mh6β, Naibuchi. H: 3/4 whorl. I: Just before 3rd whorl. J: 3.4th whorl. K: 3.7th whorl. L: 4th whorl. M: Just 5th whorl. N: 5.5th whorl. O: I4023b, from Onnenai, Hokkaido. 5.25th whorl. P: var. *tenuiliratum*, H5022, from Kawa-kami. Just 6th whorl. The horizontal bar indicates 1 mm.

spiral, however, increases after the 5th or 6th whorl and we can distinguish them if the specimens are larger than the growth stage. Further, the costae appear at about 6th or 8th whorl, and continue to one or more whorls, and the adult individual becomes very large (diameter 30 cm±). The cross section of each costa is quadrate in the early stage and is the same as that of var. *tenuiliratum*. About one whorl later the costa describes a sine-curve in cross section.

Geographic and chronologic variation: The geographic variation of var. *denseplicatum* is very little like that of var. *tenuiliratum* (HIRANO, 1975) and no significant differences are confirmed about the measured characters among the population samples from Sakhalien and Hokkaido. As an example the growth ratio

Table 1. Height of subcosta (mm) at the three different ontogenetic stages, the 4th, the 4 1/2 and the 5th whorl, of var. *denseplicatum* and/or var. *intermedium*. Samples are from Obira.

Age			the 4th	the 4 1/2	the 5th
Santonian	amakusensis	N	7	7	7
		x̄	0.019	0.041	0.078
		SD	0.011	0.028	0.034
		OR	0.008-0.036	0.013-0.096	0.028-0.098
Coniacian	mihoensis	N			1
		x̄			—
		SD			—
		OR			0.067
	unknown*	N		2	3
		x̄		0.064	0.096
		SD		0.036	0.066
		OR		0.038-0.089	0.040-0.169
	uwajimensis	N		3	3
		x̄		0.076	0.128
		SD		0.053	0.095
		OR		0.042-0.137	0.054-0.236
Turonian	teshioensis	N		4	5
		x̄		0.048	0.087
		SD		0.021	0.027
		OR		0.031-0.077	0.061-0.129
	hobetsensis upper	N	6	6	6
		x̄	0.014	0.035	0.059
		SD	0.013	0.047	0.019
		OR	0.007-0.037	0.011-0.131	0.037-0.071
	hobetsensis lower	N	7	7	7
		x̄	0.010	0.027	0.090
		SD	0.009	0.015	0.037
		OR	0.003-0.029	0.011-0.055	0.055-0.166

* The detailed age is not determined.
N: sample size, x̄: mean value, SD: standard deviation,
OR: observed range.

of the radius length to the spiral of some Santonian samples and the results of the statistical examinations are shown (Tables 7, 8). Concerning the suture, not only the basic elements but also the detailed parts show no geographic changes. This variety is distributed as far as Madacascar and differences have not been detected between the specimens from the Japan-Sakhalien area and Madagascar, although they have not been quantitatively analysed.

As has been recognized previously, any

Table 5. Number of lirae on a quarter of whorl of var. *denseplicatum*, counted at the umbilical shoulder, at some ontogenetic stages. An example is shown by the Sample N22Z from Naibuchi.

Stage	Mean	S.D.	N
3 3/4—4th whorl	20.3	6.1	3
4 —4 1/4	23.7	4.9	3
4 1/4—4 1/2	21.7	2.5	3
4 1/2—4 3/4	17.0	1.4	2
4 3/4—5	18.3	2.1	3
5 —5 1/4	20.8	1.3	4
5 1/4—5 1/2	21.3	4.0	3
5 1/2—5 3/4	17.0	0.0	2

Table 6. Position of the nepionic constriction of the pair of var. *denseplicatum* and var. *intermedium* expressed by the angle between the constriction and the protoconch aperture. Samples from Obira.

Stage	N	$\bar{\theta}$	S.D.
naumanni zone	5	355°26′	29°45′
amakusensis zone	2	355°15′	7°26′
hobetsensis zone	11	365°06′	6°17′

particular chronological transition of morphology such as increase or decrease of some quantitative characters (e.g., protoconch size), complication or simplification of suture, modification of surface ornamentation and growth pattern of whorl, and the change of position of nepionic constriction did not arise, and it follows that this evolutionary mode exhibits a morphological homeostasis. An example is shown by the growth ratio of the radius length to the spiral (Fig. 8). The mean values of the figured samples

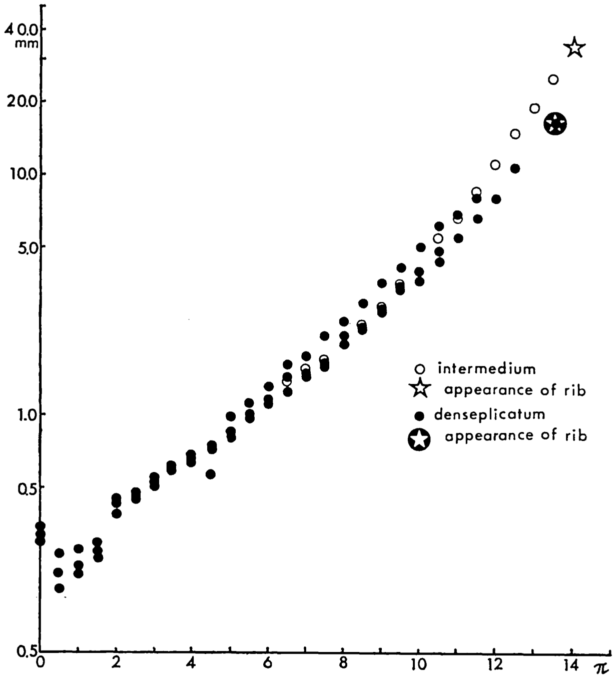

Fig. 6. Growth pattern of the whorl height to the spiral angle in var. *intermedium* and var. *denseplicatum*. Var. *intermedium*: I3849, loc. N332b, Mh6 α, Naibuchi. Var. *denseplicatum*: H2158-1, 2, 3, loc. N22Z, Mh6 β, Naibuchi.

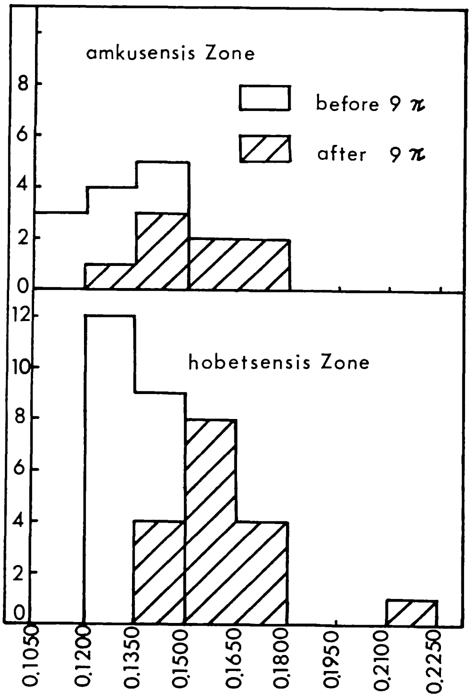

Fig. 7. Histogram of the growth ratio of the radius length to the spiral (in the stages before and after 9 π) of the pair of var. *denseplicatum* and var. *intermedium* from Obira.

in Fig. 8 are as follows in ascending order:

0.1774 0.1676 0.1639 0.1364 0.1529 0.1712
0.1715 0.1751 0.1588 0.1616 0.1564 0.1582
0.1602 0.1370 0.1236 0.1505

Here I test the randomness of this series by a runs test. The minimum value is 0.1364, maximum is 0.1774 and therefore the middle is 0.1569. Let the value larger than the middle value express a and smaller as b. Now the composition of the run is as follows.

←lower horizon upper horizon→
Composition of run:
a a a b b a a a a a b a a b b b
Run number:
3 2 5 1 2 3

Here we can get the total number of the runs, U=6, 10as and 6bs. In the table of the runs test of randomness (one side 2.5%) the rejection areas are less than four and larger than thirteen, and U is out of these areas. Thus we can conclude that the hypothesis of randomness is not rejected.

Var. *intermedium* cannot be distinguished from var. *denseplicatum* until the specimen shows mature characteristics. Thereupon I studied and compared some characters in more details.

Sutural ontogeny: No significant difference is detected (Figs. 5, 9).

Position of the nepionic constriction: The frequency distribution is bimodal (Table 9). Although the

Table 7. Growth ratio of the radius length to the spiral angle after the 9π stage in some Santonian samples of the pair of var. *denseplicatum* and var. *intermedium*.

Sample	N	$\bar{\alpha}\pm t_{0.05}\frac{S_\sigma}{\sqrt{N}}$	S_σ	O. R.
Naibuchi (j)	3	0.1374±0.0083	0.0045	0.1324-0.1412
Obira (a)	10	0.1461±0.0158	0.0224	0.1054-0.1774
Obira (n)	3	0.1505±0.0134	0.0073	0.1442-0.1585
Ashibets (y)	2	0.1693±0.0520	0.0171	0.1572-0.1814
Tomiuchi (n)	2	0.1533±0.0540	0.0177	0.1407-0.1659

j: japonicus zone, a: amakusensis zone, n: naumanni zone, y: upper part of yokoyamai zone. N: number of measured specimens, $\bar{\alpha}$: mean of growth ratios, $\frac{S_\sigma}{\sqrt{N}}$: standard error, S_σ: standard deviation, O.R.: observed range.

Table 8. Differences of the growth ratios among five Santonian samples of the pair of var. *denseplicatum* and var. *intermedium*. (Data same as Table 7).

Sample	Na(j)	Ob(a)	Ob(n)	As(y)	To(n)
Naibuchi (j)	*	1.1531	2.6459	(3.3173)	1.6103
Obira (a)	0.3234	*	0.3261	1.3659	0.4234
Obira (n)	1.1102	0.1481	*	1.7858	0.2602
Ashibets (y)	1.4769	0.5873	0.7705	*	0.9207
Tomiuchi (n)	0.7162	0.1796	0.1120	0.4598	*

Right upper: results of *t*-test. When there is a significant difference between the variances, Welch's method is applied. Significant result at 5% level is indicated by ( ). No one is significant at 1% level.

Left lower: Coefficient of difference.

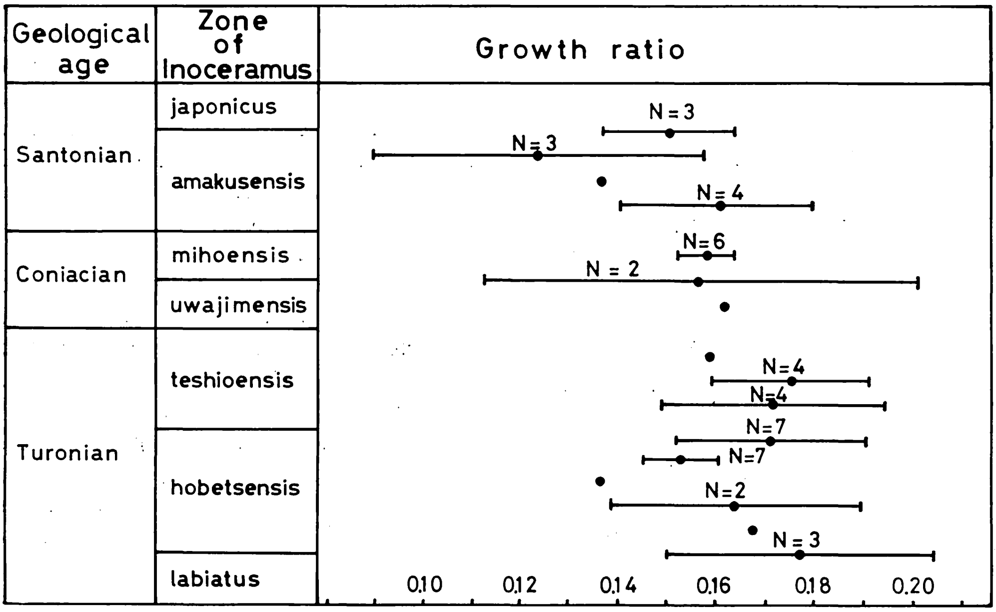

Fig. 8. Chronological change of the growth ratio of the radius length to the spiral (after the stage of $9\pi\pm$) in the pair of var. *denseplicatum* and var. *intermedium* from Obira. The mean value and the 95% confidence interval are shown. The black circle without a bar indicates a sample composed of one specimen.

boundary cannot be set objectively, in general the position of the charactor of var. *denseplicatum* is at the later stage (e.g., Sample As-1144: N=5, mean=368.95°, S.D.=4.20°) and that of var. *intermedium* is at the earlier stage (e.g., Sample As-1129a: N=1, Angle=340.70°). The unfavourable preservation of inner whorl of var. *intermedium* impedes the confirmation of this relation (The preservation of inner whorls of large specimens are usually unfavourable).

Number of subcostae: No difference is detected.

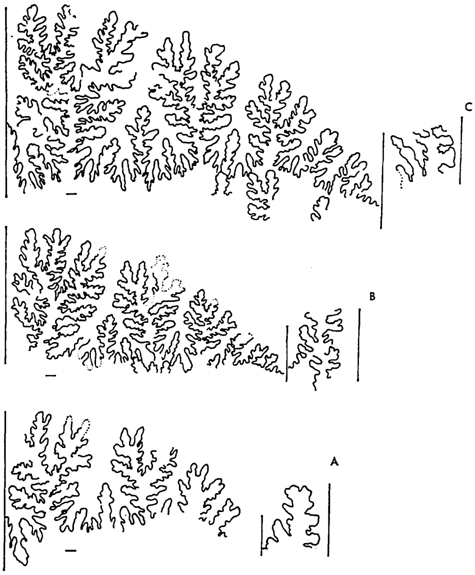

Fig. 9. Sutural ontogeny of var. *intermedium*. I3849, loc. N332b, Mh6 α, Naibuchi. A: 5-5.5 th whorl. B: 5.5-6 th whorl. C: 6-6.5 th whorl. The horizontal bar indicates 1 mm.

Height of subcostae: No difference is detected (Table 10).

Ratio of the height to the width of subcosta: No difference is detected (Table 11).

Growth ratio of the radius length to the spiral: It is very difficult to detect the difference in the stages before the costae appear (Figs. 6, 7).

Shape of costa: Usually distinguishable (see Plates).

Table 9. Chi-square test on the frequency distribution of the position of Nepionic constriction of var. *denseplicatum* and/or var. *intermedium*. Sample is of the *hobetsensis* zone in Obira.

Class	Oi	Ei
$\bar{x}-3s \sim \bar{x}-2s$	4	0.24
$\bar{x}-2s \sim \bar{x}-s$	0	1.49
$\bar{x}-s \sim \bar{x}$	0	3.75
$\bar{x} \sim \bar{x}+s$	2	3.75
$\bar{x}+s \sim \bar{x}+2s$	0	1.49
$\bar{x}+2s \sim \bar{x}+3s$	5	0.24
	N=11	10.97

$\chi^2=163.40>\chi^2_{0.05(\nu=3)}=7.8147$

Size of the adult shell: Clearly distinguishable. Var. *intermedium* attains more than 30 cm. in diameter but var. *denseplicatum* does at most 20 cm.

Stratigraphic distribution: The stratigraphic distribution of var. *intermedium* is the same as that of var. *denseplicatum* and if one increases in the number the other also does so.

Geographic distribution: Var. *intermedium* coexists with var. *denseplicatum* world-widely. In some areas which have been preliminarily studied only one of them is reported.

Discussion: As described above, var. *denseplicatum* and var. *intermedium* are hardly distinguishable from each other

Table 10. An example of the height of subcosta (mm) at three defined stages in var. *denseplicatum* and var. *intermedium*. Samples are of Santonian from Ashibets. The results of *t*-test are non significant in all stages.

Stage	var. *denseplicatum* As-1140 (N=2) mean	S. D.	var. *intermedium* As-1129 (N=1)	*t*-test
the 4th whorl	0.014	0.004	0.008	1.288
4 1/2	0.031	0.012	0.016	1.010
the 5th whorl	0.073	0.019	0.048	0.078

Table 11. Examination of the ratio of the height to the width of subcosta between var. *denseplicatum* and var. *intermedium*. Samples are of Santonian in Ashibets. The results of *t*-test are non significant in all stages.

Stage	var. *denseplicatum* As-1144 (N=5) mean	S. D.	var. *intermedium* As-1129 (N=1)	*t*-test
the 5th whorl	0. 189	0. 083	0. 163	0. 284
5 1/2	0. 284	0. 053	0. 272	0. 194
the 6th whorl	0. 333	0. 054	0. 403	1. 172

until they attained the adult condition. The close morphological resemblance and the fact that they coexist geographically and chronologically suggest they are conspecific. We cannot expect the relation of twin species (SIMPSON, 1961) for this phenomenon under such conditions mentioned above. Homeomorphy is known in various ammonites but even in such a case the suture, which has close relation to their soft parts, is commonly distinguishable, and as has been known by the studies of SCHINDEWOLF (e. g., 1954) and KULLMAN and WIEDMANN (1970) the suture is a genetically very stable character. The essentially similar pattern of rise and fall of these two phena and the sufficiently uniform numerical ratio indicate the likelihood that they belong to one and the same species.

The simultaneous occurrence of several discontinuous phenotypes or genes in a population, with the frequency even of the rarest type higher than can be maintained by recurrent mutation, is known as polymorphism (MAYR, 1970). Examples of polymorphism are numerous in living species. Is this case a sexual dimorphism or other type of dimorphism like a balanced polymorphism ?

If this is a balanced polymorphism, the characteristic differences between the two phena have possibly arisen from a pair of alleles of which one gene is dominant, and either var. *denseplicatum* or var. *intermedium* is the phenotype of dominant homozygote plus heterozygote. In some other cases such a dimorphism may be controlled by a kind of chromosome aberration like inversion. The relations between phenotypic polymorphism and chromosome aberration and the influence of chromosome aberration are discussed by many geneticists (e. g., OSHIMA et al., 1974; DOWDESWELL, 1970).

The polymorphism maintained by allelic genes which are associated with the inversion is exemplified or inferred in some living mollusks (e. g., CAIN and SHEPPARD, 1954; KOMAI and EMURA, 1955).

The mechanism of this phenotypic polymorphism is nearly impossible to know, and similarly the distinction between the balanced polymorphism and the sexual dimorphism is certainly difficult in this case. The proved dimorphisms, however, of which mode of ontogeny is hardly distinguished up to the adult and adult size shows differences, in the natural world, are usually case of sexual dimorphism, and the difference of the adult size between male and female has been exemplified in ammonoids (e. g., PALFRAMANN, 1966, 67, 69).

Thus I consider the case of sexual dimorphism. Here, I note the ratio of the two sexes ♂ and ♀ is 1 : 1 as seen in the living Sepiidae (YAMAMOTO ed., 1973) and many other organisms, although no evidence is yet obtained in ammonoids.

Upon examination of the numerical ratios of the specimens of Table 1, and no significant differences are detected from the hypothesis of a ratio 1 : 1 (Table 12).

The large size of var. *intermedium* recalls us of the autopclyploidy but such a phenomenon is very rare in animals. The fact that the ratio of two forms is kept constant in two distant areas is unfavourable for the supposition of autopolyploidy.

It is most appropriate to regard them as a sexual dimorphic pair.

Table 12. Chi-square matrix with Yate's correction (2×2 contingency table), which indicates the significance for the difference between the numerical ratio of var. *intermedium* to var. *denseplicatum* and idealized ratio on the sexual dimorphism (1 :1). Upper : Naibuchi, lower : Obira.

Stage	Mh6β	Mh6α-β	Mh6α2	Mh6α1	Mh5	Mh4
Actual ratio	8 : 9	0 : 1	4 : 1	1 : 0	0 : 2	3 : 1
Result	0.029	0.667	0.250	0.667	0.000	0.000

Stage	amakus.	miho.	uwajim.	teshio.	hobets.	labiatus
Actual ratio	1 : 0	0 : 0	1 : 6	1 : 3	2 : 9	0 : 0
Result	0.667	—	0.737	0.000	1.264	—

$\chi^2_{0.05(\nu=1)}=3.841$

Characteristics of var. *tenuiliratum*

Ontogeny: The ontogenetic development of var. *tenuiliratum* was explained in detail with the Santonian samples (HIRANO, 1975). The sutural pattern of this variety is ontogenetically same as those of var. *denseplicatum* and var. *intermedium*. The growth ratio of the radius length to the spiral is smaller in the present variety than in the other two varieties in the later stages. The cross section of the costa is quadrate like that of var. *intermedium*. The adult size of the present variety is similar to that of var. *denseplicatum*. In short, as mentioned by MATSUMOTO (1941) these three varieties are different from each other in some points but at the same time they have common or similar characters in other points.

