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Fossil on the cover is the six leaves in a whorl of *Trizygia oblongifolia* (GERM. & KAULF.) ASAMA from the Maiya Formation (*Parafusulina* zone), Maiya, N.E. Japan.

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661. ON THE NON-MARINE MOLLUSCAN FAUNA FROM THE UPPER MESOZOIC MYOGOG FORMATION KOREA*

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韓国上部中生層の卯谷層産軟体動物群について: 卯谷層産軟体動物化石の中, 二枚貝の *Koreanaia cheongi*, gen. et sp. nov. と *Nagdongia leei*, sp. nov. を記載した。*Koreanaia cheongi* はその内部構造と表面装飾上 *Nippononaia-Wakinoa-Trigonioides* (s. s.)-*T.* (*Kumamotoa*) の trigonioidid 系列の祖先型だと思われる。その外 以前に *Plicatounio* sp. と *Unio* sp. として報告されたものは同一種の unionid だと思われるがその記載は標本が少ないので将来に委ねる。田村 (1970) が記載した *Wakinoa tetoriensis* (MAEDA) は前田 (1963) の *T.* (s.s.) *tetoriensis* と表面装飾に明らかな相異点があるので, 新たに *Wakinoa tamurai* の新種名を提唱する。 梁 承 榮

Introduction

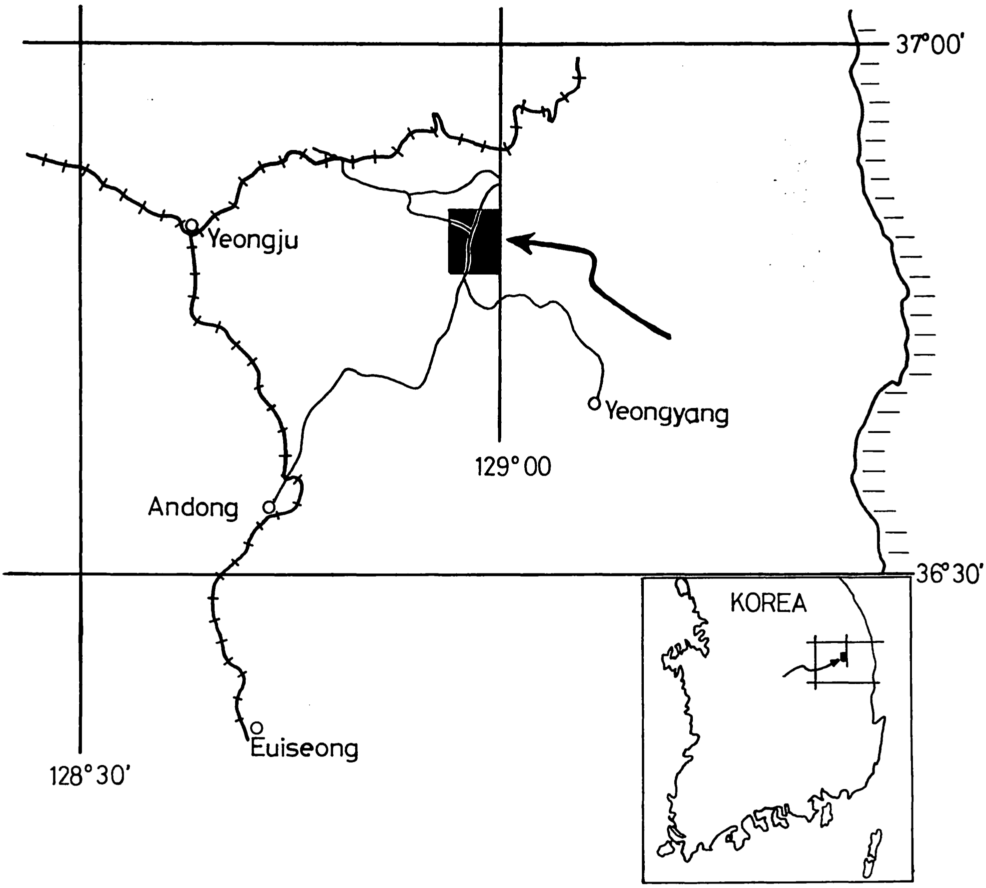
The Myogog Formation is quite important and interesting on the Korean Late Mesozoic history, because it contains a unique fauna and presents a characteristic geologic structure compared with the adjacent Cretaceous Gyeongsang Group. CHEONG and LEE (1966) reported the stratigraphy of this Formation with a list of fossils and assigned its age to Upper Jurassic. Since then, there has been dispute on the fossil contents and correlation of the formation.

In 1970, CHANG and I investigated the formation, collected a number of well preserved molluscan fossils, and briefly reported the result, regarding the formation as a part of the Lower Nagdong Subgroup. However, at that time, we did not precisely examine the fossils.

During my studying abroad at Kyushu University, Japan, I found some interesting features on the molluscan fossils. But the sample is so insufficient especially of the apparent trigonioidid features that I did not make clear the variation of its characters. Thus, since my coming back home, I have added new collection and found some new features. This paper is to describe the Myogog fauna in more detail and compare it with the Nagdong fauna and Japanese Upper Mesozoic non-marine molluscs.

This study was mostly carried out under the guidance of Professor Tatsuro MATSUMOTO at Kyushu University, Japan. I express my sincere gratitude to Professor Tatsuro MATSUMOTO for his pertinent guidance, arrangement and also critical reading of the typescript of this paper, to Professor Chang-Hi CHEONG of the Seoul National University and Dr. Ha-Young LEE of the Yonsei University who gave me invaluable suggestion on the Myogog Formation, and to Professor Ki-Hong CHANG of the Kyungpook National University who gave me privilege

* Received March 23, 1976; read October 19, 1974 at Nogoya.



Text-figure 1. Index map.

to study our common collection with warmful encouragement.

Stratigraphic note

The stratigraphy of the area around the fossil locality is as follows in descending order (after CHEONG and LEE, 1966):

Gyeongsang Group

Silla Subgroup: Cheongyangsan Formation (mainly conglomerate, marls, sandstone, mudstone, limestone and andesite lavas) about 500 m

——— disconformity ———

Nagdong Subgroup: Gasongdong Formation (mainly greenish grey marl, dark grey shale and conglomerate) about 350-450 m

Donghwachi Formation (Red mudstone Member, 100-450 m and Arkosic sandstone Member, 200-350 m)

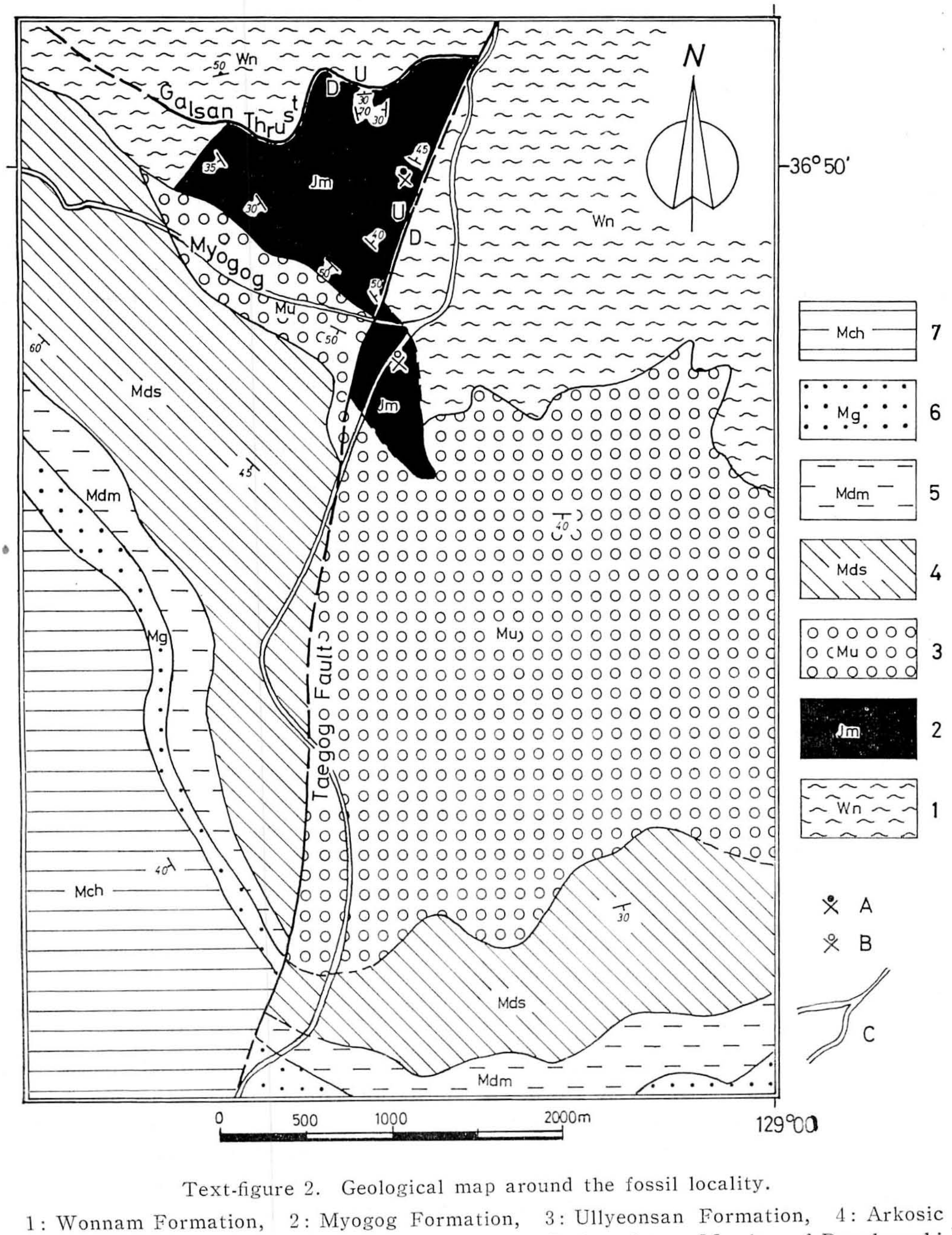
Ullyeonsan Formation (mainly cobble or boulder bearing conglomerate associated with light grey arkosic sandstone) about 500 m

——— unconformity ———

Upper Jurassic (?): Myogog Formation (mainly dark grey to black shale and sandstone) more than 150 m

——— fault contact ———

Precambrian (?): Wonnam Formation (mainly quartz-feldspar gneiss, quartz schist and limestone)



Text-figure 2. Geological map around the fossil locality.

1: Wonnam Formation, 2: Myogog Formation, 3: Ullyeonsan Formation, 4: Arkosic sandstone Member of Donghwachi Formation, 5: Red mudstone Member of Donghwachi Formation, 6: Gasongdong Formation, 7: Cheongyangsan Formation, A: Locality of fossil plants, B: Locality of molluscan fossils, C: National road.

