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EARLY DEVONIAN BRACHIOPODS FROM THE LESSER KHINGAN DISTRICT OF NORTHEAST CHINA*

By

Takashi HAMADA

Institute of Earth Science and Astronomy,
College of General Education, University of Tokyo

ABSTRACT

An old fossil collection made by Mr. J. NONAKA from the Lesser (Minor) Khingan district of Northeast China, formerly Manchuria, is kept at the Geological Institute, University of Tokyo. The collection is composed of two units, one from Houlungmen and the other from Kinsui. After careful preparation of these materials the writer distinguished 30 species of brachiopods in 29 genera, which are described in this report including one new genus and 14 new species. He also recognized 19 other fossils including bryozoa, corals, gastropods, pelecypods, cephalopods, tentaculites, crinoids, trilobites, calcareous algae and land plants.

This fauna as a whole suggests Siegen-Ems age, possibly early Emsian, as indicated by the presence of *Proschizophoria, Chonostrophiella, Aesopomum, Leptostrophia* and other characteristic genera. This is the first recognition of Lower Devonian marine fauna supported by well studied data not only in China but also from the Far East except the Russian part, though some possible Lower Devonian faunas with fish and plants occur in South China.

The Lesser Khingan fauna has a close similarity to the early Devonian Altai and Kazakhstan faunas in its general aspect. It is evident that the Lesser Khingan district was situated at the eastern portion of the Mongolian geosyncline at that time. However, as a result of detailed paleontological investigation, this fauna was revealed to be a "mixed fauna" as far as the brachiopod genera are concerned. For instance, the following brachiopods might be considered as they represent different paleobiogeographical provinces or subprovinces in early Devonian time.

Proschizophoria	Rhenish-Bohemian (Old World)
Dalejina	Bohemian-Appalachian
Reeftonia	Tasman-New Zealand
Aesopomum	Rhenish-Bohemian-Cordilleran
Chonostrophiella	Appalachian
Wilsoniella	Uralian (-Altai)
Bifida	Rhenish-Bohemian-Cordilleran

A new genus *Sinostrophia* was erected on a *Mesodouvillina* type stropheodontid with extremely multicostellate shell periphery owing to frequent bifurcation and implantation of radial costellae.

Two Middle Devonian brachiopods from the Mishan district of Northeast China are also described in this report as an appendix.

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CONTENTS

List of Tables and Text-figures

PREFACE

AHNERT was the first who made a geological reconnaissance to Northeast China and the Russian Far East (1928). However, the vast area of the southeastern margin of the Mongolian geosyncline has remained *terra incognita* geologically for many decades, especially the Lower Paleozoic sequences.

During the nineteen-forties some Japanese geologists engaged in the survey and contributed to the Devonian stratigraphy and paleontology of northeast China, formerly Manchuria (EGUCHI, KOBAYASHI, KONDO, NODA, NONAKA, SUGIYAMA, YABE et al.). After the retreat of the Japanese interests in Manchuria, Chinese geologists and paleontologists also obtained a large amount of information from the same area. As a result Silurian and Devonian fossils were reported from several spots in the Greater and Lesser Khingan ranges. A discovery of Upper Devonian clymeniid-bearing strata in the former range was notable.

On the basis of these facts learnt it might be possible to compile the Middle Paleozoic history in the eastern part of the Mongolian geosyncline. But the data are still meager if compared with the vast area, and above all paleontological and paleogeographical investigations on the faunas are quite insufficient. In addition, the Middle Paleozoic of the Russian portion of the geosyncline, where similar faunal development is expected, has been uncertain for a long time until a preliminary work on the Lower Devonian of the Zeya basin and other places was published by MODZALEVSKAYA in 1968.

The present report includes a result of the reinvestigation on NONAKA's collection from the Lesser Khingan district in comparison with the faunas from the surrounding Kazakhstan-Altai-Amur districts in a light of the early Devonian paleobiogeography.

ACKNOWLEDGEMENTS

The writer wishes to express his sincere thanks to Professor Arthur J. BOUCOT of the Department of Geology, Oregon State University, who was in the Division of Geological Sciences, California Institute of Technology, Pasadena when the writer was under his supervision, for his valuable suggestions, discussions and encouragement, without which this work could not have been accomplished. He is also much indebted to Dr. J. G. JOHNSON of the same laboratory who gave him various criticism on the brachiopod taxonomy and paleobiogeography. Dr. G. A. COOPER of the Smithonian Institution, U. S. National Museum in Washington, D. C. kindly arranged the loan of comparitive material of leptostrophiids, spiriferids, and chonostrophiids. Dr. C. W. HARPER of the University of Oklahoma who afforded valuable information on the leptostrophiid classification to the writer.

The writer had an opportunity to make a comparative study of the Russian materials during the 3rd International Symposium on the Silurian and Devonian Boundary and its field excursions to Salair and Podolia in 1968 being supported by the kindness of Academician Prof. Dr. B. S. SOKOLOV in Novosibirsk, Drs. N. N.

PREDTECHENSKY, O. I. NIKIFOROVA, M. A. RZHONSNITSKAYA, E. A. MODZALEVSKAYA of All-Union Scientific Research Geological Institute (VSEGEI) in Leningrad, and also by Dr. R. T. GRATSIANOVA of the Institute of Geology and Geophysics, Siberian Branch of the Academy of Science, U. S. S. R., Novosibirsk. Mrs. G. T. USHATINSKAYA of the University of Moscow was kindly offered a part of her brachiopod collection from the Kazakhstan Lower Devonian for comparison with the Lesser Khingan materials.

The writer's deep gratitude is due to Dr. Teiichi KOBAYASHI, Professor Emeritus of the University of Tokyo, who led him to examine the old collection from northeast China, which long has been kept in the University of Tokyo. Thanks are due to Mr. Nelson W. SHUPE, Maryland, for his laborious work on photography, and also to Mrs. Ruth TALOVICH, California Institute of Technology, for her preparing of the drawings.

This work was done as one of the projects on an exchange program no. P-I-394, 1966-1968 at the Division of Geological Sciences, California Institute of Technology, Pasadena, California. The writer owes much to the Sloan Foundation for his research expenses during the tenure.

Special thanks are due to Dr. Tatsuro MATSUMOTO, the chief editor of the Special Papers of the Palaeontological Society of Japan.

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I. Notes on the University of Tokyo Collection of the Devonian Fossils from Northeast China

There are three collections of Devonian fossils from Northeast China, formerly Manchuria, in the Geological Institute, Faculty of Science, University of Tokyo as follows.

1. The Houlungmen Fossils (abbreviation for specimens: H)

Materials: Many slabs of fossiliferous sandstone.

Locality: 1 km east of Kinsui Station, 41 km NE of Houlungmen, Nünkiang-hsien of the Lesser Khingan district (Loc. A-2 in Text-fig. 1).

Collector: Mr. R. Kondo, 1941.

Paleontological Description: Nonaka (1944).

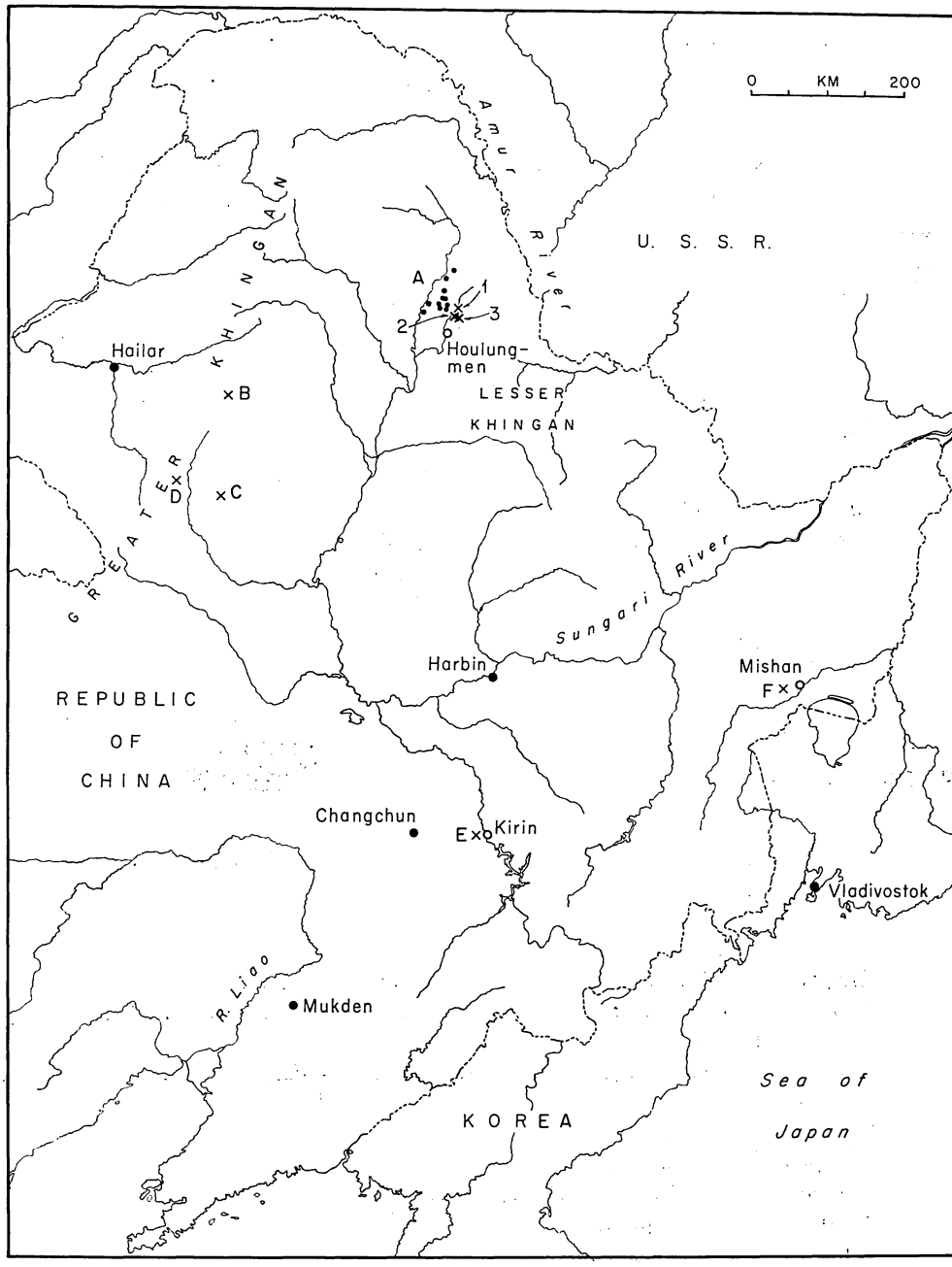
Stropheodonta (*Leptostrophia*), n. sp.
Stropheodonta, n. sp.
Gypidula cf. *mansuyi* Grabau
Camarotoechia sp. indet.
Atrypa desquamata Sowerby
Spirifer tonkinensis Mansuy

Stratigraphical data: Mr. S. Yamamoto (*in* Kobayashi & Nonaka, 1942).

Lithology: Greenish gray, fine-grained sandstone; greenish brown when weathered; partly calcareous.

Brachiopods described in this paper:

Proschizophoria kobayashii, sp. nov. (=*Gypidula* cf. *mansuyi* Grabau by Nonaka, 1944)
Reeftonia borealis, sp. nov.
Leptaenopyxis bouei (Barrande)
Megastrophia (*Protomegastrophia*) *manchurica*, sp. nov.
Leptostrophia nonakai, sp. nov. (=*Stropheodonta* (*Leptostrophia*) n. sp. by Nonaka, 1944)
Sinostrophia kondoi, gen. et sp. nov. (=*Stropheodonta* n. sp. by Nonaka, 1944)
"*Schuchertella*" sp. indet.
Aesopomum chinense, sp. nov.
Chonostrophiella khinganensis, sp. nov.
"*Camarotoechia*" sp. indet.
Wilsoniella grandis, sp. nov.
"*Atrypa*" sp. indet. (=*Atrypa desquamata* Sowerby by Nonaka, 1944)
Bifida orientalis, sp. nov.
Nucleospira musculosa, sp. nov.
Cyrtina sp. indet.
"*Howellela*" *amurensis*, sp. nov.
Acrospirifer sp. indet.
Paraspirifer aff. *cultrijugatus* (Roemer)



Text-fig. 1. Middle Paleozoic locality map of Northeast China and Inner Mongolia.

A: Lesser Khingan District
A-1: Nichiuho
A-2: Northeast of Houlungmen
A-3: East of Kinsui Station
B: Kentoho
C: East of Taminshan
D: Suhuho
E: Erhtaokou
F: Mishan

Fossils other than brachiopod (preliminarily identified):

Bryozoa
Tentaculitid
Styliolina
Probolium altaicum (KHALFIN)
Phacops altaicus TSCHERNYSHEV
Crinoid stem joints

Geological age: Early Emsian.

2. The Kinsui Fossils (abbreviation for specimens: K and Kn).

Materials: Many slabs of fossiliferous sandstone.

Locality: East of Kinsui Station of the Kakkoku line, Nünkiang-hsien of the Lesser Khingan district (Loc. A-3 in Text-fig. 1).

Collector: Mr. J. NONAKA, 1942.

Stratigraphical data: NONAKA (1946).

Lithology: There are two different lithological facies in the collection.

a) Greenish gray, fine-grained sandstone; greenish brown or brown when weathered; partly calcareous and shaly.
b) White, massive, hard, medium-grained sandstone.

The former one seems to correspond to bed 4 and the latter to bed 2 of NONAKA's sequence (1946; *Vide* p. 9 of the present paper) respectively.

Brachiopods described in this paper:

"Lingula" sp. indet.
Schizophoria sp. indet.
Proschizophoria kobayashii, sp. nov.
Dalejina kinsuiensis, sp. nov.
Reeftonia borealis, sp. nov.
Leptaenopyxis bouei (BARRANDE)
Megastrophia (Protomegastrophia) manchurica, sp. nov.
Leptostrophia nonakai, sp. nov.
Sinostrophia kondoi, sp. nov.
Pholidostrophia sp. indet. A
Pholidostrophia sp. indet. B
Strophomenid gen. et sp. indet.
"Schuchertella" sp. indet.
Aesopomum chinense, sp. nov.
Chonostrophiella khinganensis, sp. nov.
Zlichorhynchus asiaticus, sp. nov.
"Camarotoechia" sp. indet.
Wilsoniella grandis, sp. nov.
Pectorhyncha (?) sp. indet.
Uncinulus piloides, sp. nov.
Eucharitina (?) sp. indet.
Bifida orientalis, sp. nov.
Nucleospira musculosa, sp. nov.
Cyrtina sp. indet.

"Howellela" amurensis, sp. nov.
Acrospirifer sp. indet.
Paraspirifer aff. *cultrijugatus* (ROEMER)
Fimbrispirifer cf. *divaricatus* (HALL)
Spiriferid gen. et sp. indet.

Other fossils than brachiopod (preliminarily identified):

Bryozoa
Auloporoid coral
Thamnoporoid coral
Small solitary coral
Low-spired gastropod
High-spired gastropod
Bellerophontid gastropod
Tentaculitid
Styliolina
Michelinoceratoid
Paleonucula or *Toechomya*
Tolmania squamosa KHALFIN
Paramnigenia bicarinata KHALFIN
Conocardium (?)
Probolium altaicum (KHALFIN)
Phacops altaicus TSCHERNYSHEV
Crinoid stem joints
Calcareous algae
Land plant fragments

Geological age: Early Emsian.

3. The Mishan Fossils (abbreviation for specimens: M)

Material: Only a block of limestone yielding brachiopods and bryozoan remains.

Locality: Hilly land approximately 40 meters high, in Shinano-mura, southeast foot of the Wantashan, Heitai, Mishan-hsien, Manchuria (Loc. F in Text-fig. 1).

Collector: Mr. F. HATORI, 1940.

Stratigraphical data: Mr. F. HATORI (in KOBAYASHI, 1941; KOBAYASHI & NONAKA, 1942; KOBAYASHI, 1951).

Lithology: Dark brownish gray bryozoan limestone.

Brachiopods described in this paper (as an appendix):

Leptaena rhomboidalis (WILCKENS)
Mucrospirifer cf. *paradoxiformis* HOU

Fossils other than brachiopod: Bryozoan remains.

Geological age: Givetian.

4. Remarks

1) Distinction of localities

The first two localities seem to be closely situated and might represent almost the same geological horizon. The name Houlungmen fossils, is somewhat inadequate for the first collection in terms of the geographical location. However, it is

noteworthy that *Dalejina* is absent in the Houlungmen collection. There should be a slight difference in the situation of the stratigraphical sequences or of the thanatocoenoses at these localities. Therefore, it is wise to treat them as separate localities in this report since the present writer is unable to examine the stratigraphical relationship between them in the field.

The last Mishan area is far distant from the Lesser Khingan district and has a faunal assemblage different from the preceding areas.

2) Preparation of materials

These collections are rather small in quantity. The original blocks in the collection have been carefully split by rock-splitter into reasonable size and etched in dilute hydrochloric acid to obtain the internal and external casts of the calcitic fossil shells in sandy matrices. Then, they were hardened with Alvar dissolved in acetone after washing and drying. Latex replicas, which are darkened to some degree by India ink, were prepared for photographic work with ammonium chloride whitening.

357 brachiopod specimens were obtained and examined.

3) Numbering of the specimens

Each collection has its own collection number symbolized by the locality name such as H, K or Kn and M. Slabs split from a single block have the same Roman or Greek alphabetical character which is followed by a numerical indicating the number of the rock piece. Every identifiable fossil has been numbered. An example is presented as follows.

013HA2

means the specimen no. 013 on no. 2 piece from A block in the Houlungmen collection.

The counterpart of a certain specimen is indicated by a different rock piece number under the same collection and block symbols. Steinkern is attached by ′ on the same piece number as follows.

027HA4 and 027HA8

should be the counter parts of the same biological individual which was split into different rock pieces.

217Kβ3′

is a steinkern which fits to the cast numbered 217Kβ3.

II. History of the Paleontological and Stratigraphical Researches on the Middle Paleozoic in Northeast China

1. The Lesser Khingan District

In 1941, Mr. R. Kondo collected some fossils from the limestone exposed at a point 1 km east of the Kinsui Station, 41 km NE of Houlungmen, Nünkiang-hsien of the Lesser Khingan district in former Manchuria. He sent these specimens to Dr. T. Kobayashi, who preliminarily recognized *Spirifer* cf. *tonkinensis* and a phacopid trilobite among them (Kobayashi, 1941, 1942). The age of the fauna was therefore regarded as Eifelian. Kobayashi and Nonaka (1942) mentioned that *Spirifer* cf. *tonkinensis* belongs to the *S. striatus* group and closely resembles *S. speciosus*. They also listed the occurrences of a strophomenid and *Hyolithes* in addition to the preceding fossils.

According to Mr. S. Yamamoto (in Kobayashi & Nonaka, 1942), the Devonian succession at that locality is as follows:

5) Purple shale and chocolate-colored phyllitic slate with thin limestone beds
4) Black limestone intercalating chert
3) Hornfels with graphite schist
2) Fossiliferous greenish limestone
1) Conglomerate

The fossiliferous greenish limestone of bed 2 is the exact horizon from which the above mentioned fossils were collected. The nomenclature of the rock-type was somewhat vague at that time, and an extremely calcareous portion of greenish sandstone with gregareous shells could be assigned to limestone as far as judging from the present collections.

Yabe & Sugiyama (1942b, 1943) reported a possible Coblenzian fauna which was sent by Mr. M. Noda to H. Yabe. The collection was made up of some float specimens in black sandy shale which forms the basement of the gold placer deposit of the Nichiuho and had been collected by a dredger. This locality is situated adjacently north of the preceding Kondo's locality (loc. no. A-1 in Text-fig. 1). The fauna comprises

Pleurodictyum nodai Yabe & Sugiyama
Syringaxon (?) sp.
Stropheodonta cf. *sedgwicki* d'Archiac & de Verneuil
Brachiopoda gen. et sp. indet. (Strophomenida).

Nonaka (1944) described some brachiopods among Kondo's collection, and noted an additional occurrence of *Tentaculites*. He recognized and illustrated the following brachiopods.

Stropheodonta (*Leptostrophia*), n. sp. (nom. nud.)
Stropheodonta, n. sp. (nom. nud.)

Gypidula cf. *mansuyi* GRABAU
Camarotoechia sp. indet.
Atrypa desquamata SOWERBY
Spirifer tonkinensis MANSUY

NONAKA's illustration is reproduced as Plate 30 in this paper.

Geological age was presumed Eifelian by him from the brachiopod assemblage. YÜ and CHANG doubted the age in criticizing NONAKA's preliminary identification.

Later, NONAKA surveyed the area near the Kinsui station by himself to confirm the stratigraphical position of YABE and SUGIYAMA's collection. He failed to find it owing to the placer condition of the river, but he found another fossiliferous bed bed which overlies the siliceous shale bed of unknown age. There he obtained the following succession in descending order.

		Approx. Thickn.
6.	Green sandstone	(20 m+)
5.	Conglomerate	(2 m±)
4.	Fossiliferous greenish calcareous sandstone	(20 m)
3.	Bedded greenish gray sandstone	(50 m)
2.	Fossiliferous trachytic tuff	(10 m±)
1.	Massive green calcareous sandstone	(30 m±)
	..... clino-unconformity	
	Reddish purple and green siliceous shale bed	(30 m±)

Fossils were found in both of the bed 2 and 4. The latter bed has more abundant pelecypods, gastropods, trilobites and others. These strata strike N60°E-NE and dip steeply to the south, occasionally vertical in portion.

NONAKA identified the following brachiopods among the fossils of bed 4 although the paleontology was not accomplished (1941, p. 31).

Plectospirifer cf. *grabaui* YABE & SUGIYAMA
Hypothyridina parallelepipeda (BRONN) var.
Camarotoechia sp.
Schellwienella (?) sp.

After World War II, M. S. NAGIBINA collected some Devonian fossils from Kinsui (1957). According to V. N. KRESTOVINKOV's identification the collection includes the following species.

Leptostrophia magnifica HALL
Acrospirifer assimilis FUCHS
A. cf. *rousseni* ROUAULT
Schuchertella umbraculum SCHLOTHEIM
Stropheodonta virgata DREVERMANN

The age of the fauna was then presumed as late Coblenzian. No paleontological study on these materials has been published however (*in* HOU, 1959, p. 135).

In 1959, HOU described several brachiopods from the Houlungmen Formation at the east bank of Telychiho in southern Dinchanchen (his loc. no. 131). The following species were recognized and the age was thought to be Coblenzian-Eifelian.

Conchidium ex gr. *baschkiricum* (VER.)
Leptostrophia magnifica HALL

Strophonella sp.
Leptaena rhomboidalis WILCKENS
Camarotoechia ex gr. *nympha* BARR.
Acrospirifer cf. *cyclopterus* (HALL)
A. aff. *gaspensis* (BILL.)

Unfortunately the exact geographical as well as stratigraphical relationships among the NAGIBINA's, HOU's, NONAKA's and KONDO's localities are unknown to the present writer.

HOU (1959) also reported the first discovery of Givetian brachiopods for this district from the Kenlyho Formation at the west bank of the upper Daholyho, east of Kenlyho located to the northeast of the preceding locality (his loc. nos. 4891, 4807). The fossils contained are

Praewaagenoconcha kenlyhoensis HOU
Eatonia ustritskii HOU
Delthyris ? cf. *D. tiro* (BARR.)
Mucrospirifer mucronatus (CONR.)
M. paradoxiformis HOU
M. bimesialis (HALL)
M. ? sp.
Acrospirifer pseudocheechiel HOU
Atrypa bodini MANSUY

In the Compilation Table of Stratigraphy of China (1956), the Devonian system in the Lesser Khingan district was summarized and divided into the following four parts.

Middle Devonian	The Heitai Series
Lower Devonian	The Houlungmen Formation The Nichiuho Formation
Silurian-Devonian Formation (?)	

It is evident that this age assumption of the Heitai series was to take account of an occurrence of the "*grabaui*"-type *Plectospirifer*, that had been reported by NONAKA. This species characterizes the Givetian Mishan fauna as mentioned later.

HAMADA (1960) criticised some conclusions made by NONAKA and HOU, noting the absence of true *Conchidium* and *Plectospirifer* in the Lesser Khingan materials kept in the University of Tokyo after the preliminary reexamination of KONDO's and NONAKA's collections. He also noted the occurrences of dalmanitid trilobite and a few pelecypod such as *Pterinea* and *Paramnigenia*, which seem to have some similarities to the Altai Devonian fauna. Several specimens of arborescent *Thamnopora*-like "*Favosites*" were found in the collections in association with the brachiopods.

On that occasion he also summarized the general Devonian stratigraphy in the Lesser Khingan district as follows:

Age	Formation	Locality
Givetian	Kenlyho	Upper Daholyho
Coblenzian -Eifelian	Houlungmen	Kinshan-chen (=Dinchan-chen); Kinsui
Coblenzian	Nichiuho	Kameyama, Nichiuho

Quite recently, TANG and SU (1966) published a detailed stratigraphy of the Ordovician-Devonian sequence developed around Ninkiang. More than a dozen localities including the above mentioned localities were investigated. These were shown as the solid spots in the area A on a map (text-fig. 1).

According to them, the Devonian strata are rather widely distributed in the area, and several stratigraphic sections were obtained. In general, the Devonian System is divided into three parts which are well collated with the age assignment by the present writer (1960). It is significant that they recognized three stages in terms of lithology of the system within the lowest Nichiuho Formation (2700 m thick) as follows:

	Carbonate Stage	(D^2ln3): 577 m
Nichiuho Formation	Siliceous Stage (volcanics)	(D^2ln2): 1455 m
	Clastic Stage	(D^2ln1): 480 m

The basal portion was clarified to rest on the Middle Silurian and older bed with an angular unconformity.

On the left bank of Wodu river TANG and SU reported the following Coblenzian succession with a brachiopod fauna.

Upper: Fine-grained sandstone with brachiopods and rugosa
Camarotoechia sp.
Eucharitina ? sp.
Coelospira concava (HALL)
Leptocoelia aff. *biconvexa* BUBL.
D^2ln1 *Hipparionyx* ? sp.
Euryspirifer aff. *gaspensis* (BILL.)
E. aff. *murchisoni* (CAST.)
Acrospirifer sp.
Cyrtina sp.
Pateophyllum ? sp.
Lower: Conglomerate
..... angular unconformity .....
Middle Silurian

The most beautiful sequence of the Nichiuho Formation is exposed between Nichiuho and Guanwu river where was obtained the following succession.

Clastic Stage

4. Dark gray fine-grained sandstone and shale with a few amount of graywacke sandstone (400 m +)
   Fine-grained sandstone yields an abundant brachiopods and phacopid trilobites
   Brachyprion sp.
   Shaleria sp.
   Tetratomia sp.
   Leptocoelia biconvexa BUBL.
   Coelospira concava (HALL)
   Eatonia sp.
   Platyorthis ? sp.
   Isorthis sp.

Cyrtina sp.
Nephranomma sp. (trilobite)
Reedops sp. („)

3. Dark gray fine-grained sandstone and pale yellow sandstone in alternation (43 m)
2. Dark gray graywacke-type feldspar-quartz sandstone with a few amount of dark gray fine-grained sandstone (8 m)
1. Dark gray to pale yellow conglomerate with a few amount of dark gray fine-grained sandstone (29 m)

..... unconformity .....

Siliceous fine-grained sandstone of the Upper Ordovician Laho Formation.

A fossiliferous bed exposed on the eastern extension of the bed 4 yields

Euryspirifer aff. *gaspensis* (BILL.)
Chonostrophia sp.
Coelospira sp.
Rhipidomella ? sp.

The siliceous volcanic stage or the Middle part of the Nichiuho Formation is divisible into four units.

4. Pale gray to gray siliceous rocks (218 m)
3. Deep gray jasper with crystalline limestone lense which contains coral and crinoidal fossils (638 m)
2. Light gray to deep gray siliceous rocks with thin crystalline limestone (537 m)
1. Light to deep gray jasper (62 m)

Though the stratigraphic contact is not exposed, the bed 1 is presumed to overlie conformably the top bed of the clastic stage judging from the structural trends of these two units.

A part of the bed 3 shows pillow structure and has spheroidal texture. The chemical composition of "jasper" is as follows:

SiO_2 44.07,	TiO_2 1.98,	Al_2O_3 14.23,	Fe_2O_3 11.16,
FeO 4.18,	MnO 0.02,	MgO 2.05,	CaO 10.01,
Na_2O 5.76,	K_2O 0.35,	P_2O_5 0.11	

With a conformable relationship to the top bed of the volcanic stage, the carbonate stage shows the following succession, and is overlian in turn by the Eifelian conglomerate with conformity.

10. Bluish gray siliceous limestone (34 m)
9. White marbleized limestone (56 m)
8. Grayish white siliceous rock with crinoidal stems (70 m)
7. Gray to grayish yellow crystalline limestone (25 m)
6. Grayish white siliceous rock with crinoidal stems (39 m)
5. Grayish white and white, partly purplish red crystalline limestone with crinoidal stems (108 m)
4. Light grayish yellow muddy siliceous rock (173 m)
3. Deep gray andesite-porphyritic tuff (32 m)
2. Grayish white to light gray siliceous rock (9 m)
1. Deep gray fine-grained muddy rock with a thin bed of bluish marl (31 m)

In the western distribution of this calcareous stage bed 1 contains abundant brachiopod and crinoidal remains among which the following species have been identified.

Schizophoria ? sp.
Leptaena sp.
Rhytistrophia sp.
Stropheodonta sp.
Acrospirifer sp.
Atrypa cf. *waterlooensis* WEB.
Decacrinus cf. *pennatus* YELT.

Special attention was paid by TANG and SU to the similar brachiopod fauna of Devonian aspect from the completely different lithological unit at the southwest. Namely, on the north bank of the Hailito river, Inner Mongolia, approximately 50 m thick arenaceous beds consisting of quartzose sandstone and conglomerate are exposed. It overlies an errosional surface of the Lower Paleozoic strata with a distinct angular unconformity. The conglomerate and fine-grained sandstone bed in the upper portion are reported to yield the following brachiopod species.

Clarkeia sp.
Eucharitina ? sp.
Coelospira concava (HALL)
Chonostrophia ? sp.
Stropheodonta sp.
Euryspirifer aff. *gaspensis* (BILL.)
E. aff. *murchisoni* (CAST.)

The paleontological work of these newly discovered Devonian brachiopods from the Lesser Khingan district has been incomplete except for a few species written by HOU in 1959. He illustrated *Leptaena "rhomboidalis"* (WILCKENS) and *Leptostrophia magnifica* (HALL) from the Lower Devonian rocks and *Praewaagenoconcha kenlyhoensis, Eatonia ustritskii, Mucrospirifer mucronatus* (BARR.), *M. paradoxiformis, M. bimesialis* (HALL) and *Acrospirifer pseudocheechiel* from the Givetian Kenlyho Formation. Most of the listed brachiopods are, therefore, known only by tentative names.

2. The Greater Khingan District

An important contribution to the Middle Paleozoic geology of the Greater Khingan Range to the west of the above mentioned region was made by WANG and NING (1956) who reported a rich Upper Devonian fauna that contained many cephalopods. They recognized the Frasnian and Famennian faunules in the Suhuho Series around Taminshan (Loc. D in text-fig. 1). The identified fossils are as follows:

Famennian
Favosites gusimuricus var.
Plicochonetes exginanus (VERR.)
Cyclocyclicus cf. *veericoscus* GELT.
C. ex gr. *conideus* GELT.
Pentagonocyclicus ex gr. *uastus* GELT.

Frasnian

Cyrtospirifer (*Sinospirifer*) cf. *sinensis* (GRABAU)
Camarotoechia cf. *hsikwangshanensis* TIEN
Yunnanella ? sp.
Schizophoria cf. *macfarlanii* var.
Atrypa desquamata SOWERBY

Subsequently, in describing the following 12 cephalopods from the Upper Suhuho Series CHANG (1958) placed the faunule in the middle to lower Famennian or the *Sporadoceras-Prolobites* zone of the Rhine district.

Cheiloceras subpartitum MÜNSTER
C. globosum MÜNSTER
Sporadoceras pompecky WEDEKIND
S. biferum PHILL.
S. subbilobatum MÜNSTER
S. latilobatum CORRENS
S. n. spp.
Pseudoclymenia weissi WEDEKIND
P. n. spp.
Postprolobites frechi WEDEKIND
P. n. sp.
Platyclymenia annulata MÜNSTER

There arose a hot argument on Upper Devonian distribution in North China and its correlation with South China. CHANG (1958) was of opinion that the boreal *Clymenia*-fauna was only on the northern margin of the Sino-Korean platform and had been prevented from spreading over the platform to the south. YAO (1959), however, criticized CHANG's concept on the Upper Devonian in Central and South China. He insisted that the Famennian in the southern part was represented by the Hsikwangshan and Junghsien faunae in the district.

HOU (1959a) described some Devonian brachiopods from the Greater Khingan district discerning two different ages in them.

1. North bank of Kentoho, a branch of Cheruho in the Bokudo region of Inner Mongolia (his loc. no. 175).

   Loc. B in text-fig. 1, p. 4.
   Eatonia ustritskii HOU
   Mucrospirifer ? *khinganensis* HOU
   Loc. ditto (his loc. no. H-14)
   Schuchertella altaica KHALFIN
   Brachyprion aff. *nalivkini* KHALFIN

2. East of Taminshan, north of Irekude of Inner Mongolia.

   Loc. C in text-fig. 1 (his loc. no. 677-1)
   Atrypa ex gr. *desquamata* SOWERBY

He regarded the first two faunules as of Givetian age and the last ones of Frasnian age respectively. The last mentioned limestone bed with *Atrypa* contains a rich tabulate fauna in its lower portion. According to DUBATOLOV (1958), it might be Frasnian, and the following species were recognized.

Alveolites obtortus LECOMPTE
A. parvus LECOMPTE
A. suborbicularis var. *cylindrica* (TSCHERN.)

A summarized stratigraphy of the Devonian succession in the Greater Khingan was presented (*in* WANG and YÜ ed., 1964), and quoted as follows:

Upper Taminshan Formation (approx. 1600 m)
Mainly composed of acidic volcanic rocks, tuff, and intercalated with andesite porphyrite. The lowest portion of the formation is purplish red muddy limestone and yields rich clymeniid fauna.
Cheiloceras subpartitum MÜNSTER
Sporadoceras biferum PHILLIPS
Postprolobites frechi WEDEKIND
Pseudoclymenia weissi WEDEKIND
Platyclymenia annulata MÜNSTER

Lower Taminshan Formation (approx. 1000 m)
Pale yellow tuffaceous sandstone, sandy conglomerate, with light gray limestone which contains.
Alveolites obtortus LECOMPTE
A. parvus LECOMPTE
A. elongatus LECOMPTE
Atrypa ex gr. *desquamata* SOWERBY

Kentoho Formation (approx. 300-800 m)
Dark green porphyrite, purple shale and sandstone. Lower portion is limestone and graywacke sandstone with a rich brachiopod fauna.
Mucrospirifer mucronatus (CONRAD)
M. ? *khinganensis* HOU
Eatonia ustritskii HOU

Wunuerh Formation (approx. 500 m)
Gray quartzite and conglomerate with dark green shale and porphyrite. Corals found in the formation are
Favosites saginatus LECOMPTE
Thamnopora siavis DUBATOLOV
Heliolites insolens TSCHERNYSCHEV
Pachyfavosites markovskyi SOKOLOV
Caliapora elegans (YANET)

Rukou Group (Siluro-Devonian)
Grayish green phyllitic shale, black slate and porphyritic sandstone in the upper part, and limestone in the lower. The upper part contains bryozoan remains. The lower limestone yields
Favosites cf. *forbesi* EDWARDS & HAIME
F. cf. *gusimuricus* var. *sibiricus* RUKHIN
Phacops breviceps BARRANDE
..... unconformity .....
Ordovician Suhuho Group

3. The Mishan District

This is the first place in which were discovered undoubted Devonian fossils in Northeast China. Mr. HATORI collected some fossils from the limestone exposed at the

hilly land of approximately 40 meters high, in Shinano-mura, southeast foot of the Wantashan range of the Mishan district (loc. F in text-fig. 1, p. 4) (*in* KOBAYASHI & NONAKA, 1942). According to him (in KOBAYASHI, 1951), the limestone is a remarkable cliff-maker and stratigraphically occupies the lower portion of the Paleozoic sequence there as follows:

d. Bluish gray tuff bed which intercalates dark gray quartzite of 10 m thick (70 m)
c. Sandstone with dark gray quartzite bed (30 m)
b. Fossiliferous limestone (50 m)
a. Chert (35 m)
The underlying strata: metamorphic rocks

The fossils were sent to Dr. KOBAYASHI who preliminarily identified them as of Devonian age (KOBAYASHI, 1941).

Almost simultaneously with HATORI, Mr. MORITA sent his collections from the basement strata of the Jurassic coal seams of the Mishan coal field, approximately 8 km northeast of the Heitai railway station to Dr. YABE. Consequently YABE (1940) reported

Spirifer (*Adolfia*) sp. aff. *S. loriger*
Atrypa aspera
Leptaena rhomboidalis
Favosites sp.
Lioclema (*Lioclemella* ?) sp.

Upon Dr. YABE's request, Dr. NAGAO made a survey on the occurrence of these fossils (NAGAO, 1940) and collected additional materials which were described by YABE and SUGIYAMA (1942) as the second note on the Heitai Devonian fauna. They revised the first report and recognized two new species among them, i. e. *Plectospirifer grabaui* (=*Adolfia* aff. *loriger*) and *Favosites multispinulosus* (=*Favosites* sp.) The following list shows the summary of the Devonian fauna in these two collections (YABE & SUGIYAMA, 1942).

Fossils	1st coll. (by MORITA)	2nd coll. (by NAGAO)
Plectospirifer grabaui YABE & SUGIYAMA	×	×
Spirifer sp. indet.	—	×
Atrypa aspera (SCHLOTHEIM)	×	×
Leptaena rhomboidalis (WILCKENS)	×	×
Favosites multispinulosus YABE & SUGIYAMA	×	×
Lioclema (*Lioclemella* ?) sp.	×	—
Proetus-like pygidium, gen. et sp. indet.	×	×

The fossiliferous stratum was said to be in a position of ESE in its strike and dipped about 40 degrees to the SW. YABE and SUGIYAMA concluded that the geological age cannot be older than Upper Middle Devonian (Givetian).

In 1955, MU described a new species of *Devonoblastus, D. heitaiensis* from the Heitai formation. It was collected by Messrs. Y. WANG and K. C. YANG in 1950 at Chenchohoushan, a small hill, near the same locality as HATORI's collection, 1.5 km northeast of Tatouho village situated 7.5 km northeast of the Heitai railway station.

In 1950, Messrs. C. C. YÜ and W. T. CHANG also visited the same place and collected the following fossils (YÜ & CHANG, 1951; YANG, 1956).

Atrypa aspera var. *kwangsiensis* GRABAU
Leptaena rhomboidalis (WILCKENS)
Stringocephalus sp.
Spirifer sp.
Favosites sp. (sp. nov.)

On the basis of these materials the geological age of the fauna was considered as later half of the Middle Devonian. This agrees, therefore, with the conclusion made by YABE and SUGIYAMA (1942).

Stratigraphy of the Heitai formation was summarized in a Compiled Tables of Stratigraphy of China, Vol. 1 (1956) as follows:

9. Pebble-bearing arkosic sandstone and green tuffaceous sandstone (47 m)
8. Black thin-bedded shale (7 m)
7. unexposed (22 m)
6. Alternation of thin-bedded shale (green tuff ?) and sandstone (17 m)
5. Thin-bedded sandstone with *Spirifer* (13 m)
4. Impure crystalline limestone intercalating shale and sandstone (2 m)
3. unexposed (30 m)
2. Shale intercalating thin-bedded sandstone *Spirifer*, *Stropheodonta*, etc. (47 m)
1. Impure crystalline limestone; richly fossiliferous (30 m)

WANG (1956) and HOU (1959) described *Leptostrophia heitaiensis* and "*Plectospirifer*" *grabaui*. However, there was a divergence of opinion on the generic assignment of the second form. Namely, the former author referred it to *Eryspirifer* and the latter to *Acrospirifer* (?) respectively.

In describing 28 species of bryozoans in 10 genera, YANG (1956) was the first to subdivide the Heitai Formation into several zones by the fossil assemblages. Being joined together with the stratigraphic summary of the succession published in the "Devonian of China" (WANG & YÜ ed., 1964), the results are quoted as Table 1. Stratigraphical position of these fossils is collated with the recent summary by WANG and YÜ as follows:

Bed 6 Black, compact shale and sandstone (13 m)
Bed 5 Yellowish gray thin-bedded sandstone with argillaceous limestone intercalations (12 m)
Bed 4 Black siliceous shale (42 m)
Bed 3 Yellowish sandstone and shale with thin, impure limestone intercalations (21 m)
Bed 2 Gray, impure, crystalline limestone (20 m)
Bed 1 Coarse-grained sandstone; sand grains being neither well sorted nor rounded, including abundant feldspar fragments (20 m)
..... unconformity .....
Granite gneiss

The collection sites indicated in Table 1 are as follows:

2 (mid.): 5-10 m above 2 (low)

Table 1. The Mishan Fossils.

Fossils	Horizons			
	2 (low.)	2 (mid.)	3	5
Bryozoa				
Fistulipora frondosa YANG	×			
F. yui YANG	×			
F. tatouhuensis YANG	×			
F. chaoi YANG	×			
Leioclema heitaiensis YANG*	×			
L. tungi YANG	×			
L. minor YANG	×			
Batostomella lineaxis YANG	×			
Fenestella tatouhuensis YANG	×			
Unitrypa sp.	×			
Orthopora sinensis YANG	×			
Leioclema jeni YANG*	×	×		
Semicoscinium cf. *striatum* NEKHOROSHEV	×	×		
Fistulipora cf. *irregularis* YANG		×		
F. mishanensis YANG		×		
F. leei YANG		×		
Leioclema manchuriensis YANG*		×		
Fenestella mishanensis YANG		×		
Polypora lineata YANG		×		
Hemitrypa devonica var. *heitaiensis* YANG		×		
H. megafenestella YANG		×		
Unitrypa acaulis HALL		×		
Semicoscinium thyrene var. *sinensis* YANG		×		
S. megafenestella YANG		×		
Dybowskiella wangi YANG			×	
Semicoscinium sp.			×	
Hemitrypa sp.			×	
Unitrypa sp.				×
Semicoscinium delicatum KRASNOPAYEVA				×
S. kirinensis YANG				×
Leioclema sp.*				×
Brachiopoda				
Atrypa aspera var. *kwangsiensis* GRABAU	×			
Leptaena rhomboidalis (WILCKENS)	×			
Stringocephalus sp.	×			
Acrospirifer (?) *grabaui* (YABE & SUGIYAMA)	×			
Leptostrophia heitaiensis YANG	×			
Blastoidea				
Devonoblastus heitaiensis MU	×			

* Listed as *Lioclema*.

Table 1. *Continued.*

Tabulata	BE 232 (low.)	BE 233 (up.)
Thamnopora cf. *pulchra* (TCHERNSCHEV)	×	
T. mishanensis DENG		×
T. m. capistrata DENG	×	
T. yangi DENG		×
Pachypora wangi DENG	×	
P. w. thamnoporoides DENG		×
Striatopora linneana BILLINGS	×	
Syringocystis tabulata DENG	×	
Cladopora cf. *cylindrocellularis* DUB.		×
Coenites khinganensis radiatus DENG		×

3: 20-30 m above 2 (mid.)
5: 40-50 m above 3

Geological age of the Heitai Formation is likely Givetian as was thought by YABE in 1942 except the upper fossiliferous horizon (bed 3) which was presumed as early late if not the latest Devonian by YANG (1956) on the basis of the bryozoan assemblage. The presence of *Stringocephalus* sp. among the fossils (YANG, 1956) and some similarities of the bryozoan constituents to those of the Altai fauna are noteworthy.

In 1966, DENG discerned the following species of Tabulata including a new genus *Syringocystis* in WANG and YANG's collection from the Heitai Formation (YANG's Bed 2, 1956) and concluded that the age was presumed as Eifelian, criticizing the preceding results by many workers.

Thamnopora cf. *pulchra* (TSCHERNYSCHEV)
T. mishanensis DENG
T. mishanensis capistrata DENG
T. yangi DENG
Pachypora wangi DENG
P. wangi thamnoporoides DENG
Striatopora linneana BILLINGS
Cladopora cf. *cylindrocellularis* DUBATOLOV
Coenites khinganensis radiatus DENG
Syringocystis tabulata DENG

His discussion on the geological age of the coral assemblage is quoted as "..... a new species *Coenites khinganensis radiatus* is found to be much related to *Coenites khinganensis* DUBATOLOV from the lower Middle Devonian of Great Khinganling of Northeast China, and some species to have close affinity to *Thamnopora pulchra* and *Cladopora cylindrocellularis*, which are characteristic of the lower Middle Devonian (Eifelian) of Kuznetsk of U. S. S. R. Furthermore, the species described by YABE and SUGIYAMA in 1942 as *Favosites multispinulosus* and later emended by C. M. YÜ (1963) as *Squameofavosites multispinulosus* was also discovered there. As has been known, the genus *Squameofavosites* is predominant both in the Lower Devonian and in the lower Middle Devonian, but absent in the upper Middle Devonian."

4. The Kirin District

KAWADA (1932) was wise to predict the presence of Silurian and Devonian strata in the lower portion of his Kirin Formation of great thickness on the basis of his general survey of the Kirin district. In 1943, Messrs T. YOSHIDA, M. GOISHI and K. T. LIN found an exposure of fossiliferous limestone along an old road, which connects Changchun with Kirin, about 3 km southeast of Erhtaokou, 15 km west of Kirin (Loc. E in text-fig. 1).

YABE and EGUCHI (1943) first identified and described several corals among the fossils as cited below.

Favosites sp. nov. (nom. nud.)
Cf. *Striatopora cristata* (BLUMENBACH)
Cladopora ? sp.
Aulopora ? sp.

KAWADA noted that the lower division of the Kirin Formation is frequently intercalated with small limestone lenses in breccias. The fossiliferous Erhtaokou limestone is one of those lenses, and partly rich in crinoidal stem joints. According to YABE and EGUCHI, the limestone is partially very impure, being rich in clastic materials, and some parts might better be called calcareous sandstone or breccia.

During the subsequent two years, YABE and EGUCHI added the occurrences of *Pseudomphyma infundibula* YABE and EGUCHI and *Spongophyllum sugiyamai* YABE and EGUCHI, both of which were collected by Mr. K. T. LIN from the Erhtaokou limestone. They revised also their opinion on the geological age of the limestone on account of those corals, and concluded that it is by no means of Devonian but Middle Silurian age. At the same time YABE collected many specimens of *Pachypora* ?, and mentioned that it was necessary to revise the precedingly described *Striatopora cristata* and *Cladopora* ? sp. (*in* YABE & EGUCHI, 1945).

YÜ and CHANG (1951) surveyed the lower Kirin Formation and obtained the following sequence (YÜ & CHANG, 1951; in Compl. Tabl. Geol. China, 1956).