Geographic and chronologic variation: The distribution of this variety is almost restricted to Japan-Sakhalien, but from California (MATSUMOTO, 1959b) and South Africa (HOEPEN, 1921) similar ones were reported as cf. *tenuiliratum* or under a different name. Cf. *tenuiliratum*, which is not available at my hand, is however, rather rare in California and I omit this species under the assumption that this treatment does not influence on the final results. Thereupon I studied the geographic variation of the present variety in the Japan-Sakhalien area but no particular trend like cline was detected through the range as exemplified by the Santonian samples (HIRANO, 1975).

Then I examined for chronological change of the growth pattern of the spiral from the *amakusensis* zone to the *japonicus* zone (Fig. 10), but detected none.

Discussion: The morphological differences of var. *tenuiliratum* from var. *denseplicatum* and var. *intermedium* are macroscopically and biostatistically clear in some characters as mentioned in the previous section. The sutural pattern of

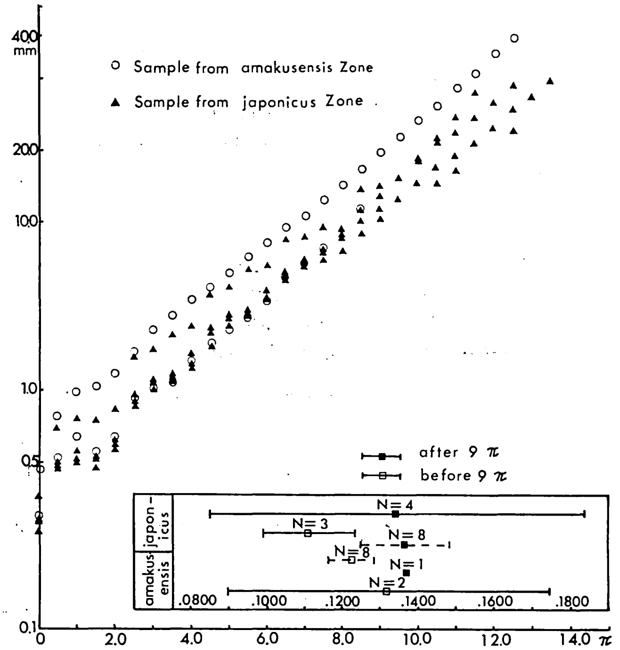

Fig. 10. Growth pattern and ratio of the radius length to the spiral of var. *tenuiliratum* from Obira. In the square, the mean value and 95% confidence interval of the growth ratio is shown. Sample from the *naumanni* zone is indicated by a broken line.

var. *tenuiliratum*, however, is not distinguishable from those of var. *denseplicatum* and var. *intermedium*.

The rise and fall of var. *tenuiliratum* are exemplified in two representative localities, Naibuchi and Obira (Table 1), and both two examples show that it began to appear in Coniacian and flourished in Santonian. Next I compare the numerical fluctuation of the specimens of var. *tenuiliratum* with that of the pair of var. *denseplicatum* and var. *intermedium* (Fig. 3).

The chronological change of the numerical ratio of the specimens of var. *tenuiliratum* to those of the pair of var. *denseplicatum* and var. *intermedium* shows nearly the same pattern in the two localities (Table 3, Fig. 3), notwithstanding the different chronologic patterns of the number of var. *denseplicatum*+var. *intermedium* in these two localities (Table 1). That is, these patterns clearly indicate that var. *tenuiliratum* replaced the pair of var. *denseplicatum* and var. *intermedium*. Var. *tenuiliratum* has been regarded a single and independent species by most authors. Did it speciate from another species than *G. denseplicatum* (=*G. d.* var. *denseplicatum*+*G. d.* var. *intermedium*) or from *G. denseplicatum* in other area like the model of allopatric speciation, migrating to Japan-Sakhalien and flourishing there, taking the niche of *G. denseplicatum*? The numerical ratios of the specimens of three varieties (var. *tenuiliratum*: var. *denseplicatum*+var. *intermedium*) in these two localities are almost equal to each other except in the case of the *japonicus* zone vs. Mh6α-β. Why did the ratios change in the same pattern in the two places, the distance of which is as great as 300 km ?

Here I consider three hypothesis which may explain the relation between *"tenuiliratum"* and the pair of var. *denseplicatum* and var. *intermedium*. The first and second hypotheses assume *"tenuiliratum"* as an independent species from *G. denseplicatum*. That is, 1. *"G. tenuiliratum"* speciated from a species other than *G. denseplicatum*, migrating to Japan-Sakhalien area and adapted to an environment of this area, 2. *"G. tenuiliratum"* speciated from *G. denseplicatum* in some marginal or semi-isolated places and migrated to the main distributional area of *G. denseplicatum* (as in the model of ELDREDGE and GOULD, 1972). In the third hypothesis, on the contrary, *"tenuiliratum"* is the polymorphic pair (transient polymorphism) with the couple of var. *denseplicatum* and var. *intermedium*. Which would be the most reasonable explanation ?

Firstly case 1 is considered. The first appearance of *"tenuiliratum"* is in the early Coniacian and therefore we must seek the ancestor in the Turonian species of *Gaudryceras*. The only applicable species is *G. varagurense* which is known in the Turonian of India and South Africa. There is not more positive evidence of the speciation of *"tenuiliratum"* from *G. varagurense* than the interpretations mentioned below although *G. varagurense* resembles *"tenuiliratum"* in appearance.

In case 2 we assume that the speciation of *"tenuiliratum"* from *G. denseplicatum* proceeded in the marginal isolated area of the distribution of *G. denseplicatum* and *"tenuiliratum"* migrated to the main area, Japan-Sakhalien, after the complete reproductive isolation was established. According to the model of ELDREDGE and GOULD (1972), this process is likely to have proceeded fairly rapidly. Because the distribution of *G. denseplicatum* of Turonian age is only Japan-Sakhalien, the isolated population must have arisen in the marginal part of Japan-Sakhalien. The Turonian sediments occur in great thickness and lateral extent in this area, and fossil preservation is very good. However, we have not succeeded in finding the intermediate form of those two "species" under discussion for the last 100 years from any locality. If we supposed that "originally such an intermediate form existed", here we can apply the model of ELDREDGE and GOULD (1972) (I do not intend to deny their model). If the transformation of morphology from the couple of var. *denseplicatum* and var. *intermedium* to var. *tenuiliratum* is gradual, the discovery of intermediate individuals would be expected. On the other hand if *"tenuiliratum"* arose as a result of adaptation for different conditions than *denseplicatum*, the optimum condition of the former would have been much different from that of the latter. However, the fact that these two "species" coexisted for 12 million years after the "speciation" denies this necessary condition.

Thereupon I search for a more reasonable explanation. That is, we are led to the thought that *"tenuiliratum"* is one and the same species as *denseplicatum*. Although they are one species, the height of the subcostae and the whorl growth pattern in some stages are different and there is no intermediate form. Therefore, they should be regarded as a pair of dimorphism. In spite of the different durations and the different patterns of local rise and fall in Japan and Sakhalien, the relative frequencies of *"tenuiliratum"* to the pair of var. *denseplicatum* and var. *intermedium* are in the same pattern as mentioned in the early part (Table 3, Fig. 3). This fact seems to suggest transient polymorphism. That is, var. *tenuiliratum* may constitute dimorphism with the pair of var. *denseplicatum* and var. *intermedium*, and arised by some mutation (gene mutation, chromosome aberration, position effect of supergene or other case) from the pair of var. *denseplicatum* and var. *intermedium* earlier than the early Coniacian, and survived until the middle or early Campanian after the decline of the pair of var. *denseplicatum* and var. *intermedium*. As the actual mode of the adaptive strategy of organisms this explanation may be more reasonable. Furthermore, the fact that var. *tenuiliratum* is rarely but actually obtained from the Turonian is reasonably explained only in this case.

Additional consideration on transient polymorphism

Studies on transient polymorphism of living organisms are not as numerous (e. g., KETTLEWELL, 1955, 56; KOMAI et al., 1950; KOMAI, 1956) in comparison with those on balanced polymorphism (e. g., KOMAI and EMURA, 1955; CAIN and SHEPPARD, 1954; SMITH, 1973; on many species of butterflies and many species of *Drosophila* by many geneticists). This is merely because long period is required for a study of transient polymorphism.

Transient polymorphism is the polymorphism existing during the period when an allele is being replaced by a superior one (MAYR, 1970).

As the polymorphism mentioned here is represented by two phenotypes (var. *tenuiliratum* and the sexual couple of var. *denseplicatum*), we can consider that a pair of allele has the relation of dominant and recessive. I consider both cases of dominant mutation and of recessive mutation, since the gene produced by mutation is usually recessive but disadvantageous (I avoid discussing the problems of neutral theory here).

The decision whether a single gene can change the morphology or not depends on the condition if the gene is a part of the polygenes or the major genes. Examples of the polymorphism owing to the mutation of a single major gene are commonly known.

Further, the rate of mutation is known as low as 10^{-5} to $10^{-6}/1$ gene locus (DOBZHANSKY, 1951). In population genetics the cases that the mutation recurrents at a constant ratio μ in each generation $[x_t = x_0 e^{-\mu t}$, t: generation, x_0: frequency of A_1 at the starting generation$]$ and that the back mutation arises $\left[x_t = \frac{\nu}{\mu+\nu} + (1-\mu-\nu)^t\left(x_0 - \frac{\nu}{\mu+\nu}\right),\ \nu\text{: rate of mutation from } A_2 \text{ to } A_1\right]$ (KIMURA, 1960; HAYAMI, 1972, 73a, b) are considered. Here I discuss the change of the gene frequency on the assumption that the change is caused not by recurrent mutation but by natural selection as has commonly been suppossed by evolutionists.

Case of recessive mutant gene: Assuming that var. *tenuiliratum* represents the recessive homozygote, I calculate the relative gene frequencies during the duration from the number of specimens (Tables 13, 14, Figs. 3, 11). The life span of the species is assumed as ten years or so based on the rate of shell secretion calculated from the isotopic study on ammonites by STAHL and JORDAN (1969), the origin of constriction of the molluscan shell studied by UNO (1962) and the ontogenetic pattern of constriction of var. *tenuiliratum* (HIRANO, 1975). The stratigraphic range of var. *tenuiliratum* is from the Coniacian *uwajimensis* zone to the Santonian *amakusensis* zone in Obira and is 9 m. y. in absolute age (HARLAND et al. ed., 1964). In Naibuchi it is from the *uwajimensis* zone to the Santonian *japonicus* zone and is 12 m. y. (Table 1).

Table 13. The change of the gene frequency from Mh4 to Mh6β observed in Naibuchi samples. The case of dominant and that of recessive are both calculated. p is the frequency of the wild type gene.

Age	Horizon	m. y.	Phenotype		Wild type	Case of dominant		Case of recessive	
			d	t	All	p	q	p	q
		—76							
Santonian	Mh6β		36	100	0.265	0.515	0.485	0.143	0.857
	Mhα-β		17	11	0.607	0.779	0.221	0.373	0.627
	Mh6α2		19	34	0.358	0.598	0.402	0.199	0.801
	Mh6α1		9	1	0.900	0.949	0.051	0.684	0.316
		82							
Coniacian	Mh5		4	0	1.000	1.000	0.000	1.000	0.000
	Mh4		7	1	0.875	0.935	0.065	0.646	0.354
		88							
Turonian	Mh3		1	0	1.000	1.000	0.000	1.000	0.000
	Mh2		1	0	1.000	1.000	0.000	1.000	0.000
	Mhl		1	.	1.000	1.000	0.000	1.000	0.000
		94							

Table 14. The change of the gene frequency from Turonian to Santonian observed in Obira samples. The case of dominant and that of recessive are both calculated. p is the frequency of the wild type gene.

Age	Zone	m. y.	Phenotype		Wild type	Case of dominant		Case of recessive	
			d	t	All	p	q	p	q
		—76							
Santonian	japonicus		0	19	0.000	0.000	1.000	0.000	1.000
	amakusensis		22	19	0.537	0.733	0.267	0.319	0.681
		82							
Coniacian	mihoensis		40	3	0.930	0.964	0.036	0.736	0.264
	uwajimensis		10	1	0.909	0.953	0.045	0.699	0.301
		88							
Turonian	teshioensis		35	0	1.000	1.000	0.000	1.000	0.000
	hobetsensis		60	0	1.000	1.000	0.000	1.000	0.000
	labiatus		5	0	1.000	1.000	0.000	1.000	0.000
		94							

Because the relative frequency of specimens is the average value in each zone, the absolute age of the middle part of each zone should be employed for the following calculation. The number of the generation follows that $6 \cdot 10^5$ in the former and $9 \cdot 10^5$ in the latter. Here, the relative frequency of the dominant gene is p, and that of the recessive gene is q (Tables 13, 14). When the wild type gene is A_1 and the mutant gene is A_2, three genotypes, A_1A_1, A_1A_2 and A_2A_2 are available. If A_2 be recessive, the wild type composed of A_1A_1 or A_1A_2, and the mutant type A_2A_2 would be observed. This means that the relative frequency of the mutant gene q of the mutant type A_2A_2 is calculated as the root of the ratio of the mutant type specimens.

Here I introduce the coefficient of selection, s (if the recessive individuals fitted better than the dominant individuals to the natural selection, s is negative) and the following formula of the change of the gene frequency, $\Delta x=\frac{sx(1-x)^2}{1-s(1-x)^2}$, x: gene frequency, is obtained. When s is much smaller than 1, we can substitute the above formula by the following equation, $\frac{dx}{dt}=sx(1-x)^2$.

In my study the absolute value of s is also assumed to be much smaller than 1. To solve the above formula, we can apply the transformation $z=\log_e\left(\frac{x}{1-x}\right)+\left(\frac{1}{1-x}\right)$ (KIMURA, 1960). Then, $\frac{dx}{dt}=sx(1-x)^2$ becomes $\frac{dz}{dt}=s$ and the value of z at the t generation is given in the formula, $z_t=st+z_0$. Here z_0 is the value of z at the initial generation and t is the generation. The generation has already estimated and now I can obtain the value of s. That is, in Obira $s=-3.5\cdot10^{-6}$ and in Naibuchi $s=-4.5\cdot10^{-6}$. The values are reasonably small as we can assume from the fact that these two types replaced through 9 m. y. or 12 m. y., and the values are one figure smaller than that of *Cryptopecten vesiculosus* (HAYAMI, 1973b).

Case of dominant mutant gene: Likewise the following values are obtained in Obira and Naibuchi, and the values of s are the figures of 10^{-6} in the two places.

Obira	$s=3.9\cdot10^{-6}$
Naibuchi	$s=3.9\cdot10^{-6}$

Discussion: As mentioned in the early part of this chapter, there are no data which are directly comparable with the above results.

Before going further I propose some values with regard to the fixation of mutant genes. As the small s worked effectively, the effective population size (Ne) of the species is assumed to exceed 10^6. The probability of fixation (U) is $2s$ in the case of the complete dominance and $U=\sqrt{2s/(\pi N)}$ in the case of the complete recessive.

The generation at which the relative frequency of the mutant attains 0.5 is calculated below.

1. Case of recessive

Obira	$t=6.3\cdot10^5$
Naibuchi	$t=3.2\cdot10^5$

2. Case of dominant

Obira	$t=1.0\cdot10^5$
Naibuchi	$t=9.2\cdot10^5$

That is, the relative frequency of the mutant gene attained 0.5 after about 1/10 total generations passed in Obira (1/14 in recessive case and 1/9 in dominant case) and about 1/13 total generations (in dominant case) or 1/38 (in recessive case) passed in Naibuchi.

In either case, dominant or recessive, the analyzed results indicate that the wild type of *G. denseplicatum* did not become extinct as it might appear but the wild type was gradually replaced by the mutant type, caused by the difference of fitness for selection in the order of 10^{-6}.

Furthermore, the mutant type of *G.*

Explanation of Plate 33

All figures ×0.8

1. *G. denseplicatum* var. *denseplicatum*. I-471, from the Miho River, Naibuchi. Horizon: Mh3 Collected by M. KAWADA, a: ventral view, b: lateral view.
2. *G. denseplicatum* var. *tenuiliratum*. I-4034, from the Second stream of the eighteenth forestry district, Naibuchi. Horizon: Mhl-3. Collected by M. KAWADA, a: ventral view, b: lateral view.
3. *G. denseplicatum* var. *intermedium*. I-185, from Makaushuppe, a branch of the Sanushibe River, Hobets. Horizon: uncertain. Collected by YABE, H.


1a


2a


2b


1b


3

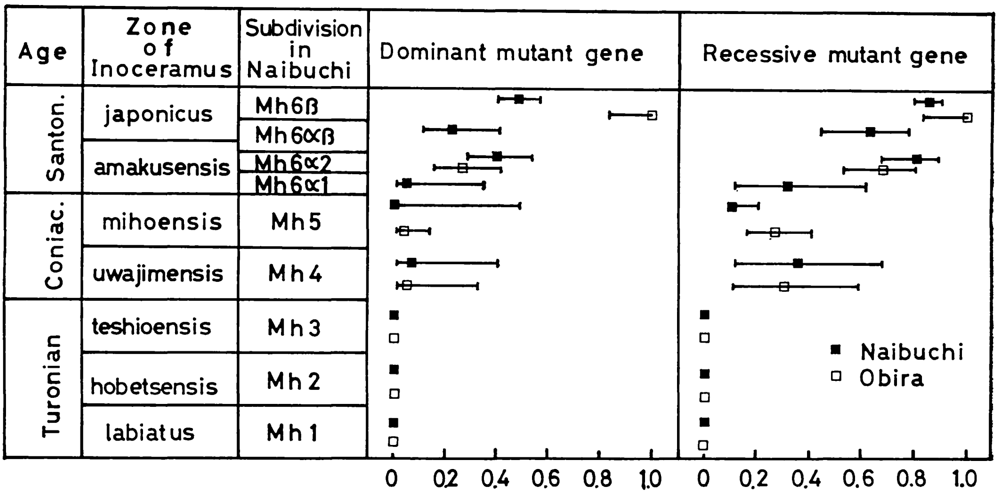

Fig. 11. Historical change of the mutant gene frequency.
95% confidence interval is shown by a bar.

denseplicatum disappears in the middle or early Campanian and *G. striatum* appears about the time. In the detailed biostratigraphic studies (MATSUMOTO, 1943, 59a; KANIE, 1966) *G. striatum* is said to overlap in time with the mutant type of *G. denseplicatum*. The morphological resemblance between these two species has already been mentioned by MATSUMOTO (1941). Transient polymorphism may have also occurred in this case. If this assumption is true, the extinction of *G. denseplicatum* in the middle or early Campanian also is not caused by a drastic change of the physical environment or similar kinds of other change.

Conclusion

The two nominal species, *G. denseplicatum* and *G. intermedium*, are explained as a sexual dimorphic pair on the basis of morphometrical distinction found only in the adult shell, insignificant chronological change of the numerical ratio of the specimens, commonly observed relation of coexistence in Hokkaido and Sakhalien, the same geographic and the stratigraphic distribution. They are here degraded to *G. denseplicatum* var. *denseplicatum* and *G. d.* var. *intermedium*, respectively.

The ratio of the frequencies of another nominal species, *G. tenuiliratum*, to var. *denseplicatum* and var. *intermedium* shows the same pattern through the duration in the two areas, Obira and Naibuchi, notwithstanding that the chronological changes of the frequencies of the pair of var. *denseplicatum* and var. *intermedium* are in different patterns between these two areas. In addition to this fact, in virtue of the consideration of the morphometric analyses, the geographic and the stratigraphic distribution, this nominal species actually seems to belong to the same species, *G. denseplicatum*, and transient dimorphism is the most reasonable relation. Here *G. tenuiliratum* is degraded to *G. denseplicatum* var. *tenuiliratum*.

The change of the relative gene frequency is obtained for the cases of the dominant mutant gene and the recessive mutant gene on the supposition that the change is not caused by recurrent mutation but by natural selection, and the coefficient of selection is obtained as the figures of 10^{-6}. Var. *denseplicatum* and var. *intermedium* may have seemingly become extinct, but they actually survived till the end of Santonian or the early Campanian. They were, however, gradually replaced by the individuals of another phenotype (dimorphic pair) which probably had higher fitness. This seems to be significant in the evolutionary studies not only of ammonoids but also many other taxa.

Speciation is a function of population size, the degree of initial variation of the gene pool in the peripheral isolate and the degree of fitness of the peripheral isolate. Therefore there can be several models on evolution. Some cases may fit phyletic gradualism and others may fit punctuated equilibria. The present case is an example of the evolutionary mode by the transient polymorphism, and it follows that the model proposed by HAYAMI (in HAYAMI and OZAWA, 1975) is supported as one of the major models of evolution not only by genetical theory but also by palaeontological evidence.