The metamorphic Wonnam Formation is unconformably overlain by Ullyeonsan and Donghwachi Formations. It has been presumed to be of Precambrian age without sufficient evidence.

The Myogog Formation crops out in somewhat triangular form, bounded by the Galsan Thrust on the northwest side and the Taegog Fault on the east side in contact with the Wonnam Formation and is overlain unconformably by the younger Ullyeonsan Formation on the southwest side. Thus, its lower limit is unknown. It displays an intense deformation in contrast with the gently inclined Gyeongsang Group.

The Myogog fossils identified by CHEONG and LEE (1966) are as follows: *Trigonioides* sp., *Plicatounio* sp., *Unio* sp., *Corbicula* aff. *tetoriensis* KOBAYASHI and SUZUKI, *Corbicula* sp., *Viviparus* sp., *Cladophlebis denticulata* (BRONG.), *C. browniana* (DUNKER), *C. geyleriana* (NATHORST), *Adiantites yuasaensis* YOKOYAMA, *Onychiopsis elongata* (GEYLER), *O. mantelli* (BRONG.), *Equisetites* sp., *Ginkgodium gracile* (?) TATEIWA, *Nilssonia* sp., *Podozamites* sp.

They considered the above to be clearly different from the Daedong biota and quite similar to but not identical with the Nagdong. Therefore, as shown above, CHEONG and LEE (1966) correlated the Ullyeonsan, Donghwachi and Gasongdong Formations to Nagdong Subgroup and the Myogog Formation to pre-Gyeongsang and post-Daedong, Upper Jurassic. However it seems necessary to restudy the fossils in the light of up-to-date paleontology.

On the other hand, the problem on the age of Gyeongsang Group itself has not been clearly solved out yet. Before the World War II, many of the Japanese geologists investigated thoroughly the age determination of the Group based on the fossils contained and attempted the regional correlation of the East Asian non-marine deposits. And since 1938 (KOBAYASHI), the Nagdong Subgroup, the lower part of the Gyeongsang Group, has been approximately correlated with Lower Cretaceous. However, a result of my previous paper (YANG, 1974) has shown that certain important species from the Nagdong Subgroup is not identical with the species from Japan. More studies in paleontology as well as in stratigraphy are necessary to draw a correct conclusion of the geological age.

Systematic description

Superfamily Unionacea

Family Trigonioididae

Genus *Koreanaia*, nov.

Type-species--Koreanaia cheongi sp. nov., to be described below.

Generic diagnosis—Shell medium in size, equivalve and subequilateral; outline suboval or subquadrate; umbo prominent, slightly prosogyrous. Surface ornamented with characteristic trigonioidid V-sculptures in the median part and the reversed V-ribs on the posterior ridge which in turn run upward to form another set of V-shape riblets on the postero-dorsal side. The angles of the median V-ornaments from 35° to 45°. Hinge plate moderate in breadth, provided with opisthocline pseudocardinal teeth and posterior lateral teeth; the number of pseudocardinal ones 3 in left valve, 2 in right valve and that of posterior lateral teeth 2 in left valve, 1 in right valve. All of the hinge teeth not crenulated, rather lamellar. Two adductor scars situated close to the outer ventral ends of the pseudocardinal and posterior lateral teeth; anterior one semicircular, and strongly impressed, accompanied with a minute pedal scar; posterior one not so prominent. Pallial line simple and distinctly impressed.

Remarks—On account of its V-shape ornamentation and the disposition of the hinge teeth, this genus is certainly allied to Trigonioididae. But the present genus *Koreanaia* is clearly different from the well-known *Trigonioides, Hoffetrigonia, Nippononaia* and *Wakinoa* on its lamellar hinge teeth and the obviously large angle of the V-sculptures. The latter genera possess, that is, crenulated hinge teeth and marked smaller angle of V-ornamentation. So far as the accessible monographs are concerned, there is no genus, fossil and the Recent, with which the present genus could be identified. This genus is at present represented only by a single species from the Upper Mesozoic formation of Korea.

Koreanaia cheongi, sp. nov.

Pl. 33, Figs. 1-18; Text-fig. 3.

1966. *Trigonioides* sp. CHEONG & LEE, *Jour. Geol. Soc. Korea*, vol. 2, pl. 1, figs. 1-4.

Etymology:—The specific name is dedicated to Professor Chang-Hi CHEONG of the Seoul National University who has largely contributed to the stratigraphy of Korea.

Material—Holotype (KPE 1031) and seventeen paratypes (KPE 1032, 1035, 1036, 1281-1294) from Myogog Formation, which are preserved in the Department of Earth-Science, College of Education, Kyungpook National University, Daegu, Korea (Coll. K. H. CHANG and S. Y. YANG, and S. Y. YANG). Two plaster casts of the above specimens (KPE 1031, 1035) are kept in the Department of Geology, Faculty of Science, Kyushu University, Fukuoka, Japan.

Measurements (in mm).—

Specimen	L*	H*	D*	I*	H/L	D/L
Holotype (KPE 1031) (BV)*	33.6	24.1	13.1	6.7×2	0.72	0.39
Paratype (KPE 1035) (BV)	25.0	18.6	9.7	5.1×2	0.74	0.39
Paratype (KPE 1036) (LV)*	16.3	11.1	7.1	?	0.68	0.44
Paratype (KPE 1281) (BV)	44.4	34.0	16.2	?	0.77	0.36
Paratype (KPE 1282) (BV)	42.0	33.9	15.9	?	0.81	0.38
Paratype (KPE 1284) (RV)*	48.7	37.6	19.2	?	0.77	0.39
Paratype (KPE 1285) (BV)	47.7	37.9	18.5	?	0.79	0.39
Paratype (KPE 1286) (RV)	24.3	14.9	10.9	?	0.61	0.45
Paratype (KPE 1287) (RV)	22.5	16.0	8.7	?	0.71	0.39
Paratype (KPE 1288) (BV)	17.0	10.9	6.4	?	0.64	0.38

Mean of H/L: 0.72; standard deviation of H/L: 0.06, mean of D/L: 0.40; standard deviation of D/L: 0.03.

(Based on ten type-specimens, exclusive of the strongly deformed or broken specimens.)

* L: length, H: height, D: distance between umbo and anterior extremity, I: inflation, BV: conjoined valve, LV: left valve, RV: right valve.

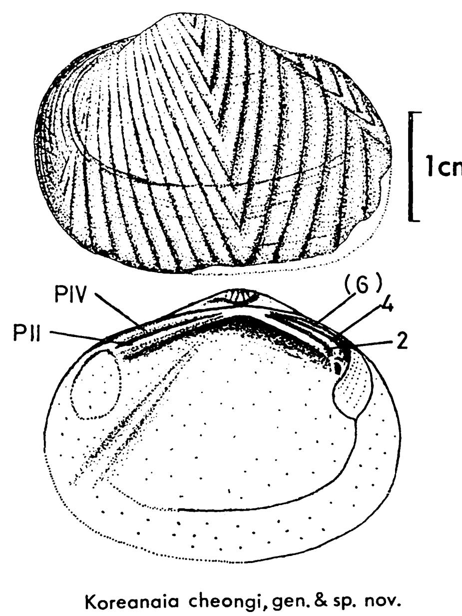
Description—Shell medium in size (about 16-50 mm in length); anterior margin well rounded, posterior one rather straight or truncated, ventral margin gently and broadly arcuate, generally suboval or subquadrate in outline; subequilateral and equivalve; ratio of H/L about 0.7; moderately inflated; test moderate in thickness; umbo slightly prosogyrous, placed about two-fifths of the shell length from the anterior extremity, projected slightly above the hinge line; escutcheon and lunule indistinct. Surface ornamented with characteristic trigonioidid V-shape ribs in the median part and the reversed V-ribs on the posterior ridge, which, in turn, run upward to make again V-shape ornaments on the postero-dorsal side, while on the anterior dorsal side the reversed Vs or V-shape riblets not clearly observed. However, on the anterior half the triple or multiple V-shape riblets presented faintly and occasionally. The angles of the median V-ribs about 35°-45° and those of the reversed V on the posterior ridge larger than 45° and those of the V-shape riblets on the postero-dorsal side about 120°. The line crossing the apices of the median V-ribs slopes posteriorly, forming about 80° with the ventral line. The ribs and grooves on the posterior half stronger and wider than those on the anterior half. The V-shape ornaments on the anterior part weakened with growth, and on the adult (large) specimens the anterior ventral part ornamented with growth-lines only. The median ribs number more than 17 in the anterior half, and 13 in the posterior. The whole surface ornamented also with fine numerous concentric growth-lines of irregular interval and prominence; strong posterior ridge running from umbo down to postero-ventral corner.

Hinge plate moderate in breadth, provided with opisthocline pseudocardinal teeth and posterior lateral teeth of unioid type; two pseudocardinal and one posterior lateral teeth in the right valve and three pseudocardinal and two postero-lateral teeth in the left valve, forming the following dental formula:

$$\frac{5\quad 3\qquad\qquad \mathrm{PIII}}{(6)\quad 4\quad 2\qquad \mathrm{PII}\quad \mathrm{PIV}}$$

All of the hinge teeth smooth, without crenulation or striation. Two adductor scars subequal in size, placed close to the outer ends of the pseudocardinal and the posterior lateral teeth respectively; anterior one semicircular, strongly impressed, accompanied by a minute pedal scar, posterior one subcircular, indistinct. Pallial line simple; umbonal cavity moderately deep. The internal mould marked with one postero-dorsal undulation running from the umbo down to the postero-ventral corner, and in small specimens provided with impression of V-shaped ornament on the flank and weak crenualtion around the ventral margin, while in large specimens it is smooth without V-shape impression or crenulation around the ventral margin.

Observations—The holotype (KPE 1031)



Text-figure 3. Surface ornamentation and internal structure of *Koreanaia cheongi*, gen. et sp. nov.

is a specimen of well preserved conjoined valves of which right valve is secondarily depressed. Eight of 16 specimens are conjoined and one (KPE 1035) of the conjoined specimens slips each other along the postero-anterior axial plane. All of the specimens possess well preserved test, then the internal structures have been observed on the 6 specimens (KPE 1032, 1289-1293) from which the test was dissolved out by dilute hydrochloric acid. So far as the examined specimens are concerned, there is no marked variation in the hinge structures. However, in the internal structures, the V-shape impressions and crenulations around the ventral margin are observed on the immature (small) specimens only. This may be regarded as an ontogenetic variation.

Occurrence—The described specimens were collected from the black shale of the Myogog Formation at Myogog, Jaesan-myeon, Bonghwa-gun, Gyeongsang-buk-do, Korea (see Text-figure 1). The black shale contains plenty of the molluscan fossils of which the present species is the least common. Half of the specimens are found of conjoined state, as pointed above, and all do not show any severe defacement besides secondary deformation, which are regarded as reflecting the fossil biocoenose or at least fossilized not far from the living place.