8. Slightly metamorphosed green shale
7. unexposed
6. Gray massive crystalline limestone with *Disphyllum* sp. (50 m)
5. Phyllitic shale (6 m)
4. Thin-bedded muddy limestone containing *Favosites*, bryozoa, Crinoids, etc. (8 m)
3. Stratified muddy limestone
2. Thin-bedded muddy limestone
1. Phyllitic shale

Though they regarded the entire Kirin Formation as Middle Silurian following YABE and EGUCHI's revised opinion, an occurrence of *Disphyllum* in the bed 6, which is 6 m higher than the tabulate coral-bearing limestone (bed 4), should not be overlooked.

In reviewing the Silurian and Devonian of Northeast China and Korea, the present writer stressed the strong Devonian aspect of the tabulate coral fauna of the Erhtaokou limestone which completely lacks the Halysitidae (HAMADA, 1960a). *Pseudamplexus* (=*Pseudomphyma*) and *Spongophyllum* were not regarded as keen

indicators of Silurian by him.

KUO (1962) described four Silurian trilobites from Ehrtaokou and showed the stratigraphical succession of the fossiliferous beds as follows in descending order:

7. Intermediate—acidic volcanic series. (300 m)
   ..... fault .....
6. Dark gray shale with trilobites, corals and brachiopods. (11 m)
   Encrinurus sinicus KUO
   Otarion sphaericum KUO
   O. diffractum conveximarginatum KUO
5. Tuffaceous sandstone with trilobites and brachiopods. (19 m)
   Encrinurus sinicus KUO
4. Greenish gray sandstone, shale and limestone lenses with trilobites, brachiopods, bryozoans and crinoid stems. Trilobites are fragmentary. (192 m)
3. Silicified tuff, tuffaceous sandstone and acidic lava; with crinoid stems. (58.5 m)
2. Silicified limestone and marl with greenish black shales; corals in limestone, brachiopods and trilobites in shales. (50 m)
   Pseudomphyma infundibula YABE & EGUCHI
   Calymene cf. *blumenbachi* BRONGNIART
   Otarion diffractum conveximarginatum KUO
   O. sphaericum KUO
1. Fine-grained sandstone, phyllitic shale with thin silicified limestone; with brachiopods, crinoid stems. (592 m)

The recent detailed study on the Erhtaokou stratigraphy summarized by MU (1964) shows an occurrence of *Encrinurus* (*Coronocephalus*) *rex* GRABAU (?) from the brachiopod-bearing sandstone. Therefore, MU was convinced that the age of the formation was definitely Silurian. However, he mentioned that there was needed more careful study in quoting YÜ's opinion that there are some Devonian elements in the fauna. The stratigraphical succession is as follows:

7. Black shale, thin crystalline limestone bed in the upper portion (50-100 m)
6. Yellowish brown coarse-grained sandstone with brachiopods and *Encrinurus* (*Coronocephalus*) *rex* GRABAU (?)
5. Brown, black and variegate fine-grained sandstone with thin crystalline limestone layer (200 m)
4. Black shale and sandstone in alternation (5-100 m)
3. Light gray thick-bedded limestone and muddy limestone with corals, brachiopods and bryozoans (30-100 m)
2. Variegate sandy shale with crinoidal stem joints (300 m)
   ..... Granite intrusion .....
1. Slightly metamorphosed black shale with a few sandy shale and crystalline limestone layers (100 m+)

As was discussed elswhere by the present writer (HAMADA, 1961), most of the generic identification of "*Coronocephalus*" in China is not satisfactory. However, an occurrence of a form of the Encrinuridae implies the Pridoli (=Skala) age of the fauna in the bed 6 at the youngest. The bed 3 probably corresponds to the Erhtaokou limestone of YABE and EGUCHI or the bed 4 in the precedingly cited sequence. It is unfortunate that there is no indication of the *Disphyllum* occurrence

Table 2. Correlation chart of the Middle Paleozoics of Northeast China and Korea.

Geol. Age \ District		Inner Mongolia	Northeast China			Korean Peninsula	
		Greater Khingan	Lesser Khingan	Kirin.	Mishan	Chonsong-ni	Kosu-ni
Devonian	Famennian	U.Taminshan Ser.	?				
	Frasnian	L.Taminshan Ser.	Tungkulan Group				
	Givetian	Kentoho Form.	? Kenlyho Form.	?	Heitai Form.	Tenseiri Ser.	Kosori Ser.
	Eifelian	Wunuerh Form.	Houlungmen Form.	Upper Kirin Form.	? ?		
	Emsian		Nichiuho (Qiu River) Form.				
	Siegenian						
	Gedinnian	Lukou Group (Sil.-Dev.)					
Silurian	Pridoli						
	Ludlovian	? ?		Lower Kirin Form.			
	Wenlockian		Guan Wu River Form.				
	Llandoverian		Huanghuano (Luo River) Form.	? ?			
Underlying bed		Ord. Suhuho Group	Up. Ord. Laho Form.	Metam. Rocks	Mashan Group	Mid. Ord.	Mid. Ord.

in the latest stratigraphy although it can be imagined that the crystalline limestone bed in the upper part of the bed 7 might correspond to the *Disphyllum*-bearing crystalline limestone (bed 6) in the former result. The Devonian problem of the Erhtaokou sequence is thus a matter of dispute at the present time.

III. Geological Age and Correlation of the Lesser Khingan Lower Devonian

The Houlungmen (H) and Kinsui (K) collections from the Lesser Khingan district include about 30 species of brachiopods, among which 14 are new and three identical with or closely similar to the known species. Therefore, the age assumption based on this brachiopod assemblage can be done only in generic rank. Consequently, the known geological ranges of some selected genera have been examined to find the age of the fauna as common diviser.

The genus *Proschizophoria* includes three species and ranges from early Gedinnian through Siegenian age (Boucot, Gauri, and Johnson, 1966). *P.* cf. *personata* (Zeil.) was, however, reported to occur in the Lower Emsian bed in Gornyi Altai (Gratsianova & Kulikov in Khalfina ed., 1961, p. 221).

Dalejina first appeared in the upper Llandoverian (C_3) and flourished during early Devonian time and ranges up to the Upper Emsian bed (Boucot, Johnson & Walmsley, 1965). The type-species *D. hanusi* Havlíček was obtained from the Zlichov Limestone of late Emsian age. In the Appalachian province the genus is most abundant during Siegenian times (Port Jervis limestone and Oriskany sandstone) and more than 19 species have been reported (Boucot & Johnson, 1967).

Reeftonia is restrictedly known from the Reefton beds of New Zealand (Allan, 1947) and from the Dead Bull and Kilgower Members of the Tabberabbera Formation of Victoria, Australia (Gill, 1949 as *Cariniferella*; Talent, 1963). Johnson and Talent (1967) consider both occurrences to be of Emsian age.

Leptostrophia in the common sense is a fairly large genus group including some questionable forms. *Leptostrophia* and "*Rhytistrophia*", which has been widely accepted as a valid genus but regarded as synonymous with the former in the *Treatise* (1965, p. H398), are popular in the Silurian and Devonian rocks of the world. However, in the Appalachian province the last species of this genus appeared in the *Etymothyris* zone of the Esopus Formation, namely in Early Emsian.

The Pholidostrophiinae were recently revised in great detail by Harper, Johnson, and Boucot (1967). According to them there are two subgenera in the genus *Pholidostrophia*, i. e., *Pholidostrophia* s. str. and *Mesopholidostrophia*. A subgenus *Lissostrophia* (*Mesolissostrophia*) was clarified to be synonymous with the second subgenus since the type-species of these subgenera were proved to be conspecific. The typical *Pholidostrophia* ranges from Pridoli through Givetian on the one hand, and *P.* (*Mesopholidostrophia*) from Upper Llandovery (C_3) to Lower Givetian on the other.

Aesopomum aesopeum (Barrande) is the type-species of this characteristic orthotetacean genus and distributed in the Konieprus and Mnienian or Pragian and Zlichovian of the Barrandian sequence. That means it ranges from Late Siegenian to Late Emsian. *Aesopomum* species occur in the Gedinnian-Siegenian Roberts Mountain Formation of central Nevada (Johnson, Boucot, & Murphy, 1968; Boucot, Johnson, & Talent, 1968). *Aesopomum* cf. *varistriata* Johnson and *A.* sp. from the

Table 3. Range chart of some brachiopod genera.

GENUS \ LOW. DEVONIAN	GEDINNIAN		SIEGENIAN		EMSIAN	
	Low.	Up.	Low.	Up.	Low.	Up.
Proschizophoria	———	———	———	———	———	———
Dalejina	←———	———	———	———	———	———→
Reeftonia			?	———	———	
Protomegastrophia		———	———	———	———	———
Leptpstrophia	←———	———	———	———	———	———→
Pholidostrophia			?	———	———	———→
Aesopomum		———	———	———	———	———
Chonostrophiella		———	———	———	———	
Zlichorhyncus			———	———	———	———
Wilsoniella				?	———	
Bifida			———	———	———	———→
Nucleospira	←———	———	———	———	———	———→
Howellella	←———	———	———	———		
Paraspirifer					———	———→
Fimbrispirifer				———	———	———→
NUMBER OF COMMON GENERA	5	8	10	13	14	10

Table 4. Lower

ARDENNES		RHEINLAND		BARRANDIAN			USSR			KAZAKHSTAN		SALAIR
COUVINIAN	D_2	Eifelian		Eifelian		D_2	"Eifelian"	Up.	D_2	Besoba Horizon		Mamontovo Horizon
		Up. Emsian		Zlichovian				L.		Kazak Horizon		Shanda Horizon / Poluyakhtov Hor. / Salairka Horizon
EMSIAN		Low. Emsian (Arhian)		Pragian			"Coblenzian"			Sardzhal Hor.		Malobachat Hor.
SIEGENIAN	D_1	Siegenian	Up.			D_1	"Gedinnian"		D_1	Balkhash Horizon		Krekov Horizon
			M.									
			L.									
GEDINNIAN		Upper Gedinnian		Lockhovian					?			
		Lower Gedinnian					Tiverian		S_2	Kockbaktal or Kara Sespe Horizon	Bala Bed	Tomchumysk Horizon
		Skalian		Budnany	Pridoli	S	Skalian				Ainasu Bed	
		Ludlovian			Kopanina		Ludlovian					

Yukon Territory of Canada are known to occur in the *Spiriferina* unit of probable early Siegenian age (LENZ, 1968). Possible *Aesopomum* species, i. e., *A.* (?) *deformis* (HALL) and *A.* sp. are in the Lower Helderberg Formation in New York, but they have not been studied yet.

Chonostrophiella is a genus with restricted distribution in the Appalachian province. It ranges from the Upper *Nanothyris* zone of Late Gedinnian or the middle Helderbergian stage (Kalkberg-New Scotland) to the *Etymothyris* zone of Esopus Formation (early Emsian) (BOUCOT & AMSDEN, 1964; BOUCOT & JOHNSON, 1967, 1968), though BOUCOT and HARPER (1968, p. 146, text-fig. 1) showed that it probably ranges from Ludlovian to the end of Siegenian.

Zlichorhynchus was only known from the Upper Emsian Zlichov bed in Bohemia (HAVLÍČEK, 1961). A closely allied genus *Thliborhynchia* was described from the Late Siegenian bed of Royal Creek, Yukon Territory (LENZ, 1967). Quite recently SAVAGE (1968, p. 166) cited an occurrence of *Zlichorhynchus* sp. from the basal limestone of the Mandagery Park Formation, of which the geological age was suggested to be early Siegenian by the asociated conodont fauna, in the Manilda district, New South Wales.

Wilsoniella (=*Ussovia*) was first described from Lower Emsian beds of Gornyi Altai by KHALFIN in 1939. Recently the second species, *W. borissiakae*, was reported by NILOVA (1965) from the Karaespinesk horizon, though its generic assignment is questionable.

Bifida species are widely distributed in a wide span of time and space (BOUCOT, JOHNSON & STATON, 1964). This genus first appeared in Siegenian time and was distributed in the Rhenish-Bohemian province and was spread almost all over the world during the Eifelian as indicated by the distribution maps of some selected brachiopod genera in the Lower and Middle Devonian by BOUCOT, JOHNSON, & TALENT (1968, pp. 1243-1247, figs. 2-4). A closely related genus *Coelospirina* HAVLÍČEK is only known from the Upper Emsian Zlichov limestone of Czechoslovakia.

Devonian of Asia.

GORNYI ALTAI	LESSER KHINGAN	UPPER AMUR	N.E.USSR	JAPAN			
				Inner Zone	Kitakami	Outer Zone	
Shivertinsk Hor.	Houlungmen Form.	Jmatchin Form.	Vercherninsk Horizon	Takaharagawa Series	Nakazato Series		
Korgon Horizon							
Kuvash Form.							
Kirejer Form.	Nichiuho (Qiu River) Form.						
Jakuschin Form.			Beljak Horizon			Gion	
		Solsheneversk Form.		Fukuji Series	Ono Series		G_4
			Tikhii Ruchei Horizon			-yama	
Remnev Form.		?		----?----			
		Omutnin Form.	Fav. forbesi Beds		Takainari Series	Series	
					Kawauchi Series		G_3

Nucleospira and *Howellella* in the revised sense of BOUCOT (1957) are the common spiriferaceans in the Silurian and early Devonian of the world. The latter genus is, however, limited to the Siegenian strata at the latest.

Paraspirifer and *Fimbrispirifer* are essentially Middle Devonian genera. *P. cultrijugatus* zone is in the "Couvinian" of Ardennes, and *Fimbrispirifer* species characterizes the Belyak horizon of late Siegenian to early Emsian age in Northeastern USSR.

In summarizing the above stated ranges of the selected brachiopod genera, Table 3 is presented to suggest the faunal age for the Lesser Khingan early Devonian. As seen at the lower line of the chart the number of common genera in each stage seems to be significant. 13 genera are in the Lower Emsian stage which might, therefore, be the most plausible age on the basis of brachiopod assemblage.

As reviewed previously the two collections now under examination may be derived from somewhere in the Nichiuho (Qiu River) Formation of TANG and SU's stratigraphy. They regarded this formation as Coblenzian or early Emsian in the present usage. Consequently it is reasonable to assume that the lower part of the formation below the fossiliferous bed may extend down to the Siegenian in age.

Incidentally, the Lower Devonian Bolsheneversk Formation in the upper Amur region yields a quite similar brachiopod fauna as the Lesser Khingan fauna as will be mentioned in the next chapter, and it also has been dated as Coblenzian by MODZALEVSKAYA (1968).

Table 4 shows a tentative correlation of some Lower Devonian successions to obtain a general concept on the Lower Devonian distribution in Northeast Asia. At the same time the typical stage names in various classical Lower Devonian localities are also given to refer, because some usages of stage names, Eifelian as an example, have been often confused in different areas.

The Silurian-Devonian boundary problem is now under discussion as a world-wide cooperative subject in the Commission on Stratigraphy of the International Geological Congress, and the transitional stage name, i. e., Pridoli or Skalian, is provisionally adopted as the top of the Silurian in this table.

IV. Paleogeographical Significance of the Lesser Khingan Early Devonian Fauna

Paleobiogeographical analysis of early Devonian time in East Asia has been done only for the northern part by some Russian paleontologists. A paleogeographic map of China compiled by Liu (1955) was, then, the first effort to solve this problem in this vast Chinese mainland. However, the marine early Devonian rocks are rather poorly developed in China owing to the Kwangsi movement, the Caledonian equivalent. Most of the Upper Silurian and the Lowest Devonian strata are missing or represented by continental sediments with some fish and plant remains, especially in Central and South China (Hamada, 1968). The so-called Lower Devonian in China is, consequently, mostly composed of the strata higher than the Lower Emsian stage. Namely the continental Lunghuashan Series may represent Gedinnian and the marine Szupai Series late Emsian. The marine Siluro-Devonian transition bed may be present somewhere in the Yunnan-Malayan geosynclinal belt and the Yunnan-Tonking belt as its eastern branch. Actually, the Siegenian-Lower Emsian graptolite facies was recently revealed to exist in North Thailand (Jaeger, 1969). *Monograptus hercynicus* type graptolite-bearing strata are also widely discovered in Malaysia (Malaya) (Jones, 1960). Eifelian to Givetian was the most transgressive time for the Chinese mainland where the northeastern part had remained as a land area named the Sino-Korean massif. The Lesser and Greater Khingan districts are situated just on the northern margin of the Sino-Korean massif and superimposed on the Mongolo-Okhotsk geosynclinal belt.

The Kinsui (K) and the Houlungmen (H) collections under examination are very similar to each other in the faunal constituents as already reviewed. However, it is worthy to note that the former has richer contents than the latter as far as the brachiopods are concerned. For example, *Dalejina kinsuiensis* is abundant in the Kinsui collection, hence the specific name, whereas only two questionable fragments are found in the Houlungmen collection as shown in Table 5. The same tendency is remarkable for a characteristic atrypacean *Bifida*, namely, *B. orientalis* is common in the former but only some indeterminable fragments are known in the latter. It is rather difficult to conclude that the two collections represent distinct horizons or areas on the basis of the faunal difference above stated, since these collections are rather small in quantity, besides the stratigraphic relations are unknown. Therefore, the writer tentatively regards them merely as two different collections with close similarity and would discuss the faunal characteristics as a whole. The Lesser Khingan brachiopods described in this paper include 14 new species. Therefore, the significant comparison with other faunas can be done only at generic level.

A remarkable North American affinity of some Lower Devonian fossils from the Lesser Khingan district was reported by Tang and Su (1966). They listed, for example, *Coelospira concava* (Hall), *Hipparionyx* ? sp., *Howellella* aff. *gaspensis* (as *Euryspirifer*), *Acrospirifer* aff. *murchisoni* (as *Euryspirifer*), *Chonostrophia* ? sp., and

Table 5. Distribution of the Early Devonian brachiopods from the Lesser Khingan District.

Taxa \ Distribution	Collection		Geographical Distribution**				
	H	K, Kn	A	R-B	K-A	C	T-N
1. "*Lingula*" sp.		r					
2. *Schizophoria* sp.		r					
3. *Proschizophoria kabayashii*	f	f	?	×	×	?	
4. *Dalejina kinsuiensis*	?	a	×	×			×
5. *Reeftonia borealis*	c	c			×*		×
6. *Leptaenopyxis bouei*	f	f					
7. *Protomegastrophia manchurica*	f	f					
8. *Leptostrophia nonakai*	f	f					
9. *Sinostrophia kondoi*	a	a		×*	×*		
10. *Pholidostrophia* sp. A		r	×	×			
11. *P.* sp. B		r					
12. Strophomenid gen. et sp. indet.		r					
13. "*Schuchertella*" sp.	f	f					
14. *Aesopomum chinense*	f	f	?	×		×	
15. *Chonostrophiella khinganensis*	c	c	×				
16. *Zlichorphynchus asiaticus*		r		×			
17. "*Camarotoechia*" sp.	f	f					
18. *Eucharitina* (?) sp.		r					
19. *Wilsoniella grandis*	c	c			×		
20. *Pectorhyncha* (?) sp.		f					
21. *Uncinulus piloides*		r					
22. "*Atrypa*" sp.	r						
23. *Bifida orientalis*	?	c		×		×	
24. *Nucleospira musculosa*	f	f					
25. *Cyrtina* sp.	f	f					
26. "*Howellella*" *amurensis*	a	a					
27. *Acrospirifer* sp.	f	f					
28. *Paraspirifer* aff. *cultrijugatus*	f	f					
29. *Fimbrispirifer* cf. *divaricatus*		r					
30. Spiriferid gen. et sp. indet.		r					

* Identified by the present writer.

** Geographical distribution of some selected genera.

Abbreviation

H: Houlungmen, K, Kn: Kinsui

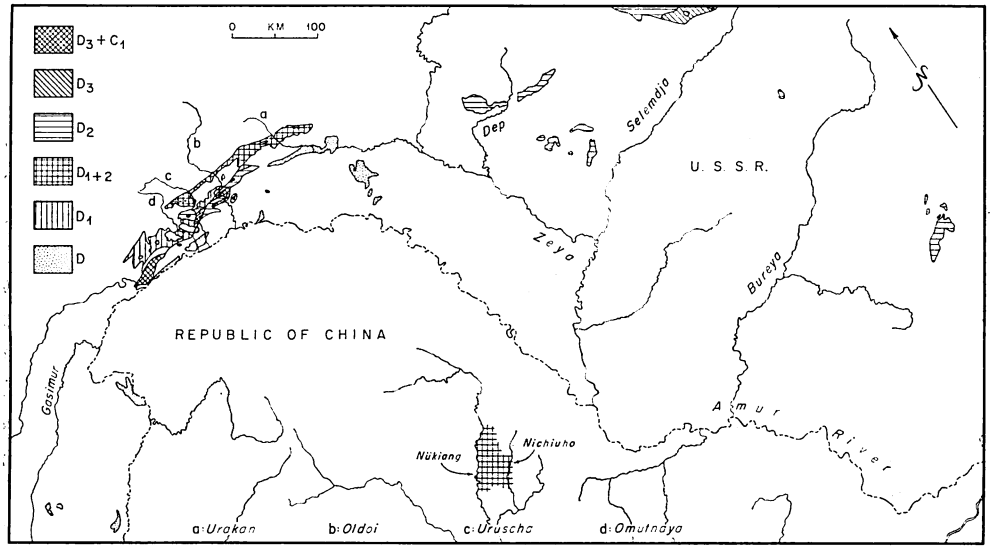
a: abundant, c: common, f: fairly common, r: rare

A: Appalachian province, R-B: Rhenish-Bohemian province (Old World), C: Cordilleran province, K-A: Kazakhstan-Altai province (including the Uralian province), T-N: Tasman-New Zealand province.

Rhipidomella ? sp. Since no paleontological data has been given for these brachiopods, it would be undesirable to make a comparative discussion. However, one can easily assume that *Chonostrophia* ? sp. and *Rhipidomella* ? are probably collated with

Chonostrophiella and *Dalejina* in this report respectively. *Coelospira concava* by TANG and SU may be a small anoplothecean brachiopod closely allied to *Bifida orientalis*. If the identification is correct, this should be the first report of the Devonian *Coelospira concava* outside North America as the distribution of the genus has been considered to be limited in North and South America (BOUCOT & JOHNSON, 1967). Another interesting point is the presence of *Clarkeia* sp., *Rhytistrophia* sp. and *Leptocoelia* aff. *biconvexa* BUBL. in their list. The first genus was only known from South America. *Rhytistrophia* is the world wide *Leptostrophia* with subconcentric corrugation of the shell and has been reported from Kazakhstan, Upper Amur and other places in the Mongolo-Okhotsk geosynclinal area as will be mentioned later (p. 52). The last occurrence gives us an important information on the distribution of this genus. According to AMOS and BOUCOT (1963) *Leptocoelia* has been known only from Kazakhstan in Asia. This might be, therefore, the second occurrence in this part of the would. Detailed investigation on the listed species is eagerly wanted to be published as soon as possible.

In the Upper Amur district of the Russian part there are some Devonian localities as shown in Text-fig. 2. From the Zeya basin NAGIBINA and KRESTOVNIKOV (1959) reported the occurrence of some stropheodontids like *Stropheodonta beckii*, *Stropheodonta* (*Leptostrophia*) aff. *magnifica*, *Stropheodonta stephani*, *S. interstrialis* and *Eospirifer iribitensis*. This fauna could be of the Lower Devonian (*in* TANG & SU, 1966).



Text-fig. 2. Distribution of Devonian strata in the Amur region.
(Mainly after the Geological Map of U.S.S.R. 1960)

Quite recently MODZALEVSKAYA (1968) has reported some Devonian fossils from the Borsheneversk Formation of the Upper Amur region, immediately north of the Lesser Khingan district. Among the brachiopods illustrated by her, following species are clarified to be identical with or closely allied to the Lesser Khingan species, as is precisely explained in the description chapter.

Taxa	Pl.	fig.	Collated Lesser Khingan species
Rhipidomella musculosa HALL	2	2	*Dalejina kinsuiensis*
R. assimilis HALL	„	3, 4	„ „
Chonetes aff. *crenulatus* SCHUNUR	„	5, 6	[absent]
Stropheodonta aff. *inequiradiata* HALL	„	7	? *Megastrophia* (*Protomegastrophia*) *manchurica*
Leptaenopyxis bouei BARR.	„	8	*Leptaenopyxis bouei* (BARRANDE)
Eatonia aff. *sinuata* HALL	„	9	[not clear]
Rhytistrophia beckii HALL	„	10, 11	*Leptostrophia nonakai*
Plethorhyncha speciosa var. *ramsayi* HALL	„	12a, b	*Wilsoniella grandis*
Paraspirifer ex gr. *cultrijugatus* ROEMER	„	13a-d	*Paraspirifer* aff. *cultrijugatus* ROEMER
Acrospirifer aff. *murchisoni marylandicus* (SCHMIDT)	„	14a, b	[?]
Delthyris perlamellosus HALL	„	15	[?]
Stropheodonta virgata DREVERMANN	„	16	*Sinostrophia kondoi*

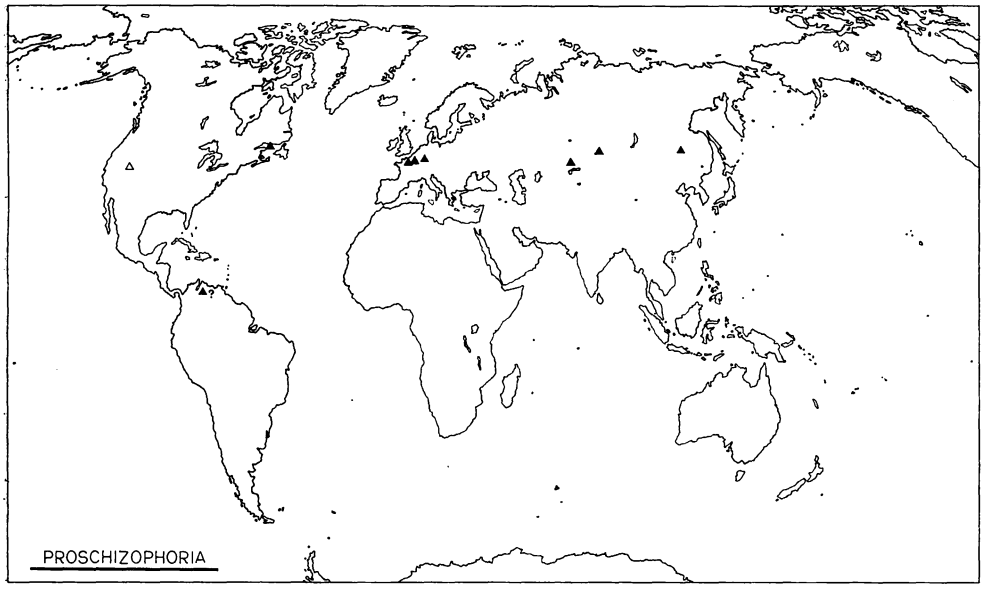
Thus, the Upper Amur brachiopod fauna is almost similar to the Lesser Khingan fauna in its constituent so as to be regarded definitely as in the same faunal province. On the basis of such abundant occurrence of the Appalachian elements in the former, MODZALEVSKAYA concluded that it comprised a separate Mongolo-Okhotsk province in the Pacific paleobiogeographical realm.

Prior to this the Kazakhstan-Altai aspect of the Lesser Khingan Devonian fauna was provisionally noticed by the present writer (1960). In Gornyi Altai, characteristic Australian *Reeftonia* species, one of which is possibly conspecific with the Lesser Khingan *R. borealis*, are recently clarified to exist by him when he visited Salair in participating the field excursions of the Silurian-Devonian Symposium in Leningrad, 1968 (*vide* page 45 for the detailed comparison). Although they are not described as yet, some phacopid trilobites in the Houlungmen and Kinsui collections also seem to have great similarity to those of Gornyi Altai Lower Devonian.

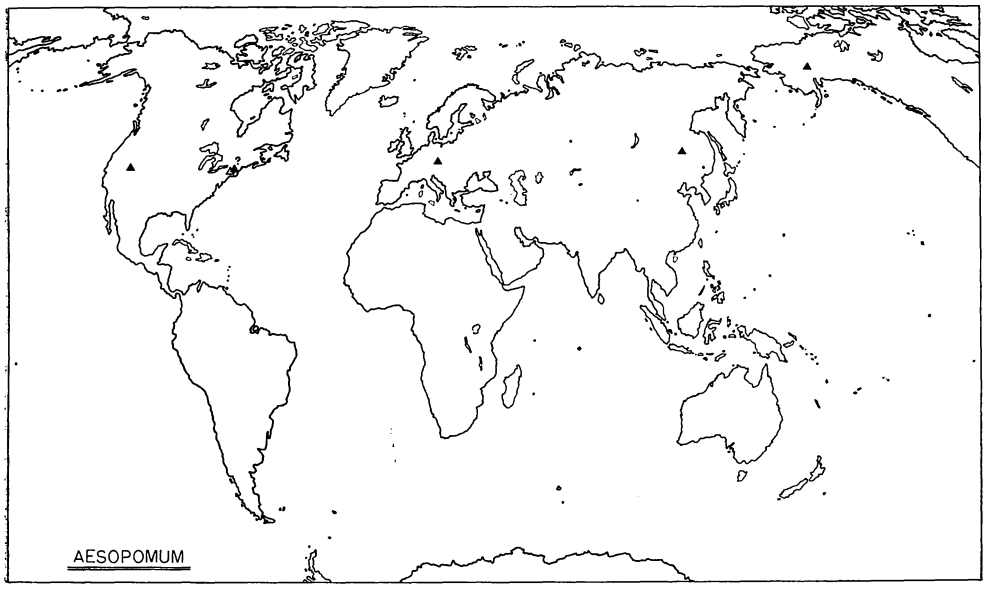
Selected genera of the Lesser Khingan brachiopods are listed in Table 5 to show their stratigraphical distribution in the world. Among them the known geographical distribution of the genera such as *Proschizophoria*, *Aesopomum*, *Bifida*, *Reeftonia* and *Chonostrophiella* are indicated also in the world maps (text-figs. 3-7). As a result one may easily understand that certain genera are rather restrictedly distributed and represent some zoogeographical provinces and subprovinces in early Devonian time as follows.

Proschizophoria *Aesopomum* *Bifida*	Rhenish-Bohemian-Cordilleran
Reeftonia	Tasman-New Zealand
Chonostrophiella	Appalachian
Wilsoniella	Uralian-Altai
Zlichorhynchus	Tasman-Bohemian

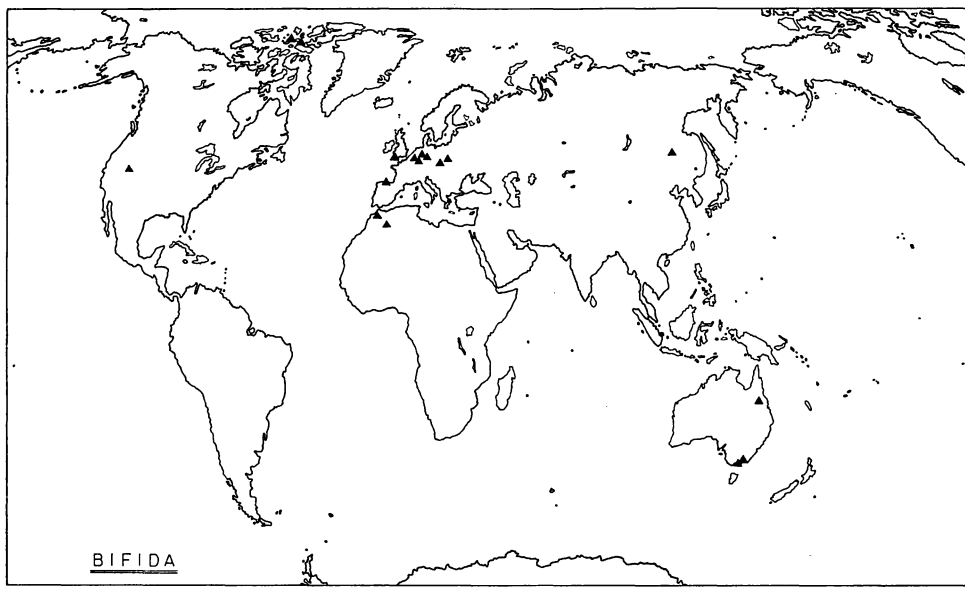
BOUCOT, JOHNSON, & TALENT (1968, 1969) summarized the Lower and Middle Devonian faunal provinces based on brachiopoda. They distinguished the provinces



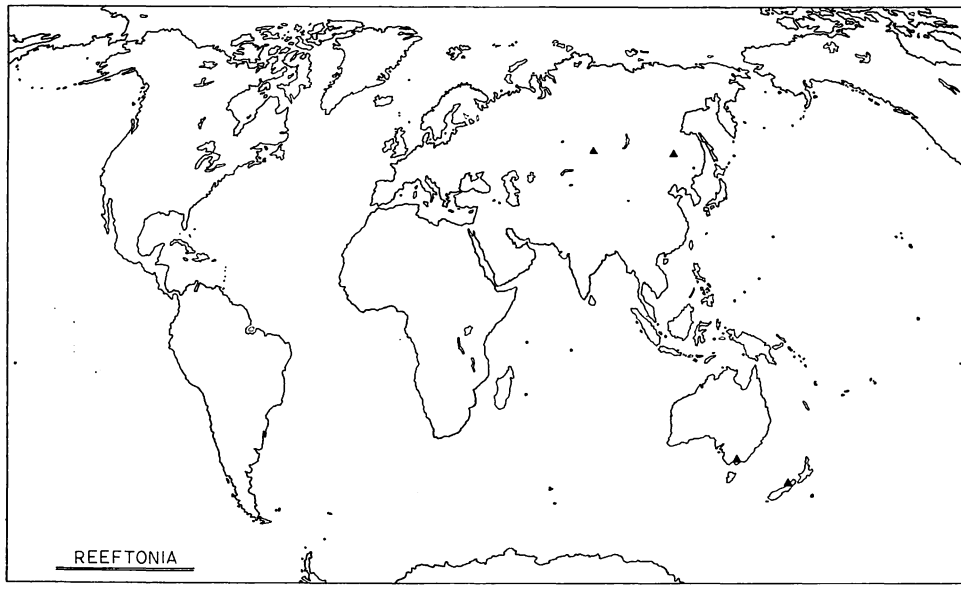
Text-fig. 3. Distribution of *Proschizophoria*.
(Open triangle: taken from unpublished data)



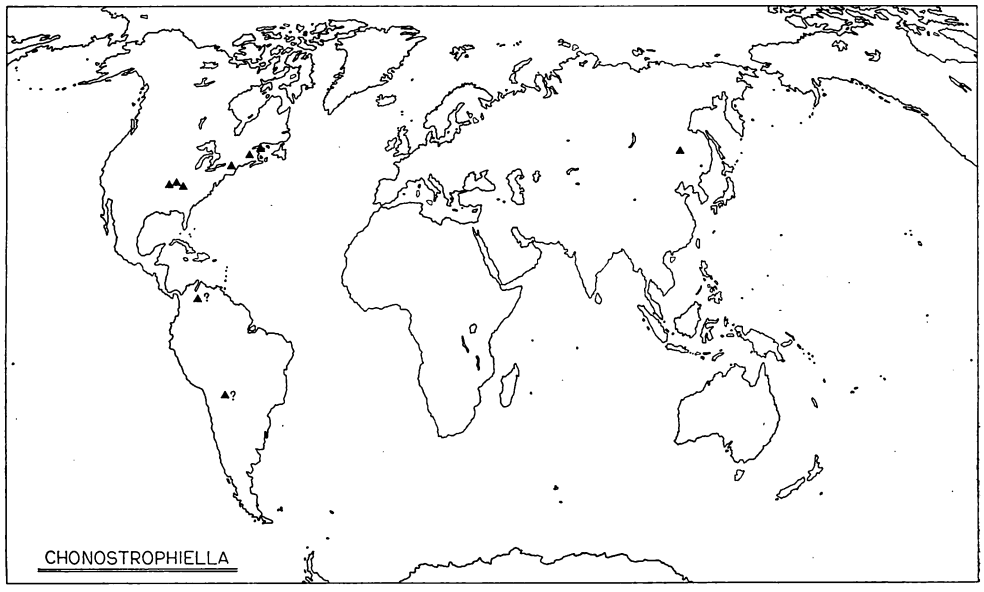
Text-fig. 4. Distribution of *Aesopomum*.
(Open triangle: taken from unpublished data)



Text-fig. 5. Distribution of *Bifida*.



Text-fig. 6. Distribution of *Reeftonia*.



Text-fig. 7. Distribution of *Chonostrophiella*.

and subprovinces in early Emsian time as quoted as follows.

Old world province
  Rhenish-Bohemian subprovince
  Uralian subprovince
  Cordilleran subprovince
  Tasman subprovince
  New Zealand subprovince
Appalachian province
Malvinokaffric province

They also discussed the significance of the Appalachian elements such as *Leptocoelia*, *Meristella*, large costellate *Leptostrophia* of *magnifica* and *beckii* types, and large *Acrospirifer* of *murchisoni* type in the Kazakhstan Lower Devonian which had been reported by BUBLICHENKO (1960) and KAPLUN (1961). They noticed the presence of the Appalachian element *Chonostrophia* and the Tasman element *Reeftonia* in the Lesser Khingan materials in referring the provisional identification of the present writer at the same time. *Chonostrophia* is, of course, *Chonostrophiella* in today's sense. They mentioned the presence of another Tasman element *Maoristrophia* (*Leptostrophia carinata*) in Kazakhstan also.

As summarized in Table 5, the Lesser Khingan fauna has rather wide generic similarities to several known provinces and subprovinces in terms of the brachiopod distribution. This fact may mean that the Lesser Khingan fauna is a certain type of "mixed fauna". The paleozoogeographical significance of this "mixed fauna" should be investigated in connection with the faunal characters of other fossils as well as the paleogeographic or paleotopographic analysis of the region.

HILL summarized the coral distribution in the U. S. S. R. in 1967 and referred to

the provinciality mainly based on the results by DUBATOLOV on Tabulata (1964) and SPASSKY on rugose corals (1965). She noticed that the Altai-Sayan fauna in Siegenian to Emsian age was characterized by the presence of *Pseudamplexus, Tryplasma, Spongophyllum* and the development of squamulate favositids and the thick-walled branching forms like *Parastriatopora.* On the contrary, *Tryplasma, Alveolites* and *Heliolites* are absent while *Pleurodictyum* and *Squameofavosites* are rather common in the Mongolo-Okhotsk region where the Lesser Khingan and the Upper Amur districts are included.

Concerning the late Silurian and early Devonian trilobite assemblages in central Kazakhstan, MAXIMOVA (1968) mentioned that the district was a route of faunal migration between the Atlantic and the Pacific realms. According to her about 20 per cent of species are analogous or close to the European ones, especially to the Barrandian and the Harz species, and some 30 per cent are close to the North American or the Appalachian ones among some 70 species of the Kazakhstan trilobites.

Such terms as the Atlantic and the Pacific realms have been frequently employed by Russian paleontologists to describe the paleobiogeographical provinces in Siberia and its surrounding areas. In 1968 RZHONSNITSKAYA presented some maps for early Devonian time to show this provinciality in the U. S. S. R. territories mainly based on the brachiopod assemblages. Being combined with the paleogeographic map made by LIU (1955) for the Chinese mainland and a paleobiogeographic map of the U. S. S. R. published in 1969 the present writer compiled a paleobiogeographic map of northeastern Asia as shown in Text-fig. 8. Some paleogeographic maps of coral disiribution above mentioned were also in consideration.

RZHONSNITSKAYA defined the provinces as follows. The collated provincial names for the coral distribution are given also.

Atlantic realm		
Mediterranian province	(outside of the map in Text-fig. 8)	
Uralo-Tien Shan province	(1):	Uralo-Tien Shan province
Arctic province	(2):	Indigiro-Kolyma province
Altai-Sayan province	(3):	Altai-Sayan province
Pacific realm		
Dzhungaro-Balkhash prov.	(4):	Dzhungaro-Balkhash prov.
Mongolo-Okhotsk province	(5):	Mongolo-Okhotsk province

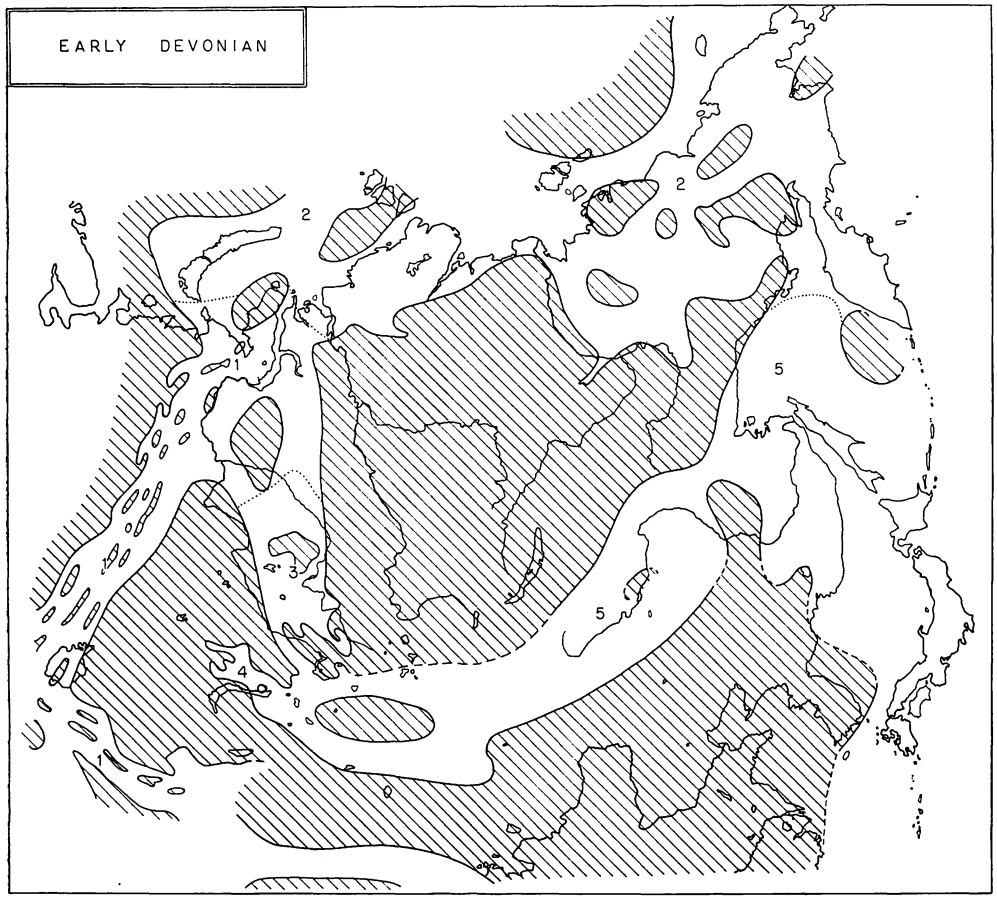
Although the detailed paleogeography within the Mongolo-Okhotsk province is still unveiled, the general aspect of the Mongolian geosyncline in early Devonian time is indicated in the map. Noteworthy is that the presence of North American elements of brachiopods in Kazakhstan, Altai, and Amur regions including the Lesser Khingan district are explained by BOUCOT *et al.* (1968) as the faunal communication was established with the Appalachian province, through or around Nevada in Siegenian time along a circum-north Pacific route, entering U. S. S. R. in the region of Trans-Baikal. Certain coral genera might vindicate this assumption also. The Russian species *Tryplasma altaica* is found in Canada, for an example (OLIVER, 1968).

Subsequently, the recently published paleogeographical maps of the U. S. S. R. (1969) adopted the following provincial names for the zoogeographical divisions of

the early Devonian seas.

Mediterranean realm
  Uralo-Tien Shan province
  Altai-Sayan province
Siberian-Canadian realm
  Taimyr-Kolyma province
Kazakhstan-Mongolian realm
  Dzhungaro-Balkhash province
  Mongolo-Okhotsk province

The Rhenish-Bohemian elements are especially dominant in the Devonian (Siegen-Ems) faunas of the western part of the Mongolian geosyncline indicating the sea connection with Europe through the Altai-Sayan province or a possible linkage to



Text-fig. 8. Early Devonian paleobiogeographical map of Northeast Asia.
(mainly after Liu, 1955/62; Dubatolov, 1964; Spassky, 1965; Hill, 1967; Rzhonsnitskaya, 1968)

Shaded area: land
Open area: sea
1: Uralo-Tien Shan province
2: Taimyr-Kolyma province
3: Altai-Sayan province
4: Dzhungaro-Balkhash province
5: Mongolo-Okhotsk province

the Uralo-Tien Shan province to the south, though the Dzhungaro-Balkhash province is shown as disconected with it in Text-fig. 8. Some peculiar ecological condition might be prevalent in the Dzhungaro-Balkhash embayment at that time as indicated by the occurrence of small solitary dissepimented rugosa without other corals (DUBATOLOV, 1964).

As reviewed above, the Lesser Khingan "mixed fauna" is understood reasonable and has a great significance in paleobiogeography of the world occupying a place near the junction between the western, or the Atlantic, realm and the North American province in early Devonian time.

V. Systematic Description of Brachiopods

Phylum Brachiopoda Duméril, 1806

Class Inarticulata Huxley, 1869

Order Lingulida Waagen, 1885

Superfamily Lingulacea Menke, 1828

Family Lingulidae Menke, 1828

Genus *Lingula* Bruguière, 1897

(Type species: *Lingula anatina* Lamarck, 1798)

"*Lingula*" sp. indet.

Plate 1, fig. 1.

Material:—Only an external mold of pedicle valve in the collection.

Description:—Shell extremely small in size, 2.4 mm in length and 1.4 mm in width, elongate oval in outline; the maximum width at the middle of shell length; moderately inflated; surface ornamented by regularly interspaced concentric growth lamellae which are countable about five on the anterior half of the shell; shell slightly corrugated on the growth lamellae.

Comparison:—As to the shell outline and the corrugated growth lamellae the present specimen somewhat resembles to *Lingula miciformis* Mikrukov which was described from the Middle Devonian of North Bashkiri (Mikrukov, 1955, p. 222, pl. 1, figs. 1, 2). *L. subparallela* Sandberger & Sandberger by the same author (1955, p. 223, pl. 1, fig. 6) and *L. ligea* Hall (Hall, 1867, p. 7, pl. 1, figs. 2a, b) also resemble to this indeterminable species. But they slightly differ from this in their more elongate form with the maximum width at the anterior half of the shell.

Illustrated specimen:—247K.1.

Class Articulata Huxley, 1869

Order Orthida Schuchert & Cooper, 1932

Superfamily Enteletacea Waagen, 1884

Family Enteletidae Waagen, 1884

Subfamily Schizophoriinae Schuchert & Le Vene, 1929

Genus *Schizophoria* King, 1850

(Type species: *Conchyliolitus* (*Amonites*) *resupinatus* Martin, 1809)

Schizophoria sp. indet.

Plate 1, fig. 2.

Material:—Only an internal mold of juvenile brachial valve is available.