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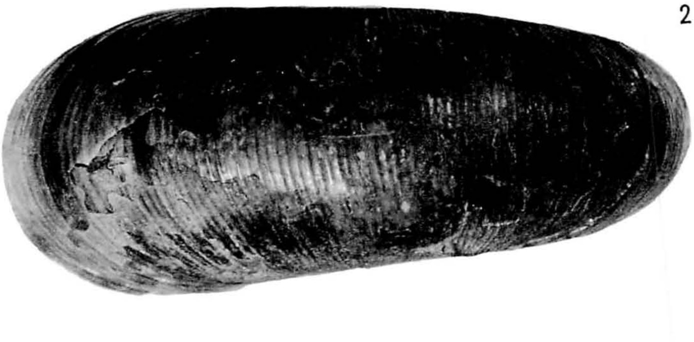
Explanation of Plate 34

All figures ×0.8

1. *G. denseplicatum* var. *denseplicatum* (a fully grown up specimen). R2113-1, from the Obirashibe Riber, Obira. Horizon: *I. hobetsensis* zone. Collected by HIRANO and TANABE.
2. *G. denseplicatum* var. *intermedium*. Ventral view of the Pl. 33, Fig. 3.

1



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後期白亜紀アンモナイト *Gaudryceras* の表現型置換：日本および樺太より得られた *G. denseplicatum*, *G. intermedium*, *G. tenuiliratum* の標本について，個体発生様式の生物測定，地理的・層序的分布，個体数比等の検討をしたところ，松本 (1941) に指摘され懸案となっていた上記三者の関係が次の様に説明できることが判った。すなわち，*G. denseplicatum* と *G. intermedium* は，これまでに知られている形態発生上の著しい類似の他に，共産の事実，分布地域及び時代の一致，更に全存続期間を通じての一定の個体数比の維持から性的二型と判断される *G. tenuiliratum* はこの両者に共通する形態的特徴を有し，北海道小平及び樺太内淵で，上記二型との個体数比の変遷を求めると同じパタンを示す。これらの間の関係を説明するために，三つの仮説をたて検討した結果，*G. tenuiliratum* は前記二型と同一種で過渡的多型として説明するのが最も合理的と思われた。そこで若干の集団遺伝学的吟味を試み系統発生について考察した。

平野弘道

Explanation of Plate 35

1. *G. denseplicatum* var. *intermedium*. N191-p, from the Santan River, Naibuchi. Horizon: Mh6α. Collected by T. MATSUMOTO × 0.8


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Trans. Proc. Palaeont. Soc. Japan, N. S., No. 109, pp. 259-279, pls. 36-38, April 30, 1978

686. ADDITION TO THE MESOZOIC PLANTS FROM THE AKAIWA FORMATION (UPPER NEOCOMIAN), THE ITOSHIRO GROUP, CENTRAL HONSHU, INNER ZONE OF JAPAN*

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Abstract. This paper deals with the additional palaeobotanical descriptions of newly discriminated species to the Akaiwa flora formerly described by us (1976) in the present transactions. The newly described species are as follows; *Gleichenites nipponensis*, *Coniopteris saportana*, *Adiantopteris sewardii*, *A. toyoraensis*, *Raphaelia diamensis*, *Dictyozamites* cfr. *obliquus*, *Nilssonia schmidtii*, *Butefia?* sp., *Ginkgoites paradiantoides*, *Arctobaiera?* sp., *Elatocladus* sp. C, *E.* sp. D, *Protodammara* sp. and *Carpolithes* sp. In addition, both *Gleichenites porsildii* and *Cladophlebis* ex gr. *williamsonii* are redescribed with some emendation and additional remarks respectively.

It might be notable that *Raphaelia diamensis*, which has so far been regarded as a Jurassic species, is now found from the Japanese Lower Cretaceous. The occurrence of *Coniopteris saportana*, *Dictyozamites* cfr. *obliquus*, *Nilssonia schmidtii*, *Ginkgoites paradiantoides* and *Protodammara* sp., is the first record in Japan.

After all, the Akaiwa flora is now consisting of 26 genera and 53 species. As formerly mentioned by us, both the Akaiwa flora (late Neocomian) and the underlying Oguchi flora (early Neocomian, the main part of the "Tetori flora") in the Inner Zone of Japan, are similar in composition to the coeval floras in VAKHRAMEEV's Siberian Palaeofloristic Area, but are not so to those in the Outer Zone of Japan.

Introductory

Last year we described the Akaiwa Flora with its comparison with the coeval floras in the Outer Zone of Japan and in the Siberian Palaeofloristic Area formerly proposed by VAKHRAMEEV, and mentioned its significance in the Mesozoic floral change in Japan and her adjacent areas (KIMURA & SEKIDO, 1976b).

Afterwards we collected many more specimens from the Bettokuzure point, of the upper layers of the Akaiwa Formation, the Itoshiro Group, the Tetori (or Tedori) Supergroup, and found additional fifteen new forms among them.

The present work deals with the description of these new forms, most of which are common to the Late Jurassic to the Early Cretaceous floras in the VAKHRAMEEV's Siberian Palaeofloristic Area.

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* Received July 20, 1977; read Jan. 21, 1977 at the annual meeting of the society, Tokyo.

Table 1. Composition and localities of the Akaiwa Flora (KIMURA & SEKIDO, 1977)

Genera & species \ Localities	BK	OS	T	OG	SI	OZ
Equisetites spp. (stem and tubers)	○		○	○	○	
Gleichenites nipponensis OISHI*	○			○		
G. porsildii SEWARD**	○	○			●	
Coniopteris burejensis (ZALESSKY) SEWARD		○		○	○	
C. saportana (HEER) VACHRAMEEV*	○				○	
C. sp. cfr. *C. hymenophylloides* (BRONGNIART) SEWARD	○			●	●	
Birisia onychioides (VASSILEVSKAJA & KARA-MURSA) SAMYLINA			○	○	○	
Asplenium cfr. *dicksonianum* HEER		○			●	
Adiantopteris sewardii (YABE) VASSILEVSKAJA*	○			○	○	
A. toyoraensis (OISHI) VASSILEVSKAJA*	○	○		○	●	
A. spp. (A, B, C)	○	○	○	○	●	
Onychiopsis elongata (GEYLER) YOKOYAMA	○	○	○	○	○	○
Sphenopteris ex gr. *goepperti* DUNKER	○			○		○
S. kochibeana (YOKOYAMA) OISHI	○			○	●	
Cladophlebis ex gr. *denticulata* (BRONGNIART) NATHORST			○	○	●	●
C. (*Osmundopsis*) *distans* (HEER) KIMURA & SEKIDO (MS)	○			○	○	
C. ex gr. *williamsonii* (BRONGNIART) BRONGNIART*	○			○	○	
C. spp.	○	○				
Raphaelia diamensis SEWARD*	○			○	○	
R. spp. (A, B)	○				●	
Dictyozamites cfr. *cordatus* (KRYSHTOFOVICH) PRYNADA	○				●	
D. cfr. *obliquus* SAMYLINA*	○				●	
Nilssonia kotoi (YOKOYAMA) OISHI	○			○	●	
N. lobatidentata VASSILEVSKAJA	○			○	○	
N. nipponensis YOKOYAMA	○			○	○	
N. cfr. *orientalis* HEER			○	●	●	●
N. schmidtii (HEER) SEWARD*	○				●	
Tetoria endoi KIMURA & SEKIDO	○			○		
Butefia? sp.*	○				●	
Ginkgoites digitata (BRONGNIART) SEWARD	○			○	○	
G. huttonii (STERNBERG) BLACK	○			○	○	
G. paradiantoides (SAMYLINA) KIMURA & SEKIDO*	○				○	
G. sibirica (HEER) SEWARD	○			○	○	
Ginkgoidium nathorstii YOKOYAMA	○			○	●	
Pseudotorellia sp.	○		○	○	●	

Czekanowskia sp.	○			●	●	
Arctobaiera? sp.*	○				●	
Leptostrobus sp.	○				●	
Podozamites angustifolius (EICHWALD) HEER	○				○	
P. ex gr. *lanceolatus* (LINDLEY & HUTTON) BRAUN	○			○	○	
P. reinii GEYLER	○		○	○	○	
Elatocladus spp. (A, B, C*, D*)	○			●	●	
Pityophyllum lindstroemi NATHORST	○			○	●	
Protodammara sp.*	○					
Xenoxylon latiporosum (CRAMER) GOTHAN (MS)	○	○		○	○	
Carpolithes sp.* (*Ginkgoites* seeds?)	○				●	
Seeds	○					
Problematica	○	○				

*; Additional forms here described to our previous work (KIMURA & SEKIDO, 1976b, p. 346, tab. 2).
**; Additional description and illustration to our previous work.
BK; Bettokuzure, southwestern slope of Mt. Hakusan (2,702 m), Shiramine-mura, Ishikawa-gun, Ishikawa Prefecture.
OS; Osugidani, Irahara, Shiramine-mura, Ishikawa-gun, Ishikawa Prefecture.
T; Tamodani, Hambara, Izumi-mura, Ono-gun, Fukui Prefecture.
OG; Common or allied forms to the underlying Oguchi Flora (Early early Cretaceous in age).
SI; Common or allied forms to the floras ranging from the Late Jurassic to the Early Cretaceous in age in VAKHRAMEEV's Siberian Palaeofloristic Area.
OZ; Common or allied forms to the coeval floras with the Akaiwa Flora in the Outer Zone of Japan.
(open circles and solid ones showing common and allied forms respectively).

Table 1 shows the composition and localities of the Akaiwa Flora newly edited by us, among which the species with an asterisk and two asterisks are described in this paper.

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Systematic description

Filicales

Family Gleicheniaceae

Genus *Gleichenites* SEWARD, 1910: 351

Gleichenites nipponensis OISHI

Pl. 37, figs. 4, 5; Pl. 38, figs. 3, 4;
Text-fig. 1

Gleichenites nipponensis OISHI; OISHI, 1940, p. 202, pl. 3, figs. 2, 3, 3a (Kaisekiyama, the Ryoseki formation; Kuwashima, the Oguchi formation); KIMURA, 1958, p. 13, pl. 1, figs. 2, 3; pl. 3, fig. 4; pl. 4; fig. 5; text-figs. 1, 2 (Mochiana, the Upper Jurassic Kuzuryu group).

Description:—Ultimate (the last) pinnae mostly long and narrow, nearly parallel-sided, 4 mm wide, straight and attached at interval of 7 mm to the axis at a wide angle. Pinnules set closely, small, semicircular with broadly rounded apex, typically 1.3 mm long and 1.2 mm wide, upper surface strongly convex, and attached by the whole base perpendicularly to the pinna axis; midnerve indistinct, forking at its tip, sending off a pair of lateral, forked once. Sori circular, 0.5 mm in diameter, consisting of five sporangia with a prominent central placenta. Sori occurring on each side of midnerve, but often restricted to one on the acroscopic side. (The details of sporangia not known).

Several fragments of penultimate pinnae were newly obtained. Pl. 37, fig. 5 shows possibly an apical portion of a penultimate pinna in which ultimate pinnae are reduced in length, their apical halves are not segmented into pinnules but only shallowly lobed and ending with acutely pointed apex. Text-fig. 1 (a-d) shows outline of sterile pinnae (la) and fertile ones (lb) and position of sorus (lc-d).

Remarks:—The present specimens agree well with the original ones described by OISHI from Kuwashima (or Kuwajima) of the Oguchi formation and also with those by KIMURA from Mochiana of the Kuzuryu group.

In the present material the sori each composed of five sporangia are seen clearly but their cells were not visible.

The present species resembles *Gleichenites vegagrandis* HERBST (HERBST, 1962a, p. 145, figs. 11, 14-15) and *G. san-martini* HALLE (Ditto, p. 142, figs. 1-5, 12-13, 16) from the Lower Cretaceous (?) Baqueró formation, Patagonia and also *G. juliensis* HERBST (HERBST, 1962b, p. 188, pl. 1, figs. 1-5; text-figs. 1, 2) from the Middle Jurassic of Patagonia. But *Gleichenites nipponensis* differs from the above three in its venation and fewer of sori on a pinnule.

KRASSILOV regarded *G. nipponensis* as the fertile frond of his cyatheaceous *Alsophilites nipponensis* (KRASSILOV, 1967, p. 113-117). But the Japanese specimens clearly have *Gleichenia*-like sori.

Occurrence:—Rare.

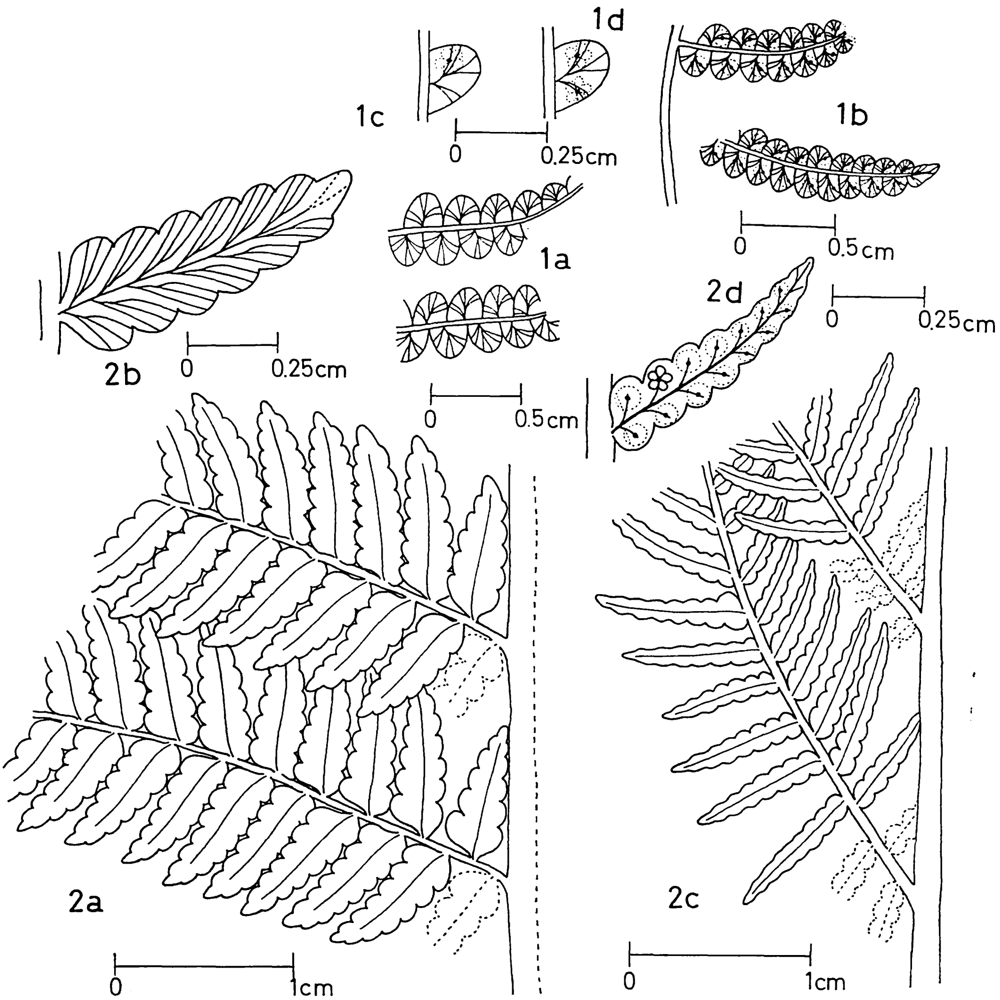
Specimens:—BK6-010 (A-F).

Gleichenites porsildii SEWARD

Pl. 37, fig. 3; Text-fig. 2

Gleichenites aff. *porsildii* Seward; KIMURA, 1975, p. 70, pl. 7, figs. 1-3; pl. 8, fig. 2; text-fig. 4-4a, b (Uppermost member of the Tamodani formation); KIMURA & SEKIDO, 1976b, p. 351, pl. 36, fig. 2; text-fig. 2 (Bettokuzure and Osugidani, the Akaiwa formation).

Description:—Proximal portion of a frond with three incompletely preserved pinnae. Pinnules fertile, long and narrow, nearly parallel-sided, ending with rounded apex, typically 0.8 cm long and 1.2 mm wide at the middle portion, and the upper surface strongly convex; margins lobed except near apex, a basal pair of lobes expanded. Midnerve of pinnule distinct, persisting to the tip, sending off once or sometimes twice forking secondaries, the number of secondaries corresponding to that of lobes. Sporangia all shed leaving, the depression and the trace of a central placenta on the centre of each lobe, but



Text-figs. 1-2: 1 (a-d) ; *Gleichenites nipponensis* Oishi. 1a ; sterile pinnae (BK6-010A). 1b ; fertile pinnae, showing venation and position of placentae (small solid circles) (BK6-010B). 1c-d ; showing sori reconstructed from their depressions, enlarged partly from 1b. 2 (a-d) ; *Gleichenites porsildii* Seward. 2a ; sterile pinnae (BK6-063). 2b ; showing detailed venation enlarged partly from 2a, each secondary nerve is forking once, then an apical branch forking again, but a proximal one does not so in general. 2c ; fertile pinnae (BK6-028) drawn from Pl. 37, fig. 3 (BK6-028). 2d : showing detailed venation and position of sori, and a sorus reconstructed from its depression, in which solid circles show placentae and open circles with dotted line show the depression of sorus. (Parts drawn by dotted line are imaginary).

judging from the shape of depression, sori circular in form, 0.6 mm in diameter and probably consisting of several sporangia.

Sterile pinnules set closely, similar in form to fertile ones, but broader than fertile ones and secondary nerves forked twice.

Text-fig. 2 (a-d) shows outline of sterile pinnae (2a), venation (2b), fertile pinnae seen also in Pl. 37, fig. 3 (2c) and details of a pinnule together with a restored sorus (2d).

Remarks:—We describe two finer specimens than those formerly illustrated by us. Judging from its thick rachis, the present specimen shown in Pl. 37, fig. 3 might represent the proximal portion of a frond. Similar specimens, though representing the apical portions of fronds, to present one were already described by us. The present and our former specimens are referable to those originally described by SEWARD (1926, p. 76, pl. 6, figs. 18-19, 24, 30) from the Cretaceous of Greenland, that by SEWARD & CONWAY (1935, p. 5, pl. 1, fig. 5) from the same bed, those by KRASSILOV (1967, p. 107, pl. 9, figs. 1-2) from the Lower Cretaceous of Southern Primorye, and those by BELL (1956, p. 63, pl. 14, fig. 4; pl. 19, fig. 4; pl. 21, figs. 2, 3) from the Lower Cretaceous of Western Canada.

Cfr. *Gleichenites porsildii* recently described by SAMYLINA (1976, p. 21, pl. 2, fig. 1) from the Lower Cretaceous (dated as Aptian by her) of the Omsukchan Coal-Field on the right bank of the Kolyma is indistinguishable from our sterile specimens.

Occurrence:—Common.

Specimens:—BK6-028, BK6-063.

Family Dicksoniaceae

Genus *Coniopteris* BRONGNIART, 1849: 26

Coniopteris saportana (HEER) VACHRAMEEV

Pl. 36, fig. 1; Pl. 37, fig. 6; Pl. 38, fig. 2;
Text-fig. 3

Dicksonia saportana HEER; HEER, 1876, p. 89, pl. 17, figs. 1, 2; pl. 18, figs. 1-3 (Jurasso-Cretaceous of the Bureja and the Amur).

Dicksonia gracilis HEER; HEER, 1876, p. 92, pl. 17, fig. 3 (Jurasso-Cretaceous of the Bureja).

Coniopteris saportana (HEER) VACHRAMEEV; VAKHRAMEEV, 1958, p. 79, pl. 4, fig. 4; pl. 5, fig. 3 (Lower Cretaceous of the Lena); VAKHRAMEEV & DOLUDENKO, 1961, p. 56, pl. 4, figs. 3, 4 (Jurasso-Cretaceous of the Bureja); LEBEDEV, 1965, p. 66, pl. 5, figs. 1-4; pl. 6, fig. 1; pl. 7, figs. 4-5; text-fig. 15 (Upper Jurassic of the Zeia); SAMYLINA, 1964b, p. 61, pl. 10, figs. 3, 4a (Lower Cretaceous of the Zyrianka Coal-Field); 1976, p. 29, pl. 7, figs. 3-6 (Lower Cretaceous of Omusukchan Coal-Field); VASSILEVSKAJA, 1966, p. 52, pl. 1, fig. 3 (Lower Cretaceous of the Lena).

Description:—Frond at least bipinnate. Rachis comparatively thick, 2 mm across at the middle portion of frond (or penultimate pinna) with a prominent median groove on the upper surface and thinly winged along both lateral sides. Pinnae elongate-oval or elongate-lanceolate in form, flexible, more than 9 cm long and 2.2 cm wide at the widest portion and attached alternately to the rachis at an angle of 35 degrees, then bending outwards, the distance being 1.25 cm. Pinna axis slender and with a distinct median groove. Pinnules katadromic in order, set closely, rhomboidal in form, acuminately pointed at apex, typically 1.2 cm long and 3 mm wide at the widest portion, decurrent at base, distal half of margins serrate, serration typically 6-7 in number and directed forwards. Nerves *Sphenopteris*-type, midnerve originating near the basiscopic base, slightly sinuous and sending off 6-7 pairs of simple or rarely once forking secondaries directed forwards. The first basiscopic pinnules specialized, triangular in form, the apex sometimes bilobed and originating below the base of the pinna axis and distinctly decurrent to form wings along both sides of main rachis. Fertile pinnae and pinnules, similar in form to sterile ones, but mostly reduced in size, 0.4-0.5 cm long and 1.3 mm wide at the widest portion, in the largest one, more than 1 cm long and 7 mm wide at the widest portion. Sori circular or oblong, variable in size, 0.2-1 mm across, one or rarely two in number on the distal part of each serration, or on the distal part of the acroscopic secondary nerves in case of larger pinnules.