The stratigraphic investigation of the present area was carried out mostly by LEE (1965) and modified a little by CHANG and YANG (1970).

Comparison—At first sight this species looks like a certain species of *Trigonioides* in surface ornamentation, but it is not related with the latter, because the angles of the V-shape ribs on the median part are larger than any species of *Trigonioides*. From this point of view the present species is closer to *Wakinoa* than *Trigonioides*. The multiple V-shape ornaments are occasionally and irregularly found on the anterior half of the present species just like the *T*. (s. s.) *tetoriensis* (by TAMURA, 1970; and not by MAEDA, 1963) and *T*. (*Kumamotoa*) *matsumotoi* KOBAYASHI and SUZUKI, 1941, as pointed out by TAMURA (1970). However, the angles of them are also still larger in the former than in the latter two.

What is more important is that the internal structures of this genus are certainly different from those of *Wakinoa* OTA, 1963 and *Trigonioides* KOBAYASHI and SUZUKI, 1936. The hinge teeth of the present species are rather smooth without crenulation or striation. It is interesting that the *Nippononaia tetoriensis* from the uppermost Jurassic (?) Itoshiro Subgroup, Tetori Group, possesses lamellar smooth hinge teeth as the present species. But the number of the hinge teeth is not identical and the surface ornamentation and the outline are clearly different from each other.

The material of *Trigonioides yunnanensis* KU et MA, 1962 from China is so fragmentary or ill-defined that sufficient comparison cannot be made. However, it is noted that the Chinese species is similar to the present species in the V-shape patterns and smoothness on the internal surface and lamellar hinge teeth. But the difference can be clearly found by a careful comparison between the two. The present species has smaller angles of the median V-ribs than *T. yunnanensis*. In the Chinese species the chevron-shaped patterns are present on both sides and the hinge teeth are not completely lamellar, but have crenulations at least partly. Moreover, the outline and the ratio of H/L are obviously different between the two species.

If the phylogenetic series of *Nippononaia*-*Wakinoa*-*Trigonioides* (s. s.)-*T*. (*Ku-*

mamotoa) is assumed (HAYAMI and ICHIKAWA, 1965; OTA, 1963; YANG, 1974), the present genus *Koreanaia* can be regarded as representing an ancestral group of the series. In other words, the present genus may be considered as most intimate to unionids among the trigonioidids from Far East Asia.

Revision on the Trigonioides tetoriensis—MAEDA (1963) reported the occurrence of *Trigonioides* from Tetori Group and named it *T. tetoriensis* with a detailed description on the hinge teeth. Subsequently, TAMURA (1970) observed MAEDA's specimens, collected his own samples from the Tetori Group, and referred it to *Wakinoa*.

YANG (1974) considered it as belonging to *T.* (*Kumamotoa*) on the basis of the original description of MAEDA (1963). After that, I have had a chance to observe the type specimens by courtesy of Dr. MAEDA. From my observation, I can certify that the *T. tetoriensis* (MAEDA's, not TAMURA's) is an only species to be referred to *Trigonioides* (s. s.) among the Japanese trigonioidids so far. The difference between *T.* (s. s.) *kodairai* and *T.* (s. s.) *tetoriensis* can be read only in inflation, that is, the *T.* (s. s.) *tetoriensis* is more inflated than the type-species. In other characters, there are no essential difference between the two species. The specific identity between TAMURA's *T. tetoriensis* and MAEDA's *T. tetoriensis* is open to question as the identity of the fossil localities and the stratigraphic horizons is so. The internal structures of the two are fairly similar, but the surface ornaments are clearly different. The so-called *W. tetoriensis* of TAMURA shows distinctly the double or multiple V-sculptures on the anterior surface, and the V-angle is much larger than that of *T.* (s. s.) *tetoriensis*. And the former possesses better developed pseudocardinala than *W. wakinoensis*. It can be considered that *W. tetoriensis* of TAMURA is a transitional form placed between *Wakinoa* and *Trigonioides* (s. s.). And it is reasonable to separate TAMURA's *Wakinoa tetoriensis* from *T.* (s. s.) *tetoriensis* MAEDA. Here I propose ***Wakinoa tamurai***, sp. nov. for TAMURA's specimens. And KE 1970 (fig. 1 of pl. II, TAMURA, 1970) is designated as its holotype.

Family Unionidae

Subfamily Unioninae

Genus *Nagdongia* YANG, 1975

Type-species—Nagdongia soni YANG, 1975

Generic diagnosis—See YANG, 1975, p. 178

Nagdongia leei, sp. nov.

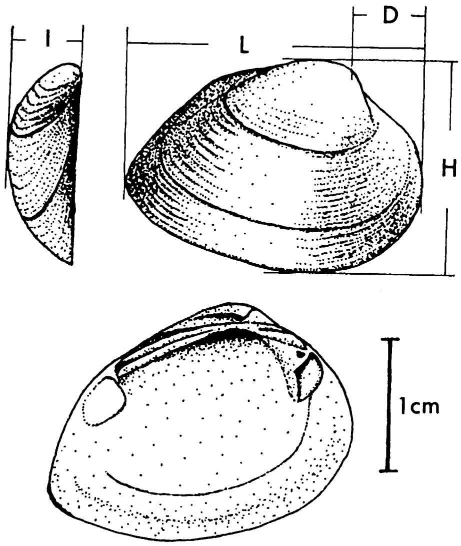
Pl. 34, Figs. 1-60; Text-fig. 4.

1966. *Corbicula* sp. CHEONG & LEE, *Jour. Geol. Soc. Korea*, vol. 2, no. 2, pl. 1, fig. 9.
1966. *Corbicula* aff. *tetoriensis*, CHEONG & LEE, *ibid.*, pl. 1, fig. 10.

Etymology—The specific name is dedicated to Dr. Ha-Young LEE of the Yonsei University who has contributed to the stratigraphy of Myogog Formation and the paleontology of Korea.

Material—Holotype (KPE 1219) and 376 paratypes (KPE 1201-1218, 1220-1277, 1301-1600) from the Myogog Formation, which are preserved in the Department of Earth-Science, College of Education, Kyungpook National University, Daegu, Korea (Coll. K. H. CHANG and S. Y. YANG, and S. Y. YANG).

Description—Shell small for the genus, commonly about 20 mm in length, oc-



Nagdongia leei, sp. nov.

Text-figure 4. Basic morphology and internal structure of *Nagdongia leei*, sp. nov.

casionally larger than 30mm; subequilateral and equivalved; generally subelliptical or suboval in outline; anterior margin well rounded, postero-dorsal margin rather straight or subtruncated, forming obtuse angle with posterior margin, ventral margin broadly arcuated. Beak blunt below the umbonal line and turned forward, situated at about one third (0.3-0.4) of shell length from anterior extremity. Hinge line gently arcuated. Surface sculptured with concentric growth-lines roughened at irregular intervals. Posterior ridge blunt and indistinct.

Pseudocardinal teeth 2 in right valve, 1 in left valve, posterior lateral teeth 1 in right, 2 in left valve. Posterior lateral ones parallel to the hinge line, well marked, rather sharp, the upper one in left valve thinner and not extending as far back as the lower, pseudocardinal tooth in left rather stout and higher but shorter than the posterior ones. Posterior tooth in right valve distinct and stronger than those in left valve, lower one of two pseudocardinal teeth in right valve blunt and high, while upper one thinner and lower. All of the hinge teeth without crenulation or striation, rather lamellar. Two adductor scars placed close to the outer ends of the hinge teeth, subequal in size, anterior one more strongly impressed, accompanied with a minute but distinct pedal scar, posterior one not so distinct; pallial line simple; internal margin smooth; umbonal cavity moderate deep; test fairly thick.

Observations—The holotype (KPE 1219) is a well preserved right valve (L: 20.8 mm, H: 15.7 mm, D: 8.2 mm, I: 5.6 mm) and the paratypes are also well preserved, in which 167 are right valves, 147 left valves, and 63 conjoined valves. Besides these, there are numerous fragmentary or deformed specimens. All of the specimens have well preserved test. The internal structures have been observed on the six specimens (KPE 1255-1260) from which the tests were dissolved out by dilute hydrochloric acid.

Occurrence—The specimens under consideration were collected from the same locality as the above species (*Koreanaia cheongi*). This species occurs innumerably, but the range in size is fairly small. About 17% of the specimens are conjoined and the tests are conserved, not worn down.

Comparison—At a first glance this species looks like a certain species of *Corbicula* in outline and size, but it does not show the characteristic cardinal teeth of *Corbicula*. The present species is similar to but not identical with *Sphaerium anderssoni jeholense* in outline. In the latter species the postero-dorsal margin is clearly truncated and rather straight,

Table 1. Measurements of L, H, D and I.

Specimen	L	H	D	I	L/H	D/L	I/L
KPE 1201(RV)	12.9	8.6	4.5	2.4	1.50	0.35	0.19
KPE 1202(RV)	13.7	10.8	4.2	3.6	1.27	0.31	0.29
KPE 1203(RV)	15.5	11.4	5.3	3.3	1.36	0.34	0.21
KPE 1204(RV)	16.2	12.4	5.4	4.9	1.31	0.33	0.30
KPE 1205(RV)	16.0	10.6	5.3	3.7	1.51	0.33	0.23
KPE 1206(RV)	16.8	11.7	5.3	?	1.44	0.32	—
KPE 1207(RV)	17.8	12.1	6.6	3.5	1.47	0.37	0.20
KPE 1208(RV)	16.5	12.3	6.8	3.7	1.34	0.41	0.22
KPE 1209(RV)	19.2	13.3	6.7	5.4	1.44	0.35	0.28
KPE 1211(RV)	18.1	13.4	6.5	4.8	1.35	0.36	0.27
KPE 1212(RV)	22.6	15.6	9.2	6.9	1.45	0.41	0.31
KPE 1213(RV)	19.7	14.1	7.4	5.1	1.40	0.38	0.26
KPE 1215(RV)	21.4	14.4	7.8	4.9	1.49	0.36	0.23
KPE 1216(RV)	22.1	16.1	8.5	6.3	1.37	0.38	0.29
KPE 1217(RV)	20.9	15.1	7.6	6.1	1.38	0.36	0.29
KPE 1218(RV)	26.2	17.2	9.4	6.1	1.52	0.36	0.24
KPE 1219(RV)*	20.8	15.7	8.2	5.6	1.32	0.39	0.27
KPE 1220(RV)	20.1	14.8	7.3	5.5	1.36	0.36	0.27
KPE 1221(RV)	19.7	14.8	7.2	5.2	1.33	0.37	0.26
KPE 1222(RV)	24.5	18.0	8.7	6.8	1.36	0.36	2.28
KPE 1223(RV)	21.8	15.3	6.8	5.8	1.42	0.31	0.27
KPE 1224(RV)	22.0	16.6	7.2	5.5	1.33	0.33	0.25
KPE 1225(RV)	27.6	19.4	11.0	6.9	1.42	0.40	0.25
KPE 1227(RV)	27.3	20.7	10.1	7.7	1.32	0.37	0.28
KPE 1228(RV)	28.5	20.5	9.9	7.3	1.39	0.35	0.26
KPE 1229(RV)	27.0	19.6	9.7	7.5	1.38	0.36	0.28
KPE 1230(LV)	14.7	9.8	5.4	3.3	1.50	0.37	0.22
KPE 1231(LV)	13.9	9.4	5.0	?	1.48	0.36	—
KPE 1232(LV)	16.2	10.7	5.7	5.2	1.51	0.35	0.32
KPE 1233(LV)	16.9	11.3	6.3	3.3	1.50	0.37	0.20
KPE 1234(LV)	16.4	11.4	5.9	3.7	1.44	0.36	0.23
KPE 1235(LV)	17.4	11.6	5.8	5.3	1.50	0.33	0.30
KPE 1236(LV)	18.6	14.1	6.2	5.4	1.32	0.33	0.29
KPE 1237(LV)	20.4	14.4	7.3	5.7	1.42	0.36	0.28
KPE 1238(LV)	18.8	14.4	5.3	5.1	1.31	0.28	0.27

KPE 1219(RV)*: Holotype.