Description:—Shell small, 9 mm in width and 8 mm in length, hemicircular in

outline, gently convex; the maximum width at about middle length of the shell; cardinal extremities rounded, hinge straight, narrow, shorter than the shell width; chilidium open, with small, blade-like cardinal processes; brachiophores thin and straight, diverging anteriorly, being supported by thin brachial lamellae which raised from the shell floor; muscle fields elongated cordate in outline, weakly impressed and medianly separated by slender myophragm; adductor and diductor scars are hardly recognizable separatedly; postero-lateral boundaries are continuous with brachial lamellae; frucral plates rather well developed; inner surface faintly crenulated at the frontal margin.

Comparison:—This juvenile specimen is so poorly preserved and represented only one internal mold that no specific character is available to compare with the known species. There is a slight possibility that this indeterminable form belongs to a young individual of *Proschizophoria kobayashii*. However, there is no material to show the ontogenetical gradation between the two forms before hand.

The brachial interiors obtained from the Wentworth Group in Australia, which are illustrated by TALENT (1963, pl. 29, figs. 7, 8) as pedicle internals of rhipidomellid, are actually the brachial interiors of a certain schizophoriid* and have some similarity to the present form to some extent in their straight, thin brachial lamellae and the weakly impressed muscle fields.

Illustrated specimen:—180KU1.

Family Rhipidomellidae SCHUCHERT, 1913

Subfamily Proschizophoriinae BOUCOT, GAURI & JOHNSON, 1966

Genus *Proschizophoria* MAILLIEUX, 1911

(Type species: *Orthis personata* ZEILER, 1857)

Proschizophoria kobayashii HAMADA, sp. nov.

Plate 1, figs. 3-7; Plate 2, figs. 1-4;
Plate 30, figs. 5, 6; text-fig. 9.

Gypidula cf. *mansuyi* GRABAU (not GRABAU, 1931), NONAKA, 1944, *Japan. Jour. Geol. Geogr., Vol. 19, Nos. 1-4*, p. 251, pl. 27, figs. 5, 6.

Material:—Three of pedicle and brachial interiors and pedicle exteriors respectively are in the repository.

Description:—Shell large, rounded transversely oval in outline, unequally biconvex with much greater convexity of brachial valve; hinge line short and straight, approximately a half of the shell width where is at the midlength; broad and ill-defined ventral sulcus and dorsal fold may be present; anterior commissure weakly uniplicate; surface multicostellate with somewhat fine, uniform radial costellae with interspaces of almost the same width; costellae increase in number by bifurcation.

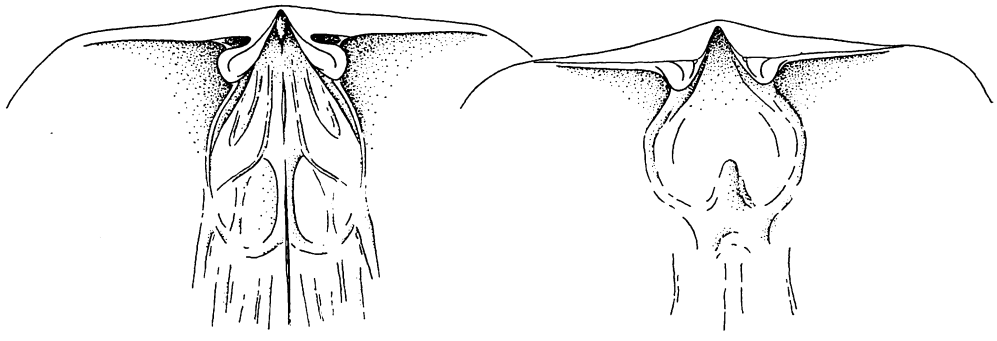
Pedicle valve rather flattish, with a broad median sulcus at anterior portion; area low, triangular, apsacline with widely open delthyrium; teeth stout, projecting antero-dorsally, being supported by short but thick dental lamellae; dental lamellae

* Personal communication from Dr. J. TALENT, Oct., 1967.

diverse anteriorly and continuous with low, encircling ridges bounding the muscle fields; muscle scars well impressed, broadly oval in outline with an anterior re-entrance, about half the shell length and one third the shell width; vascula media present; no median septum developed; inner shell margin with fine denticulations; postero-lateral portion of inner surface pustulated by secondary shell thickening.

Brachial valve well convexed, hemispherical; beak not prominent strongly; interarea narrow, broadly triangular, orthocline; notothyrium open, triangular; brachiophores long and project postero-ventrally; crural basis directly on the shell floor which joined anteriorly with low, lateral bounding ridges of muscle fields; dental sockets lateral to the crural plates, deep and posteriorly covered by outer hinge plates; a boss-shaped cardinal process in the notothyrial cavity is supported anteriorly by a fairly short, thin median ridge; anterior to the median ridge a low and broad myophragm is developed; muscle fields subcircular in outline, consist of a pair of posterior adductor impressions that become narrow posteriorly and a pair of anterior adductors of subquadrate outline; these impressions are medianly separated by a low inflation of shell substance, and the anterior and posterior ones are also separated from each other by anteriorly diverging low ridges at the middle portion of the fields; inner surface of shell radially striated being correspond to the surface costellation; shell margin finely crenulated.

Comparison:—This species was originally identified as *Gypidula* cf. *mansuyi* GRABAU by NONAKA owing to the insufficient information on the interior (Plate 30, figs. 5, 6). It is obvious that he misunderstood the laterally compressed specimen of this species (Plate 2, figs. 1a, b) as an original form of some galeatiform pentameroid shell. To the matter worse he could not find any pedicle valve of this species at that time.



Text-fig. 9. *Proschizophoria kobayashii*, sp. nov.
Brachial (A) and pedicle (B) interior (×1.5).

This species is distinct from the hetherto known species of the genus in its large shell size with somewhat small cardinal process lobe and the feebly developed myophragm in the brachial valve. *P. torifera* (FUCHS) from Belgium, which was cautiously described and illustrated by BOUCOT (1960), is provided with a strong cardinal process lobe and prominently developed median myophragm. *P. personata* MAILLIEUX, the type species of the genus, also sometimes attains large size as the

present species. However, it has an extremely stout cardinal process, which is anteriorly supported by a thick median myophragm, being different from the feeble development of these structures in this new species. Most of the known species (BOUCOT, GAURI, & JOHNSON, 1966) have rather coarsely multicostellate outer shell ornamentation and mainly reported from Siegenian.

Illustrated specimens:—017HA3-4, 064HI1, 073HL1-2, 111KB1, 228K$_\zeta$1, 235K$_\eta$1, 276K$_\nu$1, 316K$_\phi$1, 344KnC1.

Superfamily Enteletacea WAAGEN, 1884

Family Rhipidomellidae SCHUCHERT, 1913, emend.

BOUCOT, JOHNSON, & WALMSLEY, 1965

Subfamily Rhipidomellinae SCHUCHERT, 1913, emend.

BOUCOT, JOHNSON, & WALMSLEY, 1965

Genus *Dalejina* HAVLÍČEK, 1953

(Type species: *Dalejina hanusi* HAVLÍČEK, 1953)

Remarks on the genus:—HAVLÍČEK (1953) erected this genus on the Upper Emsian species *D. hanusi* from Bohemia. In 1958 BOUCOT and AMSDEN made a new genus *Rhipidomelloides* on *Rhipidomella henryhousensis* AMSDEN, 1951 from North America. In Treatise on Invertebrate Paleontology, Part H, WILLIAMS and WRIGHT (1965) included the following five genera, i.e. *Rhipidomella*, *Perditocardinia*, *Platyorthis*, *Reeftonia*, and *Thiemella* in the family Rhipidomellidae. They regarded *Rhipidomelloides* as well as *Pseudodicoelosia*, *Loganella*, and *Strixella*, which all had been erected by BOUCOT and AMSDEN, were synonymous with *Rhipidomella* OEHLERT. At the same time *Dalejina* was included in *Mendacella* COOPER under the family Dalmanellidae by the same authors. However, BOUCOT, JOHNSON, and WALMSLEY (1965) revised the family Rhipidomellidae with the redescriptions of *Dalejina* and *Mendacella*, stressing that these two genera are closely related and distinct in generic rank. *Rhipidomelloides* is, then, confirmed as a junior synonym of *Dalejina* in examining the Bohemian material.

Incidentally, *Reeftonia* ALLAN was seggregated from the Rhipidomellidae by JOHNSON and TALENT (1967) and included in their new subfamily Cortezorthinae as described later.

According to BOUCOT & AMSDEN (1958) and BOUCOT et al. (1965), the distinction of *Dalejina* from *Rhipidomella* is mainly in the nature of the marginal crenulation of inner surface. Namely the former including *Rhipidomelloides* has flat and medianly grooved denticulation while the latter has simple and rounded ones.

During the course of this study the present writer has an opportunity to examine abundant specimens of *Dalejina* from various localities and related genera in BOUCOT's collection in the California Institute of Technology. It is worthy to note that there are two major groups in the genus *Dalejina* in terms of the development of pedicle muscular impressions. Simple, or an ellipsoid group is represented by *Dalejina hanusi*, typical of the genus, and the other, i.e. the flabellate group including *D.*

musculosa and its subspecies. The former is, therefore, more closely similar to *Mendacella* which is provided with the lanceolate muscle fields, of which the outer lateral sides tend to be parallel with each other. There is an intermediate form between those two groups such as *D. hybrida* that is characterized by rather small, somewhat flared field outline. Due to an expanding of the pedicle diductor scars from *Mendacella*-type group to flabellate group, the relative position of the adductor scars to the diductors tends to move posteriorly, and finally the adductors become to be deeply enclosed in the *musculosa* group of *Dalejina*.

Dalejina kinsuiensis HAMADA, sp. nov.

Plate 3, figs. 1-12; Plate 4, figs. 1-9;
Plate 29, figs. 3-8; text-fig. 10.

1968. *Rhipidomella musculosa* HALL, MODZALEVSKAYA. *Intern. Symp. Dev. System, Calgary 1967, Vol. 1*, p. 552 (plate 2), fig. 2.
1968. *Rhipidomella assimilis* HALL, MODZALEVSKAYA. *Ibid., Vol. 1*, p. 552 (plate 2), figs. 3, 4.

Material:—About forty specimens are available in the Kinsui collection.

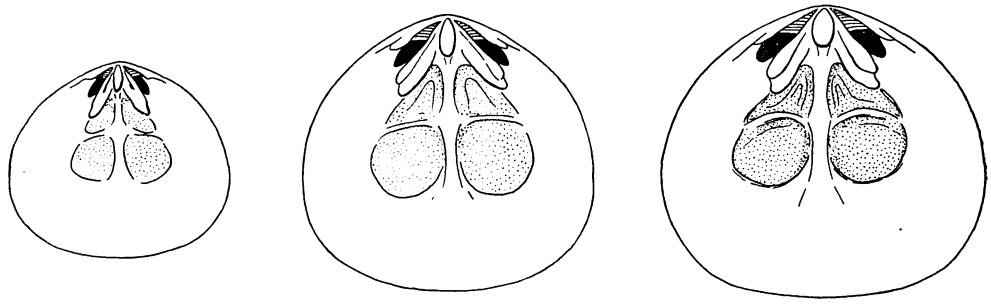
Description:—Shell medium to large for the genus with thick test, unequally biconvex being the brachial more convex, transversely elongate oval in outline; rectimarginate; the maximum width at the middle of the shell length; costellate with simple, fine radial costellae which increase in number by implantation and bifurcation; concentric growth lamellae scarcely recognizable except near the anterior margin where a few irregularly interspaced lamellae are found on some larger shells.

Pedicle valve with a narrow, triangular cardinal area which is flat or slightly concave, high and apsacline occupying approximately half the shell width; beak moderately prominent; delthyrium open, triangular in outline. Interior with anteriorly divergent teeth of moderate size which are laterally supported by the thickened shell floor at the outer side; dental lamellae very short and almost merge into the thickened shell floor; pedicle callist smoothly concave; muscle fields deeply impressed, widely flabellate being divided by a long and narrow median septum which originates from the enclosed adductor scars at the posterior portion of the fields; diductor fields radially striated by three to four distinct ridges which irregular interspaces, and antero-laterally palmate and scallopped; muscle fields occupy almost six-sevenths the shell length and nine-tenths the shell width at the most; adductor scars small and sub-elliptical in outline, one-third the shell length; anterior margin of shell weakly crenulated by flat, medianly grooved crenulations being correspond with the radial striae on the outer surface.

Brachial valve with extremely narrow, low, apsacline and triangular cardinal area with transverse striae parallel to the hinge line, the area divided into two parts on each side, i. e. the inner plates which cover the sockets and outer ones of the main area; cardinal process lobe prominent ventrally, elliptical in cross section, roundly pointed at the proximal end, unites with brachiophore base to form a solid elevation of shell floor at the posterior end, from which originates a low, broad median myophragm; brachiophores diverging anteriorly being supported by the thick

postero-lateral muscle bounding ridges at the posterior ends; dental sockets open anteriorly, and the posterior portion covered by narrow inner plates of interarea; interior surface of the sockets striated by concentric growth lamellae; muscle fields quadripartite, divided medianly by a low myophragm which extends approximately a half the shell length; anterior scars are larger and almost circular in outline being separated from the triangular posterior ones by the low, lateral ridges; inner surface of shell weakly striated being correspond to the outer radial ornamentation, and well crenulated by flat, medianly grooved crenulations at the periphery.

Comparison:—This new species belongs to the flabellate group of *Dalejina*, and closely resembles to *D. musculosa solaris* (CLARKE)* in general feature, especially in its somewhat transversely elongate shell outline (BOUCOT, 1959, p. 740, pl. 90, figs. 1, 2; BOUCOT, JOHNSON, & WALMSLEY, 1965, pl. 46, figs. 19-22). But, *musculosa solaris* differs from this in its smaller interarea. *Kinsuiensis* has a stout cardinal process lobe, thick brachiophores and wider interarea of pedicle valve (text-fig. 10). The pedicle muscle fields are extremely well developed in this new species though they are roughly lobate rather than multilobate as in some large *Dalejina* species from the Oriskany Group in the Appalachian region.



Text-fig. 10. *Dalejina kinsuiensis*, sp. nov.
Development of cardinalia and muscle fields in brachial valve (×2).

Rhipidomella musculosa HALL and *R. assimilis* HALL illustrated by MODZALEVSKAYA (1968, Pl. II, figs. 2 and 3, 4) from the upper portion of the Bolsheneverskaya Group of the Russian part of the Upper Amur region excellently fit the above described *D. kinsuiensis* in every respect, and could be of conspecific.

Illustrated specimens:—088KA3, 097KA4, 103KA4, 104KA4, 125KC1, 154KO1, 147KL1, 177KT1, 186KW1, 195K$_{\alpha}$1, 198K$_{\beta}$1, 210K$_{\beta}$2-3, 226K$_{\delta}$1, 227K$_{\varepsilon}$1, 245K$_{o}$1, 248K$_{\iota}$1, 250K$_{\iota}$1 (holotype), 253K$_{\iota}$1, 255K$_{\iota}$1, 300K$_{\tau}$1, 309K$_{\phi}$1.

Subfamily Cortezorthinae JOHNSON & TALENT, 1967

Genus *Reeftonia* ALLAN, 1947

(Type species: *Reeftonia marwicki* ALLAN, 1947)

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* *D. muscularis* var. *solaris* (CLARKE) by BOUCOT, JOHNSON & WALMSLEY (1965, p. 339, explanation of plate 46, figs. 19-22) should be written *D. musculosa* var. *solaris* (CLARKE), and may represent a distinctive subspecies as was once regarded by BOUCOT (1959, p. 740, pl. 90, figs. 1, 2).

Reeftonia borealis HAMADA, sp. nov.

Plate 5, figs. 1-13; Plate 6, figs. 1-8;
Plate 7, figs. 1, 2; text-figs. 11, 12.

Material:—More than twenty specimens of disarticulated shells in the collections.

Description:—Shell medium in size, oval in outline with slight and broad prominence at the anterior portion, wider than long; the maximum width near the mid-length of the shell; cardinal angles well rounded; hinge line fairly short and approximately half the maximum width of the valve; interarea of the pedicle valve low triangular, apsacline, slightly incurved, with high triangular delthyrial cavity; interarea of brachial valve short and triangular, almost flat and anacline; pedicle valve bears a broad median fold which develops increasingly toward the anterior margin, and the opposite valve is provided with a corresponding median sulcus; commissure gently uniplicate and the median portion prominent anteriorly especially in younger individuals.

Surface ornamentation consists of extremely fine, simple and round-topped radial costellae which increase in number anteriorly by implantation; costellae become to be gently bent posteriorly at the postero-lateral margin of the shell; irregularly spaced faint concentric growth lamellae intersect the costellae.

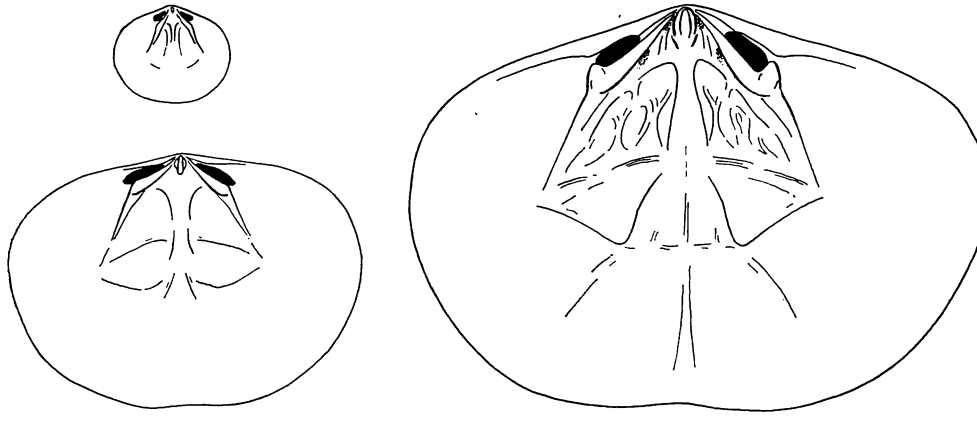
Interior of pedicle valve is provided with stout and triangular teeth at the delthyrial margin. The posterior surface of the teeth smooth and continuous with the areal surface; supported by short and stout dental lamellae; lateral bounding ridges of muscle area narrow and sharp being connected with the dental lamellae posteriorly and inwardly curving to surround the oval muscle area; adductor muscle scars small and elongate oval in shape at the anterior portion of the area; muscle area divided medianly by a narrow septum except at the posterior end.

Interior shell surface narrowly and weakly crenulated at anterior peripheral by the impression of the costellae.

Brachial interior with widely divergent brachiophores which stand almost vertically to the shell floor being supported by brachiophore bases and define the deep sockets anteriorly; a part of the anterior edge of interarea overhangs the socket in form of shade, especially in the small individuals; brachiophores become broader gradually toward the anterior, and rather sharply truncated at the rod-like anterior edge where the bases connected with them arising from the floor; no fulcral plates are recognizable; cardinal process lobe fairly massive, projecting posteriorly, and trilobate at the tip; stout and short myophragm is continuous from the cardinal process and divides the posterior part of the muscle area; posterior adductor scars triangular in outline being defined by inner and outer bounding ridges; anterior adductor scars quadrate being separated from the posterior ones by narrow transverse grooves; the anterior angle of the scar antero-medianly pointed; between the anterior adductor scars a low but sharp median myophragm originates and anteriorly it becomes to diminish its height merging into the broad fan-shaped median sulcus of the valve.

Inner surface of the shell is finely crenulated at the anterior margin by the impression of the outer costellae.

Text-fig. 11. *Reeftonia borealis*, sp. nov.
Variation of muscle fields in pedicle valve (×3).



Text-fig. 12. *Reeftonia borealis*, sp. nov.
Development of cardinalia and muscle fields in brachial valve (×2.5).

Comparison:—The genus *Reeftonia* was first described by ALLAN (1949) and thoroughly discussed on its taxonomic position and relationship to other genera in the subfamily Cortezorthinae by JOHNSON and TALENT in their recent paper (1967, pp. 1960-1962). According to them there are two species, i. e., *R. marwicki* ALLAN and *R. alpha* (GILL) both of which are from the Emsian formations of New Zealand and Australia.

The present new species is, therefore, the third species of the genus and the first occurrence in the northern hemisphere hence the specific name *borealis*. *Borealis* differs from the austral species of *Reeftonia* in its extremely fine costellation of shell surface in external character, and also in its well developed muscle areas of the brachial interior, where the anterior and posterior adductor scars are distinctly separated by a transverse groove. This well impressed musclature pattern is almost similar to that of some *Cortezorthis* species.

There are several *Levenea* species, which resemble *Reeftonia* in the Lower Devonian formations of the Asiatic portion of the U. S. S. R. *L. inostracevi* (PEETZ) from the Kuznetsk basin (ALIKSOVA, in SARITCHEVA ed., 1960, pl. XIV, fig. 1), *L. taeniolata* KHALFIN (KHALFIN in KHALFIN ed., 1955, pl. L, fig. 1; GRATSIANOVA et al.

in KHALFIN ed., 1960, pl. D-64, figs. 1-6) and *L. altaica* KHALFIN are the examples. The present writer had an opportunity to examine the brachiopod collections from the Siegenian Ganinskaya formation in Gornyi Altai when he visited Belovo on the way of the field excursion to Salair on July 26, 1968. Among the collections *Levenea altaica* KHALFIN (coll. nos. T-10-115, T-15-7, T-4^{b}-63) was confirmed to be a species of *Reeftonia* that closely similar to the Lesser Khingan species being characterized by the transversely elongated oval shell outline with fine radial costellae. *L. taeniolata* KHALFIN (coll. nos. T-10, 14-2, T-15-8, T-16-2) also seemed to be another species of *Reeftonia* judging from the features of the pedicle valve though the brachial internal structure was not available to examine. However, one may be convinced that an illustration by GRATSIANOVA et al. (in KHALFIN, 1960; pl. D-64, fig. 3) well shows the brachial internal of the species which strongly suggests the cortezorthinid musclature.

Dr. JOHNSON kindly suggested to the writer (in oral communication) that there is another possible species of the Asian *Reeftonia* in China. YIN had described a new species of *Thiemella* ? *communis* from the Pochiao Shale of Eastern Yunnan (1939, pp. 44-45, pl. 1, figs. 15b, c; pl. 2, figs. 1a, b, 2, 3a-c; pl. 5, figs. 2b-e) which had been correlated to the *Cultrijugatus* zone of Central Europe. As far as can be judged from his description and illustrations, *communis* has a characteristic oval muscle fields on its pedicle valve. Furthermore it is provided with the broad and anteriorly expanded ventral fold and dorsal sulcus as noticed by YIN himself thought it was questionably placed in *Thiemella* with the reverse fold and sulcus. Unfortunately, no illustration reveals the brachial muscle fields on this Chinese species again. Therefore one might not be able to conclude that *communis* belongs to *Reeftonia* at present. The rounded shell outline resembles to that of *L. taeniolata*, and the coarser costellation is clearly distinct from *R. borealis*.

Illustrated specimens:—011HA1, 021HA3-4, 026HA4, 031HA6, 051HF1 (holotype), 071HK1, 085KA1, 123KB1, 132KE1, 135KF1, 178KT1, 190KY1, 205K$_{\beta}$1, 213K$_{\beta}$2-3, 241K$_{\theta}$1, 256K$_{\iota}$1, 265K$_{\kappa}$2, 266K$_{\kappa}$2, 2′, 269K$_{\lambda}$1, 321K$_{\omega}$1, 329KnC1.

Order Strophomenida ÖPIK, 1934

Suborder Strophomenidina ÖPIK, 1934

Superfamily Strophomenacea KING, 1846

Family Leptenidae HALL & CLARKE, 1895

Genus *Leptaenopyxis* HAVLÍČEK, 1963

(Type species: *Leptaena rugosa* BARRANDE, 1848)

Leptaenopyxis bouei (BARRANDE), 1848

Plate 7, figs. 3-6.

1848. *Leptaena bouei* BARRANDE. *Haiding. Abhandl., II*, p. 85, pl. 22, figs. 1-3.
1879. *Strophomena bouei* BARRANDE. *Syst. Sil. Centr. de la Bohém. pt. I, Paléont., Vol. V, Brachiop.*, p. 10, pl. 45, figs. 29-37.
1955. *Leptaena bouei* (BARRANDE), KHALFIN in KHALFINA ed. *Atlas of Index Forms, Fauna & Flora of S. Siberia, Vol. 1*, p. 235, pl. L, figs. 2-9.

1959. *Leptaena rhomboidalis* WILCKENS, HOU. *Acta Palaeontol. Sinica, Vol. 7, No. 2,* p. 143, pl. 2, figs. 3, 4.
1960. *Leptenella bouei* (BARRANDE), GRATSIANOVA et al. in KHALFIN ed. *Biost. Paleoz. Sayan-Altai Refions, Vol. 2,* p. 434, pl. D-68, fig. 7.
1964. *Leptaena "rhomboidalis"* (WILCKENS), WANG et al. ed. *Brachiop. Foss. China, Vol. 1,* pp. 185-186, pl. 26, fig. 15.
1968. *Leptaenopyxis bouei* (BARRANDE), MODZALEVSKAYA. *Proc. Intern. Symp. Devonian Syst. Calgary, 1967, Vol. 2,* pl. II (p. 552), fig. 8.

Material:—Internal and external impressions of brachial valves and two fragmentary specimens at hand.

Description:—Shell large; gently convex, elongate rhomboidal in outline, equidimension or slightly longer than wide; the maximum convexity at the midlength of the shell, geniculation may be present at the anterior portion; radial costellae fine, simple, evenly distributed and increase in number by implanation; concentric rugae strong, somewhat irregularly spaced and broader at the middle of the shell than at the cardinal margins; anterior margin broadly and weakly sinuated.

Brachial interior with a narrow, straight interarea which is weakly striated vertically; socket small but deep at outside the posterior end of the lateral bounding ridges; cardinal process lobes short and almost parallel with each other being supported by the solid muscular lateral bounding ridges; a slender median ridge between two cardinal lobes; muscular scar strongly impressed, subpentagonal, short but strong median septum present in it; anterior to the muscle fields a short myophragm present; ventrally projecting ridge strong at the lateral portion, but almost absent at the anterior margin; posteriorly it sloped down to the shell floor; outer lateral sides of the ridge coarsely pustulate.

Comparison:—This species is characterized by its large shell size and the elongated form without remarkable geniculation, and internally it is also distinguishable from the known other *Leptaena* species by the strongly impressed muscle fields without submedian and lateral septa.

HOU's specimen from the same area as the present one shows an incomplete ventral valve without anterior fringe. His description, therefore, did not refer neither the nature of geniculation nor sulcation. The rest feature, however, especially of the ornamentation, fit quite well the present specimen.

Leptaenopyxis bouei (BARRANDE) (MODZALEVSKAYA, 1968, p. 552, fig. 8) occurs in the Lower Emsian Bolsheneverskaya Formation of the Upper Amur region and the Ganinskaya Formation of Gornyi Altai (YANOV et al., 1968, pp. 44-56). The present writer examined more than 30 specimens of this species from the latter formation and reached a conclusion that the Lesser Khingan form is conspecific with the Altai forms.

This species somewhat resembles to *Leptenella rhomboidalis* var. *sinuata* RZHONSNITSKAYA from the Middle Devonian of Khazakstan (GRATSIANOVA et al., 1960, pl. D-68, fig. 6) as HOU also noticed the large size and non- or weak geniculated nature of the valve. *L. rhomboidalis* var. *sinuata* is, however, provided with the distinct sinus at the anterior margin hence the variety name.

Illustrated specimens:—008HA4, 118KB1, 221K$_7$1, 259K$_8$1-2.

Family Stropheodontidae CASTER, 1939

Subfamily Stropheodontinae CASTER, 1939

Genus *Megastrophia* CASTER, 1939

Subgenus *Protomegastrophia* CASTER, 1939

(Type species: *Stropheodonta profunda* HALL, 1857)

Megastrophia (*Protomegastrophia*) *manchurica* HAMADA, sp. nov.

Plate 8, figs. 1-5; Plate 29, fig. 1.

Material:—Two pedicle interiors, two brachial interiors and two brachial exteriors are in the collections.

Description:—Shell medium to large in size, strongly cancavo convex and semicircular in outline; cardinal extremities somewhat alate, but not sharply pointed; hinge line straight; wider than long; the maximum width near the hinge margin.

Pedicle valve well concave, the maximum concavity at the anterior half of the shell but not geniculate; hinge straight; beak faintly prominent from the hinge line; interarea orthocline, narrow and wide as long as hinge line, coarsely denticulate on inner margin; surface coarsely ornamented by round-topped, simple radial ribs which become obsolete and irregularly bifurcate to form weak fasciculate ribs at the anterior margin of the margin of the mature shell; weak median fold is recognizable in frontal half of the shell.

Pedicle interior with wide, triangular delthyrium which is centrally filled by a small ventral process; short, anteriorly divergent dental lamellae-like blades support the inner margin of deltidial opening; muscular impressions cordate in form and weakly marked occupying approximately half of the shell length and one-third the shell width; muscle bounding ridges low and divergent and originate from inner side of the dental lamellae-like blades; anterior part of the fields faintly defined; adductor scars centrally disposed and oval in shape which is bounded by low and short posterior ridges that connect with the base of the ventral process, separated by a small, low myophragm at the anterior portion, being entirely enclosed by moderately flabellate diductor scars which are reentrant at the anterior portion; inner shell surface roughly corrugated being correspond with the surface ribbing.

Brachial valve moderately to well concave with the maximum concavity at the anterior half of the shell; hinge line straight; cardinal extremities not pointed; the maximum width at a place just anterior to the hinge line; faint, angular median sinus at the anterior margin; surface radially ornamented by coarse, round- or flat-topped, simple ribs near the beak and irregularly bifurcate and somewhat fasciculate ribs at the anterior and lateral margins of the mature individuals; concentric growth lamellae not remarkable, irregularly spaced; beak not prominent from the hinge line; interarea quite narrow, anacline to catacline, along the entire hinge margin.

Brachial interior with ventrally diverging cardinal process lobes of which posterior haces faintly concave and directed posteriorly or almost parallel to a plane of the interarea; socket ridges obsolecent and widely divergent on larger individual and rather distinct and long on the smaller specimen; muscle fields rather well

marked; adductor muscle scars disposed antero-laterally to the cardinal processes being bounded by loop-like bounding ridges on the mature individual, but somewhat faintly impressed on the younger ones; diductor scars small, elongate, in front of the adductors; both scars are separated by a keel-form median myophragm which terminate anteriorly at the end of diductors; inner surface of shell broadly and radially waved being correspond to the surface radial ornamentation.

Comparison:—This species is distinguishable from the other known species of the genus by its radial ornamentation which is composed of rather broad, flat-topped, simple ribs in early stage of growth stage (Pl. 29, fig. 2) and becomes bifurcate or polyfurcate at the marginal portion of the grown shell (Pl. 29, figs. 1a, b) and further fasciculate at the gerontic stage (Pl. 8, figs. 1a, b). Weakly fasciculate or bundled slender ribs are seen on *Megastrophia concava* (HALL) (HALL, 1800, p. 91, pl. 16, figs. 1a, d, e) from the Helderberg Group of North America. *Stropheodonta* aff. *inequiradiata* (HALL), illustrated by MODZALEVSKAYA (1968, p. 552, fig. 7), from the Lower Devonian Bolsheneverskaya Formation of the Upper Amur region seems to be conspecific with *P. manchurica* in terms of its broad radial ribs and the moderately concavo-convex shell forms, though none of description was given by her.

As to the shape of muscle fields, this species is characteristic in its inwardly curved muscle bounding ridges. The type species of the subgenus, *M. profunda* (HALL) (WILLIAMS, 1953, p. 39, pl. 9, figs. 1-3) from the Middle Silurian is provided with almost straight bounding ridges. *Leptostrophia* sp. from the Devonian of Tarbagatai (SOKOLISKAYA in ORLOV ed., 1960, p. 215, fig. 172) is almost similar in size and general shape to the present *P. manchurica* except somewhat smaller muscle fields. However, there is no description on other respects to compare it with this new species.

Illustrated specimens:—083HM1, 110KB1, 126KD1, 236K$_{\eta}$1, 284K$_{\xi}$1, 343KnG1.

Subfamily Leptostrophiinae CASTER, 1939

Genus *Leptostrophia* HALL & CLARKE, 1892

(Type species: *Stropheodonta magnifica* HALL, 1857)

Leptostrophia nonakai HAMADA, sp. nov.

Plate 9, figs. 1-6; Plate 10, figs. 1-4;
Plate 30, fig. 1; text-fig. 13.

1949. *Stropheodonta* (*Leptostrophia*), n. sp. NONAKA (non. nud.) *Japan. Jour. Geol. Geogr., Vol. 19, Nos. 1-4*, pp. 250-251, pl. 27, fig. 1.
1959. *Leptostrophia magnifica* HALL, HOU. *Acta Palaeont. Sinica, Vol. 7, No. 2*, p. 123, pl. 1, figs. 2, 3.
1964. *Leptostrophia magnifica* HALL, WANG et al. ed. *Brach. Foss. China, Pt. 1*, p. 195, pl. 28, fig. 5.
1968. *Rhytistrophia beckii* HALL, MODZALEVSKAYA. *Proc. Intern. Symp. Dev. Syst., Calgary, 1967, Vol. 1*, p. 552, pl. II, figs. 11, 12.

Material:—Ten individuals including two brachial interiors are available.

Description:—Shell large attaining 6.7 cm in length at the largest, subquadrate in outline, very gently concavo-convex; the greatest width at the middle of the

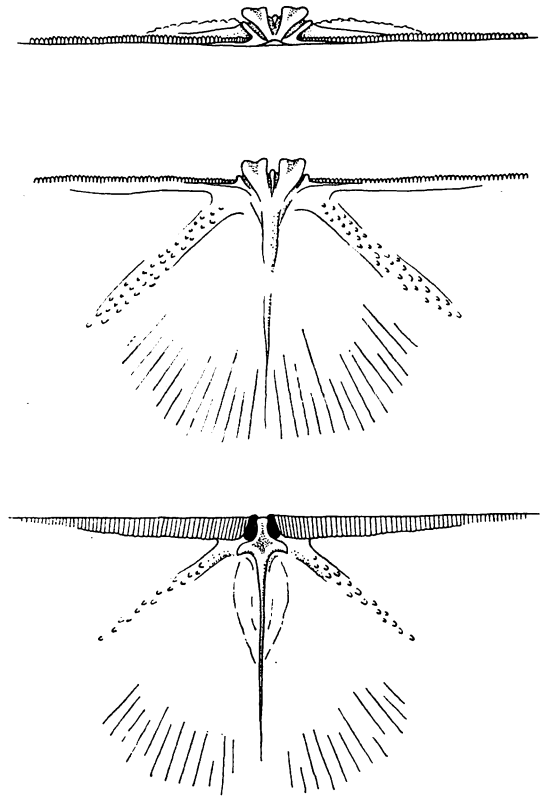
shell; hinge line straight, slightly shorter than the greatest width; cardinal angle not alate but somewhat angular; surface multicostellate; radial ornamentation finely marked by almost straight, simple, round-topped striae with even interspaces at the middle portion of the shell; on lateral flanks the costellae become to be bent gently towards the cardinal extremities; costellae are countable about 12 or 13 in 5 mm width at the shell margin of adult individual, but in juvenile ones they are hardly recognizable unless the lightening condition is favorable; they increase in number anteriorly by an inplantation; as the gerontic character the radials tend to be bundled to form somewhat fasciculate aspect with irregular intervals at the shell periphery; the shell surface is also provided with weak and irregularly spaced concentric rugae; at the cardinal margin the rugae diverge posteriorly and become to oblique to the hinge line; shell substance and its microstructure unknown.

Neither a sulcus nor a sinus is developed.

Pedicle valve faintly convex; beak not prominent; interarea flat, moderately apsacline, narrow, and as wide as the entire hinge line, striated vertically by minute, equidistant, closely set lamellae; hinge margin finely denticulate along almost the whole length of the hinge line being correspond to the striation on the area; delthyrium open, small, triangular; pedicle foramen not recognizable; pseudodeltidium developed posteriorly being connected with the ventral process anteriorly; ventral process becomes diverge anteriorly being grooved mesially to form a low, concave platform of diagonal outline, and its anterior portion projects into median septum; laterally expanded portions of the platform do not reach the bounding ridges of muscle areas on both sides; median septum low, thin, short and rarely attains approximately one-fourth the shell length; muscle areas almost flat and broadly flabellate toward the anterior being bordered by straight, narrow but sharply elevated muscle bounding ridges postero-laterally; bounding ridges originate at the inner shell floor below both lateral ends of delthyrium to form a low, longitudinally parallel elevation, which bounds the cardinal process sockets, but does not reach the hinge margin and then becomes to diverge laterally to form almost straight ridges; crest of the ridges pustulose, especially on its anterior portion; the ridges form an angle 80–100 degrees in plan, and are slightly inclined antero-dorsally; the muscle scars distinctly bordered by these ridges at the posterior half, but faintly bounded anteriorly; the area almost flat, but shallowly striated by 7 or 8, narrow but sharp radial striate of various length and strength on each side; triangular areas posterior to the bounding ridges are obscurely pustulated by secondary shell deposition; inner surface of shell is impressed by fine radial ornamentation being correspond to the outer radial striations.

Brachial valve almost flat or faintly concave; cardinal line straight, finely and narrowly denticulate on posterior edge; inner surface of the shell also faintly striated in reflecting the surface ornamentation; concentric rugae distinct near the cardinal margin to form 3 or 4 posteriorly diverged wrinkles resulting the *Rhytistrophia beckii*-type corrugation.

Internally, two slender cardinal process lobes disjunct forming a V-shaped projection if seen dorsally, bilobed at the tips and their attachment faces are directed posteriorly being protruded a little from the line of hinge margin; socket plates



Text-fig. 13. *Leptostrophia nonakai*, sp. nov.
Brachial (A, B) and pedicle (C) interiors (×1.5).

thin and short but distinct, situated closely adjacent to cardinal process lobes being parallel to them to form a narrow sockets; when seen posteriorly the cardinal process lobes and socket plates are, therefore, divergently prominent towards the ventral side being supported by a narrow, non-denticulate and slightly concave platform (text-fig. 13); the platform occupies almost one-third the cardinal margin in length; denticulation limited on the posterior crest of the shell, and the anterior margin makes the projecting narrow ridges to the dorsal side bounding the interarea; chilidium weakly developed; muscle areas flat, not markedly impressed; lateral bounding ridges originates from the anterior bases of the socket plates to form an angle of about 90-100 degrees, almost straight, broadly round-topped, shorter and broader than those of the pedicle valve, pustulated; the pustulation is continuous with the triangular area of inner shell surface posteriorly; a median ridge low, broad and short, about half the length of the bounding ridges; a slender, short blade between the V-shaped cardinal process lobes.

Comparison:—This leptostrophiid species was first described by NONAKA as a new species closely allied to *Leptostrophia perplana* and *L. magnifica*, but no name was given at that time. Chinese paleontologists regard this form as conspecific with *L. magnifica*, ignoring the previous NONAKA's description.

In general it is characterized by its large size of slightly concavo-convex shell with simple and fine radial ornamentation on the external surface. These characters are common among some species of the genera *Leptostrophia* and *Protoleptostrophia* in a current classifications. However, the latter genus is distinguished from the former by the absence of socket plates beside the cardinal process lobes. *Perplana* belongs clearly to the latter genus.

Leptostrophia magnifica, typical of the genus, from the Lower Devonian Oriskany Sandstone of North America has a much larger and heavier shell than the present species, attaining about 10 cm in length at the maximum. This species is provided with solid socket plates and almost parallel, short bounding ridges in the brachial valve. In examining the specimens kept in U. S. National Museum the writer observed that there is wide variation in development of the ventral process. For example, *L. magnifica* shown by COOPER in SHIMER & SCHROCK (1944, p. 131, fig. 12) illustrates no process in the delthyrial cavity, and *L. magnifica* by CLARKE (1909, p. 134-135) and also by AMSDEN & VENTRESS (1963, pl. 2, fig. 1) definitely shows the well developed ventral process. It is worthy to note that as far as the writer examined, there is no difference in other respects between these two forms except the angle of the pedicle interarea. Namely, as a general tendency, the area of "*magnifica*" without any ventral process is slightly apsacline on one hand, and the ones with ventral process tend to have larger angles to the perpendicular plane of the shell profile, or moderately to highly apsacline on the other. This tendency seems to be exist on the other species of *Leptostrophia*, and the present new species definitely belongs to the latter group of the genus.

The European large strophomenaceans like *Leptostrophia explanata* (SOWERBY) and *Stropheodonta* (*Rhenostrophia*) *subarachnoidea* (d'ARCHIAC and de VERNEUIL) are somewhat similar to the present species as regard to their external features. *L.* ? *explanata* from the Lower Gedinnian of Belgium (BOUCOT, 1960a, p. 305, pl. XIII, figs. 1-2) is unknown in its brachial interior. *Protoleptostrophia explanata* from the Coblenzian of Khazakstan (KAPLUN, 1961, p. 78, pl. 9, fig. 10, pl. 11, figs. 1-3) has short, divergent bounding ridges and small socket ridges parallel to the cardinal process lobe (pl. 10, fig. 2b). Therefore, this form is by no means a *Protoleptostrophia*, but possibly a *Leptostrophia* species that closely resembles to *L. nonakai*. A new subgenus *Rhenostrophia* was erected by BOUCOT (1960b, p. 483) under the genus *Stropheodonta* HALL, 1852, designating *Orthis subarachnoidea* D'ARCHIAC & DE VERNEUIL, 1842 as the type species, though he had once regarded it as a species of *Leptostrophia* with querry (BOUCOT, 1960c, p. 304, pl. XIII, fig. 3). This subgenus is characterized by strongly geniculate shell without dental lamellae and hinge teeth in the pedicle valve being different from non-geniculate *Stropheodonta* (*Stropheodonta*) with parvicostellate surface.

One of the unique features of this new species is in the presence of the modified interarea. The brachial interarea has a slightly convex, non-denticulate, narrow platform that supports the cardinal apparatus and limits the anterior margin of the interarea to form a somewhat keen edges from the inner floor of the brachial interior (text-fig. 13). This structure should be a modified interarea, and might serve as a socket-like apparatus to the antero-median extremity of an interarea of the

opposite valve. The crenulated hinge portion is, therefore, quite restricted on the narrow crest of the posterior end of the cardinal margin on the brachial valve.

As to the weak corrugation on the shell surface at the postero-lateral margin of this species (Pl. 9, figs. 6a, b) ; Pl. 10, figs. 1a, b), the writer presumes that it is an almost similar feature to the *Leptostrophia beckii*-type or the *Rhytistrophia*-type corrugation, but more improminent, probably due to the smaller size of the specimen. MODZALEVSKAYA's illustration (1968, pl. 11, figs. 10, 11) shows clearly such a corrugation hence the generic assignment to *Rhytistrophia*. This kind of corrugation seems to be partly concerned with the specific character and partly related to the shell deformation. Some laterally compressed specimens are strongly corrugated than the longitudinally compressed ones as exemplified by KAPLUN's illustrations (1961, pl. XI, figs. 1-6) of *Rhytistrophia beckii* from Khazakstan. Almost similar relationship between compressed axis and the fasciculation of the radial costellae is possibly present on some leptostrophiid species. The writer presumes that the slightly bundled ribs of the shell margin are one of the gerontic characteristics of the strophomenaceans as well shown on the full-grown specimen of *L. "magnifica"* from the Oriskany limestone at Glenerie in New York State (CLARKE, 1909, pp. 134-135). However, such fasciculation is sometimes exaggerated at the middle of the longitudinally compressed specimen (Plate 9, figs. 5a, b ; Plate 30, fig. 1).

The Chinese species *Protoleptostrophia heitaiensis* WANG from the Mishan district is another allied form to the new species as far as the exterior is concerned. This species is, however, rather obscure in its taxonomic position as its nomenclatorial history shows. Namely, it was originally reported as *Leptostrophia* and was transfered later to *Protoleptostrophia* by the same author, then considered as *Leptostrophia* by HOU, and further turned back to *Protoleptostrophia* in the recently published monograph by WANG et al. It resembles to *Leptostrophia rotunda* BUBLICHENKO, which is rather widely distributed in the Khazakstan-Altai region (ex. KAPLUN, 1961, pl. 8, figs. 4-8 ; USCHATINSKAYA, 1966, pl. 11, figs. 2-5), in its shell outline and multicostellate surface ornamentation (WANG et al., 1964, p. 197, pl. 28, figs. 1, 2).

Illustrated specimens:—001HA1 (holotype), 003HA1, 009HA1-2, 015HA3, 023HA4, 039HE1, 128KD1, 211K$_\beta$2, 347KnG1.

Subfamily Douvillininae CASTER, 1939

Genus *Sinostrophia* HAMADA, gen. nov.

(Type species: *Sinostrophia kondoi* HAMADA, sp. nov., p. 53, Plate 14, figs. 4a, b ; Plate 16, fig. 4)

Species included:—Only the type species is known.

Generic diagnosis:—Moderately concavo-convex douvillinid with coarse, angular radial costellae which polyfurcate and diminish in size at the anterior margin. Cardinal line straight and denticulate medially about two-thirds the entire hinge length.

Pedicle valve well convex. Delthyrium open, with a pseudodeltidium at the posterior end. The "secondary hinge teeth" platy, and project anteriorly being parallel to the hinge line at the antero-ventral margin of delthyrial cavity. Ventral

process distinct. Muscle areas pentagonal being divided by a median ridge and bounded postero-laterally by thin but highly elevated bounding ridges which are not pustulated. Anterior portion of the muscular areas is obscurely bordered by weak and broad elevation of the shell floor. Adductor scars narrowly fusiform and enclosed.

Brachial valve slightly convex with a weak median sulcation. Chilidium present. Cardinal process lobes slender, sometimes medianly grooved at the tip. Socket plates present but not strong and distant from the cardinal process lobes and diverge. Muscle area defined posteriorly by thick and short lateral bounding ridges which diverge anteriorly from the base of cardinal process lobes and slightly curved inwardly. The bounding ridges not postulose. A low median septum present.

Ethymology:—The generic name *Sinostrophia* means a strophеodontid of China.

Comparison:—This new douvillinid genus somewhat resembles externally to *Stropheodonta* (*Stropheodonta*) HALL, 1850 in its mode of surface costellation, but it is quite different in the internal characters. *Strophodonta* has a complete pseudodeltidium, entirely denticulate hinge margin and no chilidium (MUIR-WOOD & WILLIAMS, in Trans. Invert. Pal., Pt. H, 1965, pt. II, p. H395) while *Sinostrophia* is provided with an open or incompletely covered delthyrium, centrally denticulate hinge margin and a chilidium.

Mesodouvillina (*Mesodouvillina*) WILLIAMS, 1950 was erected on an Upper Silurian material and includes some lower Devonian species. *Sinostrophia* has essentially similar in internal features to this subgenus except the presence of the "secondary hinge teeth" which are developed at the anterior margin of the pedicle opening. This structure seems to be originated from the antero-lateral portion of pseudodeltidium, and scarecely recognized in small specimens with an open delthyrium but quite distinctly developed in mature individuals which have an incomplete pseudodeltidium (*Vide* Plates 16, 17). This mode of development suggests that the structure is of the secondary one but not the true dental plates as exemplified in *Eostropheodonta*, and possibly homologous with the "secondary teeth" (MUIR-WOOD & WILLIAMS, Ibid., p. H364, fig. 232-1b) which are superimposed on the anterior portion of the complete pseudodeltidium.