Several specimens were obtained. Pl. 36, fig. 1 shows a part of sterile frond in which the first basiscopic pinnules are clearly seen. Pl. 38, fig. 2 shows a fertile pinna on the apical portion of a frond, attached remotely to the fairly thick rachis, 2 mm across. Pl. 37, fig. 6 shows two fertile pinnules enlarged presumably on the proximal portion of a frond, 1 cm long and 0.5 cm wide, deeply lobed, in which sori are terminated at the distal edge of each acroscopic secondary nerve in each lobe, and the laminae, except the sterile parts, are somewhat reduced. Text-fig. 3 shows outline of sterile and fertile pinnae, pinnules and their venation, and presumable transverse section of a rachis.

Remarks:—The present specimens agree with *Coniopteris saportana* known from various parts of East Siberia. The present specimens resemble HEER's original specimens in general outline of sterile pinnules and venation in which the secondaries are directed forwards, but with entire margins.

The present specimens agree closely with those described by LEBEDEV (1965) from the Upper Jurassic of the Zeia in outline of pinnules with serrate margins, venation, the form of first basiscopic pinnules and the position of sorus.

This species has been regarded as one of the characteristic ones in the VAKHRAMEEV's Siberian Palaeofloristic Area. This is the first record of *Coniopteris saportana* from Japan.

Occurrence:—Probably common.

Specimens:—BK6-031, BK6-037, BK6-042, BK6-048, BK6-092.

Family Pteridaceae?

Genus *Adiantopteris* VASSILEVSKAJA 1968: 49

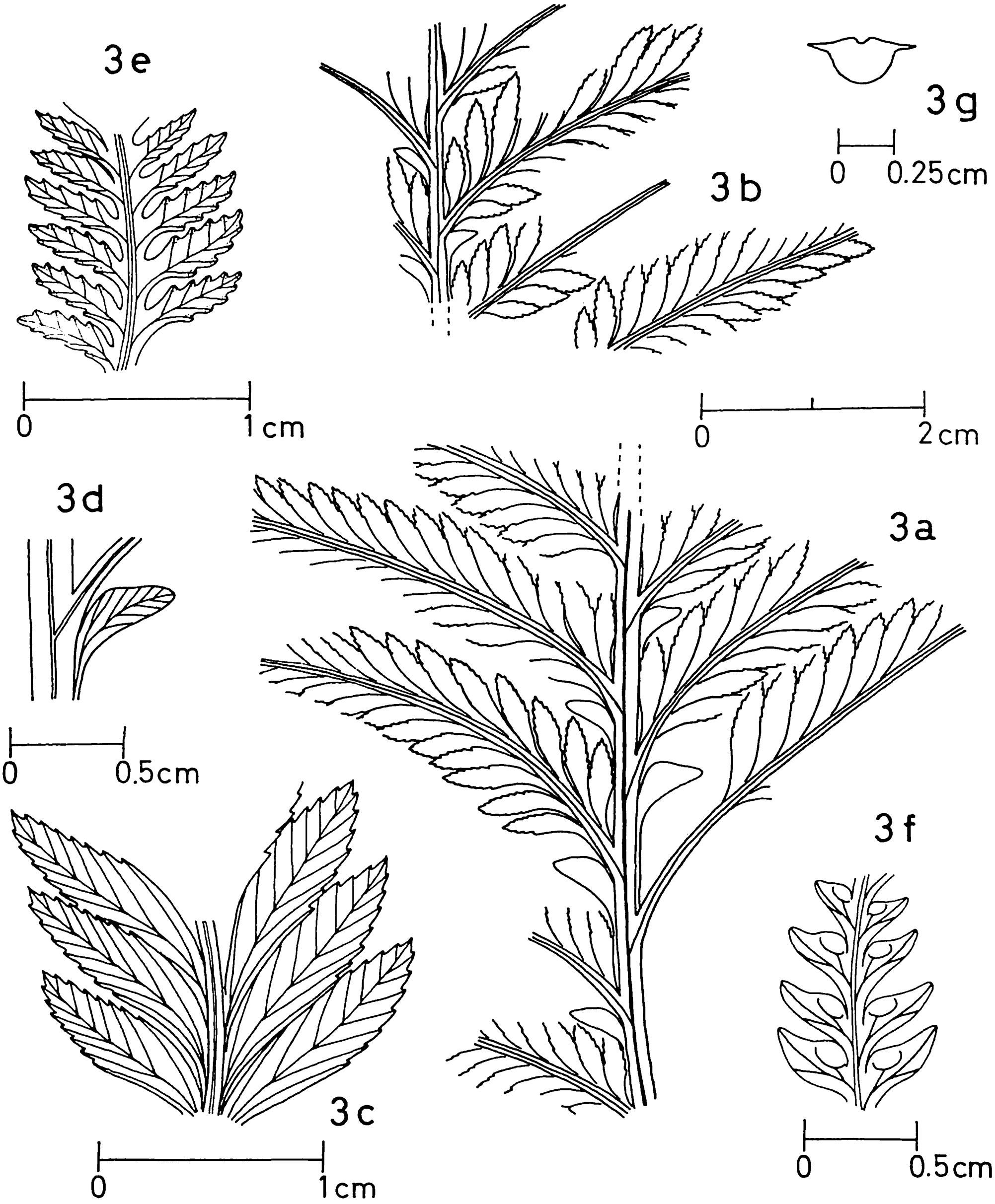
We use *Adiantopteris* VASSILEVSKAJA, 1968 instead of *Adiantites* GOEPPERT, 1836, the meaning of which is confused. We describe new material of *Adiantopteris sewardii* and *A. toyoraensis* in which we include *'Adiantites* sp. D' of KIMURA & SEKIDO, 1976b. We rename *Adiantites* sp. A, sp. B and sp. C of KIMURA, 1975 and KIMURA & SEKIDO, 1976b as *Adiantopteris* sp. A, sp. B and sp. C respectively.

Adiantopteris sewardii (YABE) VASSILEVSKAJA

Pl. 36, figs. 1, 2; Pl. 37, fig. 7A; Text-fig. 4

Adiantites sewardi YABE; YABE, 1905, p. 39, pl. 1, figs. 1-7 (Nagdong Group, Korea), fig. 8 (Kami-Uchinami, an equivalent of the Oguchi formation); OISHI, 1940, p. 233, pl. 7, figs. 1, 5 (Iwaidani and Kuwashima, the Oguchi formation), fig. 6 (a reproduction of YABE's pl. 1, fig. 3); JÄNICHEN & KAHLERT, 1972, p. 966, pl. 1, figs. 2, 3, 5 (Jurasso-Cretaceous? of Mongolia).

Adiantites aff. *sewardi* YABE; VAKHRAMEEV, 1958, p. 83, pl. 8, figs. 2, 3 (Lower Cretaceous of the Lena).



Text-fig. 3: *Coniopteris saportana* (HEER) VACHRAMEEV. a-d; sterile, e-f; fertile. a-b; a part of sterile frond (BK6-037 and BK6-048). c; showing outline and venation of normal pinnules, drawing from 3a. d; showing outline and venation of a first basiscopic pinnule, drawing from 3a. e; a fertile pinna fragment on the distal part of a frond, showing outline and venation of pinnules, and position of sorus (BK6-031). f; a part of fertile pinnule probably on the proximal portion of a frond, showing outline and venation, with deeply lobed margins, and position of sorus (BK6-042). g; a presumable transverse section of rachis with a prominent median groove above, rounded below and lateral expansions due to wings of laminae above.

Adiantopteris sewardii (YABE) VASSILEVSKAJA; KRASSILOV, 1967, p. 123, pl. 20, figs. 1, 2 (Lower Cretaceous of Southern Primorye).

Description:—Rachis slender, 0.5 mm thick, with smooth surface, bearing subopposite lateral pinnules. Lateral pinnules with short stalk, laminae somewhat inequilateral, broadly oblanceolate in form, with cuneate base, distal margin irregularly double-serrate or lacerate, and distal half of lateral margins shallowly serrate. Nerves usually prominent, arising from two in the stalk, branching throughout and showing little tendency to form strong marginal nerves, 16-18 in number per cm in density at the middle part of lamina. Apical pinnules and fructification not known.

Several detached pinnules and one fragment of a frond were obtained. Pl. 37, fig. 7A (BK6-046) shows a fragment of a frond with three broken pinnules and Pl. 36, fig. 2 (BK6-003) and fig. 1 show detached pinnules. Text-fig. 4 shows outline of pinnules and their venation drawn from BK6-046 and BK6-003 respectively.

Remarks:—This species is less common in the Akaiwa Formation than the Oguchi formation. The present specimens, though incomplete, agree with YABE's original specimens, especially with his pl. 1, fig. 3, except the venation. All nerves appear to originate from the top of stalk in YABE's illustration, while in the present specimens, nerves are arising two in the stalk, then branching throughout, as the nerves of *Ginkgo biloba* do. We imagine that the veins are imperfectly represented in YABE's figures.

Occurrence:—Not common.

Specimens:—BK6-003, BK6-046 and many small fragments of pinnules.

Adiantopteris toyoraensis (OISHI) VASSILEVSKAJA

Pl. 36, fig. 3; Text-fig. 5

Adiantites toyoraensis OISHI; OISHI, 1931, p. 11, (name only); 1940, p. 235, pl. 7, figs. 2, 2a, 3 (non figs. 4, 4a) (Upper Jurassic Kiyosué formation); JÄNICHEN & KAHLERT, 1972, p. 967, pl. 2, figs. 1, 2 (Jurasso-Cretaceous? of Mongolia).

Adiantites sp. D; KIMURA & SEKIDO, 1976b, p. 358, pl. 36, fig. 4; text-fig. 8 (Osugidani, the Akaiwa Formation).

Description:—Incompletely preserved pinnate lateral pinnules, bases missing. Laminae small, ovate in form, with a median sinus and with serrate outer margin, 2 cm long and about 1.5 cm wide at the widest portion. Nerves divergent from the point of attachment, repeatedly forking dichotomously, 18 per cm in density at the middle part of lamina. Fructification not known.

Text-fig. 5 shows two pinnate lateral pinnules and their venation.

Remarks:—The present incomplete specimen agrees in pinnule outline and venation with the original specimens described by OISHI from the Upper Jurassic Kiyosué formation, Yamaguchi Prefecture.

This species resembles *Adiantopteris gracilis* VASSILEVSKAJA known widely from the Upper Jurassic-Lower Cretaceous of East Siberia (VASSILEVSKAJA, 1957, 1966; VASSILEVSKAJA & PAVLOV, 1963; SAMYLINA, 1976).

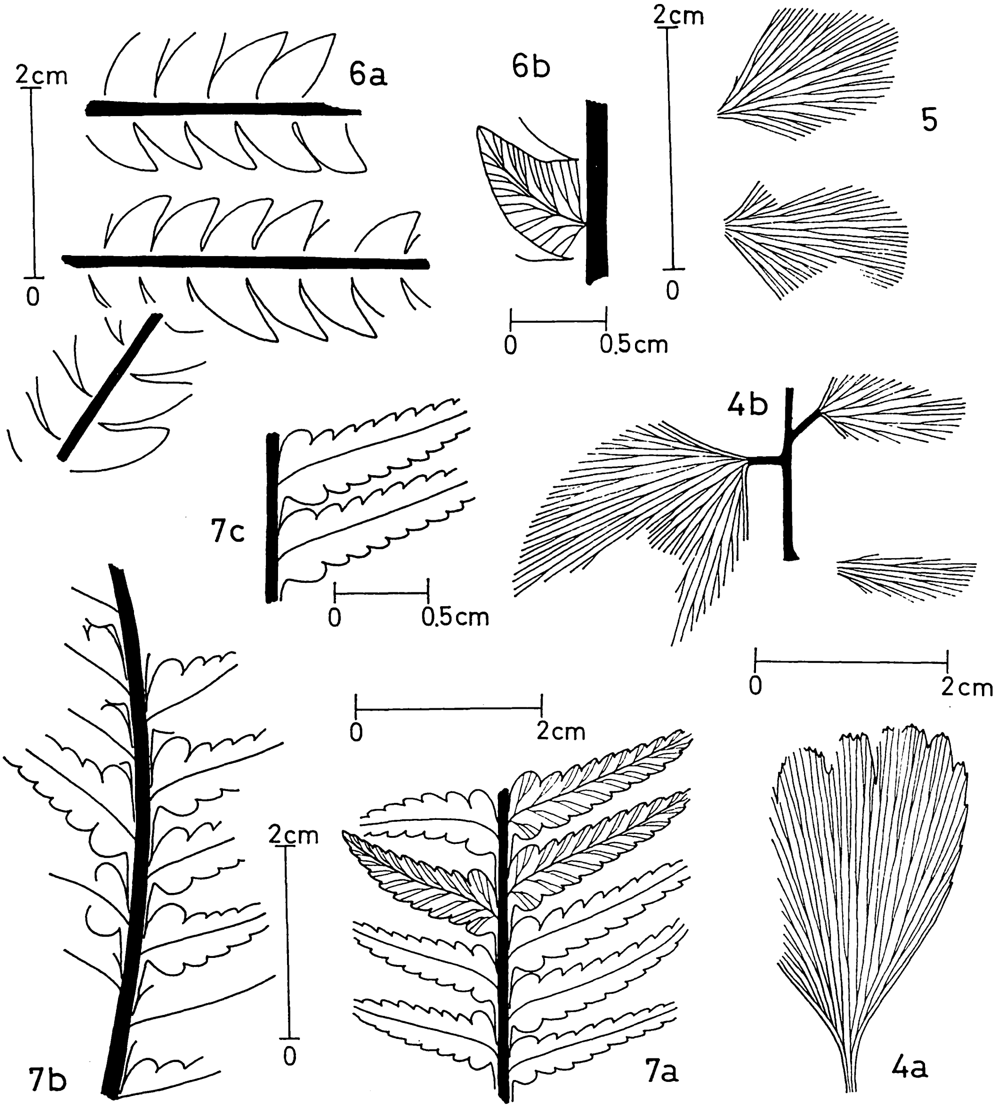
Occurrence:—Rare.

Specimen:—BK6-081.

Unclassified ferns

Form-genus *Cladophlebis* BRONGNIART, 1849: 105

From the Akaiwa Formation and its



Text-figs. 4-7. 4 ; *Adiantopteris sewardii* (YABE) VASSILEVSKAJA. 4a ; a lateral pinnule preserved almost completely, drawn from Pl. 36, fig. 2 (BK6-003), showing outline and venation of pinnule. 4b ; a part of pinna with three incompletely preserved pinnules with short stalk. 5 ; *Adiantopteris toyoraensis* (OISHI) VASSILEVSKAJA, showing two lateral pinnules and their venation, drawn from Pl. 36, fig. 3 (BK6-081). 6 ; *Cladophlebis* ex gr. *williamsonii* (BRONGNIART) BRONGNIART. 6a ; three detached pinnae drawing from Pl. 37, fig. 2 (BK6-033), showing general outline of pinnules. 6b ; showing venation drawing from 6a. 7 ; *Raphaelia diamensis* SEWARD. 7a ; showing venation (BK6-017). 7b-c ; showing outline of pinnules, the first pair of lobes is distinctly specialized in form and each lamina is decurrent to axis to form a wing (BK6-025 and BK6-047).

equivalents, the following *Cladophlebis* species have been known ; *Cladophlebis* ex gr. *denticulata* (BRONGNIART) NATHORST, *C. distans* (HEER) YABE (non FONTAINE), *C. williamsoni* (BRONGNIART) var. *tenuicaulis* THOMAS and *C.* sp.

We recently obtained good specimens from Bettokuzure of the Akaiwa Formation, assignable to *C.* ex gr. *williamsonii* and regarded here *C. williamsoni* var. *tenuicaulis* formerly described by us from the same locality as *C.* ex gr. *williamsonii.*

Cladophlebis ex gr. *denticulata* is similar in form to *C.* ex gr. *williamsonii,* but it is easily distinguishable from each other by examining their venation ; in *C.* ex gr. *denticulata,* the secondaries are once forking dichotomously except the first pair and in *C.* ex gr. *williamsonii,* they are twice forking in general.

By our finding of its fertile pinnae from the Oguchi formation, *Cladophlebis distans* is to be redescribed by us as *Osmundopsis distans* (KIMURA & SEKIDO, 1977 MS) and also *C.* sp. is at present to be referable to some *Gleichenites* species (KIMURA & SEKIDO, 1977 MS).

Cladophlebis ex gr. *williamsonii* (BRONGNIART) BRONGNIART

Pl. 37, fig. 2 ; Text-fig. 6

Cladophlebis williamsoni (BRONGNIART) BRONGNIART var. *tenuicaulis* THOMAS ; KIMURA & SEKIDO, 1976b, p. 354, pl. 36, figs. 5, 6 ; pl. 38, fig. 6 ; text-fig. 5 (Bettokuzure, the Akaiwa Formation).

HARRIS (1961) listed a large number of comparable specimens from many regions including Japan and ranging from the Upper Triassic through the Jurassic. VAKHRAMEEV (1958) and VAKHRAMEEV & DOLUDENKO (1961) gave Cretaceous references.

Description:—Sterile frond probably bipinnate, unknown size. Pinnae set closely, long and narrow, nearly parallel-sided, more than 8 cm long and 1.6 cm wide and attached to the rachis at an angle of 30–45 degrees. Pinnules set closely, broadly triangular in form, falcate, entire, basiscopic margin usually rounded, attached by their whole base at a wide angle, mostly with expanded base and subacutely pointed apex, typically 1.2 cm long and 0.6 cm wide at base. Midnerve persisting to the tip, sending off twice forking secondaries, 3 or 4 pairs on both sides of a midnerve. (No fertile material available).

Text-fig. 6a drawn from the specimen shown in Pl. 37, fig. 2 shows outline of pinnules and Text-fig. 6b shows detailed venation.

Remarks:—It would be noteworthy that such one of the older types of *Cladophlebis* species bearing large-sized pinnules as this species is fairly abundant in the Akaiwa Flora, because they have not been found from the coeval floras in the Outer Zone of Japan.

The present specimens agree in form and venation with a common form of sterile *Todites williamsoni,* though there may be *Cladophlebis* species of this form in the Upper Jurassic and Lower Cretaceous.

Cladophlebis williamsoni var. *tenuicaulis* described by us from the same locality should now be included into the category of *C.* ex gr. *williamsonii.*

Occurrence:—Common.

Specimens:—BK6-033, BK6-034 and many pinna fragments.

Genus *Raphaelia* DEBEY & ETTINGSHAUSEN, 1859 : 219

In our previous paper (1976b), we described *Raphaelia* sp. A and sp. B. Recently we obtained new material among which we discriminated a well-known *Raphaelia diamensis.*

Raphaelia diamensis SEWARD

Pl. 37, fig. 1; Pl. 38, fig. 1; Text-fig. 7

Raphaelia diamensis SEWARD: SEWARD, 1911, p. 15, pl. 2, figs. 28, 29 (Middle Jurassic of Chinese Dzungaria); VAKHRAMEEV, 1958, p. 100, pl. 21, figs. 2-4; pl. 22, figs. 1-3; pl. 23, figs. 1-6; pl. 24, fig. 1 (Upper Jurassic of the Lena); VAKHRAMEEV & DOLUDENKO, 1961, p. 75, pl. 6, fig. 5; pl. 27, fig. 1; pl. 28, fig. 1; pl. 30, fig. 4; text-fig. 22 (Upper Jurassic of the Bureja); SAMYLINA, 1963, p. 79, pl. 9, figs. 1a, 2 (Upper Jurassic of the Aldan); 1964b, p. 69, text-fig. 8 (Upper Jurassic of the Zyrianka Coal-Field); LEBEDEV, 1965, p. 87, pl. 14, fig. 2; pl. 15, fig. 3 (Upper Jurassic of the Zeia).

Raphaelia aff. *diamensis* SEWARD; SAMYLINA, 1963, p. 80, pl. 2, figs. 8-11; pl. 7, fig. 5 (Upper Jurassic of the Aldan).