Specimen	L	H	D	I	L/H	D/L	I/L
KPE 1239(LV)	18.8	13.0	6.6	4.7	1.45	0.35	0.25
KPE 1240(LV)	20.1	14.4	7.3	4.9	1.40	0.36	0.24
KPE 1241(LV)	20.9	14.8	6.7	5.9	1.41	0.32	0.28
KPE 1242(LV)	23.5	16.0	8.7	6.9	1.47	0.37	0.29
KPE 1243(LV)	21.1	16.1	5.5	6.1	1.31	0.26	0.28
KPE 1244(LV)	25.4	18.5	8.7	7.0	1.37	0.34	0.28
KPE 1245(LV)	21.4	14.7	6.5	5.1	1.46	0.30	0.24
KPE 1246(LV)	19.9	14.4	6.4	6.2	1.38	0.32	0.31
KPE 1247(LV)	20.5	15.1	6.5	4.4	1.36	0.32	0.21
KPE 1248(LV)	20.0	14.4	7.5	5.5	1.39	0.38	0.28
KPE 1249(LV)	23.7	17.0	8.8	5.4	1.39	0.37	0.23
KPE 1250(LV)	22.8	16.4	8.0	6.3	1.39	0.35	0.28
KPE 1251(LV)	21.2	15.6	7.1	5.6	1.36	0.33	0.26
KPE 1252(LV)	23.0	16.1	9.2	6.4	1.43	0.40	0.28
KPE 1253(LV)	28.6	21.2	9.4	7.2	1.35	0.33	0.25
KPE 1254(BV)	20.4	15.6	8.1	5.1	1.31	0.40	0.25
KPE 1261(LV)	23.5	17.7	7.1	7.3	1.33	0.30	0.31
KPE 1262(RV)	16.4	11.2	5.8	4.1	1.46	0.35	0.25
KPE 1263(RV)	21.2	15.0	6.6	5.0	1.41	0.31	0.24
KPE 1264(RV)	17.4	12.3	5.9	4.4	1.41	0.34	0.25
KPE 1265(RV)	13.8	9.1	4.9	3.8	1.52	0.36	0.28
KPE 1266(RV)	20.3	13.5	6.9	4.8	1.50	0.34	0.24
KPE 1267(RV)	13.4	8.6	4.5	2.8	1.56	0.34	0.21
KPE 1268(LV)	18.6	12.3	5.7	?	1.51	0.31	—
KPE 1269(LV)	22.7	17.2	7.8	7.1	1.32	0.34	0.31
KPE 1270(RV)	15.4	10.3	5.7	3.6	1.50	0.37	0.23
KPE 1271(RV)	25.7	19.8	9.7	7.1	1.30	0.38	0.28
KPE 1272(RV)	22.2	14.9	7.9	5.0	1.49	0.36	0.26
KPE 1273(LV)	16.5	11.3	5.2	3.7	1.46	0.31	0.22
KPE 1274(LV)	23.7	17.9	10.0	6.9	1.32	0.42	0.29

Measurements based on 65 type specimens, exclusive of the strongly deformed or broken specimens.

but in the former not so clearly. The species is apparently intermediate between *S. anderssoni anderssoni* and *S. anderssoni jeholense* in outline. However, with respect to the internal structures the present species is not related to *Sphaerium* but to *Nagdongia*. According to SUZUKI (1943, p. 62), *S. anderssoni* has two lateral teeth on each side of the right valve, one on each of the left, while in present species pseudocardinal teeth are two in right valve, one in left valve, posterior lateral teeth one in right valve, two in left valve. Furthermore the two adductor scars and minute pedal scar accompanied with anterior adductor scar are fairly similar to those of the *Nagdongia soni*. From the viewpoint of these internal characters the present species is certainly assigned to the genus *Nagdongia*, but its valve is distinctly more inflated than the type-species of the genus (*N. soni*). The details on the simple ratios L/H, D/L and I/L and the comparison with the *Nagdongia soni* are presented in the following.

Measurements—The basic morphology and measurements are illustrated in Text-figure 4 and recorded in Table 1, respectively.

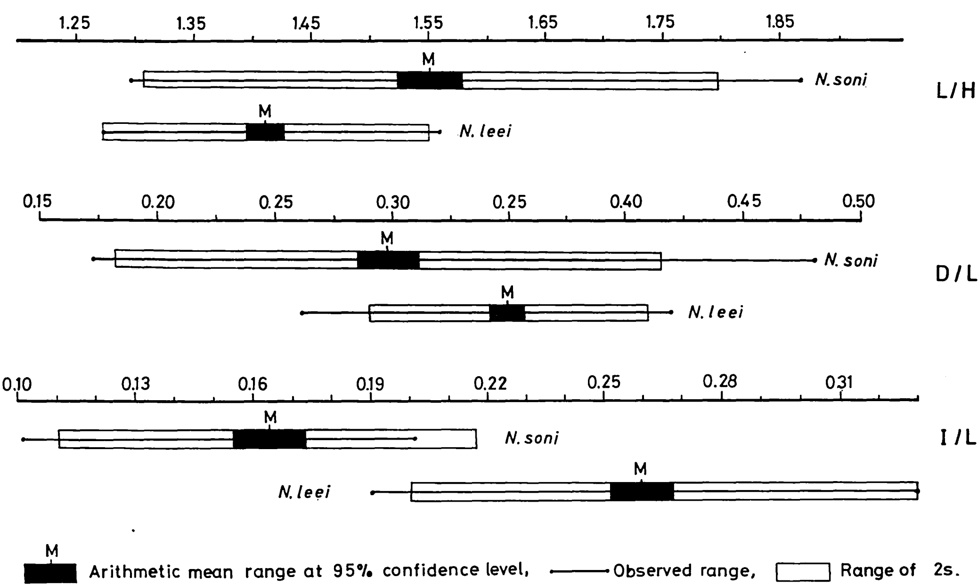
The above fundamental data (L, H, D, and I) are taken as an arithmetic mean of three times measurements by 1/20 mm scaled rule. The inflation, I, is measured on the external mould made of 'modelling compound'. On each specimen three external moulds were made and cut vertically from the umbo to the ventral margin, on which the inflations are measured.

From the above data the simple ratios, L/H, D/L and I/L, are calculated in

Table 2. Arithmetic means of the simple ratios L/H, D/L and I/L.

N*	$\bar{X} \pm t_{0.05}\sigma\bar{X}$*	V*	s*	σX	O	R*	χ^2*	Remarks
L/H 65	1.41±0.017	4.96	0.07	0.0087	1.27	1.56	5.410	N.S.*
D/L 65	0.35±0.007	8.57	0.03	0.0037	0.26	0.42	1.231	N.S.
I/L 62	0.26±0.008	11.54	0.03	0.0038	0.19	0.32	0.638	N.S.

N: sample size, $\bar{X} \pm t_{0.05}\sigma\bar{X}$: arithmetic mean with 95% confidence level, V: PEARSON's coefficient of variation, s: standard deviation, σX: standard error of the mean, O., R.: observed range, χ^2: chi-square, N.S.: not significant at 95% confidence level.

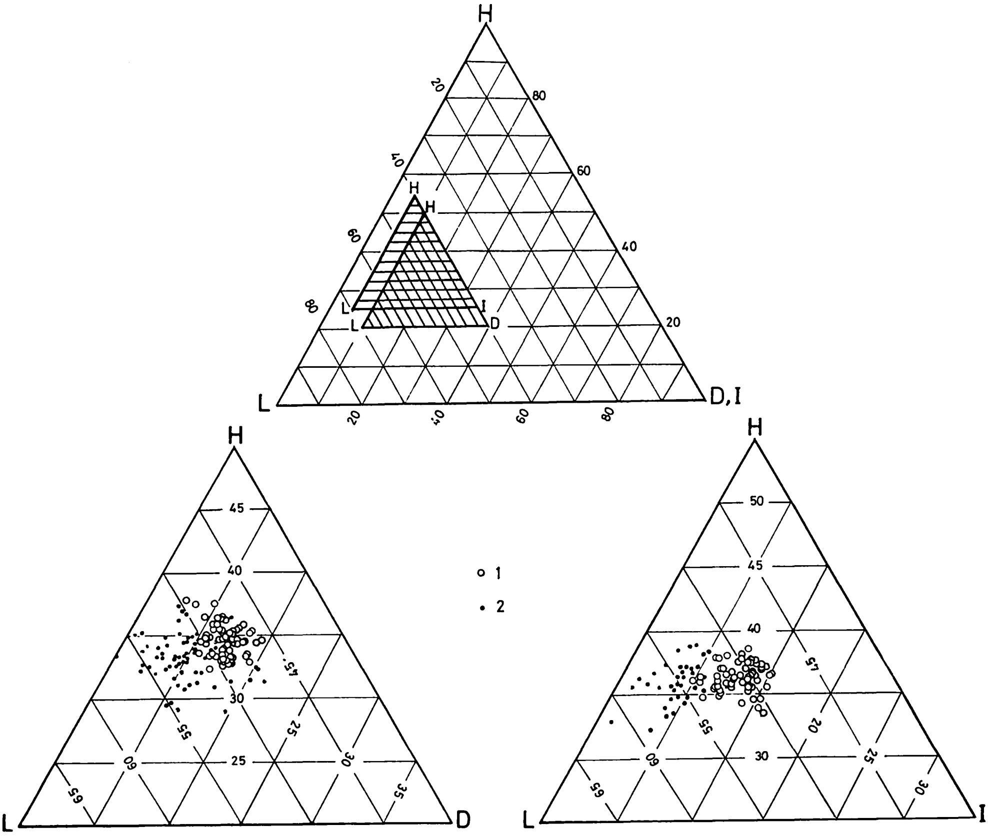


Text-figure 5. Comparison of *Nagdongia leei* with *N. soni*.

relation to the univariate values. The results are summarized in Table 2, in which the values are represented as range at 95% confidence level and the chi-square tests are shown in the right side. The results of the chi-square test indicate that the null hypothesis for a normal distribution is not rejected for the considered characters.