Mesodouvillina is known to be provided with the unequally parvicostellate shell surface being different from the multicostellate *Sinostrophia*.

Sinostrophia kondoi HAMADA, sp. nov.

Plate 11, figs. 1-9; Plate 12, figs. 1-8; Plate 13, figs. 1-7;
Plate 14, figs. 1-5; Plate 15, figs. 1-7; Plate 16, figs. 1-4;
Plate 17, figs. 1-5; Plate 30, figs. 1-4, 9; text-figs. 14, 15.

1944. *Stropheodonta*, new species (nom. nud.) by NONAKA. *Japan. Jour. Geol. Geogr., Vol. 19, Nos. 1-4*, p. 251, pl. 27, figs. 2-4, apart of the figures 1 and 9.

1968. *Stropheodonta virgata* DREVERMANN, MODZALEVSKAYA. *Proc. Intern. Symp. Dev. System, Calgary, 1967, Vol. 1*, p. 552, pl. II, fig. 16.

Material:—More than seventy specimens are available in the collections.

Description:—Shell medium to large attaining 00 cm in length at the largest,

subquadrate in outline, equidimensional; the greatest width along the hinge margin; hinge line straight; cardinal extremities angular but not alate; moderately concavo-convex, not geniculate; weak and broad fold and sulcus present; surface ornamented by numerous angular radial costellae which originate at the beak and become finer anteriorly increasing in number by implantation and bifurcation, sometimes to form rather smoothish periphery; on the lateral flanks the costellae tend to be bent toward the cardinal extremities; concentric lamellae rarely developed with irregular interspaces; microtexture of the shell material unknown.

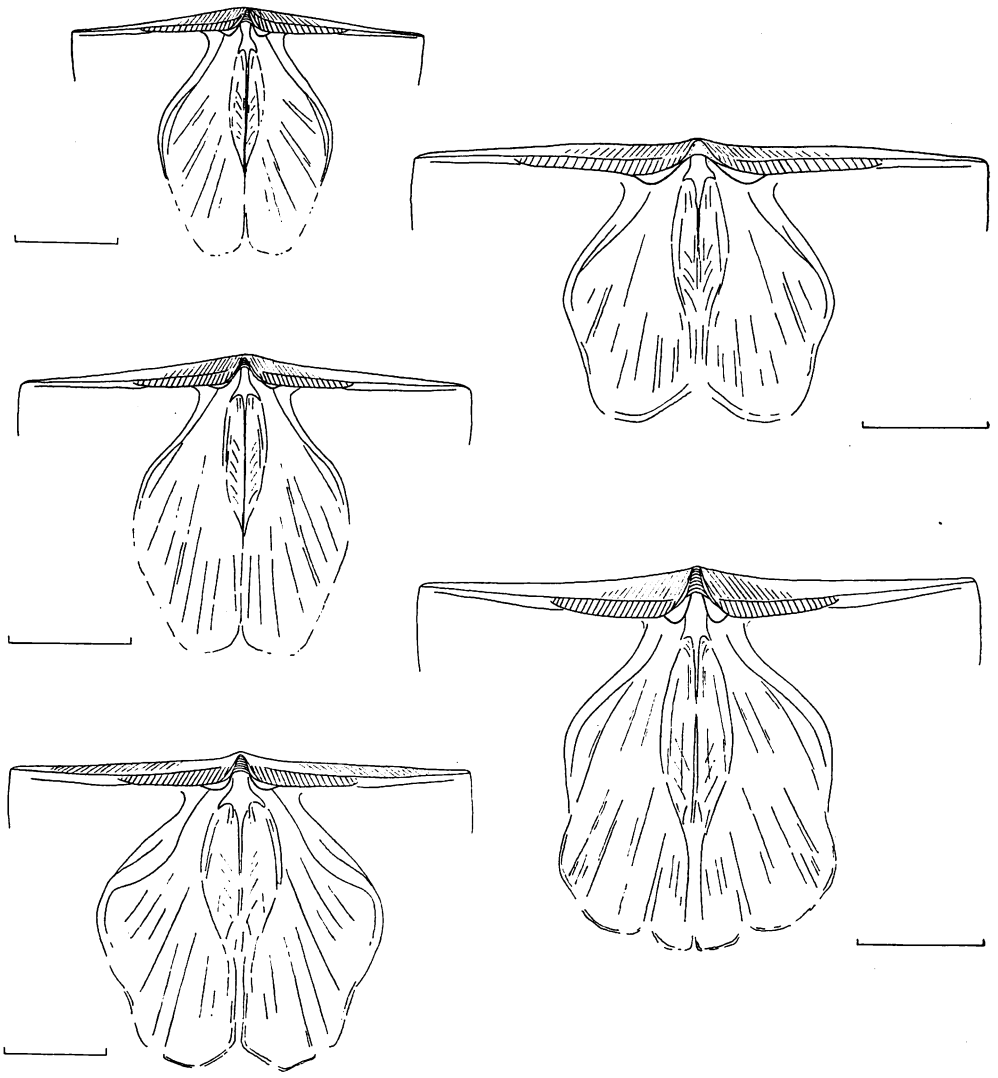
Pedicle valve fairly concave, the maximum concavity at the middle of the shell; hinge almost straight with a narrow, triangular cardinal area along the entire width; beak slightly prominent from the hinge line; interarea vertically striated on the inner surface, anterior margin denticulate along the central portion of the area leaving the non-denticulate lateral hinge margin; delthyrium open, triangular with an incomplete pseudodeltidium at the posterior end; the secondary hinge teeth small, blade-like and triangular in form being pointed antero-ventrally, degenerate at the delthyrial extremities of the anterior hinge margin; ventral process short and continuous to the median septum anteriorly; muscle area narrowly triangular or pentagonal in outline occupying approximately half of the shell length, separated medianly by a sharp median septum; adductor scar elongated, lunuliform; lateral bounding ridges high and thin at the postero-lateral margin and run posteriorly diminishing their height and reach the under surface of cardinal area where is situated just outside the secondary hinge teeth; anterior half of the muscle area somewhat faintly marked only by low swelling of shell floor even on the matured shell, and the antero-median portion is slightly embayed posteriorly; inner surface of shell marked by radial striae being correspond with the surface ornamentation especially distinct at the marginal portion; the triangular areas between bounding ridges and the hinge margin are provided with rough nervose striae with pustules in larger specimens; bounding ridges and muscle area not pustulose.

Brachial valve planate or slightly convex; the maximum convexity near the umbo; same as the pedicle valve in general outline and surface ornamentation; a narrow median sulcus present; beak not prominent; hinge line straight; cardinal area quite narrow, catacline and developed along the entire length of hinge line.

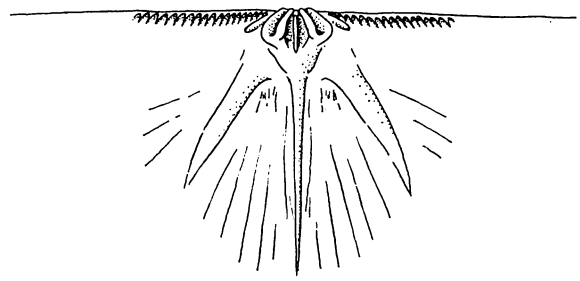
Brachial interior with two cardinal process lobes which diverge posteriorly as well as dorsally to make V-shaped projections; the attached faces of cardinal process lobes oval in outline and directed postero-ventrally, broadly bifurcate; between the two cardinal process lobes a small keel like median ridge on a platform that extends anteriorly to form a sharp median septum; median septum attains about half the length of shell and merges into a weak and narrow median sulcation anteriorly; interarea catacline, extremely narrow and the cardinal margin is minutely denticulate along the ventral edge of central half portion of the whole hinge line except the basement area of cardinal process lobes at the middle; chilidium present but small; socket plates thin and short next to the cardinal process lobes laterally; the angle between these two plates diverge anteriorly wider than that of the cardinal process lobes to make approximately 90-110 degrees; muscle area defined posteriorly by short, slightly inwardly curved lateral bounding ridges, which unite with the

cardinal process lobes and socket plates posteriorly; adductor area elongated lunuliform and roughly lobed at the posterior portion in the matured specimens; the antero-lateral margin of the area not clearly defined; inner surface gently costellate corresponding to the surface ornamentation; no pustule recognizable.

Growth:—The whole ontogeny of *Sinostrophia kondoi* is not clarified. However, it is quite clear that the smaller shell has rather simple and coarse costellation and the larger shell becomes to be provided with much finer multicostellate surface. Some mature shell is provided with rather smoothish periphery owing to the rapid increase of the costellae being accompanied by diminishing of the size of costellae as exemplified by a specimen shown in fig. 5, Plate 12. The peripheral portion of the inner shell surface is sometimes thickened moderately by the secondary shell



Text-fig. 14. *Sinostrophia kondoi*, gen. et sp. nov.
Variation of pedicle interiors. Scale shows 10 mm.



Text-fig. 15. *Sinostrophia kondoi*, gen. et sp. nov.
Brachial interior (×1.5).

deposition (Plate 12, fig. 4a; Plate 15, fig. 1a).

The pseudodeltidium is absent at first and becomes to be developed at the posterior margin of delthyrium. At the same times the secondary hinge teeth are grown as to form the broad squamulae like projections at the delthyrial edges. Internally there is a general tendency of decrease in the relative size of the socket plates to the cardinal process lobes as the shell grows. The development of the crenulate portion of hinge margin, the secondary hinge teeth and the variations in the shape of brachial muscle field are diagramatically shown in text-fig. 14.

Comparison:—*Strophеodonta* cf. *sedgwicki* d'ARCHIAC and VERNEUIL described by YABE and SUGIYAMA (1942, p. 501, fig. 3; pl. 1, fig. 4) from Nichiuho in the Lesser Khingan district is somewhat similar in general outline. However, none of internal features has been detected on that specimen. This form is distinctly fascicostellate with two orders of costellation size being different from *Sinostrophia*.

Strophеodonta virgata (DREVERMANN) described from the Lower Devonian of Khazakstan (KAPLUN, 1961, p. 72, pl. 7, figs. 16-18; pl. 8, figs. 1-3) and *Strophеodonta corrugata pseudofascicula* RHKAVISCHNIKOVA (NILOVA, 1965, p. 92, pl. 1, figs. 3-6) are hardly distinguishable in two separate species. They look like similar to some younger individuals of *Sinostrophia* as exemplified by figs. 1a-c, 2a, b on Plate 13, though any details structure is known on their cardinal apparate to compare with.

Strophеodonta virgata illustrated by MODZALEVSKAYA from the Upper Amur Devonian has a large shell with the characteristic angular, polyfurcate radial costellae and here regarded it as conspecific with *S. kondoi*.

The European species *Strophеodonta triculta* FUCHS has some similarities to *Sinostrophia* in its cardinalia and muscle impressions, but has been clarified to be a species of *Douvillina* (*Mesodouvillina*) by BOUCOT's study on the Belgian material (1960a, p. 301, pl. 11, figs. 4-5; pl. 12, figs. 1-4).

Illustrated specimens:—002HA1, 006HA1, 3, 007HA1, 3, 013HA2, 014HA3, 016HA3-4, 025HA4, 027HA4, 8, 032HB1, 2, 034HB1, 2, 040HF1, 043HF1, 048HF1, 054HF2, 056HF3, 058HF2, 068HJ1, 077HL2, 080HC2, 130KE1 (holotype), 131KE1, 138KG1, 157KP1, 158KP1, 164KQ1, 220K$_\gamma$1, 223K$_\gamma$1, 258K$_\kappa$1, 262K$_\kappa$1, 277K$_\nu$1, 278K$_\nu$1, 307K$_\phi$1, 330KnC1.

Subfamily Pholidostrophiinae STAINBROOK, 1943
emend. HARPER, JOHNSON, & BOUCOT, 1967

Genus *Pholidostrophia* HALL & CLARKE, 1892

Subgenus *Pholidostrophia* HALL & CLARKE, 1892
emend. HARPER, JOHNSON, & BOUCOT, 1967

(Type species: *Strophomena nacrea* HALL, 1857)

Pholidostrophia sp. indet. A

Plate 18, figs. 1a-c.

Material:—Only two fragmentary exteriors pedicle valve are in the repository.

Description:—Pedicle valve small, transversely elongated, strongly concave to form a cylindrical cross section but not geniculate; surface smooth except a few concentric growth lamellae; cardinal extremities alate; hinge line straight; the maximum width at the hinge margin; beak roundedly prominent from the hinge line; interarea narrow and along the entire hinge margin, transversely and vertically striated to show reticulated pattern.

Shell materials and interior features are unknown.

Comparison:—The general outline and external characters suggest that this indeterminable species belongs to *Pholidostrophia*. *Pholidostrophia* sp. indet. B described below is distinct from the form A in its equidimensional shell outline and less concavo-convex shell curvature.

Illustrated specimen:—237K$_{\eta}$1.

Pholidostrophia sp. indet. B

Plate 18, figs. 2a-c, 3.

Material:—An external mold of brachial valve and a fragmentary pedicle valve at hand.

Description:—Shell medium in size, hemi-circular in outline, approximately equidimensional, fairly concavo-convex, not geniculate; hinge line straight and occupies the maximum width of the shell; surface ornamentation not recognizable except some faint concentric growth lamellae and questionable radial striae.

Shell substance and its microstructure unknown.

Pedicle valve convex; beak broadly rounded and moderately prominent from the hinge line; fold-like swelling of the shell at the middle; interarea narrow, weakly striated in vertical direction; cardinal margin not alate.

Pedicle interior poorly known; narrowly elongate muscle fields at the postero-median portion and divided by a slender myophragm; inner shell surface not ornamented.

Brachial valve concave; beak not prominent; hinge line straight; a broad median sulcus at the central portion but not well defined.

Brachial interior unknown.

Comparison:—Almost equidimensional shell outline with ill-defined median plication is characteristic of this indeterminable pholidostrophid form B. However, no precise comparison with the known species of the genus may not be given because of its poor state of preservation and lack of material.

Illustrated specimens:—162KP1, 2, 261K$_{\alpha}$1-2.

Strophomenid gen. et sp. indet.

Plate 18, fig. 15.

Material:—Impression of interior of a brachial valve is at hand.

Description:—Shell very small in size, approximately equidimensional, almost flat; anterior margin well and smoothly rounded; shell periphery strongly crenulate probably corresponding to the surface costellation; surface costellae seem to increase in number by implantation; cardinal process lobes small and postero-ventrally projected; muscle bounding ridges well developed, anteriorly divergent; a median myophragm somewhat wide and long; hinge crenulation and socket ridges inobservable; shell material unknown.

Comparison:—This poorly represented specimen is characteristic in its coarse radial costellation for the strophomenids. The present writer is not aware of any comparable form to it except an internal impression of *Shaleria rigida* (DE KONINCK) illustrated by BOUCOT (1960, pl. 18, fig. 18) in regard to such a strong costellation. However, the Belgian species is distinctively provided with the characteristic muscle impression and socket ridges of *Shaleria*.

There is a slight possibility that this imperfect form is an immature specimen of *Sinostrophia*.

Illustrated specimen:—310K$_{\beta}$1.

Superfamily Davidsoniacea KING, 1850

Family Schuchertellidae WILLIAMS, 1953

Subfamily Schuchertellinae WILLIAMS, 1953

Genus *Schuchertella* GIRTY, 1904

(Type species: *Streptorhynchus lens* WHITE, 1862)

"*Schuchertella*" sp. indet.

Plate 18, figs. 4-12d.

Material:—Five brachial and four pedicle valves are available in the collections.

Description:—Shell small to medium in size, transversely elongate, hemi-circular in outline, unequally biconvex; the maximum width at the hinge margin; hinge line straight; beak slightly prominent; surface coarsely ornamented by simple radial ribs near the umbo; the radials increase in number by implantation anteriorly to form parvicostellate pattern in alternating two orders of ribs in size; extremely fine and somewhat imbricate concentric lamellae recognizable on some specimens; shell material not preserved.

Pedicle valve flattish, gently convex near the umbo, slightly higher than the other valve; interarea along the entire length of the hinge line, apsacline, with low dental processes; no dental lamellae; delthyrium triangular and completely closed by an arched pseudodeltidium; muscle fields indiscernibly developed; a low and short

septum at the posterior portion.

Brachial valve more convex than the other valve; socket plates faintly recurved, ankylosed to cardinal process lobes and posterior margin; chilidial plate missing; cardinal process lobes united at the base but divergent postero-dorsally, shallowly grooved on the tips; muscle fields faintly impressed, subcircular and separated by a weak myophragm at the middle; inner surface radially grooved being correspond to the outer ornamentation.

Comparison:—This poorly represented form somewhat resembles to *Morinorhynchus dalmanelliformis* HAVLICEK, but the latter species is provided with a median sulcus on the brachial valve and nas rather well developed dental lamellae on the pedicle valve. *Schuchertella altaica* KHALFIN from Gornyi Altai (GRATSIANOVA et al. in KHALFINA ed., 1961, p. 440, pl. D-68, figs. 10, 11) has much larger shell size and distinctly prominent beak than the present indeterminable species.

Illustrated specimens:—078HL1, 2, 084HM1, 091KA2-3, 115KB1, 150KM1, 171HF2, 183KV1, 218K$_7$1, 326KnB1.

Subfamily Streptorhynchinae STEHLI, 1954

Genus *Aesopomum* HAVLÍČEK, 1965

(Type species: *Strophomena aesopea* BARRANDE, 1879)

Aesopomum chinense HAMADA, sp. nov.

Plate 18, figs. 13, 14; Plate 19, figs. 1-8;
Plate 20, figs. 1, 2; text-fig. 16.

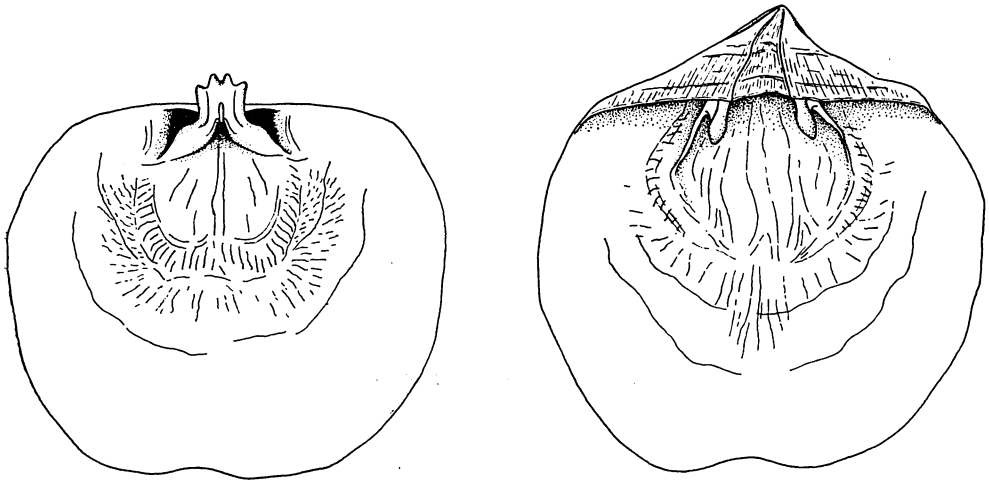
Material:—Twelve specimens are available to examine.

Description:—Shell medium to large in size, almost circular in outline, equidimensional; hinge line straight, shorter than the shell width; the maximum width at the midlength; brachial valve moderately convex; pedicle valve weakly resupinate; median fold on pedicle valve; median sinus on brachial valve broad and ill-defined near the anterior portion; commissure line broadly uniplicate; surface ornamented by fine but distinct radial costellae chiach increase in number by bifurcation and implantation; interspace narrow and deep; broad, concentric rugae prominent with irregular intervals; radial costellae near the umbo fine and almost diminish on some specimens.

Pedicle valve flattish, irregularly undulated, resupinate as a whole, being the posterior portion convex; a median fold broad and weak; beak prominent; interarea broadly triangular, apsacline, striated vertically as well as horizontally; pseudodeltidium complete; hinge teeth boss shaped, antero-ventrally projected being supported by thin but well developed dental lamellae; anterior bases of dental lamellae incurved to enclose the muscle fields which are longitudinally lobed; each lobe seems to be bifurcate anteriorly; muscle fields are further surrounded by wavy inflation of shell floor and concentric rugae.

Brachial valve irregularly convex; cardinal extremities well rounded; interarea quite narrow, catacline or slightly hypercline; cardinal process lobes extremely prominent postero-ventrally, fused with socket plates and chilidial plate to form a

solid process of which the tip tetrafurcate, and also grooved on the posterior surface; sockets lateral to the cardinal process lobes, deep; socket plates anteriorly divergent and recurved toward the lateral extremities; a broad median myophragm divides the muscle fields; muscle fields rounded and surrounded by swelled shell floor with wrincles; inner surface of the shell striated in reflecting the surface costellation; inner shell periphery finely crenulated.



Text-fig. 16. *Aesopomum chinense*, sp. nov.
Brachial (A) and pedicle (B) interiors (×1.5).

Comparison:—In the external characteristics this species almost coincides with *Aesopomum aesopeum* (BARRANDE) which is recently described and designated as the type species by HAVLÍČEK (1965). The brachial valve is sometimes distorted especially near the umbo as shown on BARRANDE's plate 133. Subconcentric rugae are much well developed in the present species than the type species. *Orthis distorta* BARRANDE (1879, pl. 60, figs. IV1a-9a; pl. 58, figs. 4a-5f?) is quite similar in its distorted pedicle valve near the umbo, but the internal features are insufficiently known to compare.

Internally the type species is provided with an extremely stout and highly projected cardinal process lobes which are fused together with the brachiophores. *Aesopomum chinense* has, on the contrary, rather slender cardinal projection.

The genus was monotypic when it was established by HAVLÍČEK. But quite recently JOHNSON (1967 in press) reported "*Schuchertella*" *deformis* from the Lower Devonian of Nevada as a species of *Aesopomum*. This is much smaller than the type species and characteristic in its strongly and irregularly convex valves, especially in the pedicle valve as to form almost conical shape.

Illustrated specimens:—010HA1, 3, 024HA4, 5 (holotype), 035HB2, 075HL1, 119KB1, 242K$_{\theta}$1, 308K$_{\phi}$1, 312K$_{\phi}$1, 314K$_{\phi}$1, 318K$_{\phi}$1, 346KnG1.

Suborder Chonetidina MUIR-WOOD, 1955

Superfamily Chonetacea BRONN, 1862

Family Chonostrophiidae MUIR-WOOD, 1962

Genus *Chonostrophiella* BOUCOT & AMSDEN, 1964

(Type species: *Chonetes complanata* HALL, 1857)

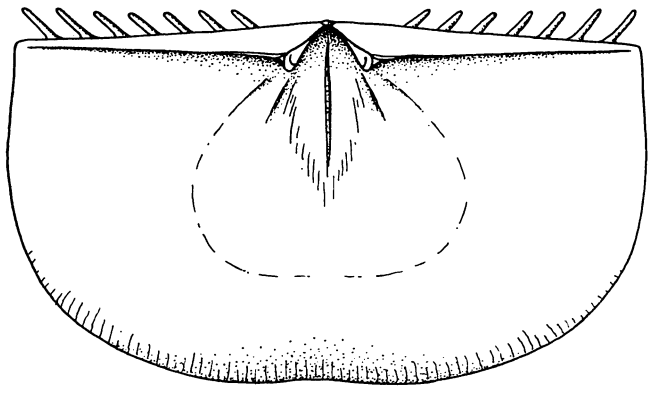
Chonostrophiella khinganensis HAMADA, sp. nov.

Plate 20, figs. 3-13; text-fig. 17.

Materials:—More than a dozen pieces of disarticulated valves are in the depository.

Description:—Shell medium in size, subquadrate in shape, moderately transversely elongate; almost flat and resupinate on pedicle valve; the greatest width at the hinge margin; hinge line straight; beak not prominent; along the hinge margin 5 to 6 slender spines on each side, posteriorly divergent, oblique to the hinge line; surface marked by exceedingly fine, simple radial costellae with narrower interspaces; costellae increase in number by implantation; irregularly spaced concentric growth lamellae faintly marked.

Pedicle interior with narrow, flat and catacline or slightly apsacline area; dental lammellae absent; cardinal teeth small and spatulate, widely divergent anteriorly; delthyrium open, triangular in outline; median septum extremely slender, attains about half the shell length; muscle fields faintly impressed, flabellate, occupying half to two-thirds the shell length as well as the shell width; low postero-lateral bounding ridges recognizable; adductor scars small, slender lunuliform along the median septum.



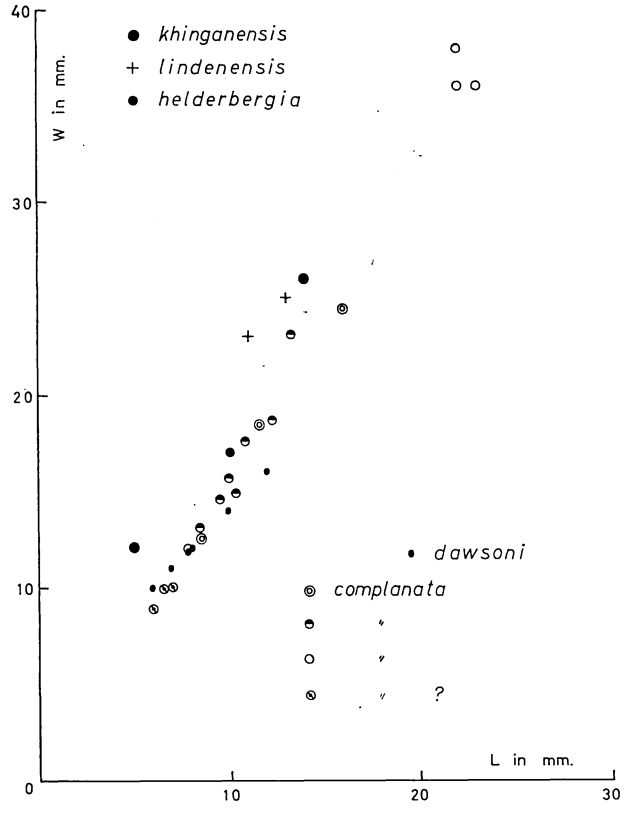
Text-fig. 17. *Chonostrophiella khinganensis*, sp. nov.
Pedicle interior (×3).

Comparison:—The following five species were assigned to *Chonostrophiella* by BOUCOT & AMSDEN (1964, p. 881) being separated from the parvicostellate *Chonostrophia*.

Chonostrophiella complanata (HALL, 1857)
C. *herderbergia* (HALL & CLARKE, 1892)
C. *dawsoni* (BILLINGS, 1874)
C. *jervensis* (SCHUCHERT, 1901)
C. *lindenensis* (FOERSTE, 1909)

Therefore, this new species is the sixth for the genus except a questionably assigned *Chonostrophia knodi* CASTER, 1939. The typical of the genus has rather large shell size and characterized by its strong median septum and well impressed muscle fields on the pedicle valve.

The rest species are known insufficiently on the interior structures to make thorough comparison. However, as far as the shell size is concerned *C. jervensis* is reported as it is considerably and uniformly small. According to BOUCOT and AMSDEN (op. cit., p. 882) *C. dawsoni* is supposed to be synonymous with *complanata*. Measurements on *dawsoni* reported by BILLINGS (1874, p. 19) also show quite uniform form ratio (W/L) as illustrated in text-fig. 18. It is rather small in size and seems to be uniform in growth rate. However, as noted by BOUCOT and AMSDEN *dawsoni* occupies the area of smaller dimension of *complanata*, and it is highly possibly that *dawsoni* represents the younger stage of *complanata*.



Text-fig. 18. Variation diagram of shell form in *Chonostrophiella* species.

Lindenensis described by FOERSTE has somewhat different form ratio. Namely, it is more transversely expanded than *complanata-dawsoni* series. In this respect the new species belongs to the *lindenensis* group as clearly shown on the diagram, though there should be some divergence caused by the shell deformation.

Illustrated specimens:—008HA1, 018HA3, 029HA5, 070HK1, 160KP1 (holotype), 182

KV1, 197K$_{\alpha}$1, 231K$_{\zeta}$1, 268K$_{\lambda}$1, 270K$_{\lambda}$1, 274K$_{\nu}$1.

Order Rhynchonellida KUHN, 1949

Superfamily Rhynchonellacea GRAY, 1848

Family Rhynchotrematidae SCHUCHERT, 1913

Subfamily Orthorhynchullinae COOPER, 1956

Genus *Zlichorhynchus* HAVLÍČEK, 1963

(Type species: *Zlichorhynchus hiatus* HAVLÍČEK, 1963)

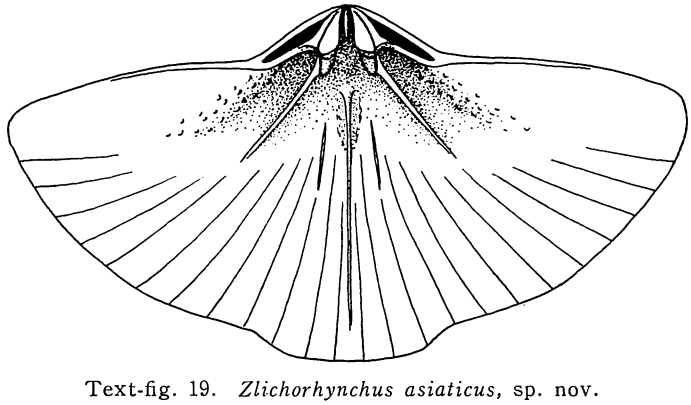
Zlichorhynchus asiaticus HAMADA, sp. nov.

Plate 21, figs. 3, 4a-f; text-fig. 19.

Material:—An internal and an external mold of brachial valves and a fragmentary pedicle exterior are in the repository.

Description:—Brachial valve transversely rhomboidal in outline, moderately to strongly convex, wider than long; form ratio or W/L approximately 2; the maximum width at posterior one-third the shell length; lateral wing bluntly pointed; beak somewhat prominent; cardinalia broad, triangular; anterior margin gently rounded with a broad median fold which is shallow and slightly projects anteriorly; fold begins at earlier one-third length of the shell; surface multicostellate with simple, high, round-topped ribs with narrower and deep interspaces; six on the fold including a pair of bounding costellae which are not remarkably different from the other costellae in shape and size; eight or nine on each flank; costellae begin from the beak, diminish their height toward the lateral extremities; no concentric growth lamellae recognized.

Internally provided with widely separated and anteriorly divergent hinge plates; outer plates triangular and serving as crural bases; sockets shallow and narrow, lateral to the hinge plates, denticulate on bottom surface; crural plates project from the inner margin of hinge plates antero-ventrally; crural bases extend to the shell floor to form low and widely divergent ridges which bound the muscle fields; notothyrial cavity not filled with the secondary shell material, provided with a sharp



Text-fig. 19. *Zlichorhynchus asiaticus*, sp. nov.
Brachial interior (×2.5).

but short process of septiform; a narrow and low median septum at the middle of the muscle fields, and attains anteriorly about three-fourths the shell length; shell floor outside of the crural bases and lamellae strongly pustulose and concave being separated from the flat and smooth postero-lateral margins; inner surface of the shell crenulated being correspond with the outer costellation; neither micro-ornamentation nor shell structure not clarified.

Comparison:—This new species resembles to *Machaeraria* in its shell form and also to *Zlichorhynchus* in its cardinal structures. Much larger shell with a distinct median fold and lateral flanks and somewhat strongly developed crural basis which bound the muscle fields are the most remarkable characteristics if compared with the latter genus. *Zlichorhynchus hiatus* HAVLICEK (1963, p. 403, pl. 1, figs. 1-5) from the Upper Emsian Zlichov limestone in Bohemia is rounded trigonal in shell outline with the greatest width toward front and has no lateral flanks as in the present species. *Machaeraria* has, on the other hand, broad and divergent bounding lobes of the median fold and sinus. A newly established genus *Thliborhynchia* by LENZ (1967, p. 1189, pl. 161, figs. 1-34) based on *T. julli* from the late Siegenian beds in the Royal Creek of Yukon is another allied form. This is much similar to *Zlichorhynchus* in every respect except the angular cross section of the ribs, and the shell is in dumpbell-shape with a "pinched" profile being different from the present new species also.

As to the shell shape, the present form might represent a new genus closely related to *Zlichorhynchus*. However, there remains a slight possibility that the juvenile form of this species might show the great similarity to *Z. hiatus*, because it seems to be unprovided with any distinct median fold as far as the available specimens are concerned. In addition to that, no pedicle interior is known to the writer at the present time. Therefore, he hesitates to establish a new genus on this new species until much proper materials would become to be accessible enough to reveal the detailed features.

Illustrated specimens:—141KH1, 323KnA1 (holotype), 324KnA1.

Family Trigonirhynchiidae SCHMIDT, 1965

Genus *Wilsoniella* KHALFIN, 1939

(=*Ussovia* KHALFIN, 1955)

(Type species: *Wilsoniella prima* KHALFIN, 1939)

Wilsoniella grandis HAMADA, sp. nov.

Plate 21, figs. 5-7; Plate 22, figs. 1-5;
Plate 23, figs. 1-3; text-fig. 20.

1959. *Conchidium* ex gr. *baschkiricum* (VERNEUIL), HOU. *Acta Palaeont. Sinica, Vol. 2, No. 2*, p. 122, pl. 1, figs. 1a, b.

1964. *Conchidium baschkiricum* (VERNEUIL), WANG et al. ed. *Brach. Foss. China, Vol. 1*, p. 173, pl. 24, figs. 6, 9.

1968. *Plethorhyncha speciosa* var. *ramsayi* HALL, MODZALEVSKAYA. *Proc. Intern. Symp. Devonian Syst. Calgary, 1967, Vol. 1*, p. 552, pl. II, figs. 12a, b.

Materials:—Eight specimens are available for examination, but no pedicle interior can be seen.

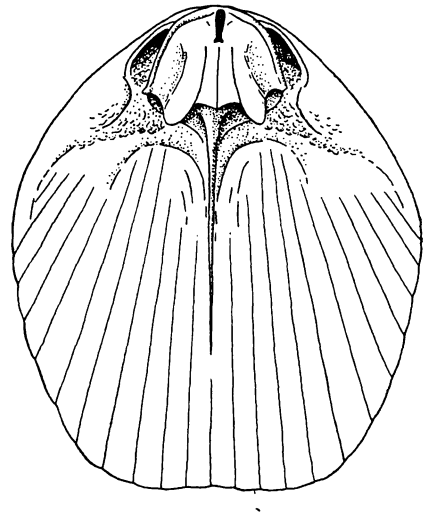
Description:—Shell large, globosely cuboidal, strongly and almost equally biconvex, pedicle beak prominent, incurved and almost overhangs the opposite beak; anterior and lateral truncation of shell not so well defined but present; surface multicostellate by low, broad and round-topped costellae in cross section; costellae approximately 28 in average number on the entire surface, rarely bifurcate, beginning at the beaks; interspaces narrow and shallow with rounded bottom; a median sinus and fold only at the anterior margin and ill defined; tongue prominent; anterior commissure deeply uniplicate; margin sharply denticulate with remarkably developed spinose insertion at the margin; anterior portion of costellae on the external surface not grooved; shell surface without any remarkable radial micro-ornamentation or concentric growth lamellae.

Pedicle valve triangular in outline in ventral view; beak strongly incurved; a median sinus at the anterior margin with dorsally prominent tongue; the border of sinus not well defined; almost equal sized eight costellae countable in the sinus; anterior commissure with an uncinuloid insertion of marginal spines to the opposite valve; interior indetectable.

Shell material thick, especially at the posterior portion, impunctate.

Brachial valve inflated especially at the antero-dorsal portion; posterior portion and the beak smoothly rounded without a median fold; ill-defined fold developed only at the anterior margin; shell material well thickened at the beak area.

Brachial interior with solid cardinalia; hinge plates unite into a thick, triangular plate which is ridged medianly; crural bases also fused with hinge plates and make broad lateral bounding ridges with broad flanks of laterally expanded septarium; crural plates short and stout and project ventrally, with an elliptical cross section; septarium extremely thickened supporting the hinge plates and crural bases and laterally expanded to form inner socket ridges to the postero-lateral portion of cardinalia; a small open pit at the posterior extremity of the hinge plate is connected with the anterior foramen which is situated below the crural bases, or posterior to a median septum; dorsal sockets narrow, triangular and deep outside of the septarium, coarsely corrugated; a median septum originates at the anterior portion of the septarium and attains almost one-third the shell length, thin and high from the shell floor at the middle portion where is supported by a broad shell inflation; postero-lateral part of inner shell surface coarsely punctated by secondary shell thickening; muscle fields ill defined, small



Text-fig. 20. *Wilsoniella grandis*, sp. nov. Brachial interior (×1.5).

rounded adductor scars on the shell inflation lateral to the median septum; a slender keel like ridge subparallel to the median septum also superimposed on the shell inflation on each side.

Comparison:—This unique large rhynchonellid was first assigned by NONAKA (1949, M.S.) to *Hypothyridina* sp. (*in* HAMADA, 1961, p. 179), though it was described and figured as *Conchidium* ex gr. *baschkiricum* by HOU (1959) on the external feature of the shells collected from the same area in the Lesser Khingan district. One may be convinced that HOU's pentameroid is congeneric, at least, with *Wilsoniella grandis*, if he compares a figure shown by WANG et al. (1964, pl. 24, fig. 6) to a figure illustrated in this paper on Plate 21, fig. 7c for example.

The most characteristic nature is in its solid hinge plates which are fused together with the crural bases into a thick, triangular cruralium. In addition, well thickened septarium is expanded laterally supporting the cruralium and form an inner ridge of the socket postero-laterally.

The large shell size and the thickened cardinaria remind the writer of some trigonirhynchiids such as *Trigonirhynchia*, *Wilsoniella* (=*Ussovia*) and *Straelenia* (=*Dinapophysia*). The last genus is rather common in the European and African Lower Devonian, and differs from the present form in its less inflated valves with slight development of sulcus and fold.

Trigonirhynchia and *Wilsoniella* are closely related to each other. Both have large, subglobose shells with much deeper brachial valve than the opposite valve. The former is, however, provided with angular costellae while the latter with rounded ones. Besides, the latter is characteristic in its solid and united hinge plates with a median ridge on them.

The present form, thus almost coincides with the Altai genus *Wilsoniella*. This genus is monospecifically erected on *W. prima* by KHALFIN, though he later afforded a different generic name, *Ussovia*, for the same species. The diagrammatic sketches drawn by KHALFIN (1948, p. 282, fig. 46; also in RZHONSNITSKAYA, 1960, p. 242, fig. 257; quoted in *Treat.*, p. H561, fig. 430-2d and KHALFIN, 1955, p. 239, fig. 193) show the unique cardinalia. *W. grandis* described here has stronger crural plates which are prominent antero-ventrally than those of the type-species.

Ussovia borissiakae NILOVA (1965, p. 97, pl. II, figs. 6, 7), from Central Khazakstan, is another species of *Wilsoniella*, but much smaller than the type-species.

Plethorhyncha, a large Lower Devonian rhynchonellid in North America, is almost similar to the present *W. grandis* in its large shell size and other general features. Only the difference is in its brachial cardinalia which are not fused to form a solid hinge plate (*Treat.*, pl. H566, figs. 1a-d). The surface costellae are somewhat numerous on *Plethorhyncha* than *Wilsoniella*. MODZALEVSKAYA (1968) assigned a large rhynchonellid exterior from the Amur Lower Devonian to a variety of HALL's species of *Plethorhyncha* probably on the basis of such similarities as pointed above. The present writer is, however, of opinion that her *Plethorhyncha speciosa* var. *ramsayi* is conspecific with *W. grandis*.

Illustrated specimens:—036HC1, 082HM1 (holotype), 142KI1, 143KJ1, 159KP1, 263 $K_{\kappa}1$, 280$K_{\xi}1$, 320$K_{\omega}1$.

Family Uncinulidae RZHONSNITSKAYA, 1956

Subfamily Uncinulinae RZHONSNITSKAYA, 1956

Genus *Uncinulus* BAYLE, 1878

(Type species: *Hemithiris subwilsoni* D'ORBIGNY, 1850)

Uncinulus piloides HAMADA, sp. nov.

Plate 23, figs. 4a-e, 5a-f.

Material:—Two free specimens of almost complete shape are in the repository.

Description:—Shell medium in size, pentagonal in outline, approximately equidimensional, unequally convex with greater convexity of brachial valve; the maximum width near the midlength; ventral sulcus and dorsal fold distinct in anterior half of the shell, broad as one-third as the shell width; truncated at the antero-lateral extremities; commissure line distinctly uniplicate; margin denticulate; uncinuloid marginal spines present; surface ornamented by radial costellae which are poorly developed at the posterior portion and almost smooth near the beak; costellae simple, low, roof shaped in cross section with narrower and shallow v-bottomed interspaces; costellae on the truncated tongues grooved longitudinally and extremely flat in cross section; four to five costellae on the median sulcus and fold; bordering costellae not well developed; concentric growth lines poorly developed except the truncated tongues where the growth lamellae of chevron shape are recognizable; shell substance thick and impunctate.

Pedicle valve with a prominent beak; postero-lateral part under beak reflects sharply to overhang the opposite valve.

Pedicle interior with large, strongly impressed muscle fields of oval shape, which are re-entrant at the anterior extremity and separated medianly by a broad myophragm; muscle fields may attain half the shell width and length respectively in dimension; posterior half of the muscle area and the cardinalia not preserved.

Brachial valve well convex, beak not prominent and almost covered by the opposite valve, flanks smoothly inflated.

Brachial interior with anteriorly diverging crural which are supported basally by a thick median septum; posterior portion of cardinalia not preserved; a median septum low and attains one-fourth the shell length and divides the oval, strongly impressed muscle fields.

Comparison:—The characteristically re-entrant muscle fields in pedicle valve of the present species show the close resemblance to those of *Uncinulus pilus* which is common in the Lower Devonian of Europe and Africa. The muscle fields are somewhat variable in size within this species. Namely, it is well illustrated that the fields occupy almost all the inner surface of the valve in some examples (ex. SANDBERGER & SANDBERGER, 1850-55, pl. 33, fig. 13b; DROT, 1964, pl. 16, fig. 11), but fairly small in others (ex. FUCHS, 1912, pl. 4, fig. 13; LAVERDIERE, 1930, pl. 8, figs. 16, 17). The present specimens distinctly belong to the latter group.

Concerning the nature of costellation, the present new species differs from *Uncinulus pilus* in its flattish roof-shaped cross section and fewer number especially on

the median folds and sulcus. Namely, *U. piloides* is provided with only four or five costellae on the median fold and sulcus while *U. pilus* has ten or more. *U. princeps* BARRANDE (ex. LE MAITRE, 1944, pl. 7, figs. 42-49) is more similar to the new species in its costellation. However, it still has seven or eight costellae in the median fold and sinus.

Illustrated specimens:—303K$_{\chi}$1, 304K$_{\chi}$2 (holotype).

Subfamily Hebetoechiinae HAVLÍČEK, 1960

Genus *Pectorhyncha* MCLEARN, 1918

(Type species: *Atrypa obtusiplicata* HALL, 1852)

Pectorhyncha (?) sp. indet.

Plate 24, figs. 1, 3, 4, 7.

Material:—Two internal molds of brachial valve and a pedicle valve at hand.

Description:—Shell medium in size, probably pentagonal in outline, moderately convex; no interarea; divided hinge plates small anteriorly divergent being supported by small septalium posteriorly; sockets lateral to the hinge plates, narrowly triangular, shallow; no cardinal process recognizable; a median septum thin and long attaining almost posterior one-third the shell length, posteriorly thickened to join the septarium; inner shell surface impressed by outer radial costellae and irregularly spaced concentric growth lamellae; costae simple and 14 in number, beginning at the beak, seem to be rounded-topped or subangular in cross section with interspaces of similarly angular shape of the bottom; a median sinus probably shallow and not well defined if present; costellae on the lateral flanks tend to be bent posteriorly; microornament and shell structure unknown.

Comparison:—Any significant comparison is impossible with this poorly known species. "*Camarotoechia*" sp. indet. in this paper somewhat resembles in its small, open cardinalia, but has a distinct median fold on the brachial valve.

Illustrated specimens:—109KB1, 134KE1, 273K$_{\mu}$1, 295K$_{\sigma}$1.

Family Eatoniidae SCHMIDT, 1965

Genus *Eucharitina* SCHMIDT, 1955

(Type species: *Terebratula eucharis* BARRANDE, 1847)

Eucharitina (?) sp. indet.

Plate 24, figs. 5, 6.

Material:—Only two external impressions of pedicle valves are available for examination.

Description:—Shell medium in size, oval in outline, somewhat flattish with a weal antero-dorsally reflected tongue; beak small and prominent with gentle lateral slopes; a small pedicle opening (?) at the tip of the beak; a broad moderately sulcate median sinus at the anterior margin; surface ornamented by simple, rather fine, flat-topped radial costellae on the anterior half of the shell with much narrower interspaces;

beak area quite smooth; no concentric growth lamellae recognizable; approximately 8 costellae in the sinus; costellae on the lateral flanks slightly curved toward the sinus; internal structure and shell substance unknown.

Comparison:—No comparison can be given for this doubtful form. Somewhat flattish oval shell shape and the inwardly curved low costellae led the writer to conclude as it may represent a form of the eucharitinid rhynchonellids.

Illustrated specimens:—133KE1, 145KK1.

Family Camarotoechiidae SCHUCHERT & LE VENE, 1929

Subfamily Camarotoechiinae SCHUCHERT & LE VENE, 1929

Genus *Camarotoechia* HALL & CLARKE, 1893

(Type species: *Atrypa congregata* CONRAD, 1841)

"*Camarotoechia*" sp. indet.

Plate 21, figs. 1, 2; Plate 24, figs. 2, 8; Plate 30, fig. 7.

1944. *Camarotoechia* sp. indet. by NONAKA. *Japan. Jour. Geol. Geogr., Vol. 19, Nos. 1-4*, p. 252, pl. 27, fig. 7.

Material:—Interiors and exteriors of each brachial and pedicle valve are in the collections.

Description:—Shell medium to large, moderately biconvex, equidimensional, pentagonal in outline with a strong sinuation at the anterior margin; the maximum width near the mid-length; costellae simple, obtusely triangular in cross section, beginning in beaks; a median fold and sulcus strong, originate from a portion about five millimeters anterior to the beak, well defined by a pair of bounding costellae, with three somewhat slender radial costellae in pedicle sinus and corresponding four costellae in brachial fold; interspaces narrower than the costellae, deep and of v-shaped bottom; the bounding costellae have steeper inner slopes as twice or tripple high as the other slopes; the lateral flanks costellate by six or seven radials, among which the lateral second or third ones from the bounding costellae strongest; anterior commissure line shrrply serrate, uniplicate; sparse and irregularly spaced growth lamellae recognizable; but closely set concentric lamellae are seen at the anterior margin of a fragmentary brachial valve; shell substance and microstructure unknown.

Pedicle valve with wide triangular interarea; hinge line straight, narrower than the maximum width of the shell; delthyrium triangular, open; hinge teeth slender, supported by short dental lamellae; muscle fields narrow, two-thirds the shell length being bordered laterally by dental lamellae and anteriorly by a low elevation of shell floor; adductor scars small, elongate oval, enclosed; a weak median myophragm in the muscle fields; inner surface roughly undulated being correspond to the radial costellae of the outer surface.