Description:—Several incomplete pinna fragments. Pinnae elongate-oval or elongate-lanceolate in form, about 1.5 cm wide at the widest portion. Pinnules set somewhat remotely, elongate-triangular in form, 1 cm long and 0.25 cm wide at base, bluntly or acutely pointed at apex, strongly constricted at base, then decurrent to the axis to form a wing and attached at a wide angle to the axis, upper surface strongly convex; margins distinctly lobed, lobes 6-7 in number on each side, with rounded apex directed forwards, the first pair of lobes mostly specialized, acroscopic ones rectangular in form, largest in size, 0.27 mm long and 0.13 mm wide and less directed forwards, basiscopic ones circular or triangular in form, sometimes reaching 0.2 mm in diameter, often decurrent along the pinna axis to form a wing, 0.3 mm wide, other lobes semicircular in form. Midnerve distinct, slightly sinuous, persisting to the tip, sending off twice or once forking secondaries at an acute angle, each lobe receiving one secondary nerve. (No fertile specimens found).

Pl. 38, fig. 1 and Pl. 37, fig. 1 show the upper and lower surfaces of pinnae respectively and Text-fig. 7 shows outline of pinnules and venation in detail.

Remarks:—The present specimens agree with the original ones described by SEWARD from the Middle Jurassic of Chinese Dzungaria and those by several Russian palaeobotanists from the Upper Jurassic rocks in VAKHRAMEEV's Siberian Palaeofloristic Area in past two decades, but the Siberian pinnules are somewhat shorter and broader than those of ours.

In VAKHRAMEEV's Siberian Palaeofloristic Area, this species appears to be restricted in the Middle to Late Jurassic floras, while in Japan this species is abundant in the early Neocomian Oguchi flora (KIMURA & SEKIDO, 1977 MS) and common in the late Neocomian Akaiwa Flora, but has not been recorded in the coeval floras in the Outer Zone of Japan.

Occurrence:—Common.

Specimens:—BK6-017, BK6-025, BK6-041, BK6-047.

Bennettitales

Genus *Dictyozamites* OLDHAM & MORRIS, 1963: 37

As was shown in detail in our previous paper (KIMURA & SEKIDO, 1976a), the Oguchi formation yields abundant and varied *Dictyozamites* species, while from the superjacent Akaiwa Formation, only *D.* cfr. *cordatus* (KIMURA & SEKIDO, 1976b) and a new type here described resembling *D. obliquus* are known in rare occurrence.

Dictyozamites cfr. *obliquus* SAMYLINA

Pl. 38, fig. 5; Text-fig. 8

Comparable specimens: *Dictyozamites obliquus* SAMYLINA; SAMYLINA, 1964a, plate, figs. 10, 11 (Lower Cretaceous of Central Primorye).

Description:—Isolated pinnae, elongate-triangular in form, upper margin straight and lower one arched, both apex and base missing, more than 3 cm long and 0.8 cm wide at basal part. Nerves fine, anastomosing to form fine meshes, upper nerves straight, parallel to the upper margin but lower nerves divergent to the lower margin.

Text-fig. 8 drawn from one of the specimens shown in Pl. 38, fig. 5 show venation in detail.

Remarks:—The present specimens are characterized by the nerves in which upper ones are straight and parallel to the upper margin and lower ones are divergent. Such nerves as in the present specimens has not yet been recorded among the known *Dictyozamites* species, except *D. obliquus.*

Therefore the present specimens might be referable to *Dictyozamites obliquus* originally described by SAMYLINA from the Lower Cretaceous of the Bikin River area, Central Primorye, but we here reserve identifying the present ones fully to SAMYLINA's species because they are too imperfect.

Occurrence:—Rare.

Specimen:—BK6-090 (one slab only).

Cycadales

Genus *Nilssonia* BRONGNIART, 1825: 200

From the Akaiwa Formation, the following *Nilssonia* species have been described; *Nilssonia kotoi* (YOKOYAMA) OISHI, *N. lobatidentata* VASSILEVSKAJA and *N. nipponensis* YOKOYAMA. In addition, we here describe *Nilssonia schmidtii* (HEER) SEWARD.

These *Nilssonia* species are common to those of the coeval floras in VAKHRAMEEV's Siberian Palaeofloristic Area, except *N. kotoi.* But *N. kotoi* is similar in form to *N. sinensis* YABE & OISHI known from the Jurassic of Northern China and *N. borealis* SAMYLINA from the Lower Cretaceous Siliap formation in the Zyrianka Coal-Field.

These *Nilssonia* leaves from the Akaiwa Formation are smaller in size in general than those from the underlying Oguchi formation.

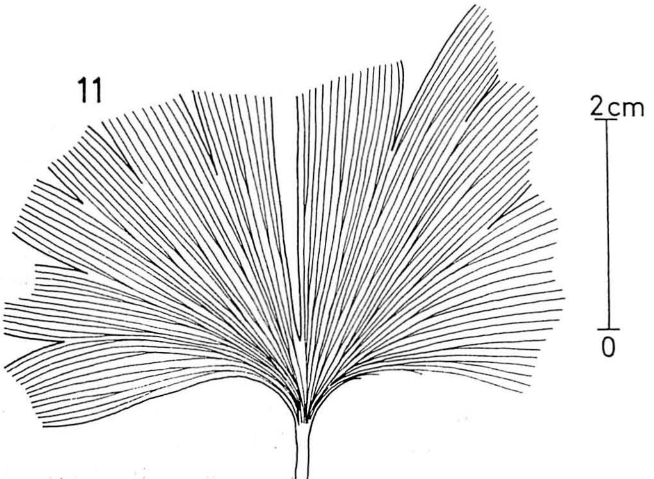
Nilssonia schmidtii (HEER) SEWARD

Pl. 38, fig. 6; Text-fig. 9

Anomozamites schmidtii HEER; HEER, 1876, p. 100, pl. 23, figs. 2, 3; pl. 24, figs. 4-7 (Jurasso-Cretaceous of the Bureja and the Amur).

Nilssonia schmidtii (HEER) SEWARD; SEWARD, 1912, p. 27, pl. 2, figs. 11, 12, 14 (Jurasso-Cretaceous of the Tyrma and the Umalta); KRYSHTOFOVICH, 1916, p. 114, pl. 10, fig. 5 (Lower Cretaceous of Southern Primorye); VAKHRAMEEV & DOLUDENKO, 1961, p. 96, pl. 43, figs. 5, 6 (Jurasso-Cretaceous of the Bureja); LEBEDEV, 1965, p. 92, pl. 22, fig. 3b; pl. 23, fig. 2; pl. 24, fig. 1 (Upper Jurassic of the Zeia).

Description:—Several isolated leaf-fragments. Leaves more than 4.7 cm long and 2.8-1.6 cm wide at the middle portion of lamina. Lamina covering the upper surface of rachis, irregularly segmented, segments 0.5-1.3 cm wide, quadrilateral in form, lateral and distal margins of narrow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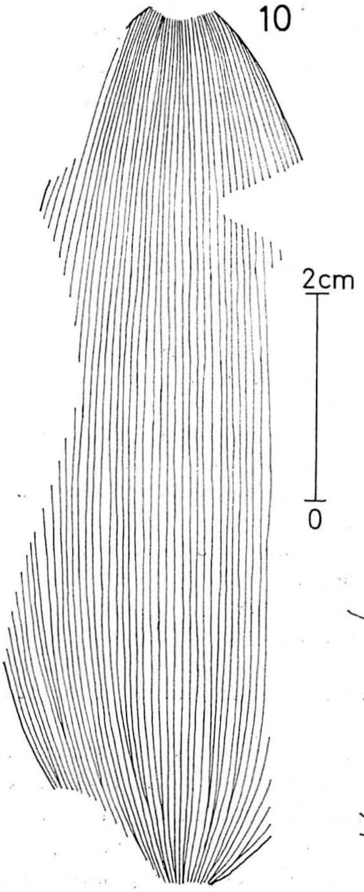
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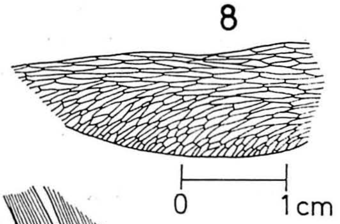
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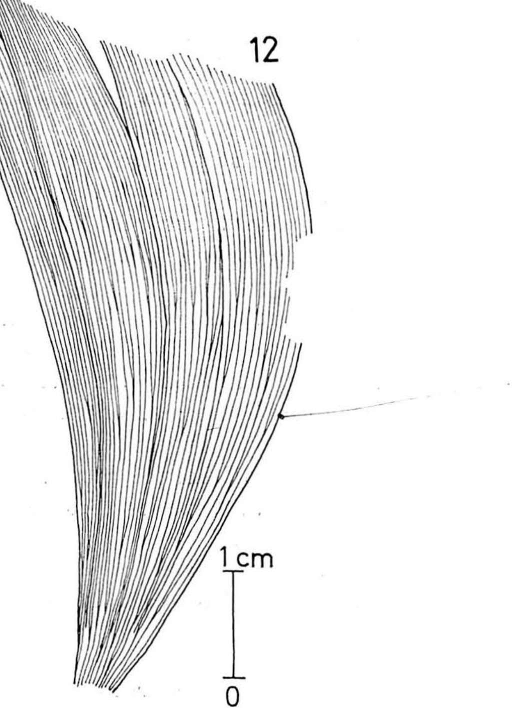
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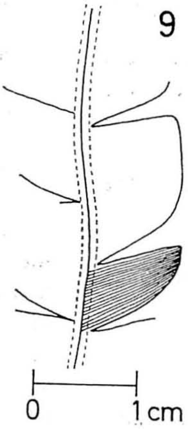
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segments rounded, but irregularly and broadly undulated in broad segments. Nerves fine, simple, parallel, 26-34 per cm in density.

Remarks:—The present specimens are referable to *Nilssonia schmidtii* in general outline. Such specimens regarded as *Nilssonia schaumburgensis* by KRASSILOV (1967) from the Lower Cretaceous of Southern Primorye as his pl. 57, figs. 3, 4, 6 resemble the present ones, but they are distinguishable from the present ones in that in KRASSILOV's specimens the incisions of laminae are mostly not reaching to the rachis, or if do so, the segments are different in form those of *N. schmidtii.*

Several specimens regarded by us as *Nilssonia nipponensis* from the same locality (KIMURA & SEKIDO, 1976b, p. 361, pl. 37, fig. 2; text-fig. 17) are similar in form to the present ones but the distal margins of their segments are mostly finely dentate and not rounded as those of the present ones.

Occurrence:—Common.

Specimens:—BK6-018, BK6-044, BK6-080.

Unclassified cycadophyte

Genus *Butefia* DOBRUSKINA, 1964: 135

In 1964, DOBRUSKINA established this genus as a new cycadophyte, based on a part of HEER's *Podozamites ensiformis* (HEER, 1878, p. 6, pl. 2, figs. 5, 6) and PRYNADA's *Glossozamites ensiformis,* including YOKOYAMA's *Glossozamites hoheneggeri* with her some doubt, and described *Butefia ensiformis* (HEER) (p. 135, pl. 12, figs. 1-3), from the Upper Jurassic in the upper course of Amur.

This genus is a form-genus known only by its external pinnate fronds. The external appearance of its pinnae reminds us of some *Podozamites* leaves, but it is generally distinguished from *Podozamites* by its apparently dichotomously forking nerves near the base.

In 1965 LEBEDEV described *Butefia burejensis* from the Upper Jurassic along the Zeia, including as synonymy PRYNADA's *Glossozamites burejensis* and DOBRUSKINA's *Butefia ensiformis* excluding her pl. 12, fig. 2.

Very recently SAMYLINA (1976) described *Butefia obliqua* as a new species from the Lower Cretaceous bed (dated as Aptian by her) of the Omsukchan Coal-Field in the right bank of Kolyma.

Butefia? sp.

Text-fig. 10

Description:—A detached pinna, base missing, elongate-ovate in outline, 8.3 cm long and 3.4 cm wide at the widest portion, apex presumably rounded. Nerves originating radially from the small area at base, dichotomously forking near base, parallel on the most part and converging near apex, apex unknown, 16 per cm in density at the middle portion of lamina.

Text-fig. 10 shows pinna outline and venation.

Text-figs. 8-12. 8; *Dictyozamites* cfr. *obliquus* SAMYLINA, showing venation in detail, drawing from one of the incomplete pinnae shown in Pl. 38, fig. 5 (BK6-090). 9; *Nilssonia schmidtii* (HEER) SEWARD, showing outline of segments and venation, drawing partly from BK6-018. 10; *Butefia?* sp., showing pinna outline and venation, drawing from BK6-029. 11; *Ginkgoites paradiantoides* (SAMYLINA), showing venation and general outline of lamina, drawing from Pl. 38, fig. 8 (BK6-035). 12; *Arctobaiera?* sp., showing venation, drawing from Pl. 38, fig. 9 (BK-106).

Remarks:—The present pinna would belong to *Butefia* owing to its venation. But it does not agree both in external outline and in density of nerves with such three species hitherto known in VAKHRAMEEV's Siberian Palaeofloristic Area as *B. burejensis*, *B. ensiformis* and *B. obliqua*. However, owing to the incompleteness of present material, we at present regard the present one hastily as *Butefia*? sp., though we should make here with our anxiety an additional remark that the present one resembles closely such *Ferganiella* species regarded by Russian palaeobotanists as having *Podozamites* affinity, as *F. lanceolata* BRICK described by BARANOVA et al. (1975, p. 133, pl. 34, figs. 7, 8) from the Jurassic of the eastern part of Caspian Basin.

Occurrence:—Rare (at present).

Specimen:—BK6-029.

Ginkgoales

Genus *Ginkgoites* SEWARD, 1919: 10

In addition to such *Ginkgoites* species as *G. digitata*, *G. huttonii* and *G. sibirica* described by us (KIMURA & SEKIDO, 1976b) from the Akaiwa Formation, a new type leaves referable to *Ginkgoites paradiantoides* are described here. Following SEWARD (1919), we have used the generic name *Ginkgoites*, instead of *Ginkgo* used by modern palaeobotanists.

Ginkgoites paradiantoides (SAMYLINA) n. comb.

Pl. 38, figs. 7, 8; Text-fig. 11

Similar specimens: *Ginkgo paradiantoides* SAYMYLINA; SAMYLINA, 1967, p. 138, pl. 2, figs. 2-5; pl. 3, figs. 1-11; pl. 4, figs. 9-10; pl. 6, fig. 7a; pl. 8, fig. 7b (Lower Cretaceous of the Zyrianka Coal-Field).

Ginkyo pluripartita SCHIMPER; SAMYLINAB, 1964, pl.17, fig. 2b (Ditto).

Description:—Leaves long petioled, petiole 4-5cm long. Laminae semi-circular with a basal angle of 180 degrees, divided by a deep median sinus reaching to the top of petiole into two halves with truncated or irregularly lobed apical margin. Nerves divergent, dichotomously forking at all levels on the apical half of lamina.

Remarks:—It is unfortunate that we cannot give details of the cuticle because it is not preserved in the present flora.

The present specimens would be referable almost to SAMYLINA's *Ginkgo paradiantoides* described from the Zyrianka Coal-Field.

Occurrence:—Not rare.

Specimens:—BK6-035, BK6-085.

Czekanowskiales

Genus *Arctobaiera* FLORIN, 1936: 118

Arctobaiera? sp.

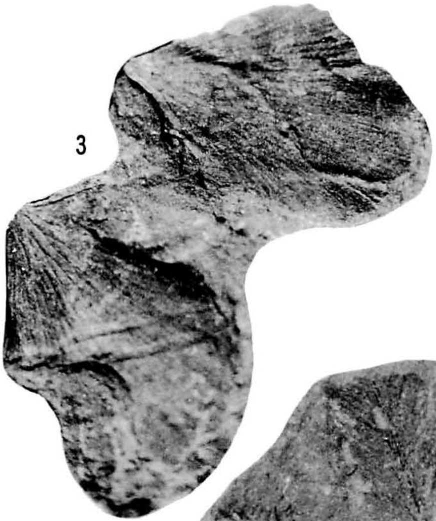
Pl. 38, fig. 9; Text-fig. 12

Explanation of Plate 36

1. *Coniopteris saportana* (HEER) VACHRAMEEV; sterile part of a frond; in association with two incomplete pinnules of *Adiantopteris sewardii* (YABE) VASSILEVSKAJA. (BK6-037), ×2.
2. *Adiantopteris sewardii* (YABE) VASSILEVSKAJA; one nearly complete pinnule and two incompletely preserved pinnule bases. (BK6-003), ×2.
3. *Adiantopteris toyoraensis* (OISHI) VASSILEVSKAJA; (=*Adiantites* sp. D in KIMURA & SEKIDO, 1976b); two pinnate sterile pinnules. (BK6-081), ×2.

4-7. *Protodammara* sp.; cone scales. (4; BK6-001, 5-7; BK6-040), ×3.

8-9. *Carpolithes* sp.; seeds of *Ginkgoites*?; (BK6-040), ×3.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Description:—A fragment of a leaf-bundle composed of four segments, uniting near base. Segments long and narrow, about 7 cm long, variable in width, ranging 5-8mm wide at the middle portion, overlapping each other laterally, narrowing gradually towards the unknown base and abruptly towards unknown apex. Nerves 5-7 in number at basal part, then dichotomously forking, as many as twice in number at middle portion, not converging at apex. Text-fig. 12 drawing from Pl. 3, fig. 9 shows outline of leaves and their venation.

Remarks:—One specimen with its counterpart was obtained. Judging from its form, this specimen might represent a leaf-bundle consisting of more than four segments and might belong to *Arctobaiera* or *Phoenicopsis* of Czekanowskiales. At present we provisionally place it *Arctobaiera*? sp.

The present specimen would remind us of *Arctobaiera florinii* originally described by LEBEDEV (1974, p. 80, pl. 20, fig. 2; pl. 21, figs. 1-4; pl. 22, fig. 1; text-fig. 37) from the Lower Cretaceous of Western Priokhotie.

Occurrence:—Rare.

Specimen:—BK-106 (its counterpart, BK-133, collected by C. SMILEY, Professor of the University of Idaho, U. S. A., in 1974).

Coniferales

Besides varied and abundant *Podozamites* species, a few conifer remains such as *Elatocladus* sp. A and sp. B, and *Pityophyllum lindstroemii* have been reported in the Akaiwa Flora (KIMURA & SEKIDO, 1976b). In addition, we describe here two types of coniferous shoots, and several coniferous cone-scales probably belonging to a same species but uncertain affinities. Conifers in the Akaiwa Formation have usually been neglected because the specimens give little palaeobotanical informations, but we point out that there are fairly numerous species in the flora.

Form-genus *Elatocladus* HALLE, em. HARRIS, 1969: 249

Elatocladus sp. C

Pl. 38, fig. 10

Description:—A single specimen of a coniferous shoot. Leaves dorsiventrally set closely, long and narrow, nearly parallel-sided throughout, constricted at base, very shortly petioled, with bluntly pointed at apex, typically 0.7 cm long and 0.9 mm wide, attached to the axis at an angle of about 60 degrees, and longitudinally traversed by an indistinct median nerve.

Remarks:—Though we have nothing to say about its affinity because of the incompleteness of material, the present specimen would remind us of such taxodiaceous genera as *Sequoia* or *Taxodium*, so far as its external appearance is concerned.

Occurrence:—Fine fragments are common.

Specimen:—BK6-009.

Elatocladus sp. D

Pl. 38, fig. 11

Description:—A single incomplete coniferous shoot. Leaves linear lanceolate in form, constricted at base and decurrent to the axis, bluntly pointed at apex, 0.5 cm long and 1 mm wide at the widest portion, and longitudinally traversed by a prominent median nerve.

Remarks:—*Palissya* sp. described by YOKOYAMA (1889, p. 64, pl. 9, fig. 11) from Kuwashima (formerly Shimamura) of the Oguchi formation somewhat resembles the present one in external appearance.

The present specimen is included in *Elatocladus* in the sense in which that comprehensive genus was proposed by HALLE.

Occurrence:—Fine fragments of leaves are common.

Specimen:—BK6-039.

Form-genus *Protodammara* HOLLICK & JEFFREY, 1906: 199

Protodammara sp.

Pl. 36, figs. 4-7

Description:—Several detached kite-like cone scales. Cone scales 0.8-1.0 cm long and 0.7-0.9 cm wide above, abruptly narrowed from about middle to the base, not apiculate but broadly undulate terminally, seed scars three in number, crescentically arranged above the middle and approximately in the broadest part of the scale, with the central one slightly higher up than the laterals.

Remarks:—In external appearance, the present specimens somewhat resemble *Protodammara speciosa* originally described by HOLLICK & JEFFREY (1906, 1909) and *Dammara minor* by HOLLICK (1906) from the Cretaceous of New York. But these American specimens differ from the present ones in having apiculate apices.

Full analysis and discussion of the present specimens will be made after a more complete study of our new material.

This generic name, *Protodammara* itself does not always mean its araucarian affinity.

Occurrence:—Not rare.

Specimens:—BK6-001, BK6-040.

Unclassified seed

Form-genus *Carpolithes* SCHLOTHEIM, 1820: 418

Carpolithes sp.