The comparison of the univariate values between molluscan samples can be carried out only on the assumption either of their isometric growth or exact determination of their same stage. However, *Nagdongia* spp. show various allometric features with characters and samples. In other words, the ratios vary with growth and samples. And it is also impossible to determine the exact same growth stage even among the different specimens in a sample. Therefore, the statistic routine works such as F-test and t-test on the present sample are not necessarily meaningfull. Thus, the comparison with *Nagdongia soni* is terminated to illustrate simply in Text-figure 5.

Illustration of the characters on triangular graphs—For illustration of the triple characters together, the triangular graphs are used. The construction is as follows: the values of three selected characters (L-H-D, L-H-I) are added



Text-figure 6. Triple characters (L-H-D, L-H-I) plotted on triangular graphs.
1: *Nagdongia leei*, 2: *Nagdongia soni*.

together for each specimen, and their ratios in percentage are calculated (BURMA, 1948). These percentages are plotted on the graph, which thus shows proportions rather than absolute values. Strictly speaking, as the ratios commonly vary with growth, the specimens of the same growth-stage should be selected as far as possible. But as pointed out above, it is quite difficult to determine the age of the shells, escpecially of different samples. Then here all the samples are dealt with together ignoring the growth stage. Thus the illustration on Text-figure 6, where the present species is shown together with *Nagdongia soni* for comparison, may reduce the essential meaning, but the two samples represent a particular pattern of dispersion respectively. The present species is fairly distinct from *N. soni* in L-H-I graph with a little overlapping. Even though in L-H-D graph the samples are somewhat partly overlapped between the two

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Explanation of Plate 33

Figs. 1-18. *Koreanaia cheongi* YANG, gen. et sp. nov.

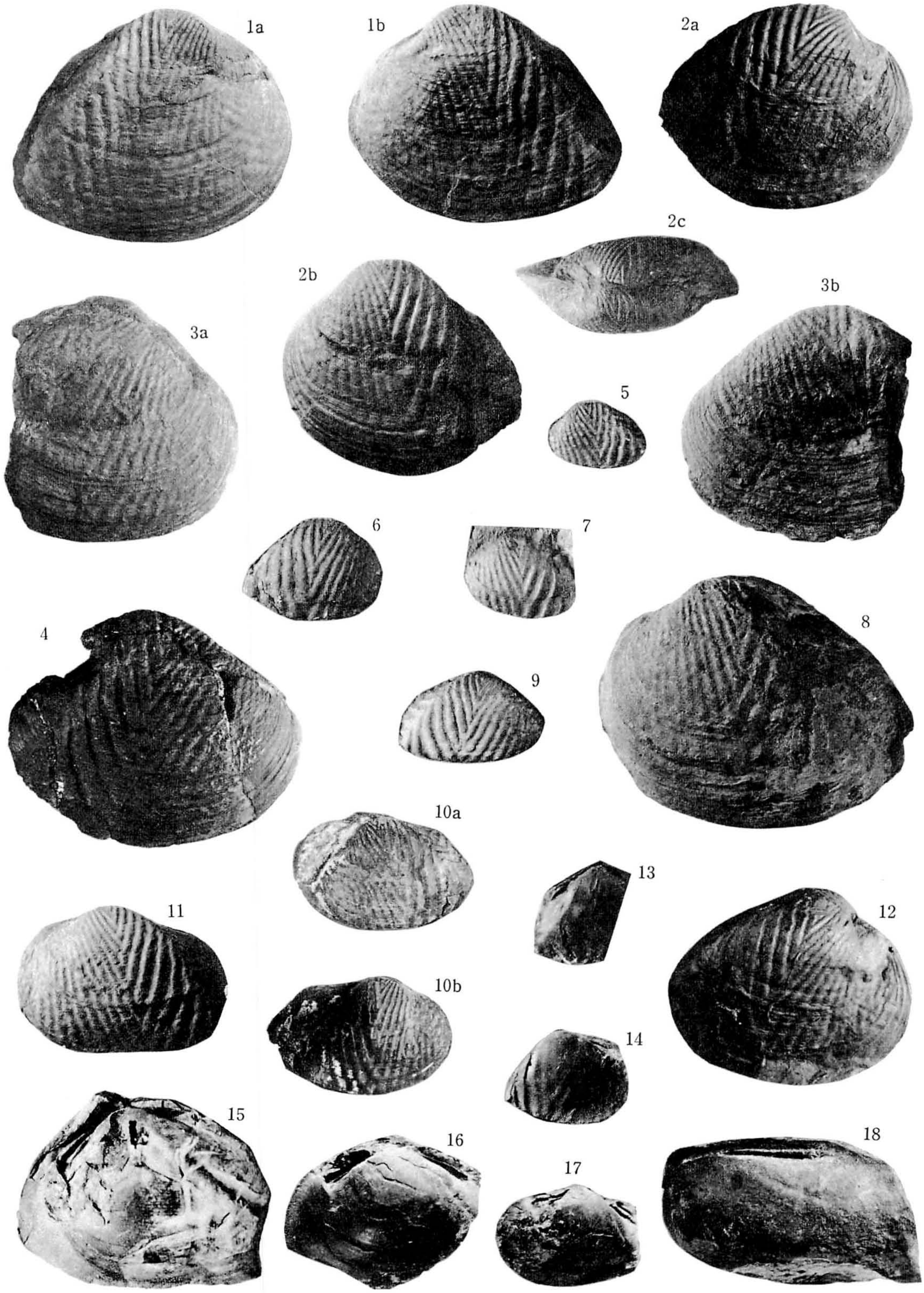
1. Conjoined valve (KPE 1281), 1a: right valve, 1b: left valve.
2. Conjoined valve (KPE 1282), 2a: right valve, 2b: left valve, 2c: dorsal view.
3. Conjoined valve (KPE 1283), posterior part broken out, 3a: right valve, 3b: left valve.
4. Right valve (KPE 1284), posterior dorsal part broken.
5. Left valve (KPE 1288), immature specimen.
6. Right valve (KPE 1287), immature specimen.
7. Left valve (KPE 1036), immature specimen.
8. Conjoined valve (KPE 1285), left side view.
9. Right valve (KPE 1286), immature specimen.
10. Conjoined valve (KPE 1035), 10a: left side view, 10b: right side view.
11. Conjoined valve (KPE 1031, holotype), left side view.
12. External mould of right valve made of clay (KPE 1289).
13. Internal mould of immature right valve (KPE 1293) showing the internal impression of crenulation on postero-ventral side.
14. Internal mould of immature right valve (KPE 1292) showing the internal impression of crenulation on postero-ventral side.
15. Internal mould of left valve (KPE 1289) showing the pseudocardinal hinge teeth and internal impression of crenulation running from near umbo toward postero-ventral corner.
16. Internal mould of left valve (KPE 1032) showing hinge teeth, muscle scar (anterior adductor scar and pedal scar) and weak impression of posterodorsal crenulation.
17. Internal mould of left valve (KPE 1291) showing hinge teeth and weak impression of postero-dorsal crenulation.
18. Internal mould of left valve (KPE 1290) showing posterior lateral teeth and weak impression of postero-dorsal crenulation.

The multiple V-sculptures are occasionally shown on the anterior half (Figs. 1, 2 and 12)

KPE 1281-1291 (Coll. S.Y. YANG), KPE 1031, 1032, 1035, and 1036 (Coll. K.H. CHANG and S.Y. YANG).

All figures are about of natural size.

Loc. Myogog, Jaesan-myeon, Bonghwa-gun, Gyeongsang-buk-do, Korea.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2c
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species, the dispersion patterns are also fairly different from each other. The *N. soni* shows wider domain than the present species. And the former preponderates toward H-L side, while the latter toward H-D and H-I sides.

On some other species—CHEONG and LEE (1966) reported *Plicatounio* sp. and *Unio* sp. But according to their illustrations, the two undetermined species seem to be fairly similar to each other. The so-called *Plicatounio* sp. shows only the compressed posterior ridge without plication of the genus. Thus, it seems reasonable to take them together as the same species. Though the sample is too small in number and fragmentary to describe and compare to another species, in the outline of the shell it is fairly different from any other Nagdong unionids so far.

Summary of results—

1) Two new species from the Myogog Formation are described, *Koreanaia cheongi*, gen. et sp. nov., and *Nagdongia leei*, sp. nov.

2) Morphologically *Koreanaia* can be regarded as representing an ancestral group of the phylogenetic series *Nippononaia*-*Wakinoa*-*Trigonioides* (s. s.)-*Trigonioides* (*Kumamotoa*).

3) The Myogog molluscan fauna is distinguishable from any other known Upper Mesozoic faunas from Far East Asia.

4) Even though the age of the Myogog Formation cannot be determined exactly from the above paleontological evidence, it can be said tentatively pre-Gyeongsang, maybe Upper Jurassic.

5) The undetermined species of the so-called *Plicatounio* and *Unio* and gastropods remain undescribed until more specimens are collected.

6) *Trigonioides tetoriensis* MAEDA, 1963 (non TAMURA, 1970) is revised to be assigned to *Trigonioides* (s. s.) instead of *T.* (*Kumamotoa*) on the grounds of the surface ornamentation and the internal structures. For the so-called *Wakinoa tetoriensis* of TAMURA, 1970, I propose *Wakinoa tamurai*, sp. nov.

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Explanation of Plate 34

Figs. 1-60. *Nagdongia leei* YANG, sp. nov.

1-29. Right valves (KPE 1201-1229).

30-53. Left valves (KPE 1230-1253).