Brachial valve without interarea; hinge plates diverge anteriorly, not fused; no septarium recognizable; a thin, low median septum originates at the under surface of the cardinalia and extends anteriorly being merged into the central costation;

dental sockets lateral to the hinge plates; crural base supported by the hinge plates and does not extend to the shell floor; inner surface of shell crenulated owing to the outer costellation.

Comparison:—This indeterminable form is characteristic in its rather large shell size and few costellae in the median sulcus. A Middle Devonian *Camarotoechia* from South China, *C. parasappho* WANG (WANG et al. ed., 1964, p. 357, pl. 59, figs. 15-18), which once had been misidentified as a species of *Anastrophia*, has some similarity to this form in general outline. But *C. parasappho* has four costellae in the median sinus instead of three.

Another Chinese species described by HOU (1959), i. e. *Camarotoechia* cf. *nympha* (pl. 2, figs. 8a-d) looks like similar to the present form.

BOUCOT (1959) described *Camarotoechia* ? sp. which is provided with three costellae in the sulcus (pl. 90, figs. 11-17). This questionable species from the Lower Devonian of New York is, however, much smaller than this form.

"*Camarotoechia*" *sinuosa* (FUCHS) reported by BOUCOT (1960a, pl. 15, figs. 5-15) from the Belgian Lower Devonian has also some similarity. This species shows variation in the number of costellae in the pedicle sinus from 3 to 6.

Illustrated specimens:—005HA1, 224K_γ1, 290K_ρ1, 296K_τ1.

Order Spiriferida WAAGEN, 1883

Superfamily Atrypacea GILL, 1871

Family Atrypidae GILL, 1871

Subfamily Atrypinae GILL, 1871

Genus *Atrypa* DALMAN, 1828

(Type species: *Anomia reticularia* LINNE, 1758)

"*Atrypa*" sp. indet.

Plate 24, figs. 9a-d; Plate 30, fig. 8.

1944. *Atrypa desquamata* SOWERBY by NONAKA. *Japan. Jour. Geol. Geogr., Vol. 19, Nos. 1-4*, p. 252, pl. 27, fig. 8.

Material:—Only a brachial valve, which shows the interior and a part of the exterior, is found in the collection.

Description:—Shell medium in size, almost equidimensional, roundedly pentagonal in shell outline being narrowed anteriorly; the greatest width near the cardinal margin; moderately convex; a median fold broad and faintly developed; beak moderately prominent, only slightly incurved; surface costellated with high, round topped costellae being separated by interspaces of almost the same breadth as the costellae; costellae sometimes bifurcate at anterior and lateral margin; concentric growth lamellae marked as short frills.

Interior with divergent hinge plates; socket seems to be crenulate; crural base present; diductor muscle scars small and rounded being separated by a weak and broad myophragm at the middle; neither spiralia nor jugum observable.

Comparison:—This specifically indeterminable form probably belong to the reticularis type of *Atrypa* in wide sense. Though it was originally described as *A. desquamata* by NONAKA, careful examination of the material lead the present writer to conclude that it is not identifiable with that species.

ALEKSEEVA (1959) erected a subgenus *Desquamatia* based on *A.* (*D.*) *khavae*. According to her the European species *desquamata* belongs to this subgenus, which is ranked as a distinct genus later in the Treatise (1965, p. H639). *Desquamatia* is characterized by 1) in the moderately curved beak of the ventral valve, which does not conceal the foramen nor the delthyrium, 2) in having an interarea, 3) in the weakly developed concentric sculpture, and 4) in the dental lamellae which are well developed on the ventral valve (ALEKSEEVA, 1959, p. 421).

As the material available now is a brachial valve, only the third character of the above mentioned diagnoses is referable to it. NONAKA did not noticed the presence of distinct and even frilled growth lamellae impressed on the outer mold of the valve, so that he compared it with rather smooth *desquamata*.

In summarizing the Chinese atrypacians GRABAU (1932, p. 469) remarked that the most mutation of *desquamata* in China are provided with the resupinate brachial valve. However, the present form does not show such a shell curvature at all.

Incidentally, concerning the reticulation of the surface ornamentation, the Chinese *A. desquamata* (WANG et al., 1964, p. 435, pl. 72, figs. 14-17) shows rather remarkable development of the shell sculpture than the original designation of the genus. On the other hand, the Chinese *reticularis* (op. cit., p. 435, pl. 73, figs. 32-35) is characteristic in its rather finely ribbed and not frilled shell of an elongated form. In spite of the original definition of the genus, some species of *Desquamatia* illustrated by ALEKSEEVA (1962) herself show distinct and somewhat imbricated growth lamellae of *reticularis* type.

The typical species of *Spinatrypa* STAINBROOK, 1951, has fewer rounded plications than those of *Atrypa* and crossed by lamellose, spinose growth lamellae (*Treat.*, p. H640). The present form is also alike in this respect.

Spinatrypina RZHONSNITSKAYA (1964, p. 101) from the Lower Pragian Krekov bed of the Kuznetsk Basin has some similarities to the present indeterminable species in its external characteristics. *S. margaritoides* R. (op. cit., pl. 1, figs. 1-8) has somewhat coarse radial costellae, which bifurcate occasionally, and transected by rather distinct concentric rugae which make the shell surface imbricate appearance. According to her the genus *Desquamatia* occurs from the Devonian rocks higher than the Eifelian stage (*Megastrophia uralensis* zone) and *Spinatrypina* ranges from Lower Pragian to upper Frasnian.

As shortly viewed above, the surface ornamentation does not seem to be critical for the generic identification at the present status. Somewhat coarse costellation of this species only led the writer to put it tentatively in the genus *Atrypa* with quotation. Besides, there should be a considerable variation in shell form even with in a species of *Atrypa*, *Desquamatia*, *Spinatrypa* and *Spinatrypina*. Therefore, the specific determination is now retained until the sufficient material could be examined especially on the pedicle interior.

Illustrated specimen:—022HA3, 4.

Superfamily Dayiacea WAAGEN, 1883

Family Anoplothecidae SCHUCHERT, 1894

Subfamily Anoplothecinae SCHUCHERT, 1894

Genus *Bifida* DAVIDSON, 1882

(Type species: *Terebratula lepida* D'ARCHIAC & DE VERNEUIL, 1840)

Bifida orientalis HAMADA, sp. nov.

Plate 24, figs. 10–17.

Material:—Three of each pedicle interior and exterior and one brachial exterior at hand.

Description:—Shell small in size, less than 5 mm in length, oval in outline, plano-convex, broadly costellate.

Pedicle valve well convex, triangularly oval being pointed posteriorly, six to eight round-topped costellae from the beak of which the middle pair is broader and higher then the rests; concentric growth lamellae faintly preserved.

Pedicle interior with long, anteriorly divergent lateral teeth attached directly to the shell floor; no dental lamellae recognizable; muscle fields oval in outline, strongly impressed, occupying the anterior two-thirds the shell length; a median system well developed, along the whole shell length, thicker and higher at the anterior portion.

Brachial valve flat, oval in outline; beak improminent; six or eight ribs on the surface; the middle costellae is narrow and the pair to it strongest to form a shallow sulcus at the anterior margin; concentric lamellae weak and recognizable only at the anterior periphery.

Comparison:—The shell outline and the costellation of the present species agree well with the revised diagnosis of *Bifida* by BOUCOT, JOHNSON, and STATON, 1964, except somewhat poorly developed concentric growth lamellae which might partly due to the preservation in rather coarse matrices. Oval and strongly impressed pedicle muscle fields and a strong myophragm are characteristic of this new species. The upper Emsian *Coelospirina* HAVLÍČEK, 1956 is provided with almost similar costellation and concentric growth lamellae, but is different from *B. orientalis* in its weakly developed muscle fields in the pedicle valve.

Illustrated specimens:—090KA2, 093KA3 (holotype), 094KA3, 095KA4, 202K$_\beta$1, 203 K$_\beta$1, 217K$_\beta$3, 3′.

Suborder Athyrididina BOUCOT, JOHNSON, & STATON, 1964

Superfamily Athyridacea M'COY, 1844

Family Nucleospiridae DAVIDSON, 1881

Genus *Nucleospira* HALL, 1859

(Type species: *Spirifer ventricosus* HALL, 1857)

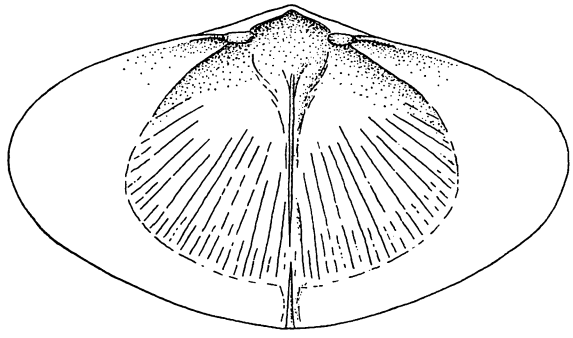
Nucleospira musculosa HAMADA, sp. nov.

Plate 25, figs. 1–4; text-fig. 21.

Material:—Four pedicle valve in the collections.

Description:—Shell fairly large for the genus attaining 27 mm in width at the maximum, transversely elongate oval in shell outline; form ratio, W/L, about 1.8; strongly and uniformly convex with a poorly defined, broad fold at the anterior margin; lateral periphery broadly rounded; anterior commissure line almost rectimarginate; shell surface smooth.

Pedicle interior with a broad triangular, open delthyrium; thick, laterally elongate hinge teeth project antero-dorsally at the delthyrial margin on hinge line; no dental lamellae recognized; a low, thin and long median septum originates at a place of posterior one-fourth the shell length and reaches to the anterior margin where the extremity is inflated and form a narrow mound; diductor muscle fields well impressed occupying approximately three-fifths the shell width and four-fifths the shell length, trigonally oval or cordate in shape being flabellate anteriorly, radially striated at the anterior half portion; adductor scars enclosed near the posterior margin of the field, small, elongate oval being separated by a median septum at the anterior half.



Text-fig. 21. *Nucleospira musculosa*, sp. nov.
Pedicle interior (×2.5).

Comparison:—This new species is characterized by the large shell size with fairly transverse shell outline. The pedicle interior with large, well impressed muscle scars and the median septum is also diagnostic hence the specific name.

Nucleospira asiatica NIKIFOROVA (1964, p. 82, pl. 1, figs. 1-14) has large, well marked muscle scars, but the median septum is characteristically broad and does not attain the anterior shell periphery. The shell outline is much roundish in this Silurian form from Tschatkalisk.

Illustrated specimens:—045HF1, 057HF2, 087KA2, 3 (holotype), 098KA3.

Superfamily Cyrtinacea FREDERICKS, 1912

Family Cyrtinidae FREDERIKS, 1912

Genus *Cyrtina* DAVIDSON, 1858

(Type species: *Calceola heteroclita* DEFRANCE, 1828)

Cyrtina sp. indet.

Plate 25, figs. 5-8.

Material:—One steinkern and its brachial exterior, two impressions of brachial exterior and a brachial interior are available for examination.

Description:—Shell small in size, moderately biconvex with high pedicle interarea, transversely elongate, wider than long; form ratio varies from 1.3 to 2 in approximation; cardinal extremities alate; the maximum width at hinge line which is straight with narrow brachial and wide pedicle interareas; a narrow and well defined median fold smooth on its surface; each flank ornamented by five to six simple, narrower costellae with well rounded cross section; interspaces deep and shallow; anterior commissure line slightly uniplicate; surface seems to be faintly striated by concentric growth lamellae; no radial striae recognizable; shell substance unknown.

Pedicle interior with prominent spondylium; area highly apsacline; other cardinal characters unpreserved.

Brachial interior with short, anteriorly divergent crural bases which are medianly separated by an open notothyrium; notothyrium seems to be filled with a chilidium and also secondary shell substance at the anterior portion; dental sockets lateral to the crural bases, shallow and narrowly triangular in shape; crural bases project anteriorly being supported by the shell fillings posteriorly; a median myophragm extremely short and slender, originates at the base of a massive cardinal process; muscle impressions not well preserved.

Comparison:—A great variation in shell form, especially in the pedicle valve, of *Cyrtina heteroclita intermedia* OEHLERT is well displayed by IVANOVA (1962, pp. 28-33, pl. 4, figs. 1-10). The width of the median fold in brachial valve and the number of radial ribs on the flanks also extremely variable and are by no means of the diagnostic features of species. Therefore, the present writer regards the transversely elongated form (figs. 5, 6, Pl. 25) as conspecific with the somewhat shorter form (figs. 7, 8, Pl. 25), though no specific name is given to such incompletely known material.

Illustrated specimens:—061HG1, 100KA3, 239K$_7$1, 286K$_0$1, 1′.

Superfamily Delthyridacea PHILLIPS, 1841

Family Delthyrididae PHILLIPS, 1841

Subfamily Acrospiriferinae TERMIER & TERMIER, 1949

Genus *Acrospirifer* HELMBRECHT & WEDEKIND, 1923

(Type species: *Spirifer primaeva* STEININGER, 1853)

Acrospirifer sp. indet.

Plate 28, figs. 3-7; text-fig. 22.

Material:—Four brachial valves and a pedicle exterior are in the repository.

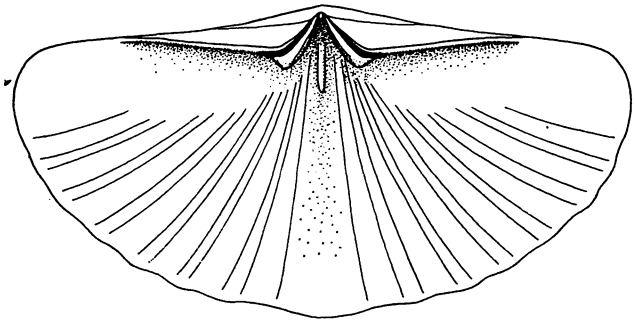
Description:—Shell large, transversely elongate; moderately biconvex; cardinal extremities rounded, not alate; the maximum width in the posterior half of shell length, but not at the hinge margin; surface multicostate with low, broad, flattish radial costae; a broad, deep median sulcus on pedicle valve and a well raised median fold on brachial valve; brachial fold bald and pedicle sulcus seems to have a narrow

ridge in the middle; seven to nine costae on each flanks being diminish in their strength towards the anterior and lateral margin of the shell where the surface is almost non-costate in some large individuals.

Micro-ornamentation and shell structure not preserved.

Pedicle valve with a moderately high interarea; beak not highly pointed and slightly incurved; area moderately apsacline; interior inobservable.

Brachial interior with a widely open notothyrium; cardinal plates long, anteriorly divergent and parallel to the notothyrial periphery; sockets narrow and deep being supported by recurved crural bases; cardinal process multistriated and weakly prominent being merged into the secondary shell deposition; a low, short median myophragm anterior to the cardinal process and does not connected to it.



Text-fig. 22. *Acrospirifer* sp. indet.
Brachial interior (×1.5).

Comparison:—The rounded cardinal extremities and the low, broad costae, which diminish their height toward the shell periphery, are quite diagnostic to this indeterminable species.

Acrospirifer is, according to the Treatise (p. H685), provided with strong, angular plications being entirely different from the present form. However, some Russian and Chinese species with low, flattish radial costae have been referred to this genus. For example, *Acrospirifer pseudofallax* (KHALFIN), *A. subgregarius* RZHONSNITSKAYA and *A. korovini* (KHALFIN) from the Lower-Middle Devonian beds in the Gornyi Altai (GRATSIANOVA et al. in KHALFINA ed., 1961, pl. D74, figs. 1-5) and *A. pseudocheechiel* HOU from the Middle Devonian Kenlyho Formation of Northeast China (the Greater Khingan Range) are all characteristic in rather weak development of the radial costae. Above all, the present form is similar to *A. korovini* (KHALFIN) in its mode of costation and transversely elongate shell outline with the blunt cardinal extremities. The greater Khingan species has rather few number of radial costae on the flanks.

Illustrated specimens:—046HF1, 2, 281K$_{\xi}$1, 282K$_{\xi}$1, 315K$_{\phi}$1, 339KnE1.

Genus *Howellella* KOZLOWSKI, 1946

(Type species: *Terebratula crispus* HISINGER, 1826)

"Howellella" amurensis HAMADA, sp. nov.

Plate 25, figs. 11–17; Plate 26, figs. 1–7;
Plate 26, fig. 1; Plate 30, fig. 9;
text-fig. 23.

1943. *Spirifer tonkinensis* MANSUY, NONAKA. *Japan. Jour. Geol. Geogr., Vol. 19, No. 1–4*, p. 253, pl. 23, fig. 9.

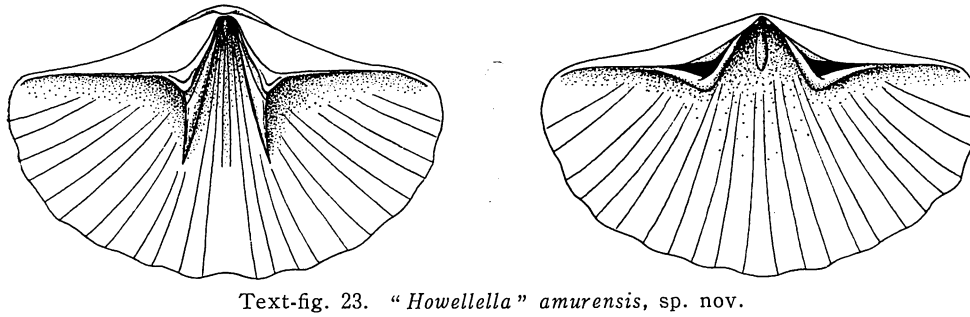
1959. *Acrospirifer* cf. *cyclopterus* (HALL), HOU. *Acta Palaeont. Sinica, Vol. 7, Pt. 2*, p. 128, pl. 3, figs. 7–9.

Material:—Approximately twenty-five specimens, most of them are disarticulated, are in the depository.

Description:—Shell large in size for the genus, transversely elongate oval in outline; from ratio approximately 1.2–1.8; not mucronate, the cardinal extremities well rounded; the maximum width at a portion slightly anterior to the hinge line; hinge line straight; unequally biconvex with slightly larger convexity of pedicle valve; anterior commissure crenulate; six radial costae distinct on each flank, rounded-topped in cross section; interspaces narrower than costae, rounded-bottomed; ventral sulcus and dorsal fold well developed, bald, not carinate, and remarkable from the beak; surface micro-ornamentation not distinct; a few growth lamellae near the shell periphery; shell structure unknown.

Interarea of pedicle valve moderately high, triangular, slightly apsacline, incurved, with a large, open and orthotrigonal delthyrium; neither pseudodeltidium nor secondary filling of delthyrial cavity recognizable; cardinalia not thickened and the steinkern has no rostral cone; dental lamellae thin and occupy the posterior one-third of the shell length, almost parallel to the radial ribs except their anterior extension where they slightly incurved to reach next costae to the bounding ribs of the median sulcus; on extremely slender median ridge at the posterior portion, originates from a small, low and elongate ventral platform in the delthyrial cavity; muscle fields weakly impressed between the dental lamellae and separated by the median ridge.

Brachial valve with a low, narrow interarea; area anacline and striated obliquely on its surface being parallel to the notothyrial margin; notothyrium open, triangular; sockets shallow and rapidly expand anteriorly; crural plates support the discrete hinge plates which reflect and form the dental sockets; a weakly developed short



Text-fig. 23. *"Howellella" amurensis*, sp. nov.
Pedicle (A) and brachial (B) interiors (×1.5).

and low myophragm is in the notothyrial cavity; at the posterior extremity of the cavity, or just inside the brachial beak, there is a medianly grooved cardinal process-like inflation of the shell floor which project anteriorly in some larger individuals; muscle fields feebly impressed.

Comparison:—This new species was first identified by NONAKA (1944) as *Spirifer tonkinensis* MANSUY, which once had been called *Rostrospirifer tonkinensis* by GRABAU. Recently the genus *Rostrospirifer* is supported to be synonymous with *Euryspirifer* WEDEKIND (*Treat.*, p. 685), though HOU (1959b) placed *tonkinensis*, which is the type species of *Rostrospirifer*, in *Acrospirifer* in examination an abundant specimens. Besides, according to him (HOU, 1959a) the Lesser Khingan form may tentatively be referred to the North American *Acrospirifer cyclopterus* (HALL) but not to the Chinese *tonkinensis*. However, *cyclopterus* is now regarded as a species of genus *Howellella* by BOUCOT (1957) and AMSDEN (1958).

The genus *Howellella* is characterized by lamellose exterior and well developed, laterally divergent dental plates and invariably developed crural plates in the brachial valve, being distinguished from the external homeomorph brachiopods, i. e., *Acrospirifer* and *Hysterolites* (BOUCOT, 1957). Although *Howellella* was first described as it is provided with rows of simple spines along the growth lamellae, TALENT (1956) and AMSDEN and VENTRESS (1963) noted that some species have distinctly double-barrelled spines. According to the revised study on the genus done by BOUCOT (1957), there are some additional diagnostic characteristics such as the presence of myophragm in pedicle valve. HAVLICEK (1959, p. 86 or 236) noticed that the basal plate (=crural plates) of *Howellella* converge in the direction towards the inner surface of the valve and rest on it by its inner edges while those in the genera *Hysterolites* and *Acrospirifer* do not meet the floor so that they are supported only by the subsocket plates.

In regard to these diagnostic the present new species is almost identical with *Howellella* in generic rank except the unknown nature of spine arrangement. However, it is worthy to note that this form obviously belongs to a group of multicostellate shell but not to a paucicostellate group such as *Howellella modesta* (HALL) (ex. BOWEN, 1967, pl. 6, figs. 21-28), *H. nucula* (BARRANDE) and its Australian subspecies *H. n. australis* SAVAGE (1969, p. 480, pl. 91, figs. 1-35).

"*Howellella*" *amurensis* resembles to *H. cycloptera* (HALL) to some degree, so as HOU (1959b) reasonably referred to it as the closest ally. *H. cycloptera* was recently described and illustrated in great detail by AMSDEN (1958, p. 125, pl. 8, figs. 14-26). According to him, the Bois d'Arc form is fairly variable in the form ratio and the number of costae on the flanks. He showed the postero-ventrally convergent dental lamellae almost fused with each other on the shell floor beneath the delthyrium. In the present new species the dental lamellae are, however, almost straight and sub-parallel. Consequently the delthyrial cavity remains open in "*H.*" *amurensis* showing the inside with a small median septum.

Howellella mercuri GOSSELET is widely distributed in the European Lower Devonian as well as in the Altai-Khazakstan area. This species was criticizedly described by BOUCOT (1960, pp. 313-314, pl. 16, figs. 8-12) and also by DROT (1964, p. 38, pl. 1, figs. 6-13; pl. 2, fig. 1). The dental lamellae of this species occupy the

first lateral interspaces. The present new species, however, has larger shell size than that species and its dental lamellae occupy the second lateral interspaces and incurved anteriorly to reach the first lateral interspaces. VANDERCAMMEN also illustrated *H. mercuri* excellently (1963, pp. 116-119, pl. 11, figs. 9-11). He showed the brachial cardinal process at the posterior end of the notothyrial cavity in his restored figure (p. 118, fig. 77). The comparative structure is seen on this new species, though it is distinctly divided medianly by a narrow groove (ex. Pl. 27, figs. 1d, e).

The Australian *H. textilis* described by TALENT (1963, p. 81, pl. 50, figs. 1-43) also has well developed crural plates, but the shell size is fairly smaller in size and provided with fewer lateral plications that "*H.*" *amurensis*. Besides, the dental lamellae of *textilis* occupy the first lateral interspaces anteriorly reach the bounding ribs of ventral sulcus.

Illustrated specimens:—019HA3, 7 (holotype), 041HF1, 044HF1, 049HF1, 050HF1, 063HH1, 089KA2, 167KQ1, 188KX1, 222K$_{\gamma}$1, 230K$_{\zeta}$1, 1′, 271K$_{\mu}$1, 283K$_{\xi}$1, 338KnE1, 340KnF1, 352KnJ1.

Subfamily Paraspiriferinae PITRAT, 1965

Genus *Paraspirifer* WEDEKIND, 1926

(Type species: *Spirifer cultrijugatus* ROEMER, 1844)

Paraspirifer aff. *cultrijugatus* (ROEMER)

Plate 27, figs. 2-7; Plate 28, fig. 2;
Plate 29, figs. 9, 10.

1959. *Acrospirifer* aff. *gaspensis* (BILLINGS), HOU. *Acta Palaeont. Sinica, Vol. 7, Pt. 2*, p. 129, pl. 3, figs. 10-13.

1968. *Paraspirifer* ex gr. *cultrijugatus* (ROEMER), MODZALEVSKAYA. *Proc. Intern. Symp. Dev. System, Calgary, 1967, Vol. 1*, p. 552, pl. II, figs. 13a-d.

Material:—A brachial and five pedicle valves and several fragmentary specimens at hand.

Description:—Shell large, subquadrate, wider than long, moderately biconvex with the greater convexity on the brachial valve; the maximum width at the posterior one-third the shell length; cardinal margin obtusely rounded; a median fold and sulcus well developed, high and deep respectively, rounded v-shaped and bald except a few faint radial costellae at the middle of the pedicle sulcus; anterior margin deeply uniplicate being the pedicle sulcus projects into a tongue dorsally; flanks costate by low, simple, flat-topped radial costae which diminish in size and strength towards the postero-lateral extremities; interspaces much narrower than costae, shallow and round-bottomed; seven to nine costae on each flank recognizable; fine ornamentation and shell structure unknown; irregularly spaced concentric growth lamellae near the anterior margin of the larger specimens.

Pedicle valve with a prominent beak which is slightly overhanging the interarea; hinge line straight, slightly shorter than the maximum width; interarea apsacline, high and incurved; delthyrium large, triangular, open, occupying almost one-fourth the shell width in breadth; ventral sulcus deep, well prominent dorsally to form a

spatula.

Internally thin dental lameller well developed and support massive teeth at the delthyrial margin; teeth project dorsally from the hinge line in triangular shape; a ventral process of fusiform small and superimposed in the delthyrial cavity; no median septum; muscle fields between the dental lamellae moderately impressed with longitudinal striations and cross striae; adductor scars narrow and elongate; anterior bases of dental lamellae incurved and convergent a little; inner surface of the shell weakly crenulate being correspond to the surface costation, and the posterior margin, especially the outside portion of dental lamellae, pustulate owing to the secondary shell thickening.

Brachial valve well convex; beak not prominent and small being rarely overhang the interarea; hinge line straight; postero-lateral margin rounded; a median fold straight; postero-lateral margin rounded; a median fold remarkable, rounded triangular in cross section, bald; the anterior portion of the bounding costae slightly grooved; the bounding costae seem to be strongest among the costae on the flanks.

Brachial interior unknown.

Comparison:—This form was first described by HOU (1959) from the Lesser Khingan Devonian as an ally to the North American *gaspensis*. Although the typical *gaspensis* was once regarded as *Acrospirifer* (SHIMER & SHROCK, 1944, p. 323, pl. 121, figs. 9-11), BOUCOT recently (1957, p. 317) placed it in the genus *Howellella*. As described above, this form is characteristic in having the low, broad costellae with the anteriorly grooved bounding costae and neither a median septum nor the secondary filling material near the beaks interiorly. These are the distinctive features of the genus *Paraspirifer* and by no means of *Acrospirifer*. Furthermore, this form is well impressed by the pedicle muscle fields between the moderately incurved deltal lamellae, and also provided with a wide and well defined V-shaped median plication. These features are, of course, not typical of *Howellella*.

Owing to the poverty of material, it is rather difficult to determine the precise specific name in the present status. However, the general feature almost coincides with the European *Paraspirifer cultrijugatus* (ROEMER), except for somewhat fewer number of costae on the lateral flanks. The Onondagan *P. acuminatus* (CONRAD) has a much broader median plication with an acute crest especially on the frontal margin of the shell.

Paraspirifer (?) *gurjevskiensis* RZHONSNITSKAYA from the Lower-Middle Devonian of Salair and the Lower Devonian of Gornyi Altai (IVANOVA in *Osnovy*, 1960, p. 273, pl. 42, figs. 8, 9; GRATSIANOVA in KHALFINA ed., 1961, p. 467, pl. D73, fig. 12) has no grooved bounding costae and characteristic in its rather well marked median fold and sulcus with a narrow groove and ridge in the middle respectively. This species may not be of the genus *Paraspirifer* but seems to belong to *Brevispirifer*, which sometimes has a median groove and ridge on the fold and sulcus respectively, as far as the shell exterior is concerned.

MODZALEVSKAYA (1968) illustrated an exterior of *Paraspirifer* ex gr. *cultrijugatus* from the Lower Devonian Bolsheneverskaya formation in the Upper Amur district. This specimen is somewhat ill-preserved, but seems to have the anteriorly grooved bounding costae on the brachial valve. The present writer regards it as conspecific

with this Lesser Khingan form, though the interior is unknown.

Illustrated specimens:—004HA1, 174KR1, 176KS1, 260K$_{\kappa}$1, 2, 272K$_{\mu}$1, 350KnI1, 351KnJ1, 354KnK1, 1′.

Subfamily Fimbrispiriferinae PITRAT, 1965

Genus *Fimbrispirifer* COOPER, 1942

(Type species: *Spirifer venustus* HALL, 1860)

Fimbrispirifer cf. *divaricatus* (HALL)

Plate 28, figs. 1a, b.

1963. *Fimbrispirifer* cf. *F. divaricatus* (HALL), AMSDEN & VENTRESS. *Oklahoma Geol. Surv. Bull., No. 94*, p. 180, pl. 18, figs. 2-11.

Material:—Only an incomplete pedicle interior is in the repository.

Description:—Shell large, seems to be transversely elongated, moderately convex; hinge line straight; a broad, ill-defined median sulcus ornamented by numerous costae which are bifurcate anteriorly; costae on lateral flanks slightly broader than those in sulcus and less frequently bifurcate; muscle impression large, roundedly diagonal in outline, occupying approximately two-thirds the shell length, radially striated at anterior portion and separated by a low, broad septu-like median ridge; muscle fields encircled by a low shell inflation which continues posteriorly to the dental lamellae; dental plates short and thin, support the teeth at the delthyrial margin; irregularly spaced concentric growth lamellae at the anterior shell periphery.

Shell micro-ornamentation, shell structure and brachial valve unknown.

Comparison:—This imperfectly known form shows a strong similarity to *F.* cf. *divaricatus* described by AMSDEN and VENTRESS from the Shallishaw Formation of the Esopus stage.

F. divaricatus (HALL) illustrated by COOPER (in SHIMER & SHROCK, 1944, pl. 123, figs. 1-2) has rather paucicostate shell than the typical specimens (HALL, 1867, p. 213, pl. 32, figs. 1-9) which were described as *Spirifera divaricata*. The types species of the genus *F. venustus* (HALL) has larger shell outline than *divaricatus* (COOPER in SHIMER & SHROCK, 1944, pl. 132, figs. 32, 33). "*Spirifer*" gen. et sp. nov., which to be dosely allied to *Fimbrispirifer* from the Lower Devonian Beechwood Limestone in Kentucky (BOUCOT et al., 1958, pl. 1, figs. 6-8) differ from *F. divaricatus* in having the pedicle muscle fields without any dividing ridge in the middle.

Fimbrispirifer pseudoconcinus (NIKIFOROVA) from the Lower Devonian Belyak horizon (*Eoglossinotoechia taimyrica* zone) in the Upper Kolyma region NIKOLAEV & RZHONSNITSKAYA, 1968, p. 490, pl. 2, fig. 6) also has a transversely elongate shell form, but is provided with fewer costae on the median fold than the above stated two species and the present form. Another transversely elongate *Fimbrispirifer* is known from the upper Siegenian—lower Emsian beds of Pre-Sahara Marroc, and described as *F.* (?) *trigeri* (DE VERNEUIL) by DROT (1964, p. 63, pl. 5, figs. 2a-c).

Illustrated specimen:—153KN1.

Spiriferid gen. et sp. indet.

Plate 25, figs. 9, 10a, b.

Material:—Interior and exterior of brachial valves are in the collections.

Description:—Shell small in size, extremely elongate in transverse direction, moderately convex; form ratio, W/L, approximately 3 or more; cardinal extremities alate; a median sinus well developed, widely triangular and bald; lateral flanks multicostate with more than ten simple, round-topped costae; interspaces narrower than the costae.

Internally short but thick dental plates developed; interarea high with a widely open delthyrium; muscle fields faintly impressed; no median septum recognizable.

Micro-ornamentation and shell structure undetectable.

Comparison:—This indeterminable species is characteristic in its extremely wide shell outline with a broad median sulcus and multicostae on the flanks. *Acrospirifer lungmenshanensis* (YOH), which originally had been called *Euryspirifer paradoxus* var. *lungmenshanensis* and has been revised as *Rostrospirifer lungmenshanensis* by WANG (1955), from the Middle Devonian of China has almost similar shell exterior (WANG et al., 1964, p. 527, pl. 99, figs. 14, 15, 17). However, it is described as provided with a low median septum internally, being different from the present form. The Couvinian *Neodelthyris sinensis* HOU, 1963, is also similar to this indeterminable form in general features except much higher and sharp costae on the flanks. The above stated two Middle Devonian species from China have larger shell size.

The present writer presumes that this form belongs to the Subfamily Delthyridinae. But poorly preserved specimens are not quite enough to make any conclusion on the taxonomic position for this spiriferid.

Illustrated specimens:—192KZ1, 229K$_2$1.

VI. APPENDIX

Two Middle Devonian Brachiopods from the Mishan District, Northeast China.

Descriptions on stratigraphy and occurrence of the brachiopods are given in page 15 of this paper.

Systematic Description

Order Strophomendia ÖPIK, 1934

Suborder Strophomenoidae MAILLIEUX, 1932

Superfamily Strophomenacea KING, 1846

Family Leptenidae HALL & CLARKE, 1894

Genus *Leptaena* DALMAN, 1828

(Type species: *Leptaena rugosa* DALMAN, 1828)

Leptaena "rhomboidalis" (WILCKENS)

Plate 29, fig. 11.

1940. *Leptaena rhomboidalis* (WILCKENS), YABE. *Proc. Imp. Acad. Tokyo, Vol. 16, No. 10,* p. 557, fig. 3.

non 1959. *Leptaena rhomboidalis* (WILCKENS), HOU. *Acta Palaeont. Sinica, Vol. 7, No. 2,* p. 125, pl. 2, figs. 3, 4.

non 1964. *Leptaena "rhomboidalis"* (WILCKENS), WANG et al. ed. *Brach. Fossils of China, Vol. 1,* pp. 185-186, pl. 26, fig. 15.

Material:—Only an exfoliated pedicle valve on a limestone slab with *Mucrospirifer* cf. *parrdoxiformis* and bryozoans remains in the repository.

Description:—Shell medium in size, rhomboidal in outline; disc area almst flat; shell with straight hinge line and a slightly prominent beak; the maximum width at the hinge margin; anterior fringe area not preserved; radial costellae slender, evenly spaced, about 20 in a space of 5 mm, increase in number by implantation; concentric corrugations narrow but distinctly marked, regularly increase in distance as the shell grows except at the anterior margin where they suddenly become broader; posterior end of these corrugations end at the hinge margin with an angle of approximately 70-80 degrees.

Comparison:—This Mishan form is distinctive from the Lesser Khingan form, *Leptaenopyxis bouei* (BARRANDE), in its smaller size and the flattish disc area with finer corrugations. Though HOU (1959) and WANG et al. (1964) regarded the Mishan form is specifically identical with the Lesser Khingan form, the present writer is of opinion that the Mishan form and also YABE's material (1940) are significantly different from *L. bouei,* especially in its delicate surface ornamentation and small shell size.

Concerning the size and general outline, it is somewhat similar to *L. "rhomboidalis"* var. *kwangsiensis* from the Middle Devonian of South China. However, that species is provided with rather coarse costellae than the present form (WANG et al. ed., 1964, p. 186, pl. 26, fig. 14).

Leptaena rhomboidalis (WILCKENS) illustrated by GOSSELET et al. (1920, pl. 11, figs. 26, 27) has a great similarity in its external features except somewhat roundish shell outline.

Illustrated specimen:—356MA1.

Order Spiriferida WAAGEN, 1883

Superfamily Spiriferaceae KING, 1846

Family Mucrospiriferidae PITRAT, 1965

Genus *Mucrospirifer* GRABAU, 1931

(Type species: *Delthyris mucronata* CONRAD, 1841)

Mucrospirifer cf. *paradoxiformis* HOU

Plate 29, figs. 1a-f.

Cf. 1959. *Mucrospirifer paradoxiformis* HOU. *Acta Palaeont. Sinica, Vol. 7, Pt. 3*, pt. 132 (p. 154, in Russ.), pl. 6, figs. 1, 2.

1964. *Mucrospirifer paradoxiformis* HOU, WANG et al. ed. *Brach. Foss. China, Vol. 2*, p. 480, pl. 83, fig. 23.

Material:—Only an external impression of pedicle valve and its incomplete steinkern are in the repository.

Description:—Pedicle valve alate, transversely elongate; form ratio, W/L, approximately 2.5; hinge line straight, slightly shorter than the maximum width; interarea narrow, flattish, moderately apsacline; shell uniformly convex; a median sulcus wide and deep with a faintly raised median ridge in it, being defined by a pair of bounding costae which are the strongest among the costae on the flanks; costae simple and lowly round-topped, 13 or 14 on each flank; the strength of these costae diminish towards the cardinal extremities where the shell surface becomes almost smooth; no striae recognizable on radial costae and bottom of the interspaces; weak but somewhat densely set lamellose growth lines near the shell periphery; shell structure unknown.

Interior poorly known; short dental lamellae incurved and cross the median sulcus at the bounding costae; muscle fields oval in shape though the posterior portion is missing on the specimen; no median septum at the anterior portion of the fields; inner shell surface crenulated at the shell periphery corresponding to the external costation.

Comparison:—The typical *Mucrospirifer paradoxiformis* was reported from the Middle Devonian Kenlyho Formation and described as it has the large form ratio attaining 3.0. The number of costae on lateral flank is reported as 15-16 on each side. This Mishan specimen has, however, lesser number of costae and less wider shell form. Another difference is in the pedicle sulcus on which the present form has a faintly raised median ridge. In this respect, it reminds the writer of *Mucrospirifer ales* (KHALFIN) from the Lower Frasnian bed in Kuzbass (GRATSIANOVA in KHALFIN ed., 1960, p. 462, pl. D72, figs. 12, 13). The median ridge in the sulcus is much stronger in this Russian form than the present specimen.

Illustrated specimen:—355MA1, 1′.

Glossary of Geographical Names in China, Korea and Japan described in this paper

Bokudo	博克図
Changchun	長春
Chenchohoushan	珍珠后山
Cheruho	綽爾河
Daholyho	大河里河
Dinchanchen (Kinshan-chen)	金山鎮
Erhtaokou (Er-Tao-Gou)	二道溝
Fukuji	福地
Greater Khingan range (Great Khinganling)	大興安嶺
Guanwu river	関烏河
Hailito river	河里図河
Heitai	黒台
Houlungmen	崔竜門
Inner Mongolia	内蒙古
Irekude	伊列克得
Kawauchi (*Kawauti*)	川内
Kakkoku line	崔黒線
Kenlyho	根里河
Kinsui	金水
Kirin (Jirin; *Kitsurin*)	吉林
Korea (*Tyosen, Chosen*)	朝鮮
Kwangsi	広西
Laho	裸河
Lesser Khingan (Little Khingan; Minor Khingan) range	小興安嶺
Lienghuashan	蓮華山
Lukou	鹿溝
Mammo	満蒙
Manchuria (Manchou; *Mansyu*)	満洲
Mishan	密山
Mongolia	蒙古
Nakazato	中里
Nichiuho	泥鰍河
Nünkiang (-hsien) (Ninkiang, Nenkiang)	嫩江 (県)
Ono (*Ohno*)	大野
Sinano-mura	信濃村
Sino-Korea platform (massif)	中朝陸台 (陸塊)
Suhuho	蘇呼河
Szupai	四排
Takaharagawa	高原川
Takainari	高荷稲
Taminshan	大明山
Telychiho	特里赤河
Tien Shan	天山
Tonking	東京
Tungkulan	東古蘭
Wantashan	完達山
Wodu river	窩都河
Wunuerh	烏奴爾
Yunnan	雲南

(Japanese spellings are in italics)

VII. REFERENCES

AHNERT, E. (1928): Morphologische und geologische Skizze des russischen fernen Ostens und Nordmandschuriens. *Proc. Third Pan-Pac. Sci. Congr. 1926, Vol. 1,* pp. 491-533.

ALEKSEEVA, R.E. (1960): New Subgenus *Atrypa* (*Desquamatia*) of the Family Atrypidae GILL (Brachiopoda). *Dokl. Akad. Nauk, U.S.S.R., Vol. 131, No. 2.*

——— (1962): Devonian Atrypids of Kuznetsk and Minusinsk Basins and Eastern Slope of South Urals. Akad. Nauk, U.S.S.R. Siberian Branch.

ALLAN, B. (1947): A Revision of the Brachiopods of the Lower Devonian Strata of Reefton, New Zealand. *Jour. Paleont., Vol. 21, No. 5,* pp. 436-452.

AMOS, A. & BOUCOT, A.J. (1963): A Revision of the Brachiopod Family Leptocoeliidae. *Palaeont., Vol. 6, Pt. 3,* pp. 440-457.

AMSDEN, T.W. (1958): Stratigraphy and Paleontology of the Hunton Group in the Arbuckle Mountain Region. Part II-Haragan Articulate Brachiopods. *Oklahoma Geol. Surv., Bull., No. 78.*

——— (1958): Ditto. Part III-Supplement to the Henryhouse Brachiopods. *Ibid., No. 78.*

——— (1958): Ditto. Part V-Bois d'Arc Articulate Brachiopods. *Ibid., No. 82.*

——— (1963): Early Devonian Brachiopods of Oklahoma. Part II. Articulate Brachiopods of the Sallisaw Formation (Devonian). *Ibid., No. 94.*

——— (1963): Ditto. Part III-Supplement to the Haragan (Devonian) Brachiopods. *Ibid., No. 94.*

——— & VENTRESS, W.P.S. (1963): Early Devonian Brachiopods of Oklahoma. Part I. Articulate Brachiopods of the Frisco Formation (Devonian). *Ibid., No. 94.*

ARBER, M.A. (1940): The Relation of the Valves to the Pedicle in the Strophomenid Brachiopods. *Geol. Mag., Vol. 77, No. 2.*

BARRANDE, J. (1879): System silurien du Centre de la Bohême, *Vol. 5,* Brachiopodes. 226p.

BERKEY, C.P. & MORRIS, F.K. (1927): Geology of Mongolia. *Nat. Hist. Centr. Asia, Vol. 2.*

BIERNAT, G. (1959): Middle Devonian Orthoidea of the Holy Cross Mountains and their Ontogeny. *Palaeont. Polonica, No. 10.*

BILLINGS, E. (1874): Paleozoic Fossils. *Canada Geol. Surv., Vol. 2,* 144p.

BOUCOT, A.J. (1957): Revision of some Silurian and Early Devonian Spiriferid Genera and Erection of Kozlowskiellinae, New Subfamily. *Senckenberg. Leth., Bd. 38, Nr. 5-6.*

——— (1959): Brachiopods of the Lower Devonian Rocks at Highland Mills, New York. *Jour. Paleont., Vol. 33, No. 5,* pp. 727-769.

——— (1960a): Lower Gedinnian Brachiopods of Belgium. *Mém. Inst. Géol. Univ. de Louvain, Tom. 21.*

——— (1960b): A new Lower Devonian Stropheodontid Brachiopod. *Jour. Paleont., Vol. 34, No. 3,* pp. 483-485.

——— (1960c): Implications of Rhenish Lower Devonian Brachiopods from Nova Scotia. *Rep. XXI Intern. Geol. Congr. Norden 1960, Pt. XII (Reg. Geol.),* pp. 129-137.

——— (1963): The Eospiriferidae. *Palaeont., Vol. 5, Pt. 4.*

——— & AMSDEN, T.W. (1958): Stratigraphy and Paleontology of the Hunton Group in the Arbuckle Mountain Region. Part IV-New Genera of Brachiopods. *Oklahoma Geol. Surv., Bull., No. 78.*

——— & ——— (1964): *Chonostrophiella,* a new Genus of Chonostrophid Brachiopod. *Jour. Paleont., Vol. 38, No. 5,* pp. 881-884.

——— & ARNDT, R. (1960): Fossils of the Littleton Formation (Lower Devonian) of New Hampshire. *Geol. Surv. Prof. Pap. 334-B,* pp. 41-51.

———, GAURI, K.L. & JOHNSON, J.G. (1966): New Subfamily Proschizophoriinae of Dalmanellid Brachiopods. *Paläont. Zeitschr., Bd. 40, Nr. 3-4,* pp. 155-172.

——— & HARPER, C.W. (1968): Silurian to Lower Middle Devonian Chonetacea. *Jour. Paleont., Vol. 42, No. 1.*

——— & JOHNSON, J.G. (1967): Species and Distribution of *Coelospira* (Brachiopoda). *Ibid., Vol. 41, No. 5.*

——— & ——— (1967): Paleogeography and Correlation of Appalachian Province Lower Devonian Sedimentary Rocks. *The Tulsa Geol. Soc. Digest, Vol. 35* (Symp. Volume) "Silurian-Devonian Rocks of Oklahoma and Environs".

——— & ——— (1968): Appalachian Province Early Devonian Palaeogeography and Brachiopod Zonation. *Proc. Intern. Symp. Dev. System, Calgary, 1967, Vol. 2,* pp. 1255–1267.

———, ——— & STATON, R.D. (1964): On some atrypoid, retzioid, and athyridoid Brachiopoda. *Jour. Paleont., Vol. 38, No. 5,* pp. 805–822.

———, ——— & TALENT, J.A. (1968): Lower and Middle Devonian Faunal Provinces based on Brachiopoda. *Proc. Intern. Symp. Dev. System, Calgary, 1967, Vol. 1.*

———, ——— & ——— (1969): Early Devonian Brachiopod Zoogeography. *Geol. Soc. Amer., Spec. Pap. 119,* 107pp.

———, ——— & WALMSLEY, V.G. (1965): Revision of the Rhipidomellidae (Brachiopoda) and the Affinities of *Mendacella* and *Dalejina. Jour. Paleont., Vol. 39, No. 3.*

———, MACDONALD, G.J.F., MILTON, C. & THOMPSON, J.B. Jr. (1958): Metamorphosed Middle Paleozoic Fossils from Central Massachusetts, Eastern Vermont, and Western New Hampshire. *Bull. Geol. Soc. Amer., Vol. 69, No. 7,* pp. 855–870.

BOWEN, Z.P. (1966): Brachiopods and Stratigraphy of the Below Ridge Sandstone (Lower Devonian) of Pennsylvania, Maryland and West Virginia. *Jour. Paleont., Vol. 40, No. 5.*

——— (1967): Brachiopoda of the Keyser Limestone (Silurian-Devonian) of Maryland and Adjacent areas. *Geol. Soc. Amer., Mem. 102.*

BUBLITSCHENKO, N.L. (1960): Terrigene Fazies des Devons in Kasachstan. *Prager Arbeitstagung über die Stratigraphie des Silurs und des Devons, Praha, 1958,* pp. 425–436.