Pl. 36, figs. 8, 9

Description:—Several incomplete seeds. Seeds or seed-stones ovate, sharply edged, rounded at base and sharply beaked at apex, 0.9 cm long and 0.6 cm wide at the widest portion.

Remarks:—The present specimens resemble the following in external appearance; seeds regarded by HEER (1876, p. 58, pl. 11, figs. 13-16) as belonging to *Ginkgo sibirica* from the Jurassic of Ust-Balei; *Carpolithes ginkgoides* by YOKOYAMA (1889, p. 65, pl. 10, figs. 20-23) from

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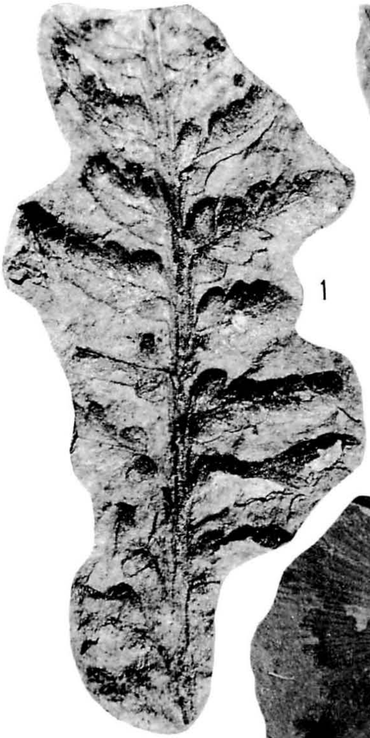
Explanation of Plate 37

1. *Raphaelia diamensis* SEWARD; a pinna fragment (back view); (BK6-025), ×3.
2. *Cladophlebis* ex gr. *williamsonii* (BRONGNIART) BRONGNIART; sterile parts of fronds piled up together. (BK6-033), ×1.
3. *Gleichenites porsildii* SEWARD; fertile pinnae with comparatively thick rachis. (BK6-028), ×2.
4-5. *Gleichenites nipponensis* OISHI; incomplete fertile pinna fragments. (BK6-010), ×2.5.
6. *Coniopteris saportana* (HEER) VACHRAMEEV; fertile pinna fragment. (BK6-042), ×3.
7. A; *Adiantopteris sewardii* (YABE) VASSILEVSKAJA; two pinnate pinnules attached to the rachis with short stalks.
   B; *Nilssonia lobatidentata* VASSILEVSKAJA; (for details, see KIMURA & SEKIDO, 1976a, b). (BK6-046), ×2.



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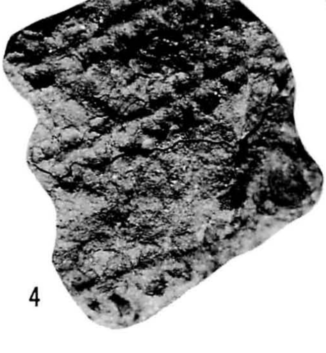

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Ozo of the Oguchi formation apart from their long beaks as shown in his figures; *Allicospermum burejense* by KRASSILOV (1972, p. 39, pl. 5, figs. 8-10; text-fig. 5d, g) from the Jurasso-Cretaceous of Bureja Basin; seeds regarded by HARRIS et al. (1974, p. 72, fig. 22C, D) as belonging to *Ginkgo huttoni* from the Middle Jurassic of Yorkshire.

Thus it would be quite possible that the present specimens belong to *Ginkgoites*.

Occurrence:—Rare.

Specimen:—BK6-040 (one slab only).

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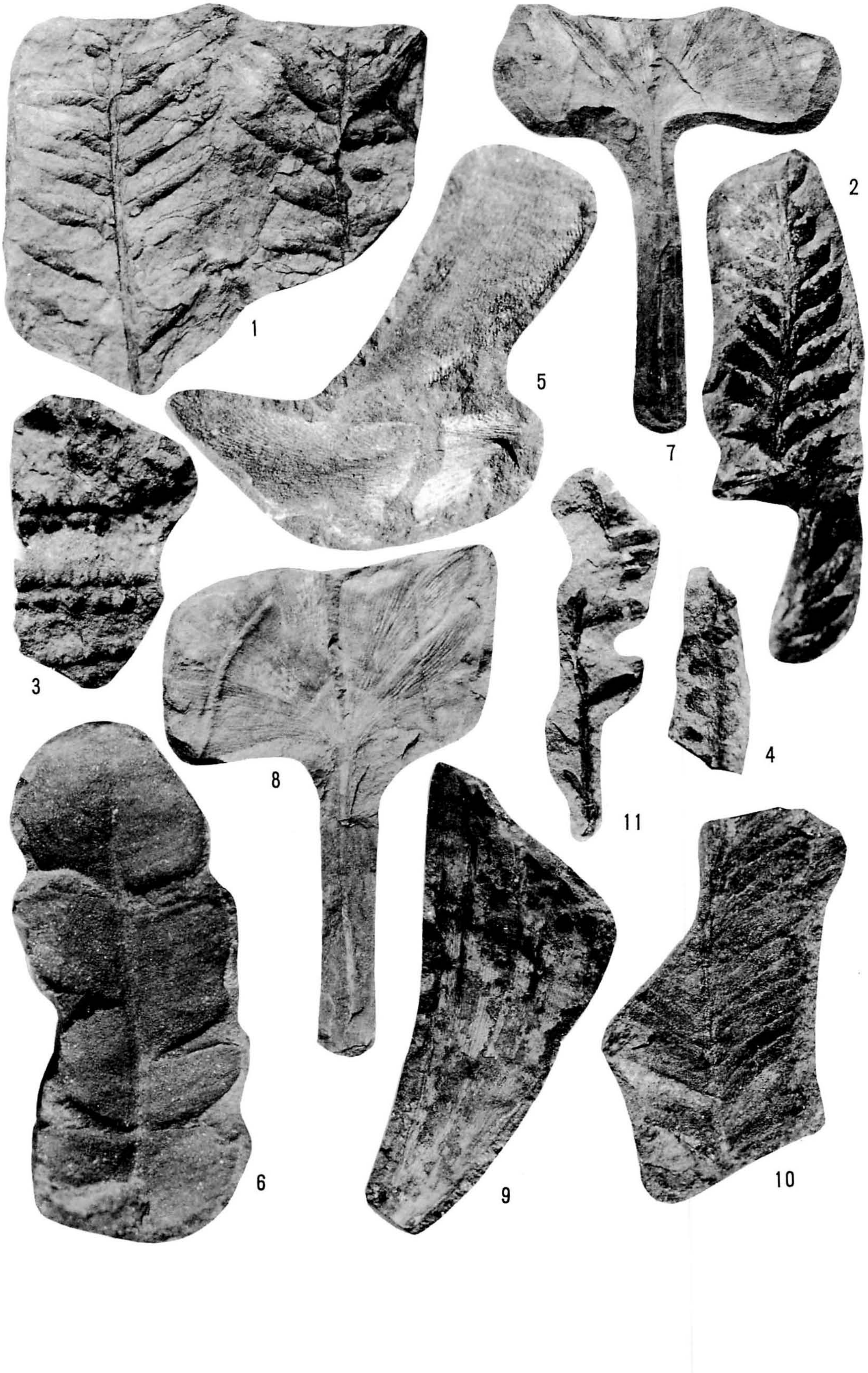
Explanation of Plate 38

1. *Raphaelia diamensis* SEWARD ; pinnules with convex upper surface (surface view). (BK6-047), ×2.
2. *Coniopteris saportana* (HEER) VACHRAMEEV ; an incomplete fertile pinna. (BK6-031), ×3.
3-4. *Gleichenites nipponensis* OISHI ; incomplete fertile pinna fragments. (BK6-010), ×2.5.
5. *Dictyozamites* cfr. *obliquus* SAMYLINA ; two incomplete pinnae isolated. (BK6-090), ×2.
6. *Nilssonia schmidtii* (HEER) SEWARD ; (BK6-044), ×2.
7-8. *Ginkgoites paradiantoides* (SAMYLINA) comb. nov. : (7 ; BK6-085, 8 ; BK6-035), ×1.
9. *Arctobaiera*? sp. ; (BK-106), ×1.
10. *Elatocladus* sp. C ; (BK6-039), ×3.
11. *Elatocladus* sp. D ; (BK6-009), ×2.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Akaiwa 赤岩, Bettokuzure 別当くずれ, Fukui 福井, Hakusan 白山, Ishikawa 石川, Itoshiro 石徹白, Iwaidani 岩井谷, Izumi-mura 和泉村, Kaisekiyama 介石山, Kami-Uchinami 上打波, Kiyosué 清末, Komatsu 小松, Kuwashima (Kuwajima) 桑島, Kuzuryu 九頭竜, Mochiana 持穴, Nagdong (Naktong) 洛東, Oguchi 尾口, Osugidani 大杉谷, Ozo 尾添, Ryoseki 領石, Shiramine-mura 白峰村, Tamodani 田茂谷(田母谷), Tetori (or Tedori) 手取

ネオコミアン上部赤岩層（石徹白層群上部）の植物化石（追加）：さきに報告（Kimura & Sekido, 1976b）した属種に加えて，さらにつぎの属種を追加記載した；*Gleichenites nipponensis*, *Coniopteris saportana*, *Adiantopteris sewardii*, *A. toyoraensis*, *Cladophlebis* ex gr. *williamsonii*, *Raphaelia diamensis*, *Dictyozamites* cfr. *obliquus*, *Nilssonia schmidtii*, *Butefia*? sp., *Ginkgoites paradiantoides*, *Arctobaiera*? sp., *Elatocladus* sp. C および sp. D, *Protodammara* sp. および *Carpolithes* sp.

これで，1976年以前には知られていなかった赤岩層および同相当層の植物群の構成属種は第一表に示すとおりとなった。さきに報告した *Adiantites* 属（Goeppert, 1836）に代わり，本論文より *Adiantopteris* 属（Vassilevskaja, 1968）を用いることとした。また *Gleichenites* aff. *porsildi* については，今般よい標本が得られ，これとさきの標本とを詳細に比較検討した結果，これらは，*Gleichenites porsildii* と区別できないことが判明したのでここに再記載した。以上のうち，*Coniopteris saportana*, *Raphaelia diamensis*, *Dictyozamites* cfr. *obliquus*, *Nilssonia schmidtii*, *Ginkgoites paradiantoides*, *Protodammara* sp. などは，日本からは最初の産出である。これらはいずれも Vakhrameev によって提唱されている，ジュラ紀から前期白亜紀にわたるシベリア植物地理区植物群にはきわめて普遍的な属種である。

木村達明・関戸信次

Trans. Proc. Palaeont. Soc. Japan, N.S., No. 109, pp. 280-292, pl. 39, April, 30, 1978

687. FURTHER NOTES ON VASCOCERATID AMMONITES FROM HOKKAIDO

(STUDIES OF THE CRETACEOUS AMMONITES FROM HOKKAIDO AND SAGHALIEN-XXXIII)

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With Notes on the Early Turonian Palaeogeography

(Tatsuro MATSUMOTO)

Abstract. Since previous descriptions (MATSUMOTO, 1973), more ammonites of the Vascoceratidae have been obtained from the Cretaceous of Hokkaido. They are described in this paper, in which a new species of *Fagesia* is included.

In connexion with the distribution of the vascoceratids, notes are given on the Early Turonian palaeogeography.

Introduction

One of us (MATSUMOTO, 1973) described three species of the Vascoceratidae from the Turonian of Hokkaido, giving a notice on their palaeobiogeographical implications. They were *Vascoceras* sp. aff. *V. durandi* (THOMAS et PERON), *Fagesia thevestensis* (PERON) and *Fagesia* sp. cf. *F. rudra* (STOLICZKA). Since then more examples of the Vascoceratidae from Hokkaido have been assembled, aided much by several friends of ours. In this and another paper (MATSUMOTO, 1977a) these species are described. We now have six species which afford us a valuable basis to discuss the Turonian biostratigraphy and biogeography.

This is a contribution to the international project: Mid-Cretaceous Events. The work has been financially supported by the Ministry of Education with the Grant-in-aid No. 154280.

Before going further we thank Dr. Hitomaro HONDA, Chief Geologist, Mr. Yasutaka FUJISHIMA, Geologist, and Mr. Tsutomu SATO of the Hokkaido Colliery & Steamship Co. Ltd., Yubari, who kindly provided us interesting specimens for our study; Drs. Hiromichi HIRANO and Kazushige TANABE and Mr. Yuichiro MIYATA (a student) of Kyushu University who cooperated with us in the field work and provided the necessary specimens for this study. Dr. K. TANABE and Miss Mutsuko HAYASHIDA have assisted us in preparing the figures and the typescript.

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* Received August 26, 1977; read Oct. 4, 1976 at Sapporo.

Systematic Descriptions

Family Vascoceratidae SPATH, 1925

Genus *Vascoceras* CHOFFAT, 1898

Type-species:—*Vascoceras gamai* CHOFFAT, 1898.

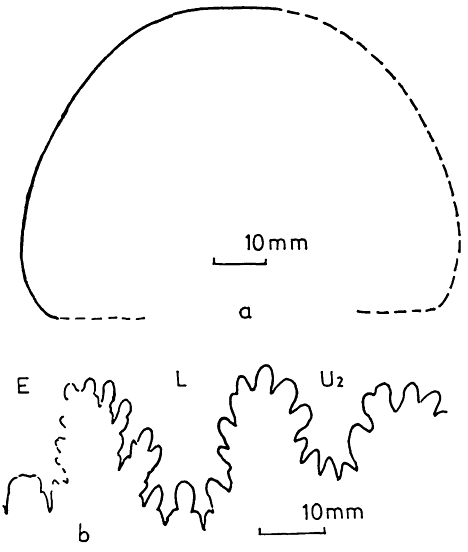
Remarks: — See MATSUMOTO 1973, p. 27-28.

Vascoceras sp. aff. *V. durandi* (THOMAS et PERON)

Text-fig. 1

1973. *Vascoceras* sp. aff. V. *durandi*, MATSUMOTO, *Trans. Proc. Palaeont. Soc. Japan*, [N. S.], no. 89, p. 29, pl. 8, fig. 1; text-fig. 1.

Material:—GK. H 5856, from loc. R 5235 pl, and GK. H 5857, from loc. R 5207 p8, along the main stream on the River Obira [=Opiraushibets]; ? GK. H 5858, from loc. Y 6017 p5, in a small valley on the right bank of the creek Taki-no-sawa, Oyubari area, Hokkaido. All three collected by a field work team of Kyushu University (H. H., K. T. & T. M.)



Text-fig. 1. *Vascoceras* sp. aff. *V. durandi* (THOMAS et PERON). GK. H5856, from loc. R5235p, lower part of unit Mj, Obira district. Diagrammatic whorl-section (a) and external suture (b) outside of the umbilical shoulder. (T. M. *delin.*)

Descriptive remarks:—The three specimens of dissimilar size are all incompletely preserved. They are smoothish and show the globose and considerably involute shell-form, with inflated flanks and a rather flattened venter. The sutures have massive broad saddles, an opened general outline of L, and moderately deep incisions at the base of L. All of these characters suggest that the specimens are probably referable to the species which was previously described under *Vascoceras* sp. aff. *V. durandi* (THOMAS et PERON, 1889) (see MATSUMOTO, 1973, p. 29, pl. 8, fig. 1; text-fig. 1).

Occurrence:—Although the three specimens were obtained from fallen or floated calcareous nodules, the two localities R5235pl in the Obira area and Y6017p5 in the Oyubari district probably indicate the derivation from a limited stratigraphic position in the lower part of the Lower Turonian. The previously reported (MATSUMOTO, 1973) specimen of *Vascoceras* aff. *durandi* came in situ from loc. R2513a, but this locality is isolated and its correlation with the better exposed and more carefully measured sequence along the main stream of the River Obira has yet to be worked out. For the locations readers may refer to the route maps in TANABE et al. (1977) and also HIRANO et al. (1977).

Genus *Fagesia* PERVINQUIÈRE, 1907

Type-species: — *Olcostephanus superstes* KOSSMAT, 1897.

Remarks:—See MATSUMOTO, 1973, p. 32.

Fagesia spheroidalis PERVINQUIÈRE

Pl. 39, Fig. 1; Text-fig. 2

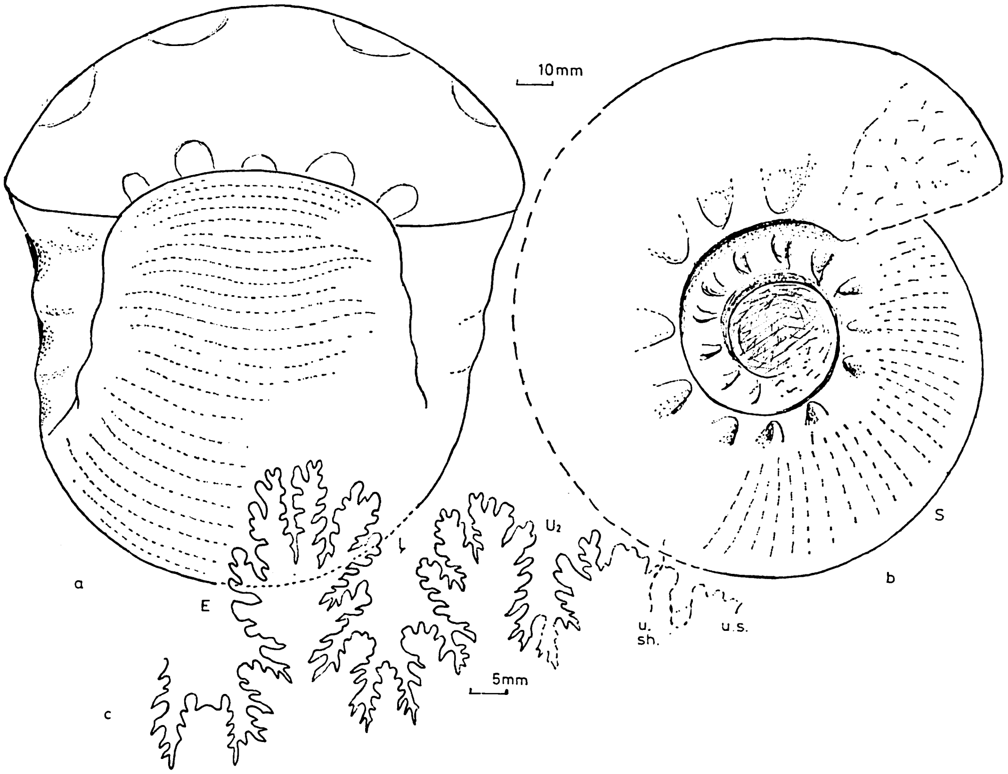
1907. *Fagesia superstes* (KOSSMAT) var. *spheroidalis* PERVINQUIÈRE, Études de paléontologie tunisienne. I. Céphalopodes des Terrains secondaires, p. 324, pl. 20, figs. 3, 4 and fig. A.
1965. *Fagesia superstes* var. *spheroidalis* COLLIGNON, *Atlas des Fossiles Caracteristiques de Madagascar*, fasc. 12, p. 46, pl. 395, fig. 1677.

Lectotype:—Of the two illustrated syntypes the larger one (PERVINQUIÈRE, 1907, p. 324, fig. 122, pl. 20, fig. 4 and fig. A) is designated here as the lectotype of *F. spheroidalis.*

Material:—Yb 3001 of K. MURAMOTO's Collection, from a calcareous nodule resting on the floor of the Taki-no-sawa, immediately west of loc. Y5102 of MATSUMOTO and OKADA (1973), in the Oyubari district of central Hakkaido.

Specific characters: — Shell large and cadicone, consisting of much depressed whorls which have a broadly arched venter and much depressed section. Umbilicus moderately narrow, about one third of the shell-diameter, deep, and surrounded by a nearly vertical umbilical wall and a subangular shoulder.

Umbilical nodes thick and blunt, about



Text-fig. 2. *Fagesia spheroidalis* PERVINQUIÈRE. Yb 3001 of K. MURAMOTO Collection, from near loc. Y5102, Oyubari area. Diagrammatic sketch of frontal (a) and lateral (b) views, with a restored shell-form; external suture (c) at the middle growth-stage (whorl-height=43 mm). (T.M. *delin.*)

12 to 13 per whorl. They may be strengthened at the umbilical shoulder on the outer whorl. Radial ribs weak, gently concave and numerous; 4 or 5 ribs corresponding to a node, some branched from the node and others inserted. On the whorl of the late growth-stage the ribs are much weakened or almost lost.

Suture of *Fagesia* type, being similar to that of *F. superstes* as illustrated by KOSSMAT (1897, pl. 17 [6], fig. 1c), having deep E and L, tall saddles at E-L and L-U2, narrow and long lobules and folioles.