54. Conjoined valve (KPE 1254) dorsal view.

55. Internal mould of left valve (KPE 1255) showing adductor and pedal scars.

56. Internal mould of right valve (KPE 1256) showing adductor and pedal scars and simple palial line.

57. Internal mould of right valve (KPE 1257) showing strong adductor and pedal scars.

58. Internal mould of right valve (KPE 1258) showing pseudocardinal teeth, anterior adductor and pedal scars.

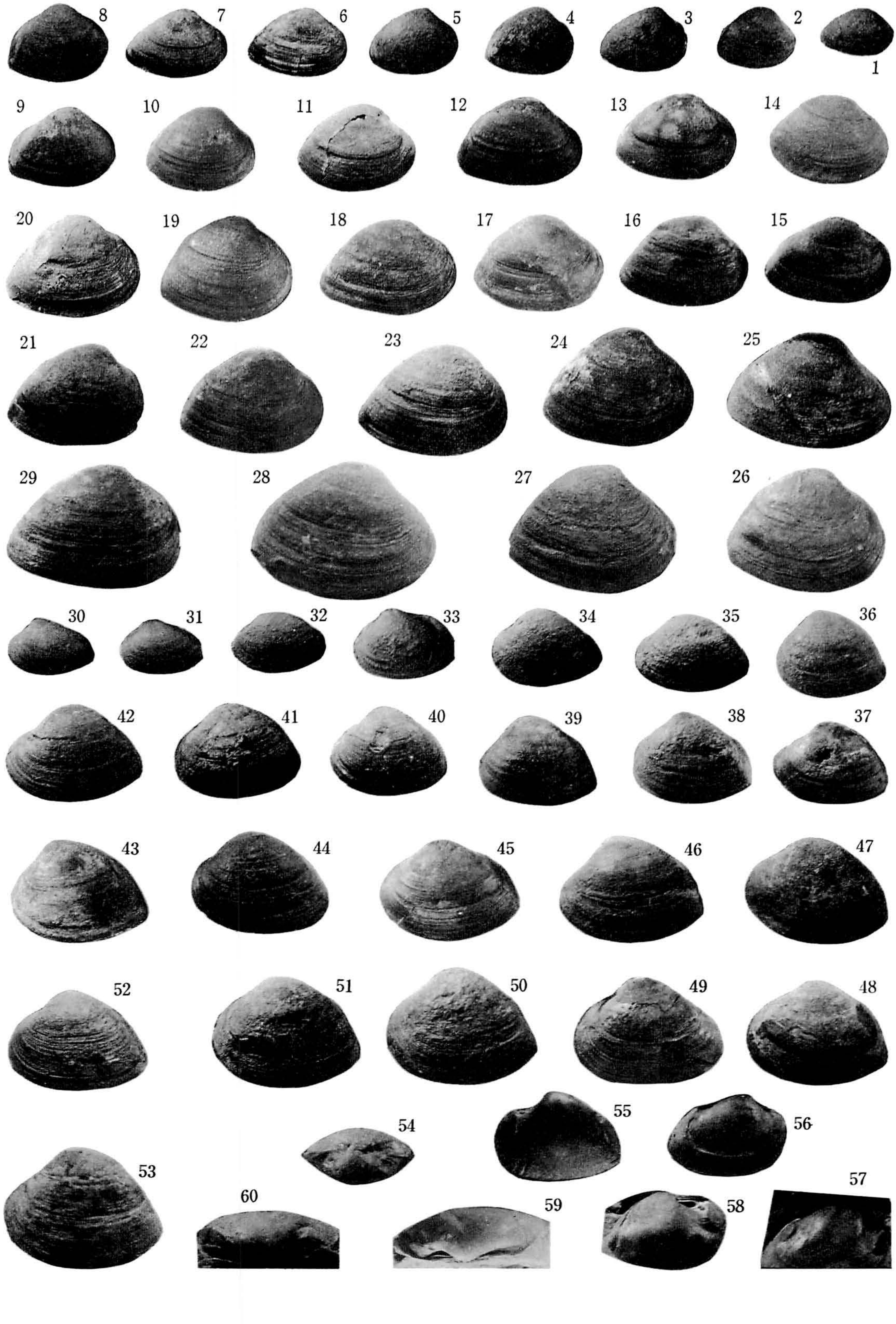
59. Internal mould of right valve (KPE 1259) dorsal view, showing hinge teeth and pedal scar.

60. Internal mould of left valve (KPE 1260) dorsal view, showing hinge teeth and pedal scar.

KPE 1203-6, 1211, 1223, 1226-7, 1232, 1236, 1243, 1249, 1260 (Coll. K.H. CHANG and S.Y. YANG), KPE 1201-2, 1207-10, 1212-22, 1224-5, 1228-31, 1233-5, 1237-1242, 1244-48, 1250-9 (Coll. S.Y. YANG).

All figures are about of natural size.

Loc. Myogog, Jaesan-myeon, Bonghwa-gun, Gyeongsan-buk-do, Korea.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Andong	安　東	Myogog	卯　谷
Bonghwa-gun	奉 化 郡	Nagdong	洛　東
Cheongyangsan	清 凉 山	Silla	新　羅
Euiseong	義　城	Taegog	台　谷
Galsan	葛　山	Ullyeonsan	蔚 蓮 山
Gasongdong	佳 松 洞	Wonnam	遠　南
Gyeongsang	慶　尚	Yeongju	栄　州
Gyeongsang-buk-do	慶尚北道	Yeongyang	英　陽
Jaesan-myeon	才 山 面	Daedong	大　同

Trans. Proc. Palaeont. Soc. Japan, N.S., No. 102, pp. 334-342, pl. 35, July 15, 1976

662. COLOUR PATTERNS IN SOME CRETACEOUS AMMONITES EROM HOKKAIDO

(STUDIES OF CRETACEOUS AMMONITES FROM HOKKAIDO AND SAGHALIEN—XXX)

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北海道産白亜紀アンモナイトの色模様—北海道の白亜系産アンモナイトには保存のよいものが少なくないので，殻の色彩の跡が残っているものはないかとかねてから留意していたが，この程6個体の例が見出された。それは天塩山地南西部の羽幌から小平にかけてのサントニアンの細砂泥岩中のもので，いずれも Texanitinae に属する。*Protexanits* (*Protexanites*) *bontanti shimizui* MATSUMOTO 4個，*Protexanites* (*Anatexanites*) *fukazawai* (YABE et SHIMIZU) 1個，*Paratexanites* (*Parabevahites*) *serratomarginatus* (REDTENBACHER) 1個の実例には，どれも巻きの方向に平行する色帯があるが，色帯の数，位置，幅，間隔の相対的の幅などが種類により異なること，1種の中では変異は僅かあるが，ほぼ一定していること，第1・2種の色帯が類似するのに対し，第3の種のそれはかなり異なることが注意される。色素は最外層部に集中しているようである。なお事実の記載に加えて，アンモナイトの殻の色模様一般に関して若干の論議を試みる。 松本達郎・平野弘道

Introduction

Traces of colour patterns are scarcely preserved on fossil shells of the Ammonoidea. The hitherto reported ones are in some particulary well preserved specimens from the Jurassic of Europe. While we are studying Cretaceous Ammonoidea from Hokkaido and Saghalien, we have recently noticed several specimens in which traces of colour patterns are preserved. In this paper we report the observed facts and extend some discussion for further study.

Before entering in the description we thank Messrs. Takemi TAKAHASHI and Kikuwo MURAMOTO who provided valuable specimens at our disposal with necessary information and Mr. Tatsuo MURAMOTO who helped us much.

Descriptions

The ammonites with traces of colour patterns were contained in calcareous nodules embedded in the Santonian fine-sandy siltstone in the western part of the Teshio Mountains, Hokkaido (Fig. 1). For the stratigraphy of this area readers may refer to the explanatory text of the geological maps of the scale 1: 50,000, "Sankei" (YAMAGUCHI and MATSUNO, 1963) and "Tappu" (TSUSHIMA et al., 1958) as well as UEDA et al. (1962) and OKADA and MATSUMOTO (1969).

The specimens are of six individuals belonging to three species of the Texanitinae, a subfamily of the Collignonicera-

* Received March 11, 1976; read Jan. 30, 1976 at Kawatabi.

tidae. For the systematic descriptions of the Texanitinae from Hokkaido and Saghalien readers may refer to MATSUMOTO (1970, '71). The observed facts about the colour pattern are described below according to the species.

1. *Protexanites* (*Protexanites*) *bontanti shimizui* MATSUMOTO

Pl. 35, Figs. 1-4

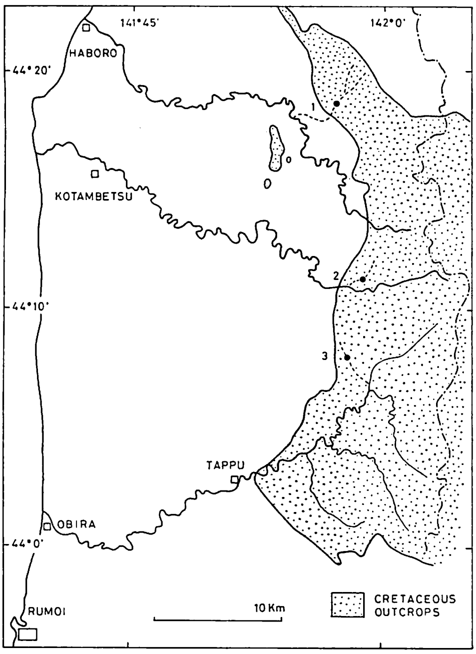
The following four specimens have traces of colour ptterns:

A. T. TAKAHASHI's specimen (Pl. 35, Fig. 1) from a floated calcareous nodule in the stream of the Detofutamata, a tributary of the River Haboro. This may have been derived from the same stratigraphic unit as B.

B. K. MURAMOTO's specimen (Pl. 35, Fig. 2) from the lower part of Unit U3 of the Upper Yezo Group (YAMAGUCHI and MATSUNO, 1963) in the same stream as A. (close to loc. CK80 of UEDA et al., 1962).

C. GK. H5632 (Pl. 35, Fig. 3; Text-fig. 2) from loc. R215 pl, Kami-no-sawa [= Haboro-goe-no-sawa], a tributary of the River Kotambetsu, probably derived from Unit U3. It was collected and described by MATSUMOTO (1970, p. 327) but was not illustrated on that occasion.

D. GK. H5797 (Pl. 35, Fig. 4), from loc. R207p, of the same stream as above, collected by T. MATSUMOTO.



Text-fig. 1. Index map showing approximate locations where ammonites with colour patterns were found. 1: Detofutamata, Haboro, 2: Kami-no-sawa, Kotambetsu, 3: Aka-no-sawa, Obira. Chain: Teshio Mountain watershed

They came from the Santonian fine-sandy siltstone in the upper reaches of the Haboro and the Kotambetsu, within the area of Geological Map "Sankei", where fossils are generally in favourable state of preservation.

The traces of colour patterns on these specimens indicate that the shell of *Protexanites* (*Protexanites*) *bontanti shimizui* MATSUMOTO has longitudinal (i. e. spiral) colour bands in three rows in lateral view, the first near the umbilical margin along the row of umbilical bullae, the second at about the middle of the flank and the third outside the row of inner ventrolateral tubercles. The last band covers the whole ventral area. For convenience' sake these three colour bands may be called the inner, the median and the outer ones. The overhanging umbilical wall is free from the inner colour band.