CASTER, K.E. (1939): A Devonian Fauna from Colombia. *Bull. Amer. Paleont., Vol. 24, No. 83.*

CHANG, A.C. (1958): Stratigraphy, Palaeontology and Palaeogeography of the Ammonite Fauna of the Clymeneenkalk from Great Khingan with Special Reference to the Post Devonian Break (Hiatus) of South China. *Acta Palaeont. Sinica, Vol. 6, No. 1* (in Chinese with Engl. Summ.).

CLARKE, J.M. (1900): The Oriskany Fauna of Becraft Mountain, Columbia County, N.Y. *Mem. New York State Mus., Vol. 3, No. 3.*

——— (1907): Some New Devonic Fossils. *Bull. New York State Mus., 107.*

——— (1908): Early Devonic History of New York and Eastern North America. *Mem. New York State Mus., No. 9 (60th Ann. Rep. 1906, Vol. 4, Appendix 7),* 250pp.

COOPER, G.A. (1930): The Brachiopod Genus *Pionodema* and its Homeomorphs. *Jour. Paleont., Vol. 4, No. 4.*

DENG, Z.Q. (1966): Some Middle Devonian Tabulate Corals from the Heitai Formation of the Mishan District, Heilungkiang. *Acta Palaeont. Sinica, Vol. 14, No. 1,* pp. 38–47 (pp. 48–53 Engl. Transl.).

DROT, J. (1964): Rhynchonelloidea et Spiriferoidea Siluro-Dévoniens du Maroc pre-Saharien. *Marocco, Ser. Géol., Notes et Mém., No. 178,* pp. 286.

DUBATOLOV, V.N. (1964): Stratigraphical and Geographical Distribution of the Tabulate, Heliolitids and Chaetetids in the Devonian of U.S.S.R. (in Russian) in DUBATOLOV, V.N. & SPASSKY, N.Y. (1964).

——— & SPASSKY, N.Y. (1964): Stratigraphical and Geographical Survey of the Devonian Corals in U.S.S.R. (in Russian) Akad. Nauk. SSSR, Siberian Branch, Inst. Geol. Geophys., 140p.

DUNBAR, C.O. (1919): Stratigraphy and Correlation of the Devonian of West Tennessee. *Tenn. Geol. Surv. Bull., 21.*

——— (1920): New Species of Devonian Fossils from Western Tennessee. *Trans. Connecticut Acad. Art & Sci., Vol. 23.*

FOERSTE, A.F. (1909): Fossils from the Silurian Formations of Tennessee, Indiana and Illinois. *Bull. Sci. Lab. Denison Univ., Vol. 14, Art. 6.*

GILL, E.D. (1948): Eldon Group Fossils from the Lyell Highway, Western Tasmania. *Rec.*

Queen Victoria Museum, Val. 2, No. 2.

——— (1949): Devonian Fossils from Sandy's Creek, Gippsland, Victoria. *Mem. Victoria Nat. Mus., Vol. 16,* pp. 91–115.

GOSSELET, J., BARROIS, C., LERICHE, M., CRÉPIN, A., PRUVOST, P. & DUBOIS, G. (1922): Description de la Faune Siluro-Dévonienne de Liévin. *Mém. Soc. Géol. du Nord, Tom. 6, Fasc. 2* (1920).

GRABAU, A.W. (1923/24): Stratigraphy of China. *Vol. 1.*

——— (1931): Devonian Brachiopoda of China, 1. Devonian Brachiopoda from Yunnan and other Districts in South China. *Palaeont. Sinica, Ser. B, Vol. 3, Fasc. 3.*

GRATSIANOVA, R.T. (1967): Brachiopods and Stratigraphy of the Lower Devonian of the Mountainous Altai. (in Russian) Akad. Nauk SSSR. Siberian Branch, Inst. Geol. Geophys.

——— (1968): Devonian Brachiopods of Mountain Altai and their Geographical Connections. *Proc. Intern. Symp. Dev. System, Calgary 1967, Vol. 2,* pp. 1269–1273.

———, JINCHENKO, B.A. & KULIKOV, N.P. (1960): Brachiopoda *in* Paleozoic Biostratigraphy of the Sayan-Altai Mountainous Region, Vol. 2. Middle Paleozoic. *Trudy SNIIGGIMS, No. 20.*

HALL, J. (1859): Descriptions and Figures of the Organic Remains of the Lower Helderberg Group and the Oriskany Sandstone. *Nat. Hist. New York, Palaeont., Vol. 3, Pt. 1.*

——— (1867): Descriptions and Figures of the Fossil Brachiopoda of the Upper Helderberg, Hamilton, Portage and Chemung Groups. *Ibid., Vol. 4, Pt. 1.*

HAMADA, T. (1960a): Gotlandio-Devonian System in Korea and Northeastern China. *Jour. Geol. Soc. Japan, Vol. 66, No. 775,* pp. 263–278 (in Japanese with Engl. Abst.).

——— (1960b): The Middle Palaeozoic Formations in China and Korea I. Korea and Northeast China. *Japan. Jour. Geol. Geogr., Vol. 31, Nos. 2–4,* pp. 165–183.

——— (1960c): Ditto II. Northwest and South China. *Ibid., Vol. 31, Nos. 2–4,* pp. 201–239.

——— (1961a): Evolution of Encrinurid Cephalons. *Ibid., Vol. 32, No. 2,* pp. 205–218.

——— (1961b): The Middle Palaeozoic Group of Japan and its Bearing on her Geological History. *Jour. Fac. Sci., Univ. Tokyo, Sect. 2, Vol. 13, Pt. 1,* pp. 1–79.

——— (1963): The Silurian and Devonian *in* TAKAI, F. et al. ed. *Geology of Japan,* pp. 15–22. Univ. Tokyo Press.

——— (1968): Devonian of East Asia. *Proc. Intern. Symp. Dev. System, Calgary, 1967, Vol. 1,* pp. 583–596.

HARPER, C.W., JOHNSON, J.G. & BOUCOT, A.J. (1967): The Pholidostrophiinae (Brachiopoda; Ordovician, Silurian, Devonian). *Senckenberg. Lethaea, Bd. 48, Nr. 5,* pp. 403–461.

HAVLÍČEK, V. (1953): O nekolika novych ramenonozcich ceského a moravského stredniho devonu. *Vesth. Ust. Ust. Geol., Soc. 28, c. 1.*

——— (1956): The Brachiopods of the Branik and Hlubocepy Limestones in the immediate Vicinity of Prague. *Sborn. Ust. Ust. Geol., Svaz. 22.*

——— (1959): Spiriferidae v ceskem silunu a devonu. *Rozpr. Ust. Ust. Geol., Vol. 25,* pp. 275.

——— (1963a): *Zlichorhynchus hiatus* n.g. et n. sp., neuer Brachiopode vom Unterdevon Böhmens. *Vestn. Ust. Ust. Geol. Roc. 38,* C. 6, pp. 403–404.

——— (1963b): Leptaenidae (Brachiopoda) from the Silurian and Devonian System. *Casop. Narod. Muz., Roc. 132, Cis. 4,* pp. 220–225.

HILL, D. (1967): The Sequence and Distribution of Ludlovian, Lower Devonian and Couvinian Coral Faunas in the Union of Soviet Socialist Republics. *Palaeont., Vol. 10, Pt. 4,* pp. 660–693.

HOLTEDAHL, O. (1916): The Strophomenidae of the Kristiana Region. *Vidensk. Skrift., I, Mat.-Naturv. Klasse, 1915, No. 2.*

HOU, H.F. (1959a): Devonian Brachiopod Fossils from Northeast China. *Acta Palaeont. Sinica, Vol. 7, No. 2* (in Chinese with Russ. Summ.).

——— (1959b): Lower Devonian and Eifelian Spiriferids from South Kwangsi. *Ibid., Vol. 7, No. 6,* pp. 450–462 (pp. 462–475 Russ. Summ.).

HUANG, T.K. (1959): New Researches on Geotectonic Subdivisions of Eastern China and their Characteristics. *Acta Geol. Sinica, Vol. 39, No. 2,* pp. 115–134 (in Chinese with Engl.

Summ.): Engl. Trans. *in Intern. Geol. Rev., Vol. 1, No. 11.*

IVANOVA, E.A. (1962): Ecology and Growth of Silurian and Devonian Brachiopods from Kuznetsk, Minusinsk and Tubinsk Basins. *Trud. Paleont. Inst., Vol. 88.*

JAEGER, H., STEIN, V. & WOLFART, R. (1969): Fauna (Graptolithen, Brachiopoden) der unterdevonischen Schwarzschiefer Nord-Thailands. *Neues Jahrb. f. Geol. Paläont. Abhandl., Vol. 133, No. 2,* pp. 171-190.

JOHNSON, J.G. (1965): Lower Devonian Stratigraphy and Correlation, Northern Simpson Park Range, Nevada. *Bull. Canad. Petrol. Geol., Vol. 13, No. 3.*

——— (1966): Middle Devonian Brachiopods from the Roberts Mountains, Central Nevada. *Palaeont., Vol. 9, Pt. 1.*

———, BOUCOT, A.J. & MURPHY, M.A. (1968): Lower Devonian Faunal Succession in Central Nevada. *Proc. Intern. Symp. Dev. System, Calgary, 1967, Vol. 2,* pp. 679-691.

——— & TALENT, J.A. (1967): Cortezorthinae, a new Subfamily of Siluro-Devonian Dalmanellid Brachiopods. *Palaeont., Vol. 10, Pt. 1.*

JONES, C.R. (1968): Lower Paleozoic Rocks of Malay Peninsula. *Amer. Assoc. Petrol. Geol., Bull., Vol. 52, No. 7,* pp. 1259-1278.

KAPLUN, L.I. (1961): Lower Devonian Brachiopods of the Northern Pribalkhash. *in* Materials for the Geology and Guide fossils of Kazakhstan, Pt. 1 (26): *Stratigr. and Paleont. Minist. Geol. Okhran. Nedr. Kazakh. S.S.R.,* pp. 64-114.

KAWADA, G. (1932): Geological Map of Kirin (Kitsurin) and its Explanatory Note, pp. 3-6.

KHALFIN, L.L. (1948): Fauna and Stratigraphy of the Devonian Deposits of the Mountainous Altai. *Izvest. Tomsk. Ord. Trud. Krasm. Znam. Politek. Inst. Imeni S.M. Kirova, Vol. 65, No. 1.*

——— (1955): Devonian System *in* Atlas of the Index Forms of the Fossil Fauna and Flora of Western Siberia, *Vol. 1.*

———, MIRONOVA, N.V., CTEPANOV, S.A., CHEREPNINA, S.K. & JAROCHINSKAYA, A.M. (1968): On the Lower Devonian of the Mountainous Altai. *Mater. Region. Geol. Siberia,* pp. 17-29. Novosibirsk, 1967.

KHALFIN, L.L. (ed.) (1961): Paleozoic Biostratigraphy of the Sayano-Altai Mining District, Vol. 2 (Lower Paleozoic). *Trud. (SNIGGIMS), Minist. Geol. Okhran. Nedr. SSR, Novosibirsk.*

KOBAYASHI, T. (1941): The Sakawa Orogenic Cycle and its Bearing on the Origin of the Japanese Islands. *Jour. Fac. Sci., Imp. Univ. Tokyo, Sect. 2, Vol. 5, Pt. 7.*

——— (1942): The Akiyoshi Orogenic Cycle in the Mongolian Geosyncline. *Proc. Imp. Acad. Tokyo, Vol. 18, No. 6,* pp. 306-313.

——— (1951): The Mammo Group in North-Central Manchuria and its Relation to the Geology of the Environs. in *Geol. Miner. Resour. Far East, Manchuria: Strat.-7,* pp. 1-12 (in Japanese).

——— (1952): On the Mammo Group. *Jour. Geogr., Vol. 54, No. 643,* pp. 335-348 (in Japanese).

KOSHKIN, V.J. (1961): Materials for the Geology and Useful Fossils of Kazakhstan, Pt. 1 (26). Strat. and Paleont.

KUO, H.T. (1962): Some Silurian Trilobites from the Er-Tao-Gou Group of Jilin. *Acta Palaeont. Sinica, Vol. 10, No. 3,* pp. 369-376 (Engl. Trans. pp. 377-381).

LAVERDIÈRE, J.W. (1930): Contribution a l'Étude des Terrains Paléozoiques dans les Pyrénées Occidentales. *Mém. Soc. Géol. du Nord, Tom. 10, Mém. 2.*

LE MAITRE, D. (1944): La Faune Coblencienne de Haci-Remlia (S-W de Taouz). *Marocco Div. Mines Géol., Ser. Géol., Notes et Mém., No. 61.*

LENZ, A.C. (1966): Upper Silurian and Lower Devonian Paleontology and Correlations, Royal Creek, Yukon Territory: A Preliminary Report. *Bull. Canad. Petrol. Geol., Vol. 14, No. 4,* pp. 604-612.

——— (1967): *Thliborhynchia,* a new Lower Devonian Rhynchonellid from Royal Creek, Yukon, Canada. *Jour. Paleont., Vol. 41, No. 5,* pp. 1188-1192.

——— (1968): Upper Silurian and Lower Devonian Biostratigraphy, Royal Creek, Yukon Territory, Canada. *Proc. Intern. Symp. Dev. System, Calgary 1967, Vol. 1,* pp. 587-599.

LERICHE, M. (1912): La Fauna du Gedinnien Inférieur de l'Ardenne. *Mém. Mus. Roy. d'Hist. Nat. Belg., Tom. 6.*

LIU, H.Y. (1955/62): Paleogeographic Atlas of China. Peking. (Russ. edition, 1962, Moscow).

MAILLIEUX, E. (1912): Deux Formes Siegéniennes. *Bull. Soc. Belg. de Géol. Paléont. d'Hydrol., Tom. 25* (1911).

——— (1941): Les Brachiopodes de l'Emsien de l'Ardenne. *Mém. Mus. Roy. Hist. Nat. Belg., Mém. No. 96.*

MAXIMOVA, Z.A. (1968): Late Silurian and Early Devonian Trilobites of Central Kazakhstan. *Proc. Intern. Symp. Dev. System, Calgary, 1967, Vol. 2,* pp. 777-787.

MCLEARN, F.H. (1924): Palaeontology of the Silurian Rocks of Arisaig, Nova Scotia. *Geol. Surv. Canada, Mem. 137, No. 118, Geol. Ser.*

MIKRUKOV, M.F. (1955): Devonian Brachiopods from Western Bashkir *in* KRIKOVA, A.K. ed. Brachiopods of the Devonian of the Volga-Ural Region. *VNIGRI, N.S., No. 88,* pp. 203-249.

MINATO, M. (1962): Über das Devon des Fernen Ostens. *Symp. Silur/Devon-Grenze,* 1960, pp. 160-164.

MODZALEVSKAYA, E.A. (1965): Paleontologically supported Stratigraphy of the Middle Paleozoic of the Far East and the Zabaikal. Biostrat. Collection, Pt. 1. *Trud. VSEGEI, N.S., Vol. 115,* pp. 3-12.

——— (1968): Biostratigraphic Subdivision of the Devonian in the Far East and Transbaikal Region, U.S.S.R. *Proc. Intern. Symp. Dev. System, Calgary, 1967, Vol. 1,* pp. 543-556.

——— & NEKHOROCHEV, V.P. (1965): Early Devonian Bryozoans of the Upper Priamur. *Ann. All-Union Paleont. Soc., Vol. 17,* pp. 115-131.

MU, A.T. (1955): A Devonian Blastoid from Kirin. *Acta Palaeont. Sinica, Vol. 3, No. 2,* pp. 133-134.

——— (Ed.) (1964): Silurian of China. *Report of the Strat. Confer., China.* Acad. Press, Peking.

MUIR-WOOD, H. (1962): On the Morphology and Classification of the Brachiopod Suborder Chonetoidea. Brit. Mu. (Nat. Hist.).

NAGAO, T. (1940): On some Geologic Problems. *Current News Centr. Nat. Mus. Manchoukou, No. 6,* p. 32 (in Japanese).

NAGIBINA, M.S. (1959): Tectonic System of North Manchuria. *Dokl. Akad. Nauk, USSR, Vol. 125, No. 5,* pp. 1089-1092.

NIKIFOROVA, O.I. (1964): Find of a new Silurian Brachiopod in the Tchatkalisk Range. *Paleont. Stratigr., N.S., Vol. 93,* pp. 81-90.

——— & ANDREEVA, O.N. Ed. (1961): Ordovician and Silurian Stratigraphy of the Siberian Platform and their Paleontological Evidences (Brachiopoda). *Biostr. Paleont. Siberian Platform, Pt. 1, N.S., Vol. 56.*

NIKOLAEV, A.A. & RZHONSNITSKAYA, M.A. (1968): Devonian of Northeastern USSR. *Proc. Intern. Symp. Dev. System, Calgary, 1967, Vol. 1,* pp. 483-502.

NILOVA, N.V. (1965): Brachiopoda of the Karazspinsk Horizon. *in* Stratigraphy of the Lower Paleozoic and Silurian Formations in Central Kazakhstan. VSEGEI.

NODA, M. (1951): Devonian. *in Geology and Mineral Res. of the Far East.* Manchuria: Strat. 5, pp. 4-6 (in Japanese).

NONAKA, J. (1944): A Preliminary Report on the Devonian Brachiopods from North Manchuria. *Japan. Jour. Geol. Geogr., Vol. 19, Nos. 1-4,* pp. 249-254.

——— (1946): Devonian Formation near the Kinsui Station, North Manchuria. *Jour. Geol. Soc. Japan, Vol. 52, Nos. 610-612,* p. 29 (in Japanese).

PAECKELMANN, W. & SIEVERTS, H. (1932): Obersilurische und devonische Faunen der Prinzeninseln, Bithyniens und Thraziens. Neue Beiträge zur Kenntnis der Geologie, Palaeontologie und Petrographie der Umgegend von Konstantinopel. *Abhandl. Preuss. Geol. Landesanst., N.F., Hft. 142.*

PHILIP, G.M. (1962): The Palaeontology and Stratigraphy of the Siluro-Devonian Sediments of the Tyers Area, Gippsland, Victoria. *Proc. Roy. Soc. Victoria, Vol. 75, Pt. 2.*

RAUPACH, F. (1934): Stratigraphische und tektonische Entwicklung des russischen Fernen

Ostens, der Mandschurai und zentralen Mongolei. Würzburg.
RUBEL, M. (1963): Silurian Brachiopods Orthida of Estonia. *Trud. Inst. Geol. Acad. Nauk, Est. SSR, 13.*
RZHONSNITSKAYA, M.A. (1964): On the Atrypids of the Kuznetsk Basin. *Paleont. Stratigr., Trud. VSEGEI, N.S., Vol. 93,* pp. 91-112.
——— (1968): Devonian of the USSR. *Proc. Intern. Symp. Dev. System, Calgary, 1967, Vol. 1,* pp. 331-348.
——— & HARIN, G.S. (1968): Devonian of the Kuznetsk Basin. *Ibid., Vol. 1,* pp. 85-88.
SANDBERGER, G. & SANDBERGKR, F. (1850-56): Die Versteinerungen des Rheinischen Schichtensystems in Nassau.
SARITCHEVA, T.G. (1960): Brachiopoda *in* ORLOV ed. *Osnovy Paleont.*
SAVAGE, N.M. (1968): The Geology of the Manildra District, New South Wales. *Proc. Roy. Soc. N.S.W.*
——— (1969): New Spiriferid Brachiopods from the Lower Devonian of New South Wales. *Palaeont., Vol. 12, Pt. 3,* pp. 472-487.
SCHMIDT, H. (1937): Zur Morphogenie der Rhynchonelliden. *Senckenberg., Bd. 19, Nos. 1-2.*
SCHUCHERT, C. & LEVENE, C.M. (1929): Brachiopoda. *Foss. Catal,* 140pp. Berlin.
SHIMER, H.W. & SHROCK, R.R. (1944/48): Index Fossils of North America ('48; 3rd ed.).
SHIRLEY, J. (1964): The Distribution of Lower Devonian Faunas. in A.E.M. NAIRN ed. Problems in Palaeoclimatology. *Proc. NATO Palaeocl. Conf., Newcastle upon Tyne, 1963,* pp. 255-261.
SPASSKY, N.Y. (1964): Devonian Tetracorals of the Soviet Union (Distribution and Stratigraphical Significance) in DUBATOLOV, V.N. & SPASSKY, N.Y. (1964).
SOKOLISKAYA, A.N. (1960): Order Strophomenida in ORLOV ed. *Osnovy Paleontologyi.* Bryozoa and Brachiopoda. Moscow.
TALENT, J.A. (1963): The Devonian of the Mitchell and Wentworth Rivers. *Mem. Victoria Geol. Surv., Vol. 24,* pp. 1-118.
TANG, K.D. & SU, Y.Z. (1966): New Data about the Paleozoic Formations and their Significance in the Northwestern Minor Khingan. *Acta Geol. Sinica, Vol. 46, No. 1,* pp. 14-28 (in Chinese with Engl. Summ.).
TERMIER, E. (1936): Études géologiques sur le Maroc central et le moyen Atlas Septentrional. *Tom. 3. Paléont., Pétrogr.*
USHATINSKAYA, G.T. (1966): *in* BOGDANOVA, A.A. ed. Silurian and Lower Devonian Stratigraphy and Fauna in the Narinsky Synclinorium. *Centr. Kazakh. Geol. Contr. Min. Geol. Dept. Kazakh. SSR, Mater. Geol. Centr. Kazakhstan, Vol. 6.*
VANDERCAMMEN, A. (1963): Spiriferidae du Dévonien de la Belgique. *Bruxelles Inst. Roy. Soc. Nat. de Belgique, Mém. No. 150,* 181p.
VERETCHAGIN, V.N. & KRASNYI, L.I. ed. (1958): Devonian System (Table xiv-xv) *in* The Resolution of Interconference for the Workings on the Stratigraphic System in the Far East. Moscow.
WANG, Y. (1956): New Species of Brachiopodes, 2. *Acta Scientia Sinica, Vol. 5, No. 3.*
——— (1957): Index Fossils of China, Invertebrates, Pt. 2; Brachiopods. Acad. Prees. China.
——— & NING, C.S. (1956): Devonian Formations at the Upper Part of the Halahaho River, Southern Central Great Khingan Range and their Lithic Characters. *Geol. Inform., Vol. 9* (in Chinese).
——— & YÜ, C.M. (1960): Devonian Formations in China. *Sci. Record, N.S., Vol. 4, No. 4,* pp. 238-247 (in Russ.).
——— & ——— ed. (1964): Devonian of China. *Report Stratigr. Confer.* 140p. Acad. Press, China.
——— et al. ed. (1964): Brachiopod Fossils of China in two volumes. Acad. Press, China.
WILLIAMS, H.S. (1913): Recurrent *Tropidoleptus* Zones of the Upper Devonian in New York. *U.S.G.S., Prof. Pap., No. 79.*
——— (1916): The Fauna of the Chapman Sandstone of Maine. *Ibid., Prof. Pap., No. 89.*
——— (1950): New Stropheodontid Brachiopods. *Jour. Wash. Acad. Sci., Vol. 40, No. 9.*

——— (1953a): The Classification of the Strophomenoid Brachiopods. *Ibid., Vol. 43, No. 1.*

——— (1953b): North American and European Stropheodontids; their Morphology and Systematics. *Geol. Soc. Amer., Mem. No. 56.*

YABE, H. (1940a): An Occurrence of Devonian Fossils in Manchoukou. *Proc. Imp. Acad. Tokyo, Vol. 16, No. 10,* pp. 555-559.

——— (1940b): Discovery of the Devonian Formation in Korea. *Science, Vol. 10, No. 3,* pp. 96-98 (in Japanese). Tokyo.

——— & EGUCHI, M. (1943): On a Limestone with *Favosites* from Erh-tao-kou, West of Kirin, Manchuria. *Proc. Imp. Acad. Tokyo, Vol. 19, No. 10,* pp. 681-687.

——— & ——— (1944): Discovery of *Pseudomphyma* in the Limestone of Erh-tao-kou near Kiturin, Mansyu. *Ibid., Vol. 20, No. 6,* pp. 382-385.

——— & ——— (1945): *Spongophyllum* from the Middle Gotlandian Limestone of Erh-tao-kou near Kiturin, Mansyu. *Proc. Japan Acad., Vol. 21, No. 9,* pp. 431-434.

——— & SUGIYAMA, T. (1940): Discovery of Corals of Devonian Types from Tyosen (Korea). *Proc. Imp. Acad. Tokyo, Vol. 15, No. 9,* pp. 305-310.

——— & ——— (1942a): Devonian Fossils from Heitai, Mishan-hsien, Manchoukou; Second Note. *Ibid., Vol. 18, No. 6,* pp. 320-325.

——— & ——— (1942b): A Lower Devonian Faunule from North Manchuria. *Ibid., Vol. 18, No. 8,* pp. 499-504.

——— & ——— (1943): On the Fossil from Nichiuho, Nenchiang-hsien, Peian Province. *Bull. Nat. Centr. Mus. (Manchoukou), No. 5,* pp. 1-9 (in Japanese with Chinese Resumé).

——— & SUZUKI, A. (1955): Second Occurrence of Colonial Corals of Devonian Type in Tyosen (Korea). *Proc. Japan. Acad., Vol. 31, No. 6,* pp. 355-359.

YANG, K.C. (1956): The Middle Devonian Bryozoa from the Heitai Formation of Mishan County, Kirin Province. *Scientia Sinica, Vol. 5, No. 4,* pp. 763-793.

YANOV, Z.N. et al. (1968): Devonian Stratigraphy and Paleontology of the Sayan-Altai Folded Mountains Region. *Trud. Vses. Naut.-Issled. Geol. Inst. (VSEGEI).*

YAO, S.C. (1959): Some Opinions to "Stratigraphy, Palaeontology and Palaeogeography of the Ammonite Fauna of the Clymeneenkalk from Great Khingan with Special Reference to the Post Devonian Break (Hiatus) of South China. *Geol. Review, Vol. 19, No. 5* (in Chinese).

YELKIN, E.A. (ed.) (1964): Standard Sections of the Lower and Middle Devonian of Northeastern Salair and their Palaeontological Characteristics. *Inst. Geol. Geophys., Akad. Nauk, Siberian Branch, Novosibirsk.*

YIN, T.H. (1938): Devonian Fauna of the Pochiao Shale of Eastern Yunnan. *Bull. Geol. Soc. China, Vol. 18, No. 1,* pp. 33-66.

YÜ, C.C. & CHANG, W.T. (1951): Marine Formations in North Manchuria. *Sci. Rep., Vol. 2, No. 6,* pp. 625-629 (in Chinese).

INDEX

Postscript

After completion of this manuscript the writer had access to some important papers of the Siluro-Devonian brachiopod palaeontology and palaeobiogeography as follows:

1) LENZ, A.C. (1970): Late Silurian Brachiopods of Prongs Creek, Northern Yukon. *Jour. Paleont., Vol. 44, No. 3,* pp. 480-500, pls. 83-87. *Aesopomum prongi* (n. sp.) occurs in a horizon between *Monograptus bohemicus* BARRANDE bed and a bed with *M. paraformosus* JACKSON and LENZ, *M.* aff. *kosoviensis* BOUČEK, and *Linograptus posthumus fenus* JAEGER. As the horizon clearly represents the early Pridolian age, considerable significance lies on the extended range of *Aesopomum* which had been thought to be a Devonian genus. Similar extension of the range was proved of *Metaplasia* and *Schizophoria* also. Two species of *Aesopomum* occur within the late Siegenian and early Emsian *Monograptus yukonensis* Zone of this district, though they have not been described yet.

2) JOHNSON, J.G. (1970): Great Basin Lower Devonian Brachiopoda. *Geol. Soc. Amer., Mem. 121,* 421 pp. (74 pls.). In his comprehensive palaeontological work on the brachiopod faunas of Siegenian and Emsian age JOHNSON revealed a large assemblage of 127 species distributed among 83 genera. Some important genera are included to compare with the Lesser Khingan brachiopods. *Dalejina musculosa* HALL, which is typical of the *musculosa* group of *Dalejina* in the present paper (p. 41), was designated as the type species of his new genus *Discomyorthis. Dalejina kinsuiensis* has extremely large, flabellate ventral diductor scars, but is unequally biconvex being different from *Discomyorthis.* According to JOHNSON's concept of the genus, *Dalejina kinsuiensis,* therefore, should remain as *Dalejina.* A new species of *Aesopomum* was named *A. varistriatus.* He also noticed a probable *Aesopomum* species in BOUCOT collection from the Upper Silurian or Lower Devonian Öved-Ramsåsa Group at Bjarspölagård parish of O. Kärstorp, Scania, Sweden. *Mclearnites,* of which a new species was established by him, is somewhat similar to *Sinostrophia* in its interior of both valves, but the exterior is characteristically parvicostellate instead of multicostellate. *Bifida* sp. occurs from the *Eurekaspirifer pinyonensis* Zone in Nevada. JOHNSON discussed about the concept of a genus *Howellella* and stated that the pauciplicate spirifers such as *Sp. modestus* HALL may be excluded from the genus. *H. cycloptera,* that is somewhat similar to *"H." amurensis,* is presumed to be intermediate between the typical *Howellella* and Mid.-Lower Devonian species of *Acrospirifer.*

3) SOKOLOV, B.S. et al ed. (1970): Distribution and Sequence of Paleozoic Corals of the USSR. *Papers of II All-Union Symposium on Fossil Corals of the USSR, Vol. 3* (in Russian). Acad. Sci. USSR. Moscow. This symposium volume includes two distinguished papers on palaeobiogeography of the eastern territory of the Soviet Union where is closely connected with the Lesser Khingan district now under discussion.

a) DUBATOLOV, V.N., & SPASSKY, N.J.: Corals of the Main Devonian Palaeo-

biogeographical Provinces. pp. 6-31.

b) KRAVTSOV, A.G.: Palaeobiogeographical Relations of the Early Devonian Tetracorals of Taimyr and Novaya Zemlya. pp. 31-44.

The Devonian palaeobiogeographical maps presented by these authors are conformable to the palaeobiogeographical reconstruction made in the present paper (p. 35).

4) KOBAYASHI, T. (1970): The Manmo Group and the Akiyoshi Orogeny in Central and North Manchuria and its Adjacence (in Japanese with English Summary). *Jour. Geogr. Soc., Vol. 79, No. 4 (778)*, pp. 1(196)-29(223). History of tectonic development of the eastern portion of the Mongolian geosyncline was extensively synthesized with stratigraphical summary on the basis of accumulated data since 1927.

(January 15, 1971)

Plate 1

Explanation of Plate 1

"*Lingula*" sp. indet. ..... page 37

Fig. 1. A small external mold of pedicle valve showing the elongate shell outline and the distantly spaced growth lamellae. Latex replica of 247K$_{\zeta}$1 (×5).

Schizophoria sp. indet. ..... page 37

Figs. 2a, b. An internal mold (a) and its latex replica (b) of a young brachial valve showing the elongate muscle field, straight and anteriorly divergent brachiophores and the narrow sockets. 180KU1 (×3).

Proschizophoria kobayashii HAMADA, sp. nov. ..... page 38

Figs. 3a–c. Dorsal (a), anterior (b) and areal (c) views of latex replica of a pedicle valve showing the dorsally projected boss-shaped teeth which are supported by thick dental lamellae. 235K$_{\eta}$1 (×1.5).

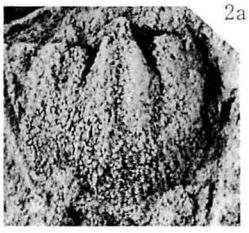
Figs. 4a, b. An incomplete brachial valve showing surface ornamentation and internal features. Latex replica of 111KB1 (×1.25).

Figs. 5a–e. A large brachial valve showing the long, curved brachiophores, boss-shaped cardinal process lobe. Note the presence of a median septum (5b), though its large portion was lost at the posterior half of the length. Fig. 5e shows the well developed fulcral plates. a and d are latex replicas. 064HI1 (e ×2.5, a–d ×1.25).

Fig. 6. Another brachial valve showing the long, curved brachiophores supported by the muscle bounding ridges. Note a low median septum. Latex replica of 344KnG1 (×2.5).

Fig. 7. An enlarged surface showing the fine radials with narrow interspaces. Latex replica of 017HA3-4 (×3).


1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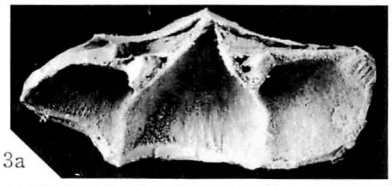
2b


3a

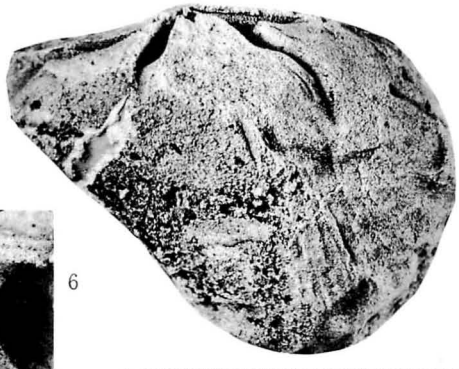

3b

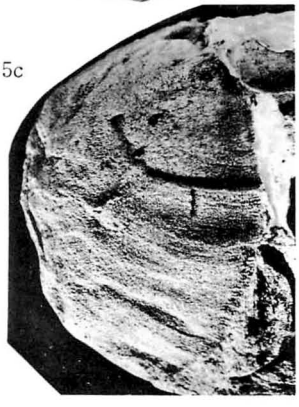

3c


4a


4b


5a


5b


5c


5d


5e


6


7

Plate 2

Explanation of Plate 2

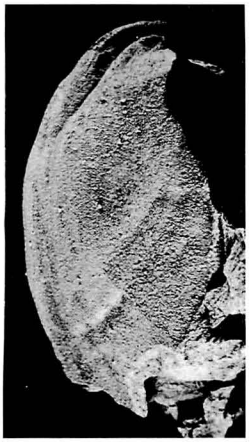
Proschizophoria kobayashii HAMADA, sp. nov. ..... page 38

Figs. 1a-e. Interior of an elongate brachial valve showing the quadripartite muscle fields and a low median septum. d and e are the latex replicas. 073HL1-2 (a-d ×1.25, e ×3). This specimen was illustrated by NONAKA (1944, plate 27, figs. 5, 6) as *Gypidula* cf. *mansuyi* GRABAU. *Vide* Plate 30, figs. 5, 6.

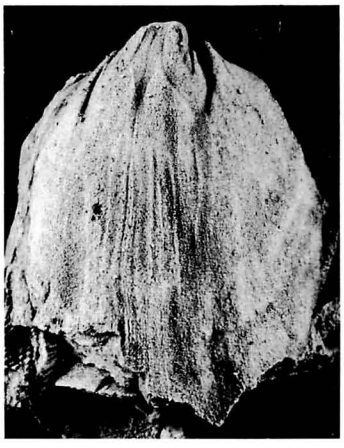
Fig. 2. Latex replica of 316K$_{\phi}$1 showing the onter surface of the shell. Note the narrow interspace and the mode of implantation of the ribs. (×2).

Figs. 3a, b. Internal mold (a) and its latex replica (b) of a transversely elongate pedicle valve showing the well developed muscle bounding ridges and the anterior reentrance of the fields. 276K$_{\nu}$1 (×1.25).

Figs. 4a, b. Another pedicle valve (a: latex replica) showing the muscle impression and the vascula media. Note the fine crenulation of shell periphery. 228K$_{\zeta}$1 (×1).

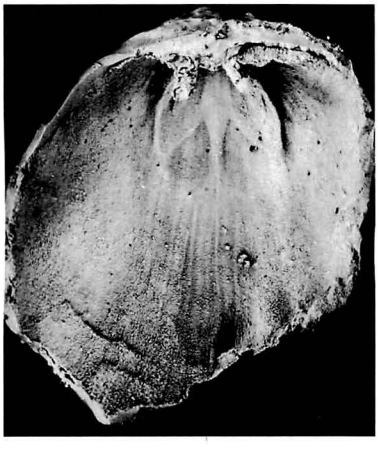


1a



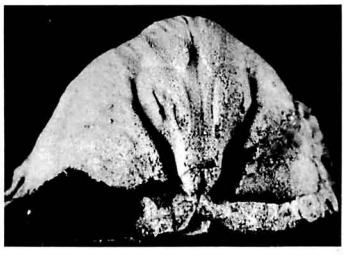
1b

1e



1d

3a



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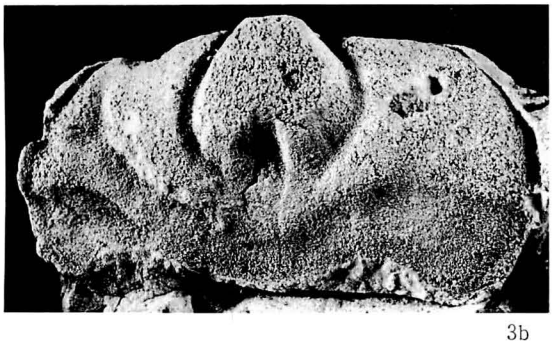
2



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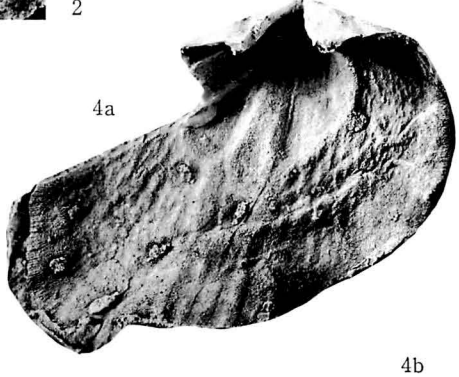
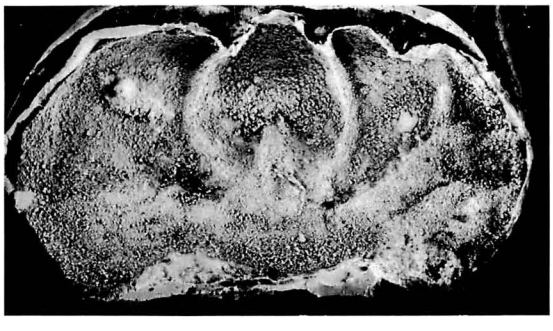


4a

4b



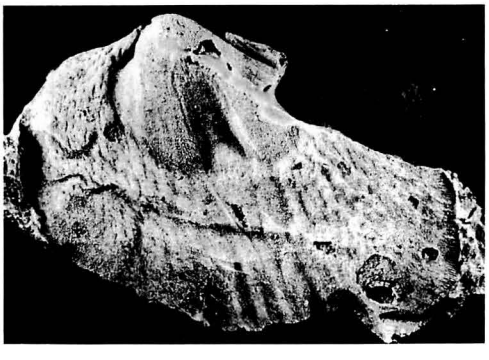


Plate 3

Explanation of Plate 3

Dalejina kinsuiensis HAMADA, sp. nov. ..... page 41

Figs. 1a, b. Lateral and ventral views of a brachial valve with thick, partly exfoliated shell substance. 147KL1 (×1.5).

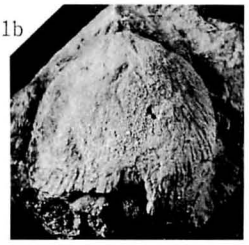
Figs. 2–6. Latex replicas of the external shell surface showing the dichotomous increasing of radial ribs. 248K$_t$1 (×3), 255K$_t$1 (×2), 300K$_t$1 (×2), 154KO1 (×2.5), 104KA4 (×2.5).

Figs. 7, 8. Cast (a) and its latex replica (b) of two small brachial valves showing the interiors. Muscle scars are faintly impressed. 125KC1 (×2), 285K$_o$1 (×2.5).

Figs. 9, 10, 12. Brachial interiors of three larger shells showing somewhat deeply impressed muscle scars. Note the bisected peripheral denticles of the shell. 253K$_t$1 (×1.5), 177KT1 (×2), 226K$_{\delta}$1 (×2). *Vide* also fig. 9 on Plate 4.

Figs. 11a–c. Well preserved interior of the holotype brachial valve showing a boss shaped cardinal process, the thick blade like brachial processes and the transversely striated area of the hinge socket cover. 250K$_t$1 (a ×4, b and c ×2).


1a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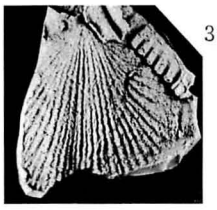
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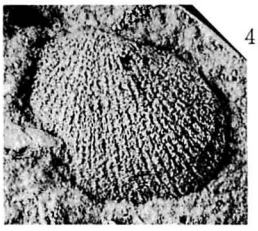
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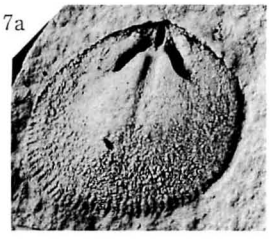
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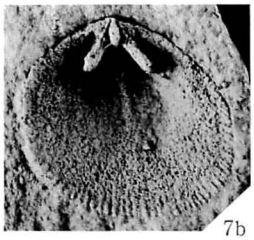
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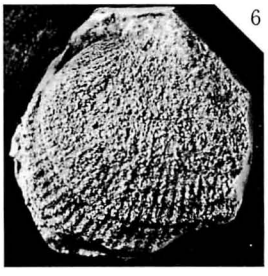
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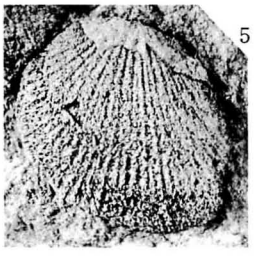
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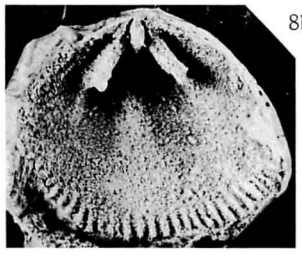
8a


8a


11a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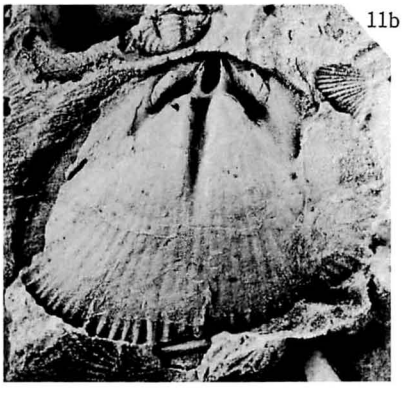
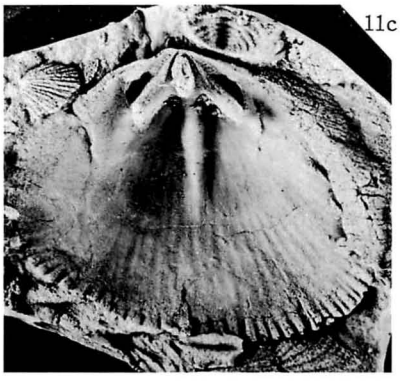
9b


11b


10a


10b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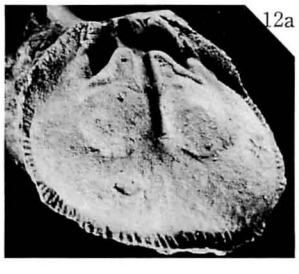
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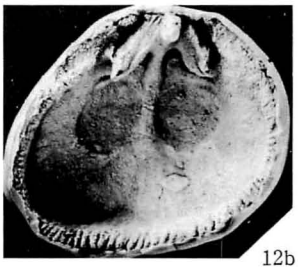

12b

Plate 4

Explanation of Plate 4

Dalejina kinsuiensis HAMADA, sp. nov. ..... page 41

Figs. 1a-d. Dorsal and ventral views of a Steinkern and latex replica of the external surface of the same individual. Note the strongly marked muscle fields. 156KO1 (×2).

Figs. 2-4. Three pedicle internal impressions and their latex replicas showing variation of the muscle fields which are divided by a blade like median ridge. 227K$_{\varepsilon}$1 (×1.5), 195K$_{\alpha}$1 (×1.5), 198K$_{\beta}$1 (×1.5).

Figs. 5a-d. One of the largest brachial valve showing its well convex shell and the strong muscle impressions. Details of the boss shaped cardinal process and the brachial processes, which are bifurcate distally, are illustrated on Plate 29, fig. 8. 186KW1 (×1.5).

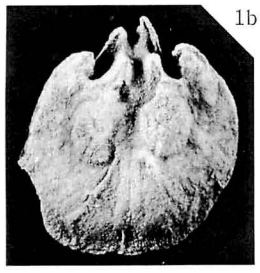
Fig. 6. Showing the hinge area with a large triangular pedicle opening and the cardinal teeth. 309K$_{\psi}$1 (×2).

Figs. 7a-c. An external (a) and an internal feature of a large pedicle valve. Note the ramose muscle fields and a long and strong median ridge. 210K$_{\beta}$2-3 (×2).

Figs. 8a, b. Slab with a pedicle interior (103KA4) and a brachial exterior (104KA4). (×2).

Fig. 9. An enlarged view of the brachial interior of 226K$_{\delta}$1 (×4). *Vide* also figs. 12a, b on Plate 3.


1a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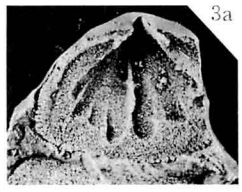
1c


1d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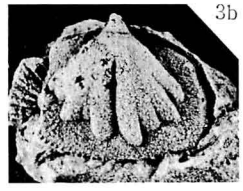
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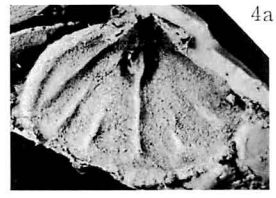
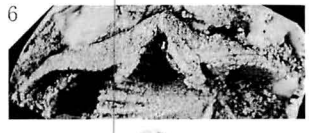

4a


4b


5a


5c


5b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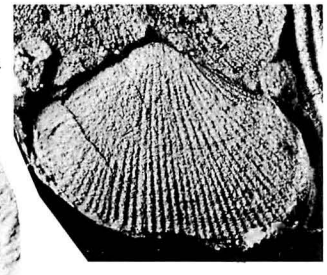
5d


9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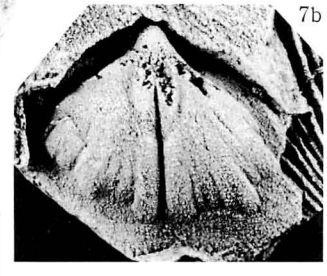
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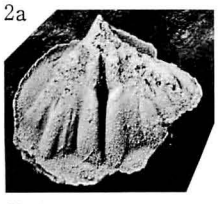
7c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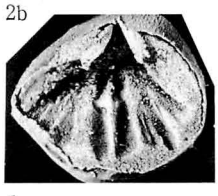
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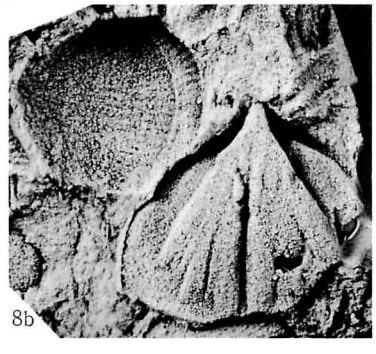
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Plate 5

Explanation of Plate 5

Reeftonia borealis HAMADA, sp. nov. ..... page 43

Figs. 1a, b, 2. Brachial interiors of two small specimens showing a tiny cardinal process and simple brachial processes. Note the faintly impressed muscle fields of the first specimen. 205K$_\beta$1 (×4), 233K$_\zeta$1 (×4).