Description of the Oyubari specimen:—This is still septate at its diameter of 163 mm, and no body-chamber is preserved. As shown in the measurements below, it is characterized by its cadicone general shell-form, much depressed whorl-section (B/H=2.46), broadly arched venter, deep umbilicus showing a stepwise structure due to the combination of a subangular umbilical shoulder and a high and vertical umbilical wall, thick nodes at the umbilical shoulder numbering 12 or 13 per whorl, and weak ribs branched at the nodes and also inserted between them. The ornament becomes blunter as the whorl grows. The suture is fairly well exposed, showing the general pattern of *Fagesia* (see Fig. 2c). L is expanded by diverging branches.

Measurements (in mm):—

Specimen	Diameter	Umbilicus	Height	Breadth	B./H.
Yb 3001	163 (1)	55 (0.34)	58 (0.36)	145 (0.89)	2.46
Lectotype	135 (1)	36 (0.27)	53 (0.39)	139 (1.72)	2.62

Discussions:—The described specimen from Hokkaido has essentially the same characters as the lectotype and other examples of *Fagesia spheroidalis* from Tunisia and Madagascar (listed above). Although it shows a somewhat broader umbilicus and a less depressed whorl, these minor differences are regarded as variations within a species, as is some range in the number of tubercles (10-13 per whorl).

Fagesia spheroidalis was established by PERVINQUIÈRE (1907, p. 324) as a variety of *F. superstes* (KOSSMAT) (1897). This has been followed by COLLIGNON (1965, p. 46). We think it better to regard them as distinct species, because of the distinct morphological difference which would be effective enough for giving rise to a dissimilar mode of life. *F. spheroidalis* has much broader whorls than *F. superstes*. In the former the umbilicus shows a step-wise deepening, whilst in the latter it is crater like. These characters should be effective to the mode of movement in the sea water. Moreover, the former has more numerous and finer ribs than the latter. L in the suture of the former has larger and more diverged branches than that of the latter.

Occurrence:—In Tunisia and Madagascar this species is reported to occur in the Lower Turonian. The locality record of the Oyubari specimen strongly suggests the derivation from a comparatively upper part of the Lower Turonian sequence along the Taki-no-sawa.

Fagesia japonica sp. nov.

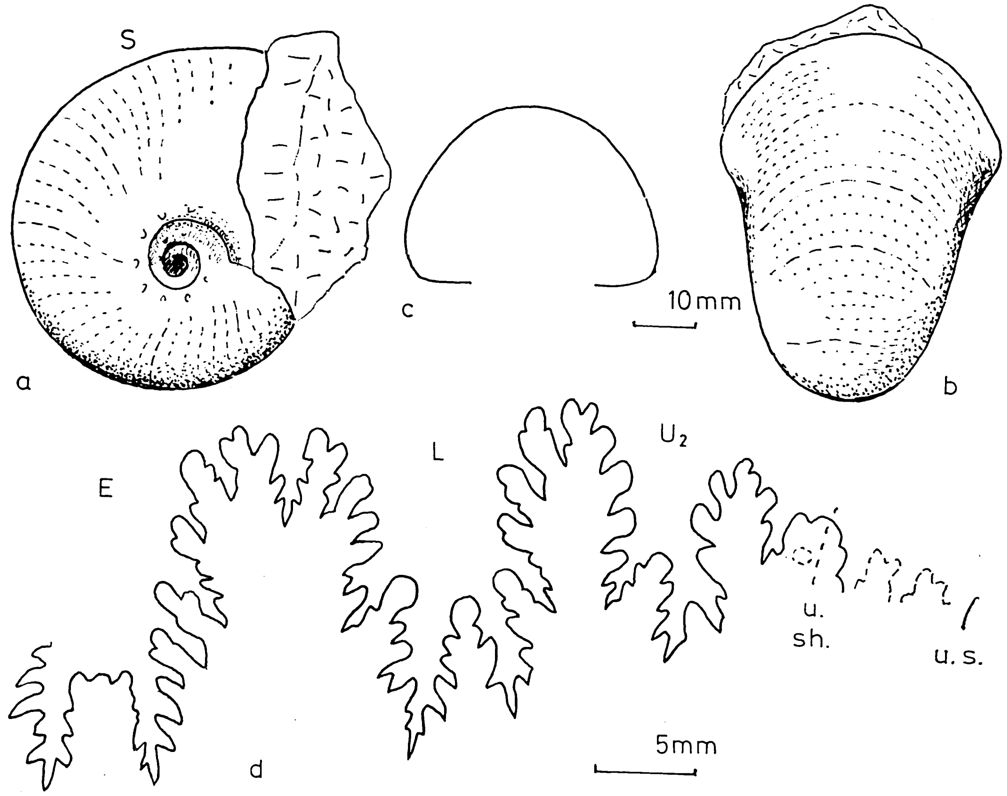
Pl. 39, Figs. 2, 3; Text-fig. 3

Material:—Holotype, HCS. No. 1, from a sandy calcareous nodule at loc. H2074, on the left bank of a creek called the Nutapomanai, a tributary of the River

Hobetsu, collected by Tsutomu SATO (Sept. 1971). Paratype 1. GK. H5855 from the mudstone at loc. R5231b, main stream of the Obira [=Opiraushibets], found by Yuichiro MIYATA during the field work by a team of Kyushu University (K. TANABE, H. HIRANO, Y. MIYATA and T. MATSUMOTO, on Aug. 13, 1975). Paratype 2, Ob1005 of K. MURAMOTO Collection (Mikasa City Museum), from a calcareous nodule at R4601, an intensely meandering point of the creek of Nakakinembetsu, a tributary of the Obira, at a point 250 m NWW from the conference with a small tributary called the 82 Rinpan-no-sawa, collected by K. MURAMOTO (Sept. 16, 1973).

Specific characters:—Shell large and globose in general aspect, consisting of fairly involute whorls, which have a steep, almost vertical, high umbilical wall, subangular umbilical shoulders, gently convex, convergent flanks passing gradually to a rounded venter, and accordingly a semi-circular to semi-elliptical cross-section, with the maximum breadth between the umbilical shoulders. Umbilicus fairly narrow and deep, showing a stepwise structure by the combination of vertical umbilical walls and subangular shoulders.

Inner whorl has small tubercles at the umbilical shoulder, 10 or so per whorl, and numerous, weak ribs, which are flexiradiate, diverged or intercalated on the



Text-fig. 3. *Fagesia japonica* MATSUMOTO et MURAMOTO, sp. nov. Holotype, HCS. No. 1 (T. SATO Coll.), from loc. H2074p, Hobetsu district. Diagrammatic sketches of lateral (a) and back (b) views and a whorl-section (c) ; external suture (d) at S. (T. M. *delin.*)

flanks and curved moderately forward on the venter, where faint constriction like, slightly deeper interspaces are periodically discernible. Outer whorl nearly smooth, but with distant, blunt umbilical nodes.

Suture essentially similar to that of *Fagesia superstes* as illustrated by KOSSMAT (1897, pl. 17 [6], fig. 1c), but has a somewhat broader stem of L and a broader saddle between E and L.

Remarks:—Holotype is immature but well preserved. Paratype no. 1 (D.=87.5) is somewhat larger than the holotype, but its outer half whorl is poorly preserved and an apparently subtrigonal whorl-section of the preserved last part may be due to the secondary deformation. Paratype no. 2 is much larger and regarded as representing the adult stage. Its last septum is at about 210 mm in diameter but its body-chamber is almost lost. Its outer whorl tends to be subtrigonal in cross-section and its height seems to be reducing.

Measurements (in mm):—

Specimen	Diameter	Umbilicus	Height	Breadth	B./H.
HCS. No. 1	57.0 (1)	10.5 (0.18)	29.0 (0.49)	42.4 (0.72)	1.46
GK. H5855	54.5 (1)	10.1 (0.19)	27.5 (0.50)	20×2 (0.7)	1.4
Ob 1005	207.0 (1)	41.5 (0.20)	41.5 (0.44)	65×2 (0.6)	1.4

Discussion:—This species is characterized by its peculiar shell-form which recalls us certain species of *Vascoceras* [e.g. *V. polygonum* BARBER (1957, p. 17, pl. 5, fig. 2; pl. 29, figs. 1-3)], but its suture is distinctly of *Fagesia* type, characterized by tall saddles deeply incised by narrow lobules.

In the same respect it resembles *Fagesia involuta* BARBER (1957, p. 27, pl. 9, fig. 3; pl. 29, figs. 6-7), from the Lower Turonian of north-eastern Nigeria, which was regarded by BARBER as somewhat intermediate between *Vascoceras* and *Fagesia.* That Nigerian species has, however, more distinctly subtrigonal whorl-section and less numerous, much coarser umbilical tubercles.

F. japonica is fairly close to *Fagesia rudra* (STOLICZKA, 1865), a more widespread species known from the Lower Turonian of southern India (STOLICZKA, 1865, p. 122, pl. 60; KOSSMAT, 1897, p. 29 [136]), Tunisia (PERVINQUIÈRE, 1907, p. 322), Madagascar (COLLIGNON, 1965, p. 48, pl. 396, fig. 1678A; p. 397, fig. 1678-B), Spain (WIEDMANN, 1960, p. 720, listed only) and probably also Hokkaido (MATSUMOTO, 1973, p. 34, text-fig. 3), in its globose aspect, narrow and deep umbilicus and weak ornament. It is, however, distinguished from that species in its somewhat higher whorl with a distinctly narrower, moderately instead of broadly rounded venter, and somewhat broader stem of L.

Some of the variable forms of *Fagesia lenticularis* FREUND and RAAB (1969, p. 36-42, with subspecific names which we regard as untenable because of their occurrence in the same zone of the same area), from Zone 6 of the Lower Turonian of Israel, may be similar to *F. japonica* in shell-form but has distinctly coarser ribs on its inner whorl.

Occurrence:—See the locality records described under the heading *Material.* The sandy layer of the type locality in the sequence of the Nutapomanai is certainly lower than but not much apart from the prolific Zone of *Inoceramus hobetsensis* and accordingly it is regarded as representing a comparatively upper part of the Lower Turonian in the Hobetsu area. The paratype no. 1 is precisely allocated at a horizon immediately below the key member of tuff and tuffite in the middle of Member Mj of TANAKA (1963). This is in the middle part of the Lower Turonian sequence in the Obira area, since *Vascoceras* aff. *durandi* came from the lower part of the sequence along the same route. The paratype no. 2 from the same Obira area is a somewhat transported calcareous nodule derived probably from somewhere within Member Mj. It should be noted that *Neoptychites cephalotus* (COURTILLER) was found in another nodule of the same spot (see MATSUMOTO, 1977a).

Appendix

Notes on the Early Turonian Palaeogeography

(Tatsuro MATSUMOTO)

In connexion with the distributional records of the vascoceratid ammonites, I should like to give further remarks on the palaeobiogeographic aspects of the Early Turonian time.

Environmental conditions:—Ammonites belonging to the Vascoceratidae normally occur abundantly in the sediments of shallow epicontinental seas. They are mostly characterized by a globose or roundish shell-form, smoothish surface with reduced ornaments and more or less pseudoceratitic sutures. Presumably these morphological characters of the shell may have been favourable for their living in very shallow, sometimes wavy seas.

In the Cretaceous rocks of Hokkaido, vascoceratid ammonites are indeed rare in comparison with desmoceratids, tetragonitids and certain groups of heteromorpha, but they do occur. Aside from two species of *Hourcquia* of later ages, there are now six species of the Vascoceratidae from the Lower Turonian of Hokkaido. One of them is *Vascoceras* aff. *durandi*, for which four examples are at our disposal and three of them came from a limited part of the Obira area. There are four species of *Fagesia*, of which one is, so far, endemic of Japan. This is represented at present by at least three specimens.

The occurrence frequency of the above species in Hokkaido is approximately the same as that of certain species of the Acanthoceratidae or Collignoniceratidae there.

As is described in another paper (MATSUMOTO, 1977a) *Neoptychites cephalotus* (COURTILLER) has recently been found from the Obira area of Hokkaido. It is represented by an adult specimen in which the body-chamber is nearly completely preserved.

The above facts altogether suggest that at least several species of the Vascoceratidae lived in the Turonian Japanese province. Postmortem drifting of shells for a long distance from somewhere in epicontinental areas around the Tethys could be considered as another alternative, but this seems to be less probable for the increasing records of the vascoceratids from our province. The relative scarcity of the fossils is probably due to that the main part of the sedimentary basin of Hokkaido (i.e. the so-called Yezo geosyncline) was more or less deeper and off-shore than the original habitats and that the optimum shallower parts at the margin of the basin may have been narrow because of the tectonic instability in East Asia. Species of *Fagesia* have more complex sutures than other genera of the Vascoceratidae and they may have an ability to go down to some deeper part of the sea. This may be consistent with the fact that fossils of

Fagesia have been found more commonly in Hokkaido than other genera of the family.

Correlation: — *Vascoceras* and *Fagesia* occur in the Lower Turonian of various region of the world and they have been found also from the Lower Turonian equivalent in Hokkaido. *Inoceramus* (*Mytiloides*) *labiatus* (SCHLOTHEIM) (s. l.) occurs in the same unit, if not in the same bed (MATSUMOTO and NODA, 1975).

If we examine more carefully the stratigraphic sequences, we notice that fossils of *Fagesia* occur in (or presumed to have derived from) comparatively upper to middle parts of the probable correlative of Lower Turonian in Hokkaido. For instance, in the sequence exposed along the main stream of the Obira, *Fagesia japonica* is found at a horizon about 50 m above that of *Vascoceras* aff. *durandi*, although there is still a doubt about the adequate correlation of the bed of the latter species exposed at loc. R2513a on the bank of the tributary Okufutamata with that of the main stream. It should also be noted that a larger example of *F. japonica* was collected from the Naka-kinembetsu, another tributary of the Obira, from the same spot as a specimen of *Neoptychites cephalotus*. Although they were obtained in transported or washed out nodules, they have the same lithologic character that suggests the derivation from the same unit Mj (see MATSUMOTO, 1977a).

The above facts are generally in harmony with the successions in the Tethys region, as revealed by WIEDMANN (1960, 1964) in Spain and by FREUND and RAAB (1969) in Israel.

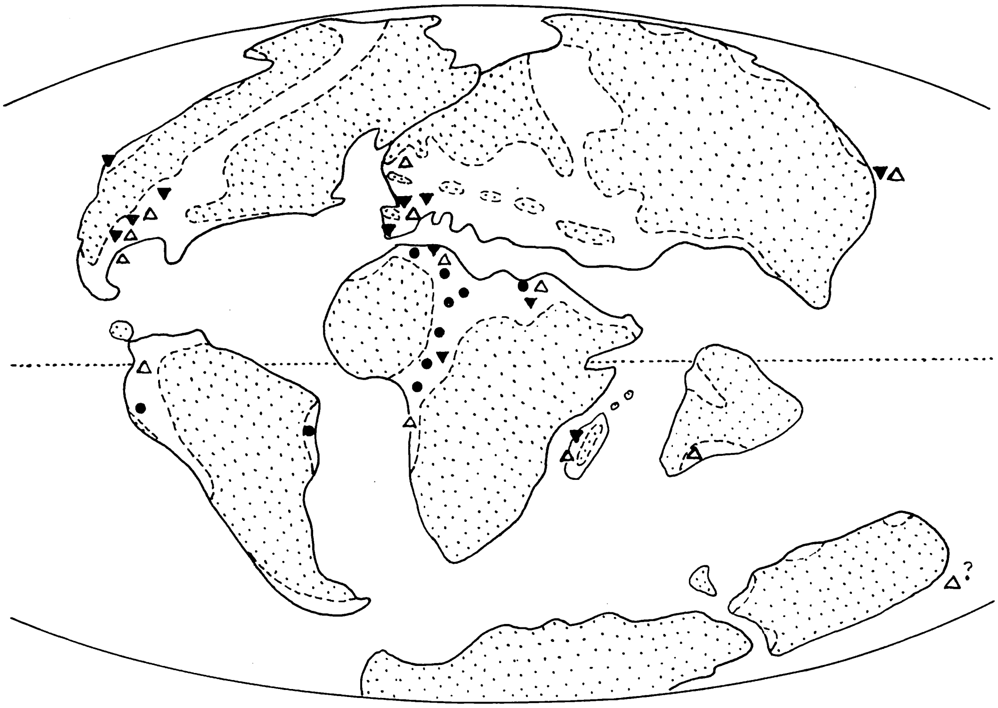
As has been pointed out by HANCOCK et al. (1977), the adequate scheme of the Turonian biostratigraphic subdivision has not yet been established even in western Europe. Although the occurrence is rather infrequent, I hope that an increasing number of records of the vascoceratid ammonites from Hokkaido may serve for the correlation of the ammonoid faunas of the Tethys region with those of the Pacific.

Palaeogeographic aspects:—Vascoceratid ammonites are distributed mainly in the Turonian epicontinental sea areas facing the Tethys Sea and its extensions. On the previous occasion (MATSUMOTO, 1973) a Turonian palaeobiogeographic map was presented, showing the distribution of selected ammonite genera. That was drawn on a world map of the present land and sea configuration.

In this paper I dare to plot the distribution data of *Fagesia* on a tentatively reconstructed palaeogeographic map (Fig. 4). For the reconstruction I depend essentially on DIETZ and HOLDEN (1976) rather than SMITH et al. (1973), because the former seems to be preferable to explain the faunal migration. For the early Turonian palaeogeography it is necessary to modify reasonably the two maps (at about the beginning and the end of the Cretaceous period) of DIETZ and HOLDEN.

One of the questions in the reconstruction is how broad or narrow was the Tethys Sea in the early Turonian time. Another question is how broad or narrow was the opening North and South Atlantic Oceans. The answers would affect the interpretation of faunal similarity and dissimilarity between both sides of the deep sea-ways.

As the Turonian is at the middle of the long period of geomagnetic quietness (i. e. a continuously normal geomagnetic polarity) (LARSON and HELSLEY, 1975), it is fairly difficult to allocate precisely the subcontinents of India and Madagascar on the map. The result would also affect the interpretation of Turonian faunal affinities between Japan and these places.



Text-fig. 4. Map showing the distribution of selected genera of the Vascoceratidae: *Vascoceras* and/or *Plesiovascoceras* with solid reversed triangle; *Paravascoceras* and *Paramammites* with solid circle; *Fagesia* with empty triangle. Tentative reconstruction of Early Turonian palaeogeography modified from DIETZ and HOLDEN (1970). (T.M. *delin.*)

In view of these difficulties, the map in this paper is quite tentative, but I have shown it towards further refinement in the future.

Some information of regional geology should be taken into consideration for the questions. For instance, the pink pelagic limestone of the Scaglia rossa of the Italian Appenines record the existence of deep sea in Late Cretaceous times up to middle Eocene (ALVRAREZ et al., 1977). The Aruma pelagic shale, comprising the Hawasina facies, of the Oman mountains record the existence of eugosynclinal deep sea in Late Santonian-Early Maestrichtian times (WILSON, 1969). In Early Turonian, therefore, the oceanic part of the Tethys must have existed with a certain breadth.

As to the South Atlantic the present reconstruction is much broader than that of REYMENT and TAIT (1972). In view of the hypothesis of a world-wide increase in spreading rates during the period of 110 to 85 m.y. ago (LARSEN and PITMAN III, 1972), it is strange to see little opening of the South Atlantic from Middle Albian to late Early Turonian in their map. Moreover, the recent information of DSDP Leg 40 tells us that the drilling cores at site 364 contain cosmopolitan Albian ammonites (*Mortoniceras, Puzosia* (?), *Tetragonites* (?) etc.) and *Inoceramus* cf. *anglicus* WOODS (see MATSUMOTO, 1977b, in press) and that the Albian and Upper Cretaceous sediments are micritic and pelagic. These suggest the existence of a free sea-way rather than a closed one in Late Cretaceous times.

The distribution pattern of the vascoceratid fauna in contrast to *Collignoniceras* (*Selwynoceras*) assemblage can be explained, even if the South Atlantic was opened with a moderate breadth. I should consider the two kinds of oceanic currents or water masses in the oceanic area and factors of optimum depth in accordance with the history of transgression-regression in the epicontinental area.

Considering the effect of subsequent erosion, the shelf sea is drawn to be somewhat broader than the outcropping area of the Lower Turonian, as in my previous map. Taking the Turonion regression from the Arabian shelf (POWERS et al., 1966; AL NAQUIB, 1967) into consideration, the epicontinental sea is revised to be reduced, although how narrow was the shelf sea in the Early Turonian is not precisely recorded in the available references. The want of information in southern Asia is the same as in the previous case.