Strictly speaking they are not equidistant. The interspace between the inner and the median bands may be somewhat broader than the colour bands themselves and that between the median and the ventral bands is distinctly narrower than the median colour band. For example, in Specimen A the following approximate proportion is shown on the left side of the shell (Pl. 35, Fig. 1a):

inner band: 7, inner interspace: 10, median band: 6, outer interspace: 4, outer band: 8 (ventrolateral)+6 (ventral half).

However the proportion is as follows on the right side of the same shell (Pl. 35, Fig. 1b):

inner band: 7, inner interspace: 8, median band: 8, outer interspace: 5, outer band: 7+6

Anyhow, the median colour band is more or less deviated outside the mid-flank.

The above description about the details of the colour patterns depends on Specimen A, on which the traces of colour bands are best preserved. The same features seem to be maintained in Specimens C and D. In D (GK. H5797), which is somewhat smaller than A, colour bands are observable on its right side where the same proportion as seen on the left side of Specimen A is shown. Specimen C (GK. H5632) is represented by a fragmentary body-chamber and its external mould of a larger, probably adult shell. So far as the preserved outer part is concerned, the same feature as seen on the right side of Specimen A is shown. Specimen B is a small, probably immature shell, on which traces of colour bands are very incompletely preserved.

In all the above specimens the traces of colour markings are shown by dark brown bands, with purplish tint in Specimen A and nearly brownish black in the external mould of Specimen C. The interspace or ground is beige or ochre, with or without pinkish tint. On the well preserved colour bands it is noticed that pigmental material is distributed only in the outer layer of the shell structure. The distribution seems to be denser in the outermost part. In our specimens the growth-lines are better marked on the dark coloured outer layer. In other words the pigmental outer layer seems to have been comparatively more stable, whereas the outer layer without pigment was dissolved away from the interspaces.

2. *Protexanites* (*Anatexanites*) *fukazawai* (YABE et SHIMIZU)

Pl. 35, Fig. 5

MATSUMOTO (1970, p. 242) reported that fossils of this species occurred fairly commonly in the Himenoura Group of west central Kyushu about the middle of the Senonian (MATSUMOTO and UEDA, 1962) and that it was rare in Hokkaido, describing only a single specimen from the upper reaches of the Haboro, as a probable example (MATSUMOTO, 1970, p. 241, pl. 44, fig. 1).

Subsequently several better preserved examples were obtained by K. MURAMOTO and T. TAKAHASHI from the Santonian of the Obira area, within the geological map quadrangle of "Tappu". They are all of moderate size, about or somewhat less than 100 mm in diameter, although they are provided with a living chamber. This is much smaller than the lectotype from Kyushu (YABE and SHIMIZU, 1925, pl. 30, fig. 1; pl. 31, fig. 6, designated by MATSUMOTO and UEDA, 1962, p. 173). However, the Hokkaido specimens are indistinguishable from the smaller specimens from the Himenoura Group and regarded as being within the variation of the same species.

One of the specimens from the Obira area, here called Specimen E for convenience' sake, in T. TAKAHASHI's collection from the Aka-no-sawa, fairly clearly shows colour markings. Here again the pattern consists of three longitudinal bands in lateral view, the inner, the median and the outer ones. Accordingly it closely resembles the above described pattern of *Protexanites* (*Protexanites*) *bontanti shimizui*.

In this example the median band is slightly broader than the inner band and the interspace between them is slightly narrower or nearly as narrow as the inner band. The outer interspace is distinctly narrower than the inner interspace, about half as narrow as the median band. Thus the median band covers the entire breadth of the row of lateral tubercles in its inner half. The outer band covers the entire ventral part outside the row of inner ventrolateral tubercles.

The following proportion illustrates the above explanation: inner band: 7, inner interspace: 6, median band: 8, outer interspace: 4, outer band: 8+6.

This difference of comparatively narrower lower interspace than in the preceding species may be correlated with the relative shortness of the whorl height in *Protexanites* (*Anatexanites*) *fukazawai* as compared with *Protexanites* (*Protexanites*) *bontanti shimizui* (about 38 percent of the diameter in the former as compared with 41 to 42 percent in the latter).

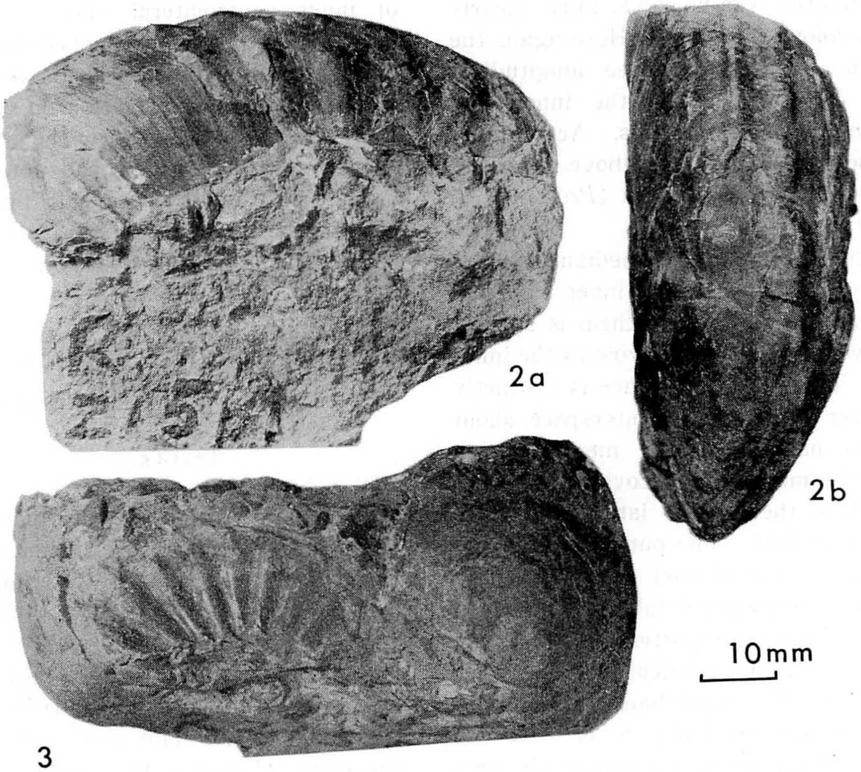
The colour bands are dark brownish when the outer layer of the shell is better preserved. The radial growth lines are marked there. The interspace is ochre on the surface of the next inner shell layer. Even if the dark colour is not well preserved on some part, the shell layer of the band is slightly but distinctly more elevated than the interspace. Probably on account of this feature, the outer margin of the median band forms a sinuous spiral line which is parallel to and at a regular distance from the row of inner ventrolateral clavi. At the middle growth-stage, with shell diameters of 40 to 50 mm, this spiral line is accompanied with slight elevation on crossing the radial ribs. Therefore, the whorl at this stage looks as if it had four rows of tubercles on its outer half, but these elevations do not persist and we do not regard them as true tubercles.

3. *Paratexanites* (*Parabevahites*) *serratomarginatus* (REDTENBACHER)

Text-fig. 3

Incomplete traces of colour bands are observable on the external mould (here called Specimen F) of the already described example, GK. H5629, of this species (MATSUMOTO, 1970, p. 260, pl. 36, fig. 3), from loc. R215 p, Kami-no-sawa [i. e. Haboro-goe-no-sawa], a tributary of the Kotambetsu. This was contained in the same calcareous fine-sandy siltstone nodule as Sample C. The previously illustrated internal mould (GK. H5629) is devoid of the shell layers and no trace of colour pattern is observable on it. The outer shell layer is attached to the external mould of Specimen F.

The colour pattern on this external mould is represented again by longitudinal stripes, but in this case the inner dark band is broad, occupying the inner half of the flank. Being separated by a narrow interspace, comes the next colour band wich runs on the row of double ventrolateral tubercles. This seems to form a narrow band independent of the true ventral band, but the preservation of the ventral part is not good enough for a definite statement. It might form a part of the broad outer band which covers the entire ventral part. Anyhow, it is clear that *Paratexanites* (*Parabeva-*



Text-figs. 2-3. Colour markings on fragmentary ammonites.

2. Specimen C [=GK. H5632], T. MATSUMOTO's Coll., from loc. R215 pl, Kami-no-sawa, Kotambetsu. Lateral (a) and ventral (b) views of fragmentary body-chamber, of *Protexanites* (*Protexanites*) *bontanti shimizui* MATSUMOTO.
3. Specimen F [=GK. H5629], T. MATSUMOTO's Coll., from the same calcareous nodule as above. External mould of *Paratexanites* (*Parabevahites*) *serratomarginatus* (REDTENBACHER). (H. HIRANO photos.)

hites) *serratomarginatus* has colour bands which are considerably different from those of the above described two species of *Protexanites*.

Discussion

Reports of the colour pattern on fossil shells of the Ammonoidea are quite few. The hitherto described specimens are mostly those from the Jurassic of Europe (e. g. GREPPIN, 1898; SCHINDEWOLF, 1928; SPATH, 1935; ARKELL, 1957). The present paper may be the first report for Cretaceous examples.

As ARKELL (1957, p. L92) summarized, the colour pattern in the Jurassic ammonites mostly take the longitudinal brown stripes on a white ground (as in the case of *Amaltheus, Androgynoceras* and *Tragophylloceras*). The said one or more lateral white stripes on brown ground in *Leioceras* and *Asteroceras* may imply that dark coloured stripes were so broad that a narrow white interspace remained. This is well suggested by the presence of a narrow interspace in our case, although we cannot state conclusively without inspecting the original specimens from Europe. Of course there can be radial and other colour patterns as reported by SCHINDEWOLF (1928) on *Pleuroceras* and as suggested by certain patterns in the Nautiloidea (RUDEMANN, 1921; FOERSTE, 1930; SEILACHER, 1971).

In the present case of six Cretaceous specimens the colour patterns are all represented by longitudinal stripes, which are parallel to the orientation of the whorl growth. In Cephalopoda the shell layers are secreted through the epitherium at the frontal margin of the mantle (MUTVEI, 1964). Therefore the secretion of the pigmental material must have been taken by definite parts of the epitherium within the entire margin. This kind of physiological allotment may be similar to that for the formation of tubercles. Incidentally the colour bands observed in our texanitine ammonites always run on or parallel to the rows of tubercles.