Figs. 3a–c. Brachial interior and exterior showing the blade like brachial processes and a small, weakly trifurcate cardinal process. Note the finely crenulate inner shell periphery. 213K$_\beta$2–3. (×2.5).

Figs. 4a–c. Another brachial interior showing the antero-dorsally projecting brachial processes and the faintly trifurcate cardinal process. 026HA4 (a, b ×2, c ×4).

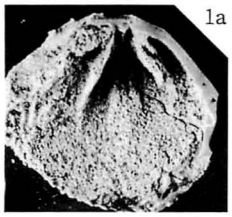
Figs. 5–7a, b. Three brachial specimens showing the development of the cardinal and the brachial processes. 321K$_\omega$1 (×1.5), 256K$_\iota$1 (×1.25), 178KT1 (×2, ×4).

Fig. 8. An external surface of the shell showing the multicostellate or somewhat parvicostellate ornamentation. 132KE1 (×2.5).

Figs. 9–11. Internal views of three large specimens showing the well marked and intricate muscle scars and the pointed brachial processes. Note the large, distinctly trifurcate cardinal process which is supported by a low, round-topped median ridge. 051HF1 (holotype ×1, 2), 265K$_\kappa$2 (×1.25), 269K$_\lambda$1 (×1.5).

Figs. 12a, b. Internal and external views of a pedicle valve. 021HA3–4 (×1.5).

Figs. 13a, b. An internal impression of a pedicle valve and its latex replica showing the elongate oval muscle fields separated by a sharp median ridge. 071HK1 (×1.5).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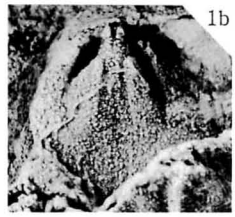
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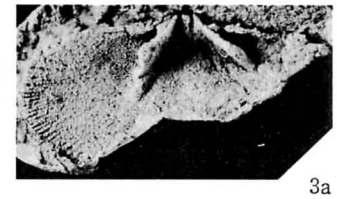

3a

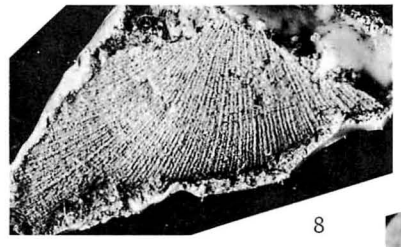

4a


5


6


3b


4b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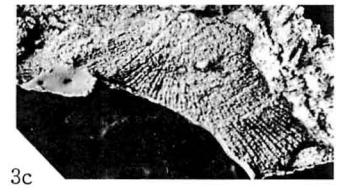
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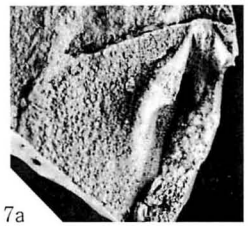
4c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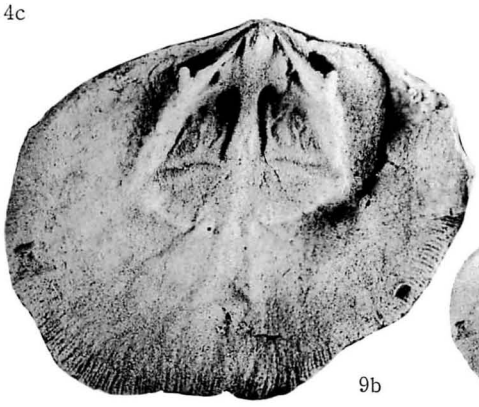
7b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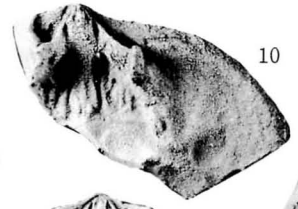
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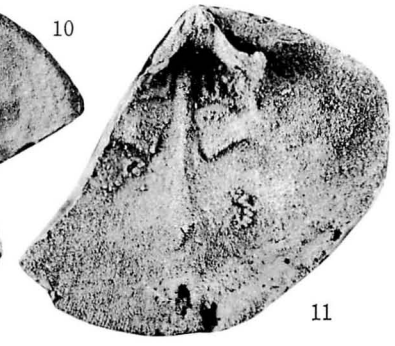
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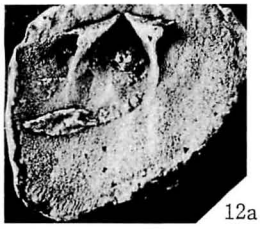
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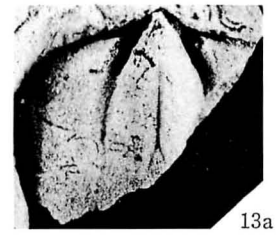

13a


13b

Plate 6

Explanation of Plate 6

Reeftonia borealis HAMADA, sp. nov. ..... page 43

Figs. 1, 2. Impressions of interior of two pedicle valves and their latex replicas. Note the oval muscle fields and a narrow median ridge. 190KY1 (×1.25), 241K_θ1 (×1.25).

Figs. 3a–d. Dorsal (a), posterior (b) and lateral views of a pedicle interior and its latex replica (c). The median ridge is somewhat bluntly developed. 135KF1 (×2).

Figs. 4a–f. Internal and external views of an obliquely compressed large pedicle valve. Note the small, elongate oval adductor scars and the distinctly divided diductor scars. 266K_κ2, 2′ (×1.5).

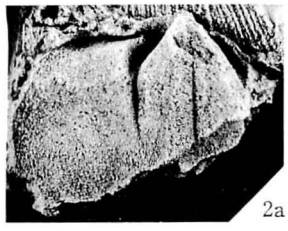
Figs. 5, 6. Two pedicle valves showing the interiors. Note the widely open pedicle opening with deltoid cardinal teeth. The diductor scars are divided by remnant of a median ridge. Each diductor scar is faintly disected also. 031HA6 (×2), 123KB1 (×1.25).

Figs. 7, 8. Two external views of the shell showing the surface ornamentation. The larger figure shows the increasing of ribs by implantation. 011HA1 (×2), 085KA1 (×3).


1a


1b


3b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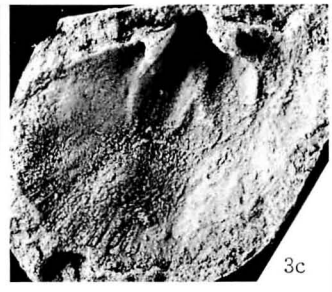
3d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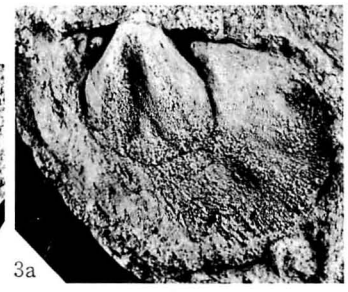
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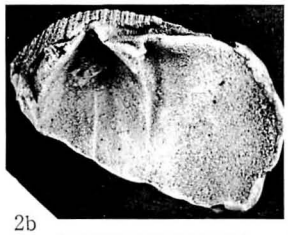
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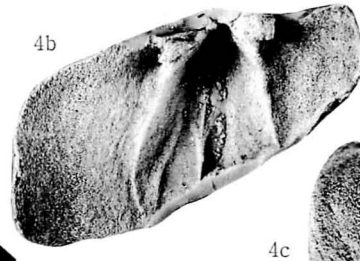
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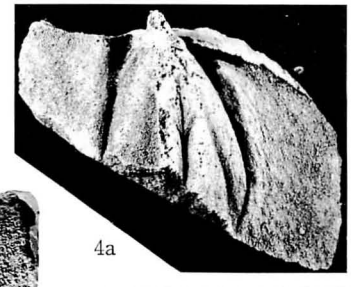
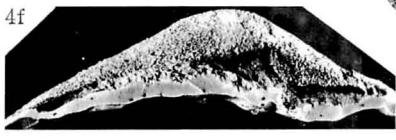

4a


4e


4c


7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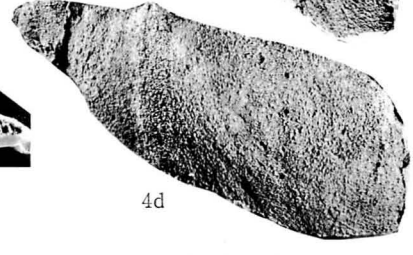
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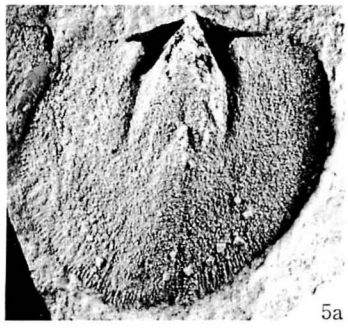

5a


6a


8


5b


6b

Plate 7

Explanation of Plate 7

Reeftonia borealis HAMADA, sp. nov. ..... page 43

Figs. 1a–d. A large pedicle valve showing the cardinal teeth (c) supported by the muscle-bounding ridges (d). 329KnC1 (×1.25, ×2.5).

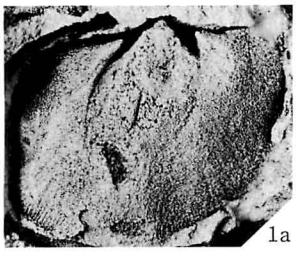
Fig. 2. Fine radial riblets which increase in number by insertion. An enlarged view of a part of the specimen is illustrated on Plate 5, fig. 12a. 021HA3 (×4).

Leptaenopyxis bouei (BARRANDE) ..... page 48

Figs. 3a–c. Internal impression of a large brachial valve and its latex replica showing the minutely crenulate hinge margin, a bilobed cardinal process and its small median septation and the strongly impressed muscle fields with highly raised boundary ridges. Note the prominent myophragm. $221K_{\gamma}1$ (×2, ×3).

Figs. 4, 6. External surface of the brachial valves showing the radial ribs and the concentric rugae. 118KB1 (×1.25), $259K_{\varepsilon}1$–2 (×1.25).

Fig. 5. A posterior view of the hingement showing the bilobed cardinal process and its small septation in the middle. 028HA4 (×2).



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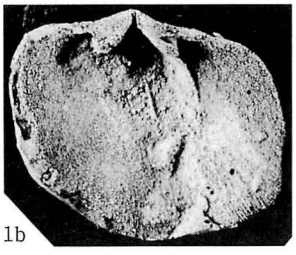
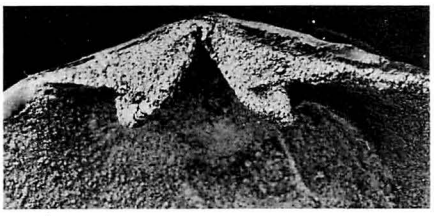
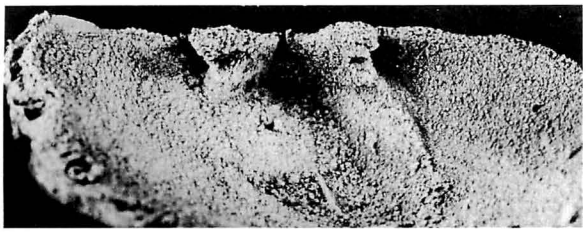


1b

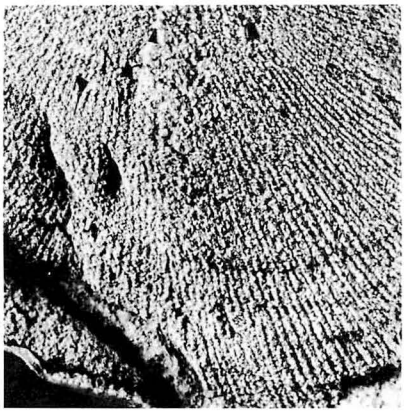


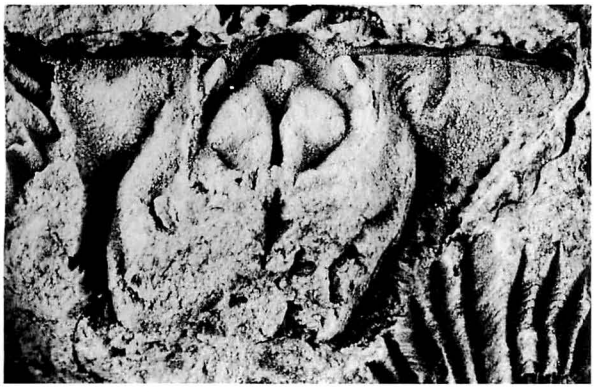
1c

2



1d





3a

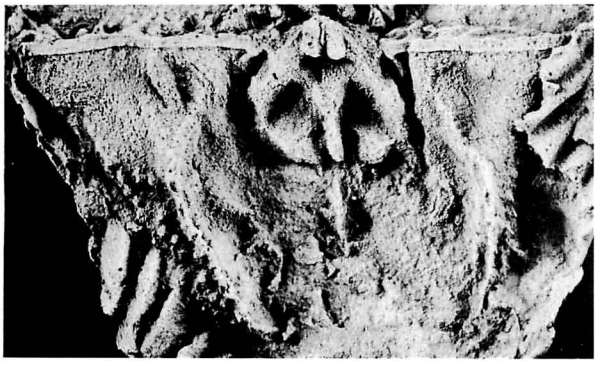
4

3c

5

6

3b



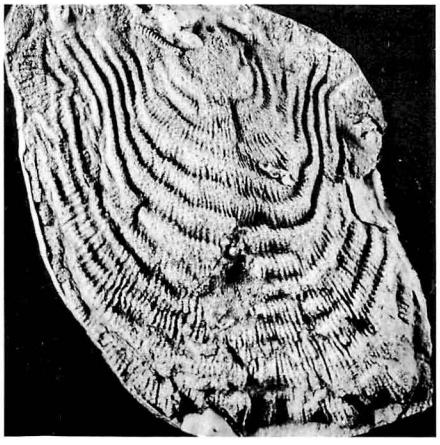


Plate 8

Explanation of Plate 8

Megastrophia (*Protomegastrophia*) *manchurica* HAMADA, sp. nov. ..... page 47

Figs. 1a-d. Exterior of a concave brachial valve showing shell convexity and the faintly fasciculate radial ribs. Note the broadly uniplicate anterior commissure line (d). 126KD1 (×1.25).

Fig. 2. Posterior view of a brachial valve of the same specimen illustrated on Plate 29, fig. 2 showing the divergent cardinal processes and a thin socket plate at left hand side of the picture. 110KB1 (×3).

Figs. 3a, b. Interior of a young pedicle valve showing the denticulate hinge margin and the divergent muscular bounding ridges which embrace a small ventral process. 083 HM1 (×2.5, ×1.25).

Fig. 4. A brachial interior showing the round-topped median myophragm and the muscle impressions. 284K$_{\xi}$1 (×1.25).

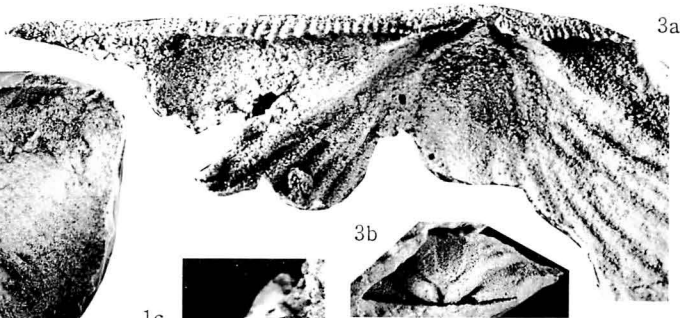
Figs. 5a-d. Pedicle interior of the holotype specimen. Note the cordate muscle fields and the embraced ventral process. 343KnG1 (×2, d ×4).

Vide also Plate 29, figs. 1a-c for the genus.


1a


1d


2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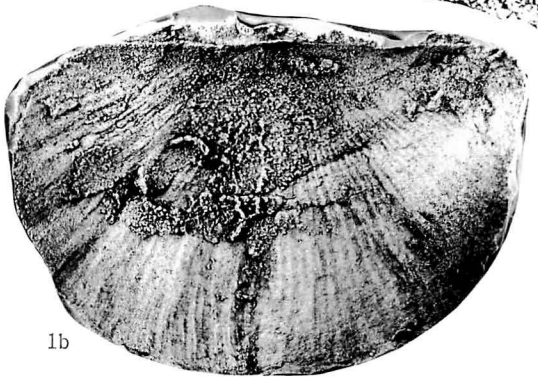
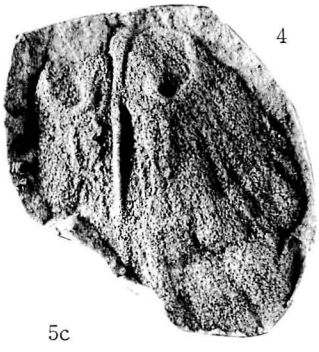

1b

3b


1c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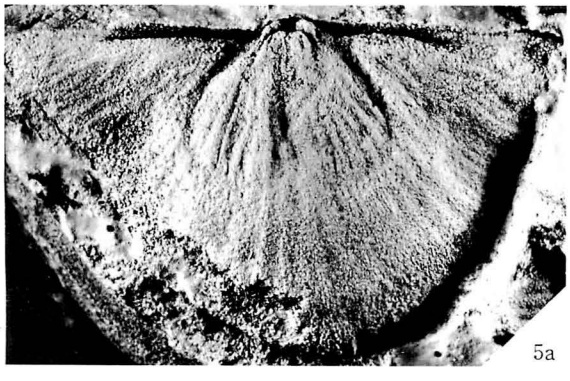

5a


5c


5b

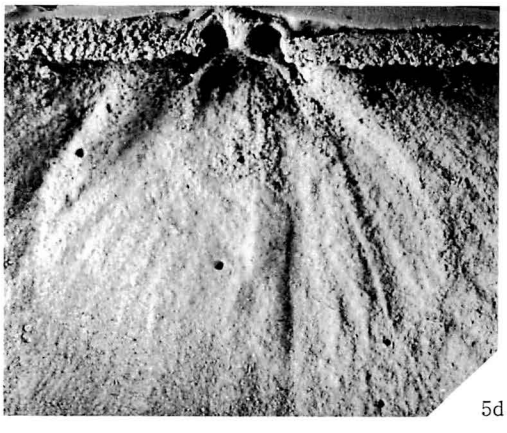

5d

Plate 9

Explanation of Plate 9

Leptostrophia nonakai HAMADA, sp. nov. ..... page 48

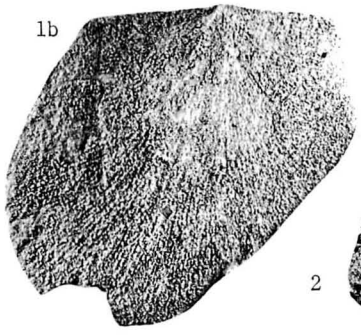
Figs. 1, 2. Exteriors of a small pedicle valve (1a, b) and a medium-sized brachial (?) valve (2) showing the finely multicostellate surface. Note the slightly fasciculate ribbing at the marginal portion of the larger shell. 023HA4 (×1, ×2), 003HA1 (×1).

Fig. 3. An imperfect internal replica of a pedicle valve. 015HA3 (×1).

Figs. 4a, b. Interior (a) and exterior (b) of a young pedicle valve. 211K_{β}2 (×2).

Figs. 5a, b. A pedicle impression (a) and its latex replica (b) of the holotype specimen. 001HA1 (×1). *Vide* also fig. 3 on Plate 10 and NONAKA's original figure reproduced on Plate 30, fig. 1.

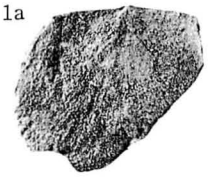
Figs. 6a–c. Latex replica of a brachial valve showing the hingement and muscle fields. Note the socket ridges parallel to the grooved cardinal process lobes. 128KD1 (a ×1.5, b, c ×3).



1b

2

4a



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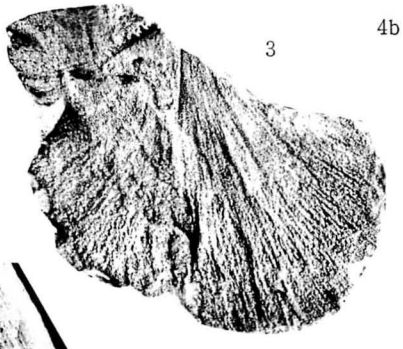

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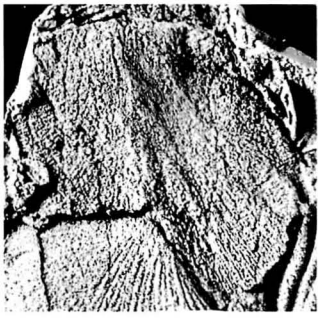
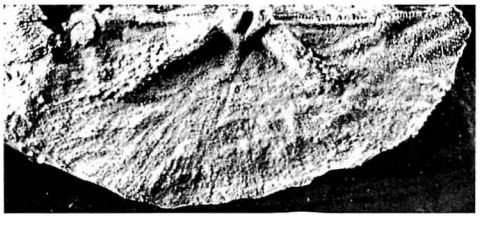


4b

5a

6b



6a

5b

6c

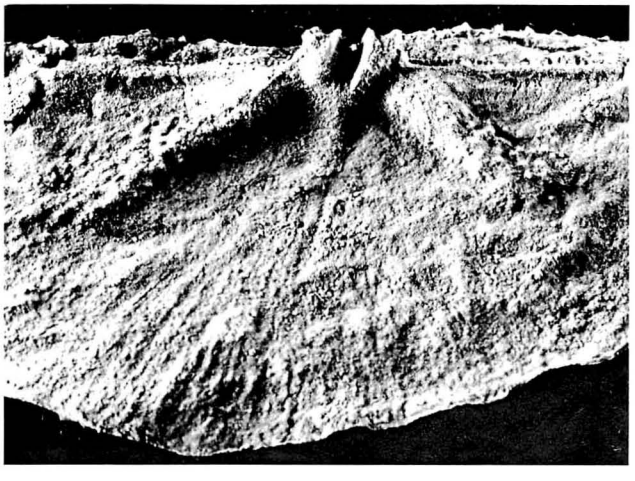


Plate 10

Explanation of Plate 10

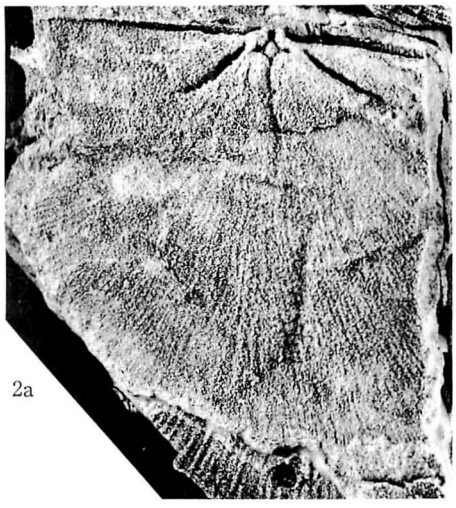
Leptostrophia nonakai HAMADA, sp. nov. ..... page 48

Figs. 1a, b. Internal and external replicas of a small pedicle valve showing several corrugations of "*beckii*" type on a lateral flank of the shell. 009HA1-2 (×1.5).

Figs. 2a-c. An internal impression of a medium-sized pedicle valve (a) and its latex replica (b, c) showing the entirely crenulate hinge margin and the anteriorly divergent muscle bounding ridges. Note the vaguely impressed muscle scars which are divided by a weakly developed median ridge that is connected with a cross-shaped ventral process in the delthyrial cavity. 347KnG1 (a, b ×1.5, c ×3).

Fig. 3. An enlarged view of the interior of the holotype specimen (see Plate 9, fig. 5a, b) showing the small pseudodeltidial plate, cross-shaped ventral process and a median ridge which separates the elongate oval adductor scars and faintly impressed flabellate diductor scars, and the anteriorly divergent muscle bounding ridges with pustules on their crests. 001HA1 (×2.5).

Fig. 4. A part of a brachial exterior showing the finely multicostellate surface with weakly fasciculate marginal portion. 039HE1 (×2).

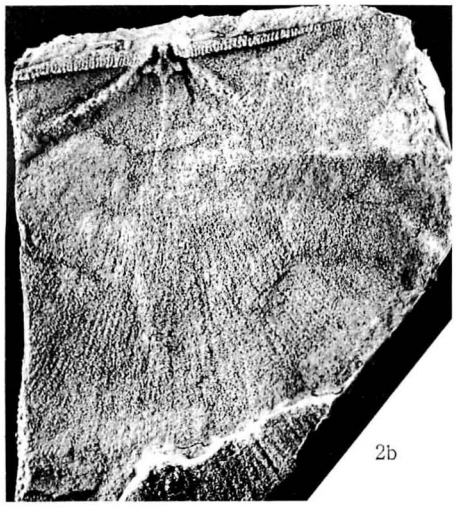


2a

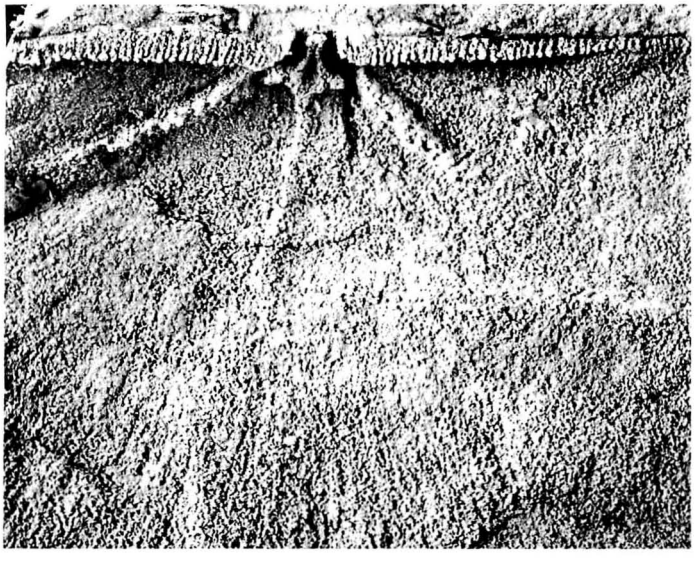
1a

1b

3



2b



2c

4

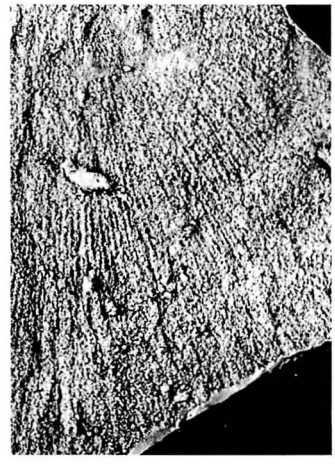


Plate 11

Explanation of Plate 11

Sinostrophia kondoi HAMADA, gen. et sp. nov. ..... page 53

Fig. 1. Latex replica of posterior portion of a brachial interior showing the hingement and muscle areas. 223K$_{\gamma}$1 (×1.5).

Fig. 2. Latex replica of a brachial valve showing almost complete outline and its interior except the hingement. 040HF1 (×1.25).

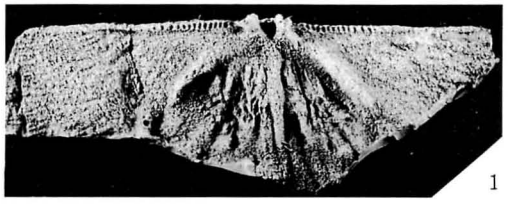
Figs. 3a–c. Impression of a brachial valve (b), its latex replica (a) and an enlarged view of the hinge portion (c) to show the denticulate margin and the cardinal process lobes with divergent socket ridges. Note the presence of a small chilidium. 056HF3 (a, b ×1.25, c ×2.5).

Figs. 4–6. Three latex replicas of concave brachial valves showing the anteriorly bifurcate radial ribs. The difference in shell outline is mainly due to deformation. 058HF2 (×1), 002HA1 (×1), 157KP1 (×1.5). 058HF2 and 002HA1 are the latex replicas of the specimens illustrated by NONAKA (1944) in his fig. 1 and fig. 9 on his plate 27 respectively. *Vide* also Plate 30 of this paper.

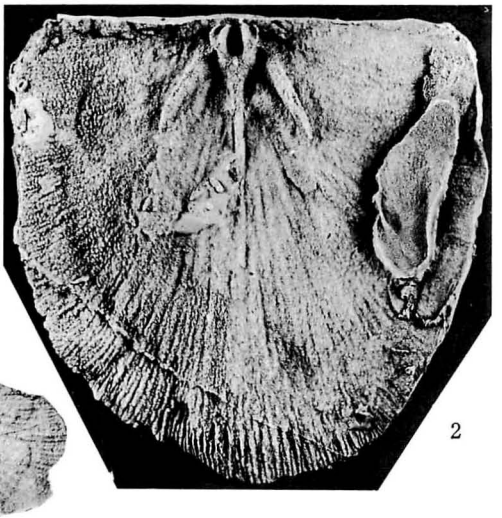
Fig. 7. Impression of the posterior portion of a brachial interior showing a median ridge between cardinal process lobes, distantly superimposed divergent socket ridges, and the crenulate hinge margin. 258K$_{\kappa}$1 (×2.5).

Fig. 8. A fairly small brachial valve showing the increasing ribs toward the shell periphery. 014HA3 (×1). *Vide* also fig. 3 on Plate 12.

Figs. 9a–c. External (a) and internal (c) latex replicas of a brachial valve. 9b displays the mode of rib increasing. Note the three different ways, i.e. implantation, bifurcation and trifurcation. 007HA1 (c ×1), 007HA3 (a ×1, b ×2.5).



1



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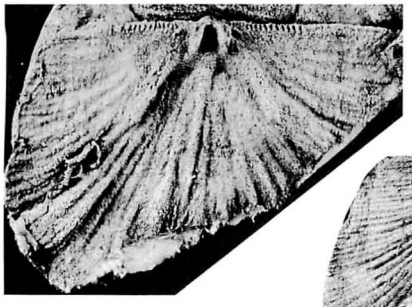

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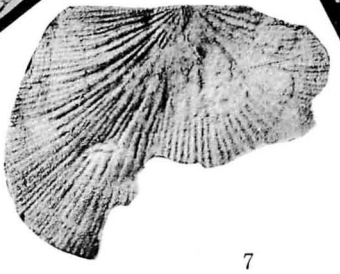

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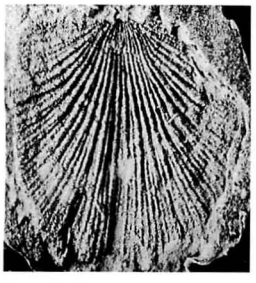

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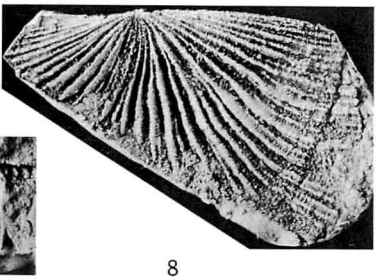
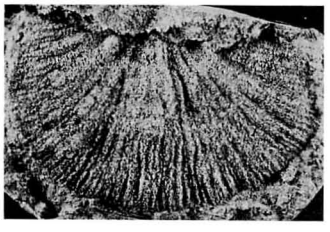


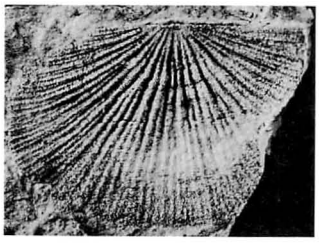
6

7

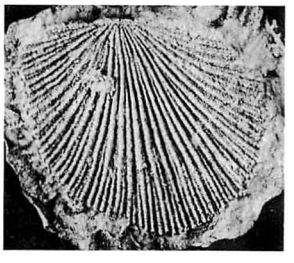
8

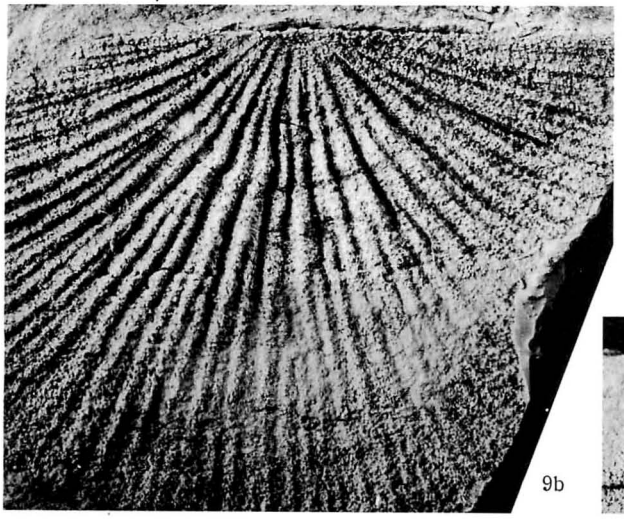


9c

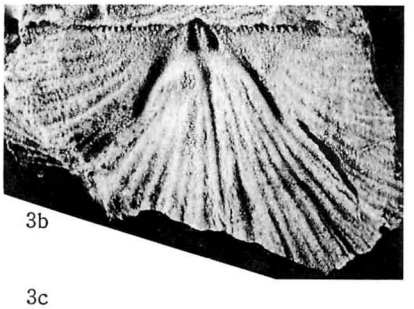


9a





9b



3b

3c

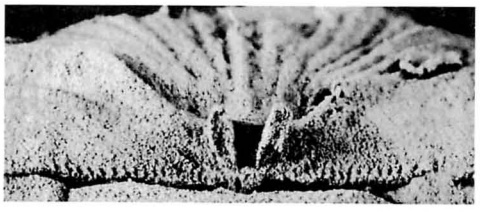


Plate 12

Explanation of Plate 12

Sinostrophia kondoi HAMADA, gen. et sp. nov. ..... page 53

Figs. 1a–d. External latex replica (a), impression of the interior (b) and its latex replica (c) of a brachial valve. The grooved cardinal process lobes are shown as 1d. 027HA4 (a ×1.5), 027HA8 (b, c ×1.5, d ×4).

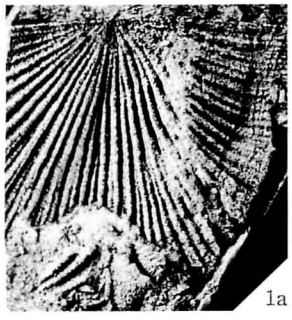
Figs. 2, 3. Two brachial exteriors showing the surface ornamentation. The latter figure is an enlarged view of the specimen illustrated on Plate 11, fig. 8. Note the mode of rib increasing. 330KnC1 (×1.25), 014HA3 (×2.5).

Figs. 4a, b. A mature brachial valve showing the interior with strongly impressed muscle areas. The enlarged picture (b) shows the denticulate hingement and weakly developed chilidium, divergent socket ridges. 006HA1 (a ×1, b ×2.5).

Fig. 5. Two external features of brachial valve. The smaller one is the same specimen as fig. 8 on Plate 11, and the larger one is the exterior of the above mentioned mature individual. Note the extremely thickened and smoothened marginal portion. 014HA3 and 006HA3 (×1).

Figs. 6a, b. Dorsal (a) and posterior (b) views of a large cardinal process lobes and the widely divergent socket ridges. 278K$_2$1 (a ×1.25, b ×2.5).

Figs. 7, 8. Small and large pedicle valves showing the different degree of development of the muscle, especially of the muscle bounding ridges. 025HA4 (×1.5), 048HF1 (×0.8).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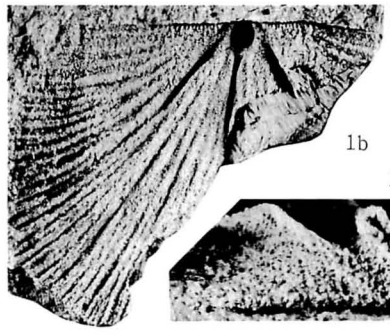
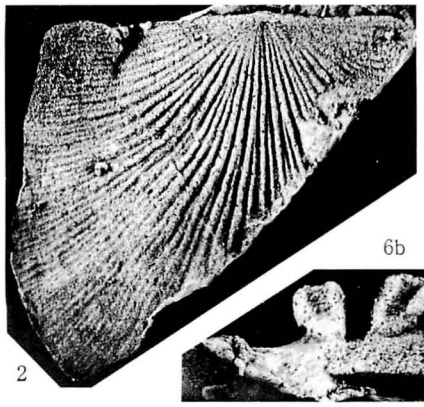

1b


1d

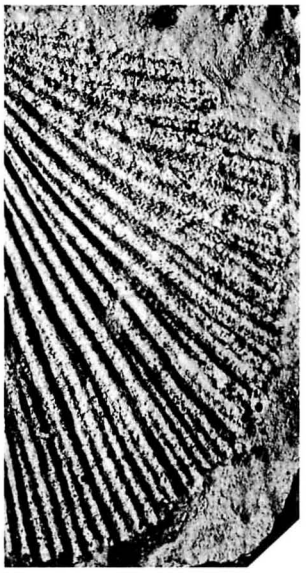
1c

3


2

6b


4a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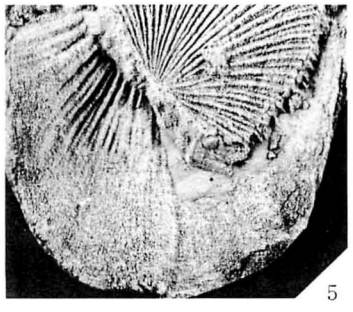
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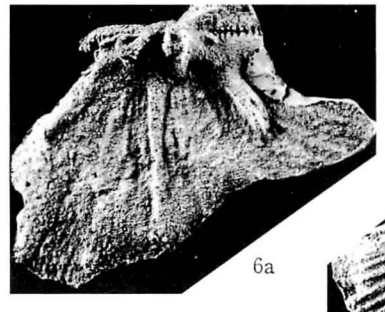
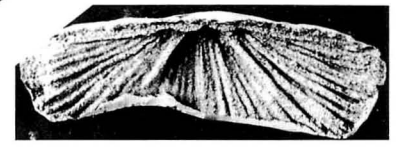

6a




4b

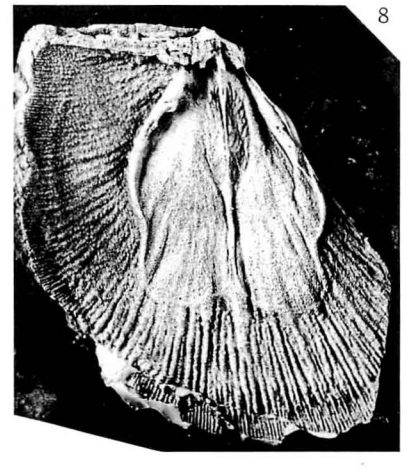

8

Plate 13

Explanation of Plate 13

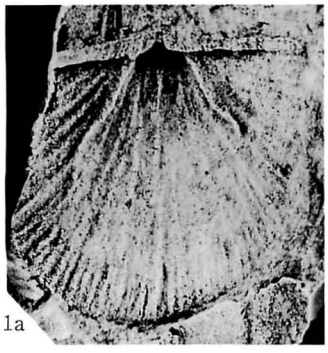
Sinostrophia kondoi HAMADA, gen. et sp. nov. ..... page 53

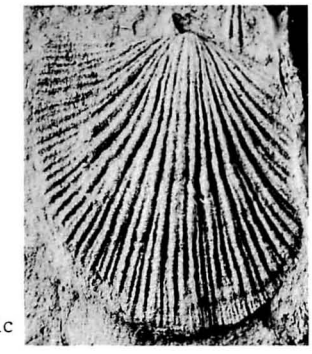
Figs. 1a-c. 1a is a latex replica from an internal impression of a young individual (b) which was once illustrated by NONAKA (1944, pl. 27, fig. 3). 1c shows its external surface (NONAKA, 1944, pl. 27, fig. 2). 032HB2 (a, b ×1.5), 032HB1 (c ×1.5). *Vide* also the reproduced plate of NONAKA on Plate 30 on this paper.

Figs. 2a, b. Another young pedicle valve illustrated by NONAKA (1944, pl. 27, fig. 4) showing the well-developed muscle bounding ridges. 013HA2 (×1). Details of the hinge structure is seen on Plate 17, fig. 3. *Vide* also fig. 4 on Plate 30.

Figs. 3-5. Three pedicle interiors of somewhat compressed specimens. Note the teeth like projections at the delthyrial margin. 138KG1 (×2), 043HF1 (×1.5), 068HJ1 (5a ×1, 5b ×2). Details of the first specimen are also seen on Plate 16, fig. 1.

Figs. 6, 7a, b. Pedicle interiors of two large individuals showing the hinge crenulation and the muscle areas. 131KE1 (×1.5), 164KQ1 (×1.25). Enlarged figures of the hinge structure of these specimens are illustrated on Plate 17, fig. 2 and figs. 4a, b.


1a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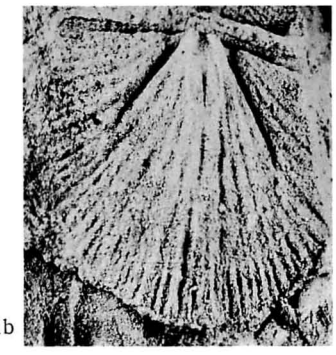
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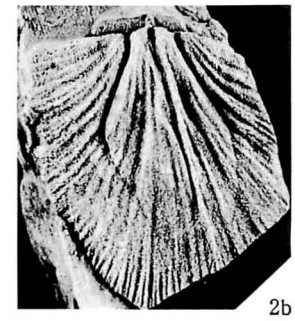
2a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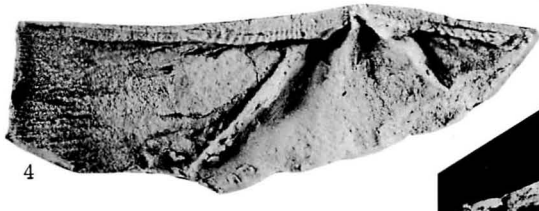
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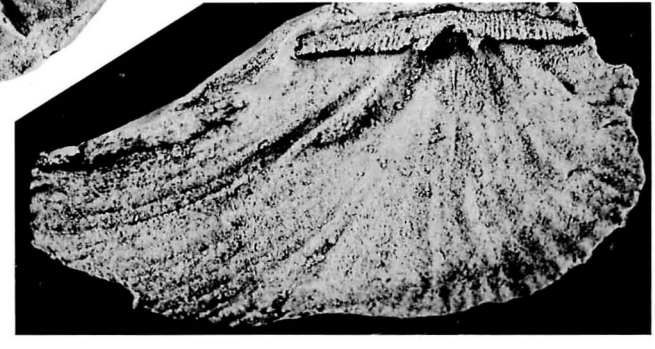
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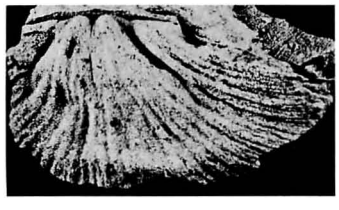
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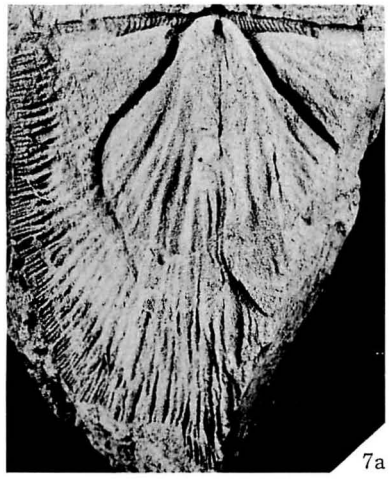
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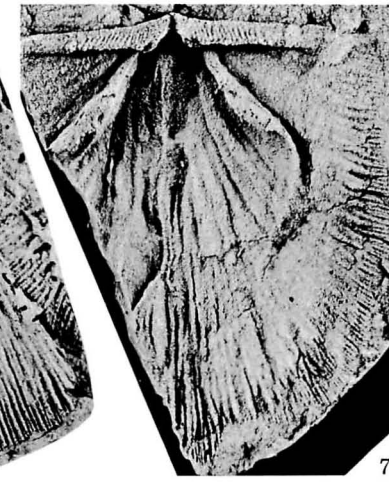
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Plate 14

Explanation of Plate 14

Sinostrophia kondoi HAMADA, gen. et sp. nov. ..... page 53

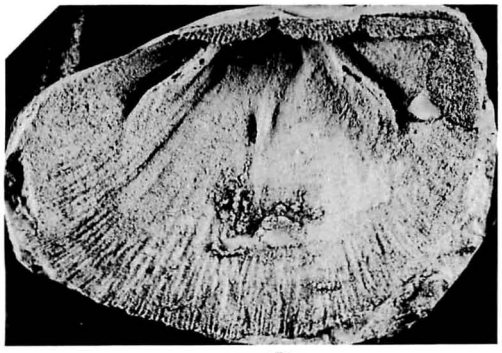
Figs. 1a-c. A medium-sized pedicle interior. 1a is latex replica of the internal impression (b). 1c is a posterior view of 1b to show the ventral process and the thickening of hinge plate at the junction with the muscle bounding ridges. $262K_{\kappa}1$ (×1.25). An enlarged figure of the hinge portion is seen on Plate 17, fig. 1.

Figs. 2a, b. Longitudinally compressed pedicle valve showing the internal and external features. Increasing of the ribs is well illustrated (b). 034HB2 (a ×1), 034HB1 (b ×1).

Fig. 3. A large pedicle valve showing somewhat weak development of the musclature. 054HF2 (×1.25). Details of the hingement are on Plate 16, fig. 2.

Figs. 4a, b. An internal impression of the holotype pedicle valve (a) and its latex replica (b) showing the well preserved hingement and the muscle fields. This specimen is slightly compressed along its longitudinal axis and was superimposed aside the specimen 131KE1 (Plate 13, fig. 6) which is compressed along the lateral axis of the shell at the same time. 130KE1 (×1.5). Details are also seen on Plate 16, fig. 4.