Although I plot the distribution data of selected five genera, the present map (Fig. 4) is fairly good to understand or interpret the following palaeobiogeographic features: (1) In general the vascoceratids were distributed in the Early Turonian epicontinental areas surrounding the Tethys sea and its extensions. (2) *Vascoceras* and *Plesiovascoceras* prevailed in the northern shelf sea, whereas *Paravascoceras, Gombeoceras* and *Paramammites* did so in the southern shelf sea, as FREUND and RAAB (1969) pointed out. (3) This faunal distinction was not strict and the two faunal elements intermingled to some extent (MATSUMOTO, 1973). (4) The intimate faunal relation between West Africa and East Brazil may have been due to the southern equatorial currents in the South Atlantic Sea. Whether the intimate faunal affinity of this region with the northern Andean province can be explained in a similar way or otherwise is a problem to be worked out. (5) The distinct fauna of Morocco (COLLIGNON, 1966) may be ascribed to the welling up of the cooler water mass of the North Atlantic (EINSELE and WIEDMANN, 1975). (6) There was naturally a faunal affinity between southwestern Europe and the Gulf Coast plus the southern Western Interior of North America. (7) The vascoceratid fauna of the Western Interior had some, if not remarkable, peculiarity (e.g. prevalence of the subgenus *Greenhornoceras* COBBAN and SCOTT, 1972) as that of central Asia had another peculiarity. (8) *Fagesia* and *Neoptychites* (see also another map in MATSUMOTO, 1977a, fig. 2), of the late Early Turonian, are more widespread than other vascoceratids. This is probably due to more active ability of their locomotion and also to expanded marine transgression in many regions. (9) There are doubtful records of *Fagesia* from New Caledonia (KILIAN, 1910) and California (represented by *F. siskiyouensis* ANDERSON, 1931), for which no suture has been described and the homoeomorphy with certain *Lewesiceras* could be considered. Aside from the above doubtful one, there is in California a species of *Plesiovascoceras* which is somewhat allied to the Western Interior species (see MATSUMOTO, 1959, p. 102). (10) It is considered that certain species of the Vascoceratidae lived in the Japanese province (see p. 286). Hokkaido is much separated from any of the known distributional areas of the vascoceratids. To make clear the route of migration the information from southern Asia is especially wanted.

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(References of the basic data for the distribution map of the vascoceratids were indicated in MATSUMOTO, 1973 and not repeated here, but for the addition of FRITZSCHE, 1924.)

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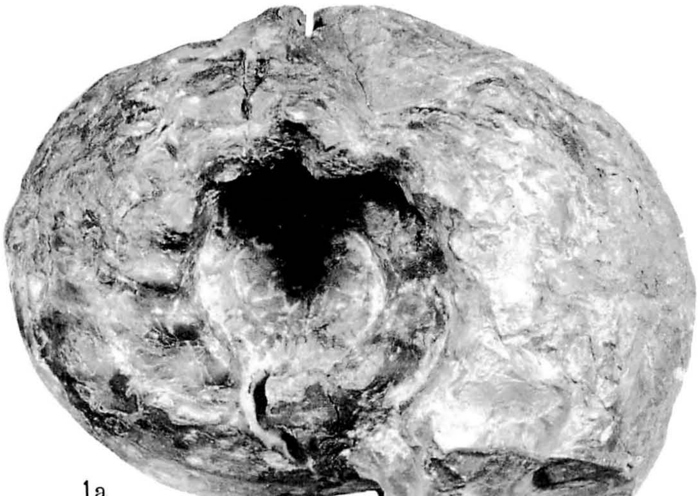
Explanation of Plate 39

Fig. 1. *Fagesia spheroidalis* PERVINQUIÈRE .... Page 282
Yb 3001 of K. MURAMOTO's Collection, from Taki-no-sawa, Oyubari area, central Hokkaido. Lateral (a) and frontal (b) views, ×0.5

Figs. 2, 3. *Fagesia japonica* sp. nov. .... Page 283
2, Ob1005 of K. MURAMOTO's Collection, from loc. R4601p, Naka-kinembetsu in the Obira area, northwestern Hokkaido. Lateral (a) and frontal (b) views of a larger paratype, ×0.3.

3, Holotype, HCS. No. 1, from loc. H2074, Nutapomanai, in the Hobetsu area, central Hokkaido. Lateral (a) and back (b) views, ×1.

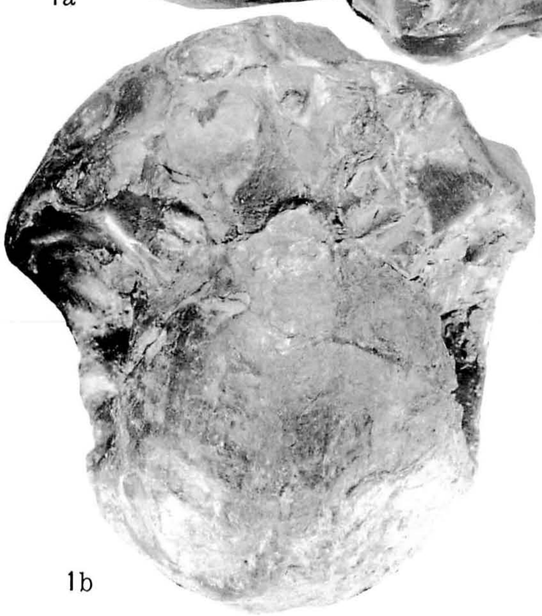
Kyushu University [K. TANABE] photos, without whitening.



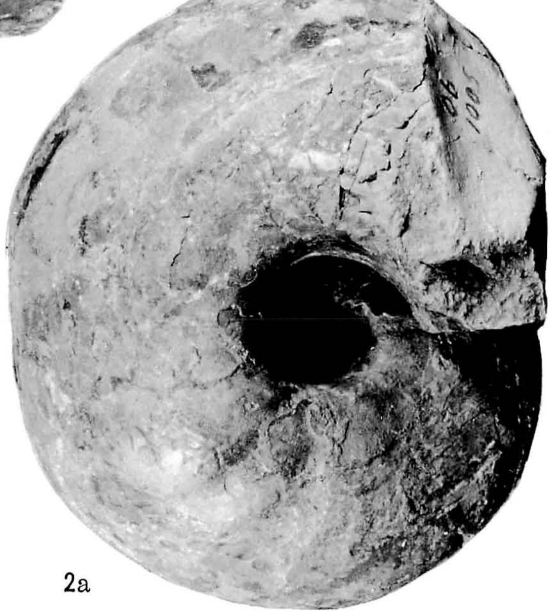
1a

3a

3b



1b



2a

2b

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82 Rinpan-no-sawa. (82 林班の沢), Hobetsu (穂別), Naka-kinembetsu (中紀念別), Nutapomanai (ヌタポマナイ), Obira (小平), [=Opiraushibets (オピラシベツ)], Okufutamata (奥二股), Oyubari (大夕張), Taki-no-sawa (滝の沢)

北海道産バスコセラス科アンモナイトの続報：北海道産のバスコセラス科アンモナイトを1973年に報告して以来，同科の化石がさらに集まった。これらを整理し，本論文では，*Vascoceras* aff. *durandi* (Thomas et Peron)（前回のと同一種の追加資料），*Fagesia spheroidalis* Pervinquière, *Fagesia japonica* sp. nov. の3種を記載した。このほか *Neoptychites cephalotus* (Courtiller) もあるが松本が別論文に記載する。

松本達郎・村本喜久雄

附録：チューロニアン初期の古地理：上記の諸種はいずれも白亜系チューロニアン下部を特色づける。*Fagesia* はその中の比較的上部か中部に広く産する。バスコセラス科のアンモナイトは，当時のテチス海とその延長に面した浅海陸棚に主として分布するが，北西太平洋の北海道での産出が無視できない数になってきたことは注意するべきである。チューロニアン初期の復元した古地理図を試作し，分布について論述を試みた。（松本達郎）

PROCEEDINGS OF THE PALAEONTOLOGICAL SOCIETY OF JAPAN

学会記事

○第106号・学会記事の追加。

〔特別会員〕 平野弘道，石橋　毅，栗原謙二，新妻信明，大場忠道（5名）

○1978年1月19日の評議員会において常務委員の役割の変更と委員の追加が決定された。（会計）浅間一男（旧会員），（会員）小畠郁生（会則第15条により追加）

○同評議員会で賞の委員会委員の半数改選が行なわれた結果，本年度の委員は鳥山隆三会長のほか早坂祥三・浜田隆士（以上留任），猪郷久義・亀井節夫（以上新任）となった。

○同評議員会で承認された会員の動静は次の通りである（受付順）。

〔入会者〕 牧野　融，川口健一，綱田幸司，伴　慎介，岡田清史，三木健二，河村善也，高橋　豊，赤松守雄，野苅家宏，都郷義寛，守随治雄，鈴木孝善，西沢　勇（14名）

〔退会者〕 瑞穂建材工業K.K，イラン石油K.K，（賛助会員2社）；光井　久，小村達夫，崔 東 竜，針生真也，高野　修，森　群平（普通会員6名）

〔逝去者〕 早坂一郎，畑井小虎，今野円蔵，平田茂留（4名）

〔特別会員に推せんされた会員〕 千坂武志，前田保夫，米谷盛寿郎，松島義章，名取博夫，西田史朗，野田雅之，尾崎公彦，斉藤靖二，斉藤常正，杉村昭弘，平　一弘，渡辺耕造，山口寿之（14名）

〔名誉会員に推せんされた会員〕 浅野　清，黒田徳米，鹿間時夫，高井冬二（4名）その結果，本会会員は普通会員311名，特別会員168名，在外会員49名，名誉会員8名，賛助会員8社となった。

○本会特別号第21号として松本達郎君ほかの “Mid-Cretaceous events, Hokkaido Symposium, 1976” が刊行された。また，第22号 “Bibliography of Paleontology in Japan, 1961-1975” が近刊の予定であるとの報告がなされた。

○1978年度学会論文賞は，山口寿之君の “Taxonomic studies on some fossil and recent Japanese Balanoidea”（報告・記事107号，108号）に授与された。

○1978年度学術奨励金は，浅間一男君（中・古生代植物化石の研究）と太田正道君（秋吉石灰岩の生相の研究）に授与された。

会則改正

1978年1月20日の総会において会則12条の一部が次のように改正された。〔 〕内は旧条文。

第12条。在外会員の会費は**年6000円（または等価の U.S. ドル）**〔U.S. $22〕とする。

日本古生物学会1978年総会・年会は1978年1月20日（金）・21日（土）に京都大学において開催された（参加者122名）。

コロキヤム “海外における古生物学の研究の最近の動向”

Mid Cretaceous Events 及び North American Paleontological convension のカンザス集会	蟹江康光
Pander Society に出席して	小池敏夫
微古生物学を中心とした世界の研究動向	斎藤常正
第10回 INQUA 大会に出席して	市原　実
第4回国際ゴンドワナシンポジウム	中沢圭二

特別講演

日本における古脊椎動物学の発達……………………………………………………鹿間時夫

個人講演

宮古沖ピストンコア中の微化石……………………………………………西村　昭・西村明子
インド洋海水中の懸濁物の垂直分布について………………………原田憲一・岡村　真・加藤義明
A few species of *Hystrichokolpoma* (Dinophyceae) from the Pleistocene sediment in Okinawa Jima ……………………………………………………………MATSUOKA, K.
能登半島法住寺珪藻泥岩の微化石層位学的検討‥‥高山俊昭・小泉　格・林　信一・米谷盛寿郎・藤　則雄
浜名湖の珪藻遺骸群集について……………………………………………高橋　豊・小泉　格
北海道の珪藻層序について……………………………………………………小泉　格
Fossil Cervidae from Taiwan……………………………OTUKA, H. and SHIKAMA, T.
On some new materials of *Gomphotherium annectens* (MATUMOTO) from the Miocene Mizunami Group…………………………………………………………………………… KAMEI, T., Okazaki, Y. NONOGAKI, I., and Paleontology Club, Aichi Gakuin Univ.
On *Hipparion* fauna of the Marageh district, North-West Iran………………………………………………………………………KAMEI, T., ISHIDA, S. and NAKAYA, H.
Eocene land turtle discovered from Yubari city, Hokkaido ……………………OKAZAKI, Y.
New species of trionychid turtle from the Pliocene Age Group………………OKAZAKI, Y.
岩手県長岩石灰岩中に人類的構造を追求する……………………………………岡村長之助
北海道奥尻島から発見された放散虫化石について………………………………長田享一
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山口寿之君: Taxonomic studies on some fossil and recent Japanese Balanoidea. Trans. Proc. Palaeont. Soc. Japan, N.S. No. 107, pp. 135-160, pls. 19-22, 1977; No. 108, pp. 161-201, pls. 23-27, 1977.

化石フジツボ類は第三系中に普通に産出するが殻が破片になりやすく，かつそれが付着する周囲の物体の形によって形態が変わるために分類がむづかしく，日本ではその組織的研究は殆んどなかった。一方現生海産無脊椎動物一般を見ても 近年の個体群間の生殖的隔離や 地理的分布に基づいた 種や亜種の研究は未だ開始されたばかりである。

本論文は日本産化石および現生の *Balanus amphitrite* 種群，*B. rostratus*, *Solidbalanus hesperius*, *Megabalanus tintinnabulum* 種群および *B. crenatus* について，それらが付着生物で浅海で野外観察ができると云う利点を生かして従来の形態の差異の程度だけに基づいた類型学的分類を検討し，現生種を調べてわかった種間および種内関係をもとにして分類学的に重みづけられた形質を時間•的空間的に過去に遡って追跡して個体群の概念にもとづく古生物の系統の追跡と分類の確立に努めたものである。本研究により日本の化石フジツボ類の知識は質量共に飛躍的に増加した。化石および現生を統合した海洋無脊椎動物分類の研究に寄与したと判断し日本古生物学会はここに山口寿之君に対して論文賞を贈る。

1977年度日本古生物学会学術奨励金推薦文

浅間一男君: 中・古生代植物化石の研究

古生代後期のカタイシア植物群の標徴植物である '*Gigantopteris*' の葉の形態はきわめて多種多様であるとともに，その大部分は現生の双子葉植物に似た広葉を示し，従来，すべて一属とし扱われていた。

浅間君は，1944年以来，中国山西省の太原炭田の二畳紀植物化石の生層序学的研究を通して，'*Gigantopteris*' 類は，数系列の植物が平行的に，複葉から単葉へと移り変わり，そして広葉が生ずるという過程を推論し，あわせて，従来の '*Gigantopteris*' 類に関する新しい分類体系を提唱した。

また以上の '*Gigantopteris*' 類の変遷と平行して，*Annularia*, *Sphenophyllum*, *Tingia*, *Alethopteris* などの多くの植物においても，環境の変化に応じて，原則的には，定方向的な変遷が行なわれたことを主張した。浅間君による以上の業績は，すでに BOUREAU, E. (1975) による Traité de paléobotanique において全面的に紹介がなされ，一般に認められつつある。

浅間君は，従来はほとんど知られていなかった日本の二畳紀植物群を，米谷・世田米・高倉山から報告し，これらがカタイシア植物群の一員であることを確認，さらに東南アジアにおいては，タイおよびマレーシア

の二畳紀植物群の研究を進め，カタイシア植物群の南限はジョホールに達していることを明らかにした。

植物が定方向的に変遷・進化するという浅間君の考えは，浅間君による成長遅滞の原則（ＧＲの原則）として発表され，従来は，東亜からの移動として解釈されていた，北米の '*Gigantopteris*' 類は，同君のＧＲの原則により，東亜とは別系統のものであることを明らかにした。さらに，中国東北部の *Schizoneura*，アンガラ植物群中の *Glossopteris* は，ゴンドワナ大陸からの移動ではなく，地域間の平行現象であることが論じられている。

浅間君は最近の同君の著書において，陸上植物の起源は，大葉・小葉・有節の三源にあり，ＧＲの原則にもとずき，三系列とも平行的にシダ，裸子・被子の各段階を経過して進化し，年較差漸増の古気候の変遷にその原因があるという一大仮設を発表している。

浅間君の研究は，古生代植物群の研究にとどまらず，最近では，東南アジアをはじめ，マダガスカルの中生代植物群についての研究も進展がなされている。よって日本古生物学会はここに学術奨励金を贈り，今後のいっそうの発展を期待する。

太田正道君：秋吉石灰岩の生相の研究

秋吉台地域は西南日本における日本列島の地史解明にもっとも重要な地域であり，1923年の小沢儀明による逆転構造の発見と主としてフズリナ類にもとづく生層序の確立以来，多くの研究者による成果が発表された。これらの研究を通して秋吉石灰岩の時代論，生層序学的考察においては，従来の多くの研究の結論に大きな差異はないが，秋吉石灰岩の成因，秋吉石灰岩とそれをとりまく非石灰相の古生層群の地質構造については研究者間に著しい意見の相違があり，その真の解明は西南日本の地史解明にも大きな意義をもつものと考えられていた。

太田君は西南日本内帯の後期古生代の石灰岩の地理的分布と構造が非調和的であること，石灰岩塊の基底部にはほとんど海底火山噴出堆積物が存在することに着目し，また石灰岩中の化石群の古生態学的，堆積学的研究から，基底部海底火山噴出岩と石灰岩の堆積機構および堆積環境を解明し，秋吉石灰岩層群は地向斜型生物礁複合体として堆積したことを明かにした。

太田君は地質時代の生物礁複合体の研究には，ただ単に古生物学的，堆積岩石学的研究を別個に行なうだけでは不充分であるという観点から，古生物群を古生態系としてとらえ，化石相と岩相の組合せから秋吉石灰岩を16の岩型に分類し，その各々と現世の生物礁複合体における各堆積相からみた環境とを比較し，古環境を明かにし，生物礁複合体の堆積機構を推定した。その結果，秋吉石灰岩層群は石炭紀前期における海底火山活動に始まり，海ユリ―コケ虫群集，単体サンゴ―コケ虫群集，群体サンゴ―コケ虫―海ユリ群集が順次発達して生物礁となり，ついで群体サンゴ―ストロマトライト―コケ虫―海ユリ群集が発生し，さらに地向斜の沈降によって，おそらく環礁を形成したものと結論した。

地質時代の生物礁の存在はヨーロッパ，アメリカなどで知られているが，日本の後期古生代の地向斜型生物礁複合体について，その成立から成長発達過程を堆積学的，古生態学的見地から論じたのは太田君の著しい業績である。この研究は秋吉台石灰岩全域についてフズリナおよびサンゴ化石に基づく詳細な生層序学的研究を基礎とし，さらに帰り水地域その他石灰石稼行地域から得られた豊富な地下データも用いて秋吉石灰岩層群と周辺の非石灰相古生層群の地質構造を考察した結果，導きだされた知見である。

以上のように，太田君の秋吉石灰岩についての研究は確実なデータを独得な方法論的手法によって，分析総合して生物礁複合体の本質を明かにしたもので学術的に高く評価されるべきものである。よって日本古生物学会は学術奨励金を贈り，今後いっそうの発展を期待するものである。

日本学術会議第73回総会報告（要約）

日本学術会議第73回総会は，1977年10月26日から28日まで開催され，鉱物資源・エネルギーに関する研究センターの設立およびエネルギー工学研究所（仮称）の設立についての勧告がその他の勧告採択され，また我が国におけるＤＮＡ分子組換え研究の進め方に関する日本学術会議の見解が声明として示された。

日本学術会議第74回総会報告（要約）

日本学術会議第74回総会は，1978年１月23日から25日まで開催された（これは第11期の最初の総会にあたる)。会長に伏見康治（第４部），副会長に岡倉古志郎（第２部）および名取礼二（第７部）が選出され，第10期の活動と第11期への引継ぎ事項に関する報告があり，活発な討論の後，第11期活動計画委員会が設置された。

行事予定

	開催地	開催日	講演申込締切
第121回 例会	筑波大学	1978年6月3日	1978年3月31日
第122回 例会	山形大学	1978年10月14日	1978年8月10日
1979年総会・年会	福岡大学	1979年1月21,22日	1978年11月20日

講演申込先：〒113 東京都文京区弥生 2-4-16 日本学会事務センター 日本古生物学会行事係

お知らせ

○さきに本会から会員候補者として推せんした大森昌衛君が第11期の日本学術会議会員に当選した。

○The 3rd International Symposium on the Mechanism of Biomineralization in the Invertebrates and Plants が1977年10月8日から12日まで賢島セミナーセンター（三重県阿児町）で開催された。

○古生物研連主催・日本古生物学会後援のシンポジウム「海の古生態—I.“サンゴ礁”の環境解析」が1977年11月1日に日本学術会議で開催された。

○Recent Progress of Japanese Sciences (Geological Sciences) は日本自然科学集報 Vol. 3 として編集され日本学術会議から出版される。

○1978年10月2日～5日筑波大学で東南アジア地質古生物に関する国際シンポジウムが開催される。

編集係より

○1977年度に投稿原稿の校閲者として尽力された諸兄に感謝いたします（御氏名は申し合わせにより公表いたしません）。

○本号より，短報を除く各原著論文に内容を簡潔に示す英文アブストラクトをつけることになりました。今後投稿される方は原稿に添えて従来の和文要約とは別に，300語以内の英文アブストラクト原稿をお送り下さい。また，本文中に引用された文献と末尾の文献リストはたがいに過不足がないようにして下さい。文献リストの原稿は本誌最近号を参照して作成して下さるようお願いします。

○現在掲載予定の投稿原稿は10篇で，その分量は約3号分にあたります。

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