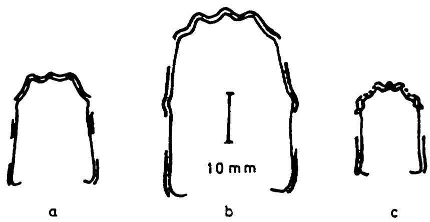
It is recalled here that in many spirally coiled shells of gastropods colour patterns are most commonly parallel to the spiral growth, although modifications to this fundamental pattern occur frequently and other patterns are also met with. This is true for the fossil shells of gastropods, as seen in a recent paper of KRIZ and LUKES (1974). In the limpet-shaped shells of gastropods the colour patterns which run radially toward the shell margin are common. In many shells of bivalves and also brachiopods, including fossil examples (e. g. CLOUD, 1941; KRIZ and LUKES, 1974), the radially coloured bands which run nearly perpendicular to the shell-margin are common. They all comform with the case of the Cephalopoda in that the pigments are secreted through certain alloted parts of the epitherium. This may suggest that colour patterns in mollusks and certain other invertebrates are not formed voluntarily but probably controlled genetically. Therefore they are fairly constant like other shell characters. A similar statement has already been expressed by OZAWA (1975, oral communication) through his study of recent populations of *Umbonium* species.

Fortunately four specimens are available for the colour pattern of *Protexanites* (*Protexanites*) *bontanti shimizui* from the Santonian of Hokkaido. They constantly show the same type of colour stripes, although there may be slight variation within the species.

The colour bands on the shell of *Protexanites* (*Anatexanites*) *fukazawai* is closely similar to but not quite identical with that of *P.* (*P.*) *bontanti shimizui.* This is interesting in view of the fact that in the morphological characters of the shell, *P.* (*A.*) *fukazawai* closely resembles *P.* (*P.*) *bourgeoisi* (D'ORBIGNY), which is allied to *P.* (*P.*) *bontanti* (see MATSUMOTO and UEDA, 1962, p. 174; MATSUMOTO, 1970, p. 240). *Anatexanites* is distinguished from *Protexanites* (s. s.) by the development of a row of lateral tubercles.

It is also interesting to see that *Paratexanites* (*Parabevahites*) *serratomarginatus*, which has some affinity with *Protexanites* (*Protexanites*) *bourgeoisi* but is separated to another genus (see MATSUMOTO, 1970, p. 263), likewise has longitudinal stripes but the mode of banding is considerably different from that of the above two species.

These facts are favourable for the above mentioned general statement. Although SPATH (1935) was pessimistic about the taxonomic distinction by colour markings, we consider that the colour patterns are important for the study



Text-fig. 4. Schematic illustration of whorl-sections, showing the position of colour bands in three species.
a : *Protexanites (Protexanites) bontanti shimizui* MATSUMOTO
b : *Protexanites (Anatexanites) fukazawai* (YABE et SHIMIZU)
c : *Paratexanites (Parabevahites) serratomarginatus* (REDTENBACHER)

of taxonomy, phylogeny, biochemical physiology and other aspects of palaeontology.

Although many other ammonites occur in the same formation of the western part of the Teshio Mountains, we have little noticed the colour patterns. This may be due in part to our careless observation and in part to the delicate difference in the state of preservation. At present we do not know what kinds of conditions are necessary for the preservation of the colour patterns on fossil shells of the Ammonoidea. We notice, however, that well preserved fossils of *Gaudryceras* sometimes have dark brownish "coating", which is probably a coloured outermost layer. In this case the whole surface may have been coloured without figures, i. e. plain dark brown.

We have not yet inspected the chemistry of the preserved pigment or somewhat altered pigmental material. The fact that the coloured outer shell layer have been resistant against the processes of fossilization, diagenesis and weathering suggests a character of the pigment. Namely the pigmental material must have been insoluble or less soluble in the sea water or interstitial water and have attached itself firmly to the conchiolin. According to COMFORT (1951) and FOX (1966), chromoproteins accompanied with melaninoid prosthetic group and tetrapyrroles are the common pigments in shells. The former is insoluble in most liquid media, whereas the latter is soluble. The former is said to be more common in advanced gastropods and bivalves.

At present we cannot exactly tell the functional meaning of the colour patterns in the natural history of the Ammonoidea. There could be various cases. Somewhat wavy pattern in *Nautilus* may serve for the animal as a camouflage against enemies. In other words the colour pattern is protective. In the present case of the Texanitinae the clearly marked subconcentric colour bands around the umbilicus may be so distinct as to act as a warning colouration. This possible interpretation may be favourable for the tuberculated ammonites belonging to the Collignoniceratidae. It may not be accidental to have colour bands along the row of tubercles, although we do not exactly know the meaning of the tubercles for the natural life of the Ammonoidea. It could also be considered that certain colour patterns might serve as a sexual fascination. How to determine one of these and other possible interpretations may be a future problem as is the problem of adaptation for a certain colouring in the Ammonoidea.

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Aka-no-sawa	赤ノ沢	Kotambetsu	古丹別
Detofutamata	デト二股	Obira	小平
Haboro	羽幌	Sankei	三渓
Haboro-goe-no-sawa	羽幌越ノ沢	Tappu	達布
Kami-no-sawa	上ノ沢	Teshio	天塩

Explanation of Plate 35

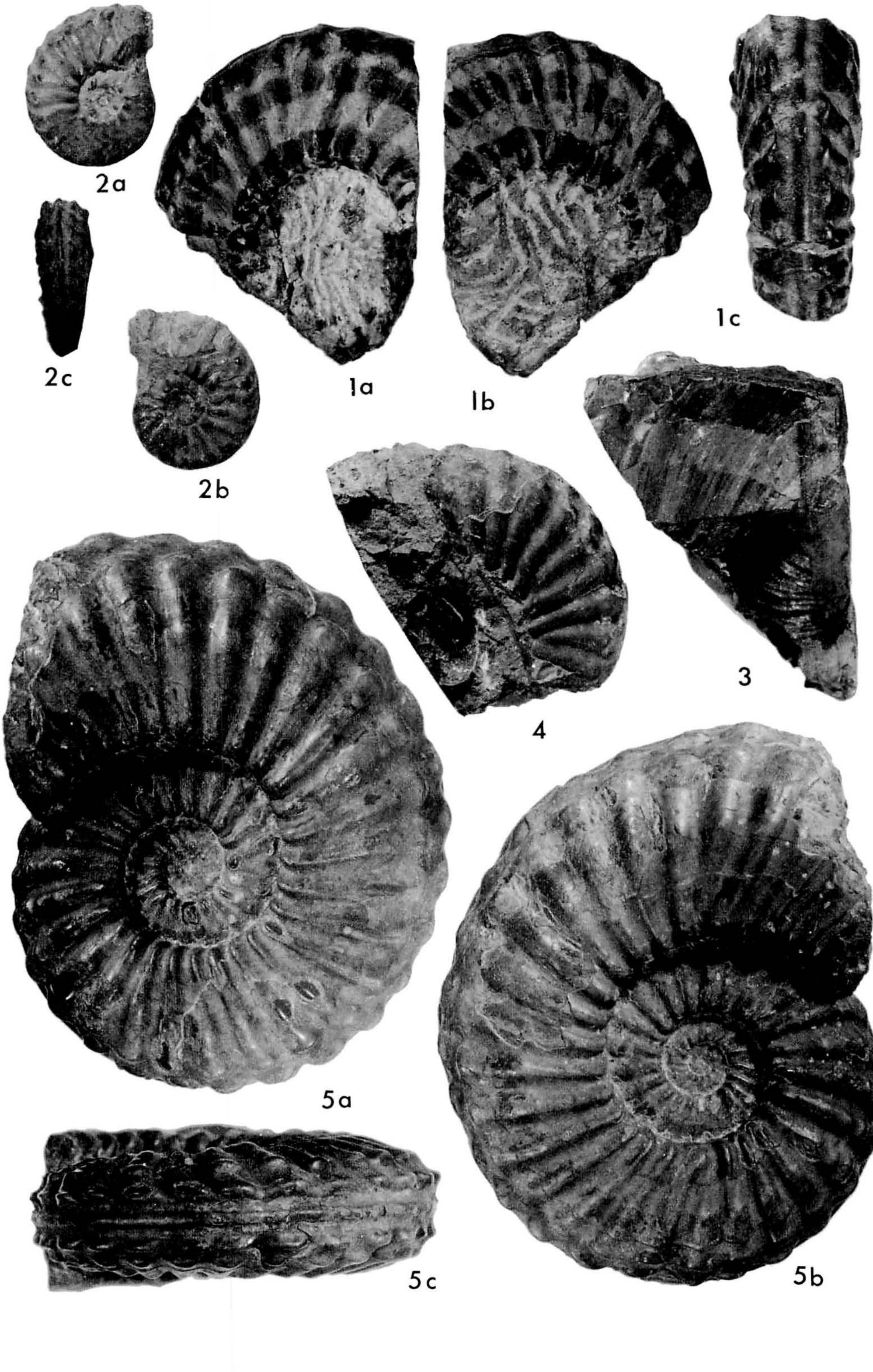
Figs. 1-4. *Protexanites* (*Protexanites*) *bontanti shimizui* MATSUMOTO ....Page 335

1. Specimen A, T. TAKAHASHI's Coll., from the Detofutamata, a tributary of the River Haboro. Left (a) and right (b) sides and ventral view (c), ×1.
2. Specimen B, K. MURAMOTO's Coll., from the same stream. Left (a) and right (b) sides and ventral view (c), ×1.
3. Specimen C [=GK. H5632], T. MATSUMOTO's Coll., from Loc. R215 pl, Kami-no-sawa, a tributary of the River Kotambetsu. Outer shell layer on a part of the external mould, with *Inoceramus* sp. at the lower right corner, ×1. (See also Text-fig. 2.)
4. Specimen D [=GK. H5797], T. MATSUMOTO's Coll, from loc. R207 pl, the same stream as C. Lateral view, ×1.

Fig. 5. *Protexanites* (*Anatexanites*) *fukazawai* (YABE et SHIMIZU) ....Page 336

Specimen E, T. TAKAHASHI's Coll., from Aka-no-sawa, a tributary of the River Obira [=Obirashibetsu]. Right (a) and left (b) sides and ventral view (c), ×1.

Kyushu University (H. HIRANO) photos.


2a
2c
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1c
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5a
5c
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Palaeontological Society of Japan, Special Papers No. 19 Bivalve Faunas of the Cretaceous Himenoura Group in Kyushu

By Masayuki TASHIRO

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The paper contains palaeontological descriptions of bivalve fossils from the Upper Cretaceous Himenoura Group in western Kyushu, based on new collections containing 57 species of 40 genera, of which one genus (*Mesochione*) and 23 species are entirely new. Notes are given on the stratigraphy of the Himenoura Group of local areas with geological maps and columnar sections that indicate collecting localities and stratigraphic positions of the described species, and the mode of occurrence of several kinds of assemblages and its relation to the lithofacies. The range of the species and the comparison with faunas of extra-Japanese provinces are also concisely given.

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◎ No. 101 学会記事欄に，係の手落ちにより古生物研連幹事の大森昌衛君の名前が欠落しました。おわびして追加いたします。第10期古生物研究連絡委員会幹事，大森昌衛君。

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