Figs. 5a, b. Another well preserved pedicle valve of medium-sized specimen. Note the somewhat weakly impressed anterior margin of the muscle fields. $220K_{\gamma}1$ (×1.5). Details of the hingement are on Plate 16, fig. 3.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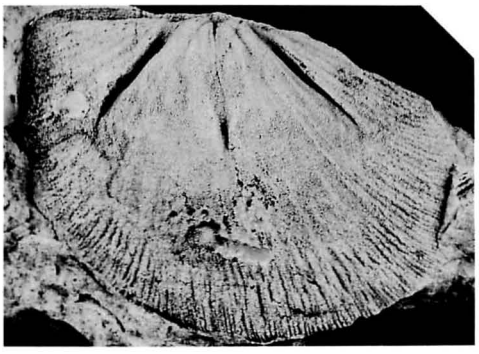
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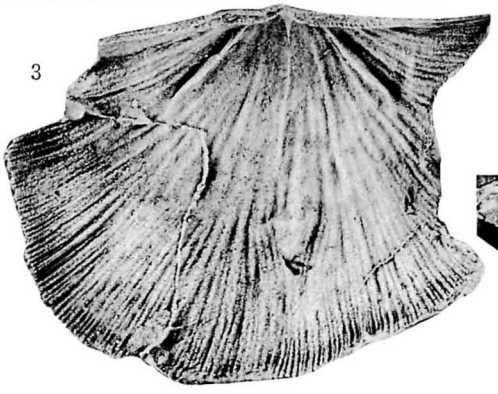
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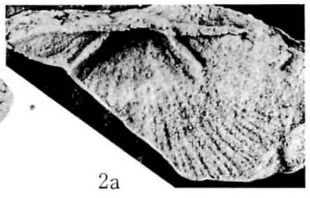
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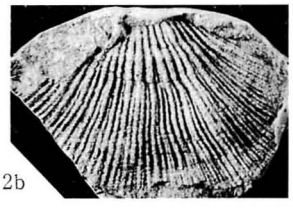
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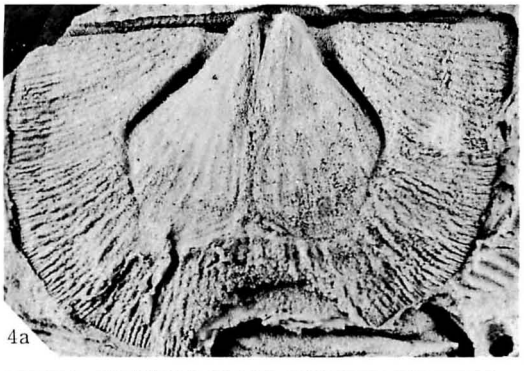
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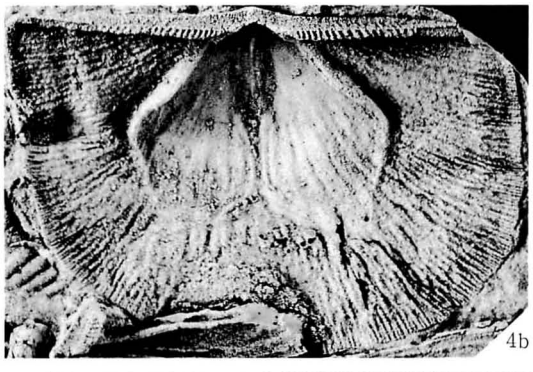
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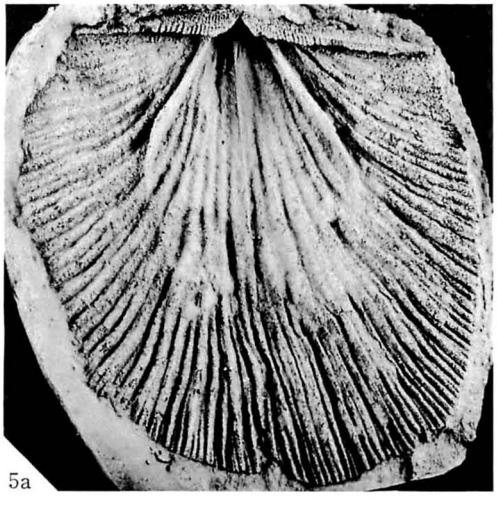
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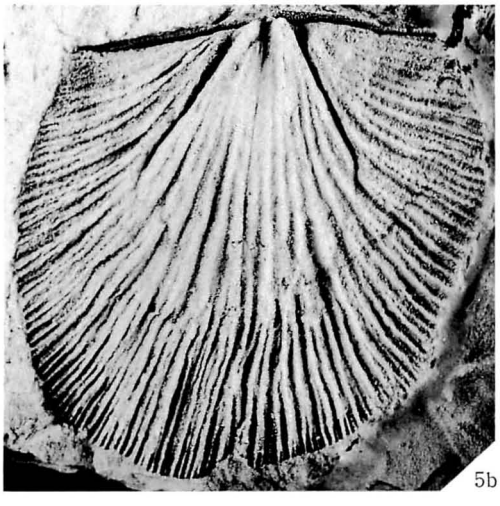
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Plate 15

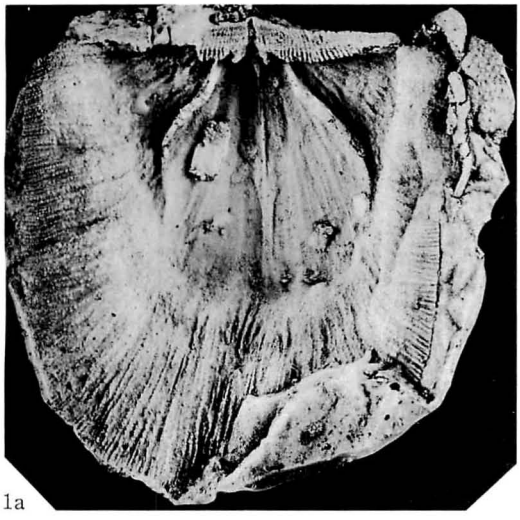
Explanation of Plate 15

Sinostrophia kondoi HAMADA, gen. et sp. nov. ..... page 53

Figs. 1, 2. Two large pedicle valves showing the well developed muscle fields. 1a and 2a are the latex replicas from the internal impressions (1b, 2b). 277K$_v$1 (×1.25), 080HC2 (×1). An enlarged figure of the first specimen is on Plate 17, fig. 5.

Fig. 3. Latex replica of interior of a small pedicle valve. Note the absence of teeth like projections at the delthyrial margin. 077HL2 (×1).

Figs. 4–6. Three pedicle exteriors showing the mode of rib increasing toward the shell periphery. Note some bundled ribs at the middle stage of development and the later surface with finely multicostellate ribs in fig. 6. 307K$_\varphi$1 (×1.5), 016HA3-4 (×2), 158 KP1 (×2).



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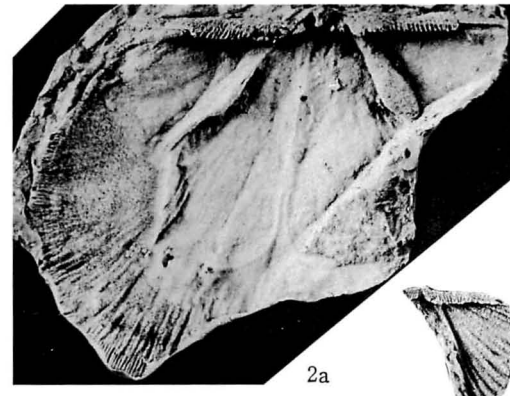

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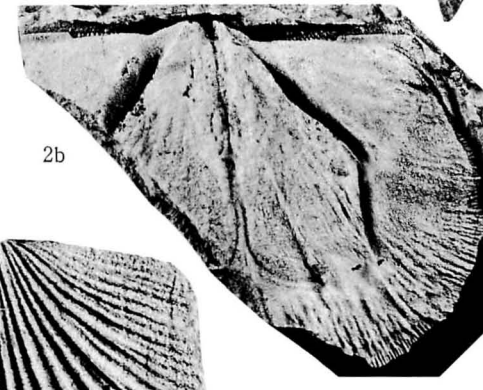

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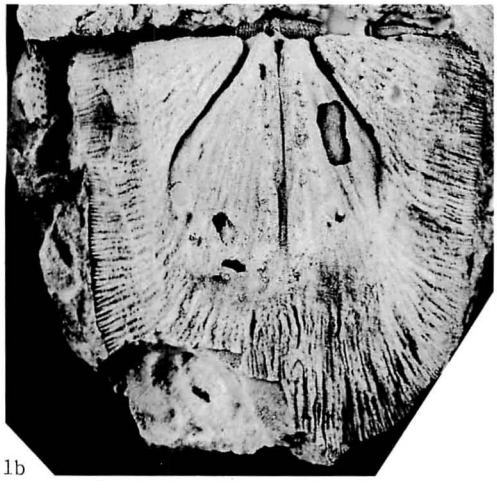

1b

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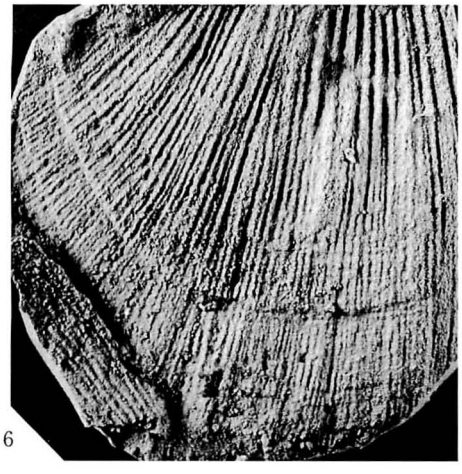
4



6

7

Plate 16

Explanation of Plate 16

Sinostrophia kondoi HAMADA, gen. et sp. nov. ..... page 53

Figs. 1–4. Four pictures display the development of hingement. Note the teeth like projections at the delthyrial margin. Denticles are restricted to approximately three fifths of the hinge length. The holotype specimen (4) shows the presence of a pseudodeltidium.

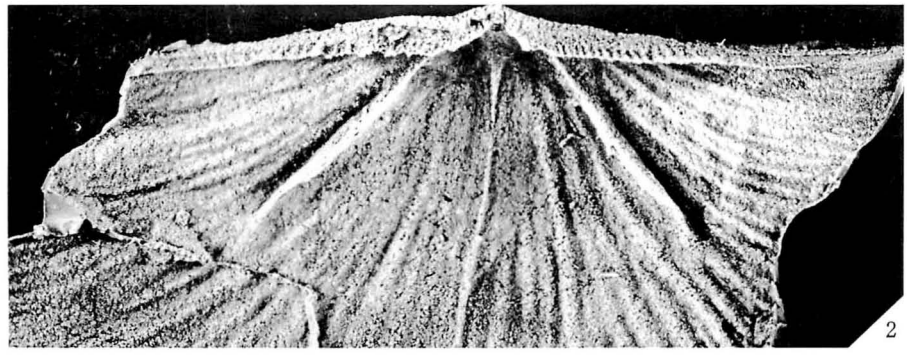
Fig. 1. 138KG1 (×5). *Vide* also fig. 3 on Plate 13.

Fig. 2. 054HF2 (×2.5). *Vide* also fig. 3 on Plate 14.

Fig. 3. 220K$_7$1 (×3). *Vide* also fig. 5a on Plate 14.

Fig. 4. 130KE1 (×3). *Vide* also fig. 4b on Plate 14.


1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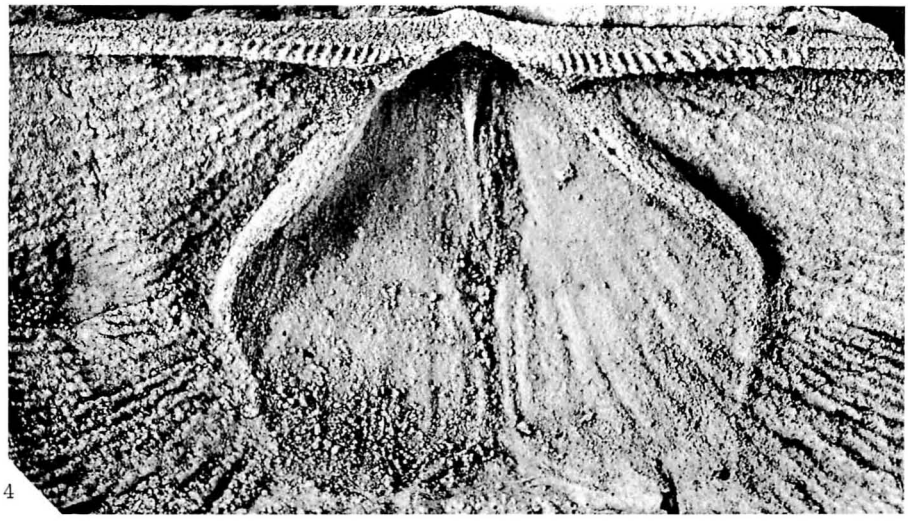
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Plate 17

Explanation of Plate 17

Sinostrophia kondoi HAMADA, gen. et sp. nov. ..... page 53

Figs. 1–5. Six pictures of five selected specimens illustrate the several degrees of development of the muscle fields and the teeth like projections at the delthyrial margin. See the figures on the preceding plate also.

Fig. 1. $262K_{\kappa}1$ (×2.5). *Vide* also fig. 1a on Plate 14.

Fig. 2. 131KE1 (×3). *Vide* also fig. 6 on Plate 13.

Fig. 3. 013HA2 (×2.5). *Vide* also fig. 2a on Plate 13.

Figs. 4a, b. 164KQ1 (×2.5). *Vide* also fig. 7b on Plate 13.

Fig. 5. $277K_{\nu}1$ (×3). *Vide* also fig. 1a on Plate 15.

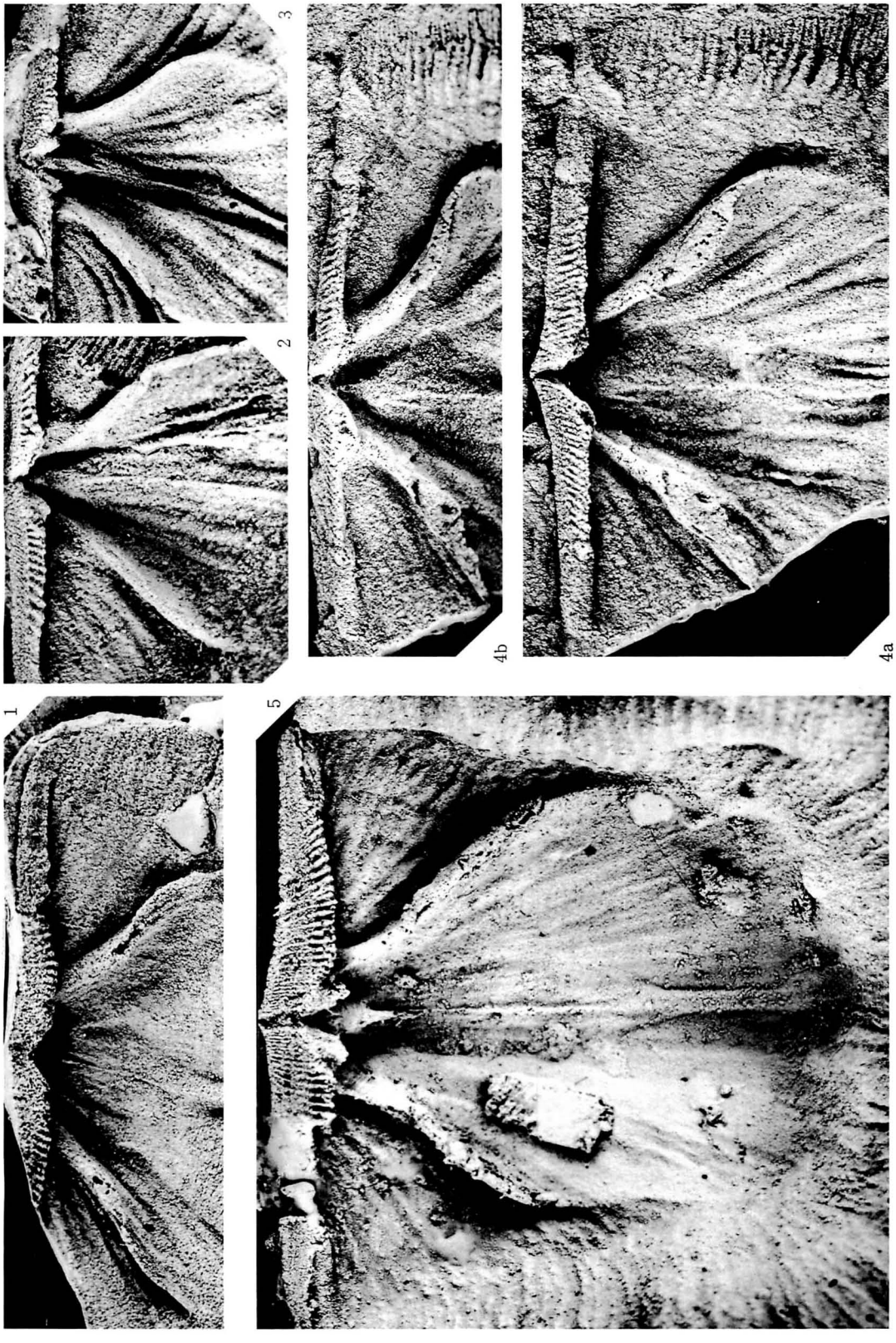

1
2
3
4a
4b
5

Plate 18

Explanation of Plate 18

Pholidostrophia sp. indet. A ..... page 57

Figs. 1a-c. Dorsal (a), lateral (b) and ventral (c) views of a strongly concave pedicle valve. 237K$_{\eta}$1 (×2).

Pholidostrophia sp. indet. B ..... page 57

Figs. 2a-d. A pedicle valve showing the interior (a) and less shell convexity (b) of the valve. Shell surface is entirely smooth. 162KP2 (a ×2), 162KP1 (b-d ×2).

Fig. 3. Almost complete brachial exterior with a reflected hinge line. Note the moderate concavity and the finely multicostellate shell surface with faint radial striae. 261K$_{\kappa}$1-2 (×2.5).

"*Schuchertella*" sp. indet. ..... page 58

Figs. 4, 6. Two small pedicle valves showing radial ribs which increase by implantation. 150KM1 (×1.5), 115KB1 (×4).

Figs. 5, 7. Two brachial interiors showing the short, divergent dental plates. 171HF2 (×4), 183KV1 (×2.5).

Fig. 8. Internal impression of a pedicle valve. 326KnB1 (×1.5).

Figs. 9a, b. Another internal impression of pedicle valve (b) and its latex replica (a) showing the divergent dental plates. 218K$_{\gamma}$1 (×1.25).

Figs. 10a, b. Dorsal (a) and posterior (b) views of rather well preserved interior of a brachial valve showing the trifurcate cardinal process and the triangular sockets. 084HM1 (a ×1, b ×2).

Fig. 11. Exterior of an imperfect pedicle valve showing radial ribs. 091KA2-3 (×2).

Figs. 12a-d. Internal impression of a pedicle valve (a) showing the thickened dental plates. b and c are its latex replicas of the exterior and interior respectively. c is an inclined and enlarged figure of the same interior to show the dental plates supporting the delthyrial margin. 078HL1 (a, c ×0.9, d ×2), 078HL2 (b ×0.9).

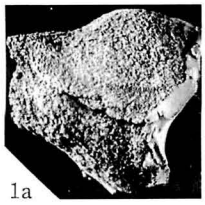
Strophomenid gen. et sp. indet. ..... page 58

Fig. 15. A small brachial interior showing two posteriorly prominent cardinal process lobes, widely divergent muscle bounding ridges, a broad median myophragm and the coarsely ribbed shell periphery. 310K$_{\phi}$1 (×4).

Aesopomum chinense HAMADA, sp. nov. ..... page 59

Figs. 13a-d. A small impression of brachial interior (a) and its latex replica (b) showing the posteriorly projecting cardinal process lobe which is supported by the anteriorly divergent crural plates. Deep sockets are formed by the ventral extension of the crural plates toward the shell floor. The cardinal process lobe is quadripartite (c) of which the central two are more prominent. External surface of the posterior portion of the specimen is almost smooth around the apex, but radially costellate at the periphery. 010HA3 (a, b ×1.5, c ×2.5), 010HA1 (d ×1.5). An enlarged figure of the cardinal portion is on Plate 19, fig. 7.

Fig. 14. Pedicle area showing the pseudodeltidium. 075HL1 (×1.5).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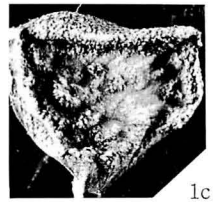
1b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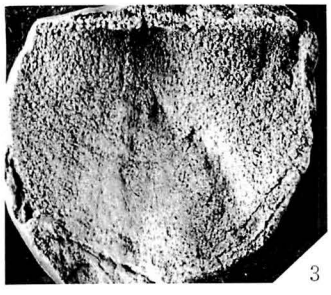
2a


2b


2c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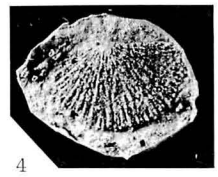
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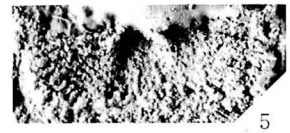
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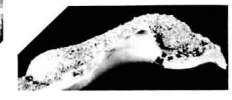
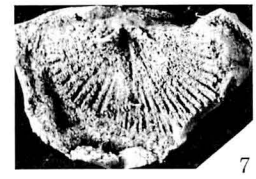



10b


8


6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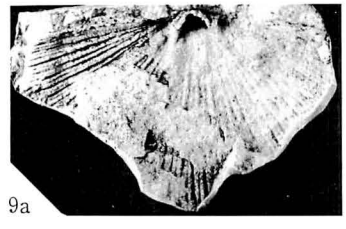
10a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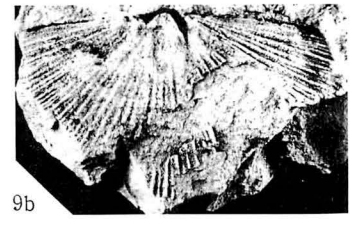
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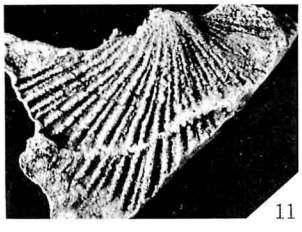
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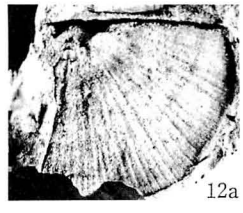
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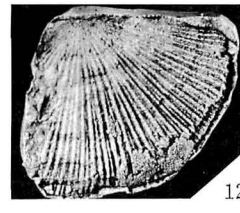
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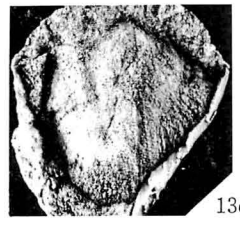
12c


13a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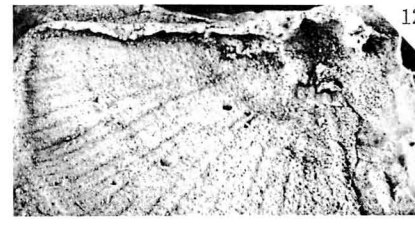
12d




13b


14


13c


15

Plate 19

Explanation of Plate 19

Aesopomum chinense HAMADA, sp. nov. ..... page 59

Fig. 1. An imperfect pedicle valve showing the surface ornamentation and the shape of anterior margin. 035HB2 (×1).

Fig. 2. Latex replica of a brachial exterior showing the multicostellate surface ornamentation and the blunt apex. 314K$_{\phi}$1 (×1.5).

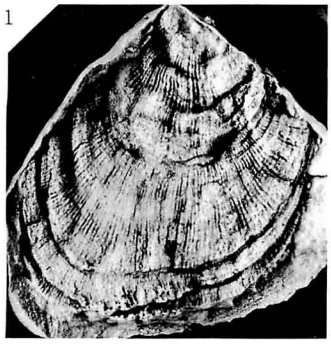
Figs. 3a–e. Exterior (a) and interior (b, c) of the holotype specimen of a young brachial valve. e and d are the posterior and dorsal views of the latex replica of the cardinal area. Note the bilobed process. 024HA4 (a ×1.5), 024HA5 (b, c ×1.5, d, e ×3).

Figs. 4a–c. Impression of a large pedicle interior (a) and its latex replica (b) showing the muscle fields, cardinal area and anteriorly projecting teeth. Anterior view of the cardinalia (c) shows the well developed dental lamellae and the muscle scars. 119KB1 (a, b ×1.25, c ×2.5).

Figs. 5a, b. Latex replica of an apical portion of pedicle valve showing smooth apex and slightly inclined pedicle area with a wide pseudodeltidium. 346KnG1 (a ×1.5, b ×2.5).

Figs. 6, 8. Two fragmentary pedicle valves showing the smooth (6) and somewhat twisted (8) apical portions. 308K$_{\phi}$1 (×3), 242K$_{\theta}$1 (×2).

Fig. 7. An enlarged anterior view of the cardinal process of the specimen illustrated on Plate 18, fig. 13b. 010HA3 (×2.5).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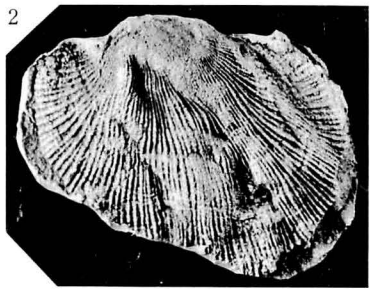
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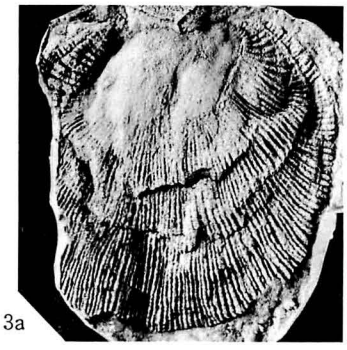
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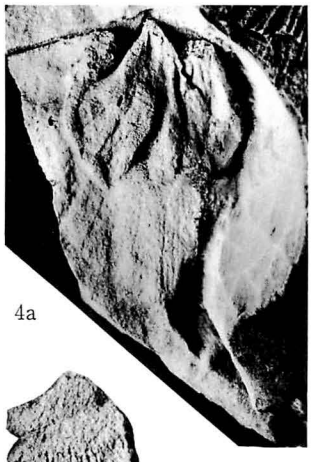
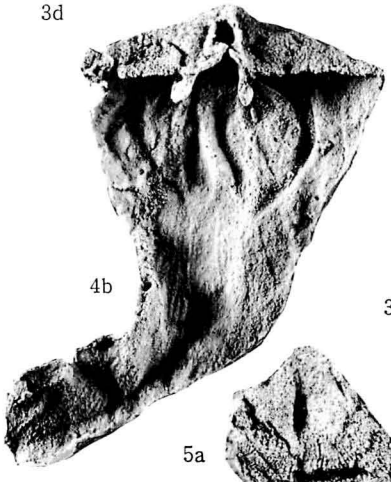
3d


4a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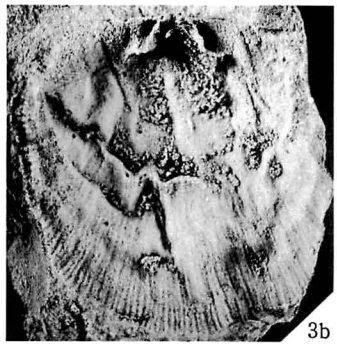
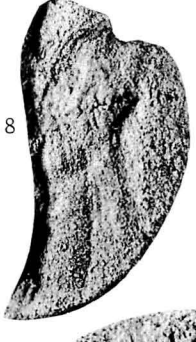

3b


3c


6


5a


7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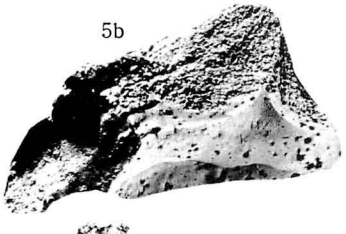

5b


4c


3e

Plate 20

Explanation of Plate 20

Aesopomum chinense HAMADA, sp. nov. ..... page 59

Figs. 1, 2a, b. Two large brachial valves showing the interior. Note the highly prominent, quadripartite cardinal process lobe, deep sockets, widely divergent crural plates and socket ridges, deeply impressed muscle scars. 318K$_{\phi}$1 (×2), 312K$_{\phi}$1 (a, b ×1.5).

Chonostrophiella khinganensis HAMADA, sp. nov. ..... page 61

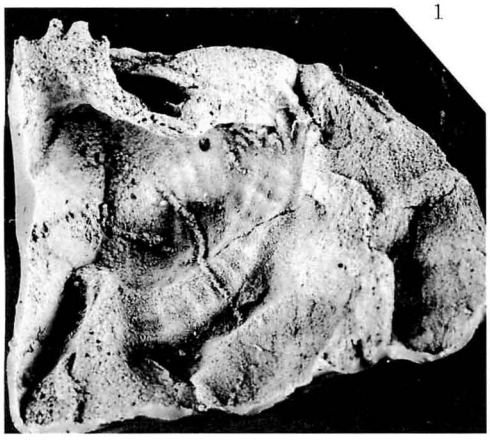
Figs. 3a, b. Pedicle exterior showing the multicostellate shell surface and the cardinal spines (b). 274K$_{\nu}$1 (a ×2, b ×2.5).

Figs. 4–6. Three pedicle exteriors showing the transversely elongate shell outline and cardinal spines. 029HA5 (×1.5), 182KV1 (×2), 268K$_{\lambda}$1 (×2.5).

Figs. 7a, b. Latex replica of an interior of the holotype specimen showing the narrow interarea with an open delthyrium, cardinal teeth and the weakly impressed adductor scars separated by a short median septum, and a small pseudodeltidial plate ? 160KP1 (a ×1.5, b ×5).

Figs. 8a, b. Another replica of a pedicle interior showing the anteriorly reflected shell margin. 070HK1 (×1.5).

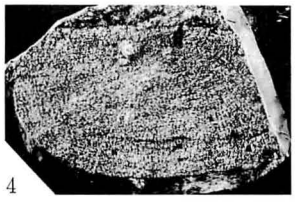
Figs. 9–13. Five pedicle interiors showing the teeth and pseudodeltidium (?) (11), a median septum (11, 12) and the cardinal spines (13). 018HA3 (×2), 197K$_{\alpha}$1 (×1.5), 270K$_{\lambda}$1 (×2), 008HA1 (×1.5), 231K$_{\zeta}$1 (×2).


1


2a


2b


3a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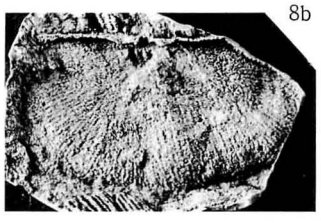
8a

6


5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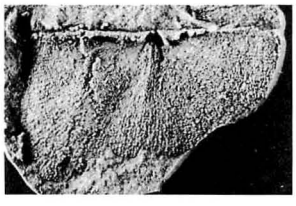
7a



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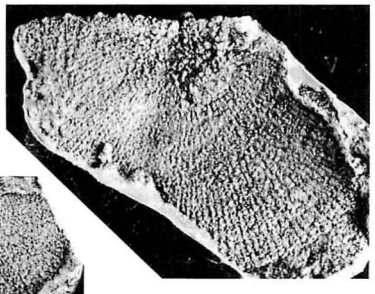

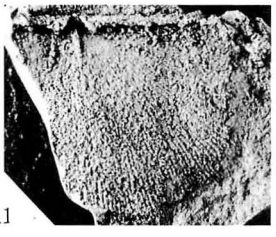
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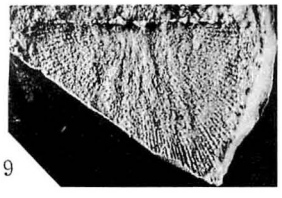
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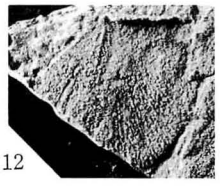
7b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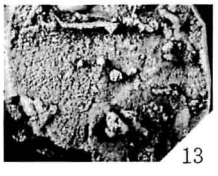

13

Plate 21

Explanation of Plate 21

"*Camarotoechia*" sp. indet. ..... page 69

Figs. 1a-d. Dorsal (a), posterior (b), anterior (c) and lateral (d) views of latex replica of pedicle external surface showing somewhat angular radial ribs and the strongly sinuated anterior margin. Note the strongest boundary radials of the sinus. 296K$_{\tau}$1 (×1.25).

Figs. 2a-e. Internal impression of a brachial valve (c-d) and its latex replica (a, b) showing a short myophragm which supports the small, open crural plates without any distinct cruralium. 290K$_{\rho}$1 (a, c-e ×1.5, b ×3). (*Vide* also figs. 2a, b and 8 on Plate 24)

Zlichorhynchus asiaticus HAMADA, sp. nov. ..... page 63

Fig. 3. Small exterior of a pedicle valve showing rather broad and shallow sinus at the frontal margin. 141KH1 (×2).

Figs. 4a-f. The holotype specimen of brachial valve showing the posterior (a), ventral (b) and lateral (f) views of the internal impression and its latex replica (c-e). Note the small cardinal process superimposed on the notothyrial platform in the uncovered cavity, the prominently developed crural bases and a low but long myophragm (c, d, e). 323-4KnA1 (a-d, f ×1.5, e ×3).

Wilsoniella grandis HAMADA, sp. nov. ..... page 64

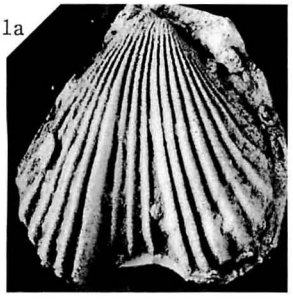
Figs. 5, 6. Two fragmentary brachial valves showing the round-topped radial ribs. 263K$_{\kappa}$1 (×1.5), 159KP1 (×1.5).

Figs. 7a-c. Dorsal (a), posterior (b) and lateral (c) views of exterior of a brachial valve compressed along its axis. The interior is on Plate 22, figs. 2a-d. 143KJ1 (×1.25).


1b

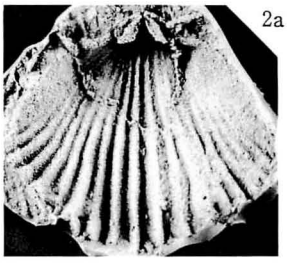

3


4a


1a


2b


4b


2a


1c

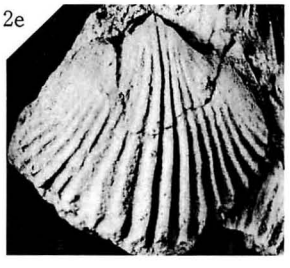

4c

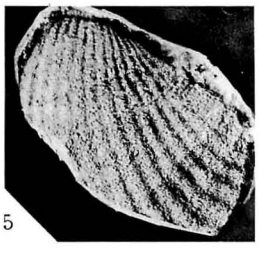

1d


2d


2c


4d


2e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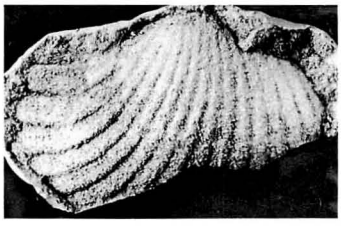

6


4f


7b


7a


7c


4e

Plate 22

Explanation of Plate 22

Wilsoniella grandis HAMADA, sp. nov. ..... page 64

Figs. 1a-d. Posterior (a), anterior (b) and ventral (c) views of impression of a brachial valve and its latex replica (d). Note the well-developed keel like median myophragm that supports the connected hinge plates. 320K$_{\omega}$1 (×1.25). *Vide* also an enlarge figure of the hinge plates on Plate 23, fig. 3e.

Figs. 2a-d. Posterior (a), ventral (b) and lateral (c) views of an internal impression of the brachial valve shown on Plate 21, figs. 7a-c. 2d is an enlarged picture of 2a showing the small opening at the posterior end of the hinge plates and its anterior extension. Note the roughly corrugate inner surface of the sockets (b). 143KJ1 (a-c ×1.25, d ×2).

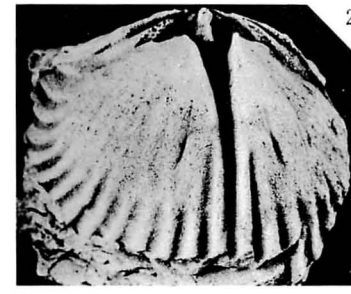
Figs. 3a-e. Lateral (a), posterior (b), ventral (c) and anterior (d) views of an impression of the holotype brachial interior and its latex replica (e). Note the strongly uniplicate anterior commissure line (d) and a narrow blade like myophragm (b). 082HM1 (×1). *Vide* also on Plate 23, figs. 2a, b for the enlarged figures of the hinge portion.

Fig. 4. An inclined view of another brachial interior to show the well-developed myophragm, inner opining of the notothyrial foramen and one of the crural plate. 280K$_{\xi}$1 (×1.25).

Fig. 5. An antero-lateral view of a Steinkern showing the strongly uniplicate commissure line with the marginal spines. 036HC1 (×1).


1a


2a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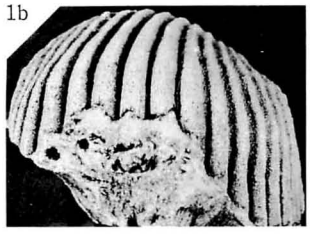
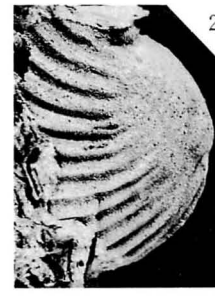

1b


1d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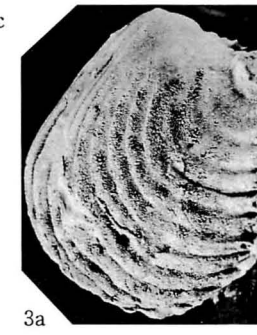
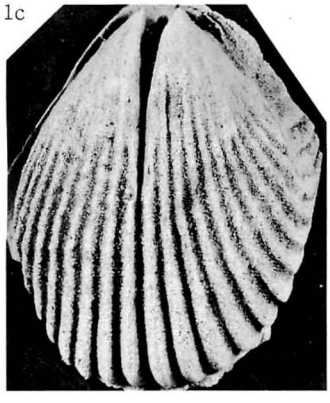

3a


1c

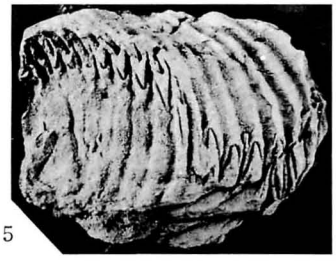

2d


3b


1e


3e


3c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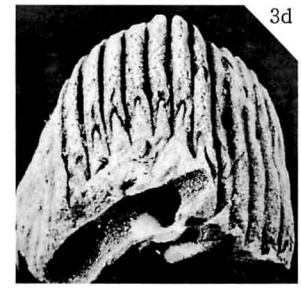

3d

Plate 23

Explanation of Plate 23

Wilsoniella grandis HAMADA, sp. nov. ..... page 64

Figs. 1a-f. A deformed specimen with shell material which is partially exfoliated. Note the strongly uniplicate anterior commissure line with the long marginal spines (f). 142KI1 (×1.25).

Figs. 2a, b. Two enlarged figures of the hinge portion of the holotype specimen illustrated on Plate 22, fig. 3e to show an elongate outer opening and its inner gape of triangular shape of the notothyrial foramen, the thick conjoined hinge plates and the boss-shaped crurae. 082HM1 (×2).

Fig. 3. Another enlarged figure of the hinge portion of a younger individual showing the thinner hinge plates and shallower sockets. 320K$_{\omega}$1 (×2.5). *Vide* also fig. 1e, Plate 22.

Uncinulus piloides HAMADA, sp. nov. ..... page 67

Figs. 4a-e. Dorsal (a), lateral (b), ventral (c), anterior (d) and posterior (e) views of an isolated specimen to show the general outline of the shell. Note the antero-laterally reflected brachial flank (b) and the rectangularly uniplicate anterior commissure line (d). 303K$_{\chi}$1 (×1.5).

Figs. 5a-f. Five views of the holotype Steinkern show the shell outline and some internal features. a and c show the pedicle interior with a short but strong septum and the muscle scars. b and d illustrate the brachial muscle scars and deep brachial sinus. e is an enlarged figure of d to show the long marginal spines at the antero-lateral edge. 304K$_{\chi}$2 (a-d, f ×1.5, e ×3).

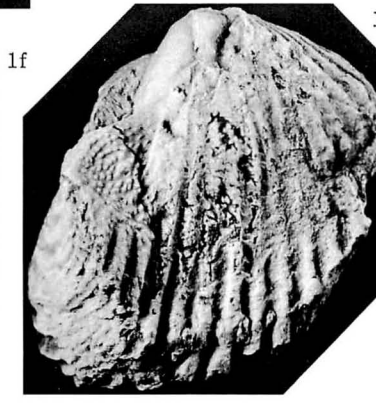

1a


1b


1c


1e


1f


1d


2a


2b


3


4d

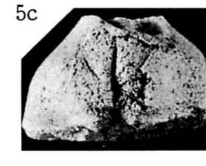

4e

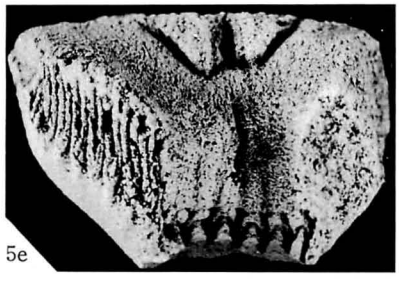

4a


4b

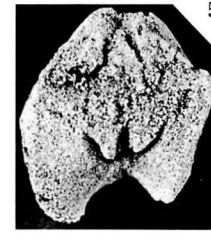

4c


5d


5c


5e


5f


5b


5a

Plate 24

Explanation of Plate 24

Pectorhyncha (?) sp. indet. ..... page 68

Figs. 1a, b. Latex replica (a) and impression of a pedicle interior. 134KE1 (×2.5).

Figs. 3, 4. Two brachial internals showing the well developed median septa and the small septaria (3a, 4a, c). Note the widely divergent and open hinge plates and the posteriorly curved ribs on lateral flanks. 295K$_{\sigma}$1 (3a, b ×2.5, 3c ×5), 273K$_{\mu}$1 (×2).

Fig. 7. An exterior of brachial valve showing the round-topped and posteriorly curved ribs on the lateral flank. 109KB1 (×2.5).

"*Camarotoechia*" sp. indet. ..... page 69

Figs. 2a, b. Impression of a pedicle interior (a) and its latex replica (b) showing the strong hinge lamellae and a short median septum in the muscle field. 005HA1 (×2). This specimen was illustrated by NONAKA (1944, plate 27, fig. 7). *Vide* Plate 30.

Fig. 8. A brachial exterior showing the angular radial ribs and the closely set growth lamellae. 224K$_{\gamma}$1 (×2). *Vide* also Plate 21, figs. 1, 2.

Eucharitina (?) sp. indet. ..... page 68

Figs. 5a–c. A pedicle exterior showing the anteriorly sinuated shell with numerous flat-topped radial ribs. Note the pedicle opening (b). 145KK1 (×1.5).

Fig. 6. Another pedicle exterior to show the surface ornamentation. 133KE1 (×2).

"*Atrypa*" sp. indet. ..... page 70

Figs. 9a–d. Impression of a brachial interior (a), its latex replica (b, c) and replica of the exterior (d). Note the presence of a low median myophragm (a, c). 022HA4 (a, b ×1.5, c ×2.5), 022HA3 (d ×1.5). This specimen was illustrated by NONAKA on his plate 27, fig. 8 (*Vide* Plate 30).

Bifida orientalis HAMADA, sp. nov. ..... page 72

Figs. 10, 11a, b. Two pedicle exterior showing the broad median fold with a narrow plica on it. 094KA3 (×5), 090KA2 (a ×1, b ×5).

Fig. 12. Latex replica of a pedicle interior showing the prominent median septum. 095 KA4 (×5).

Figs. 13, 14a, b. Impression of a slightly compressed pedicle interior (13) along the axis and its latex replica of the exterior (14a, b). Note the well-developed median septum and the strongly impressed muscle fields on the anterior portion of the shell. 217K$_{\beta}$3′ (13 ×5), 217K$_{\beta}$3 (a ×1.25, b ×5).

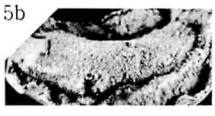
Figs. 15a, b. Impression (a) and its latex replica (b) of an obliquely compressed pedicle interior. 203K$_{\beta}$1 (×4).

Figs. 16a–d. Impression of the holotype pedicle interior (a, b) and its latex replica (c, d). Note the oval muscle field and a median septum. 093KA3 (a, c ×1, b, d ×5).

Figs. 17a, b. An obliquely compressed brachial exterior showing the broad sinus with a median plica. 202K$_{\beta}$1 (a ×1, b ×5).


1a


1b

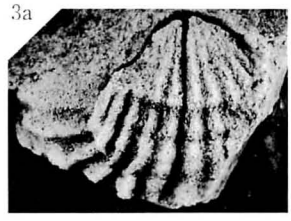

5b


5a


2a


2b


6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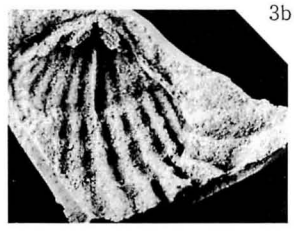

3b

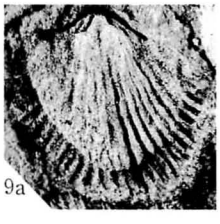

5c

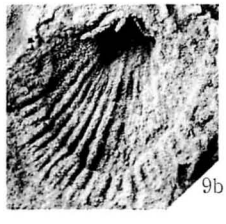

4a


4c


4b

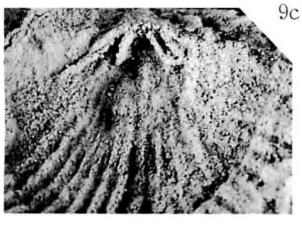

3c


9a


9b

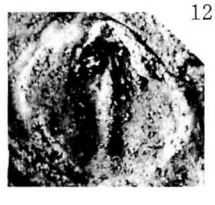

7


8


9c


9d


10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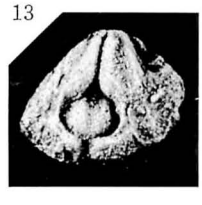
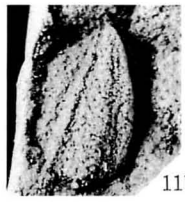

13


16a

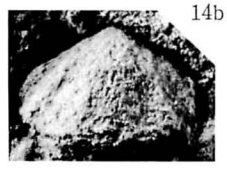

16c

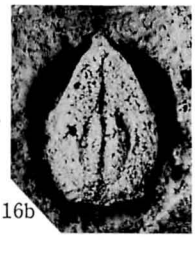

11a


11b


14a


17a


14b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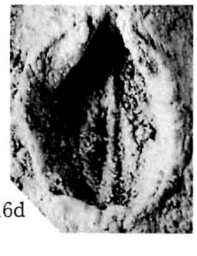

16d


17b


15a


15b

Plate 25

Explanation of Plate 25

Nucleospira musculosa HAMADA, sp. nov. ..... page 72

Fig. 1. Pedicle interior of a young individual. 098KA3 (×2.5).

Figs. 2, 3. Two latex replicas of pedicle interior showing the muscle scars and a narrow, long median septum attaining the anterior periphery. 045HF1 (×1.25), 057HF2 (×1.5).

Figs. 4a–c. The holotype pedicle specimen showing the interior (a, c) and exterior (b). Note the large flabellate muscular impression and narrow but prominent median septum. 087KA3 (a ×1.5, c ×4), 087KA2 (b ×1.5).

Cyrtina sp. indet. ..... page 73

Figs. 5a–c. A brachial interior showing the alate shell outline and the hinge margin. Note the presence of a small median ridge in the beak area (c). 061HG1 (a ×1, b, c ×3).

Figs. 6a, b. Another alate form of brachial valve showing the exterior. 239K$_{\gamma}$1 (a ×1, b ×4).

Figs. 7a–c. Posterior (a) and dorsal (b) views of a Steinkern and a latex replica of its brachial exterior showing the widely open delthyrium and a strong median septum and septarium. 286K$_{o}$1′ (a, b ×3), 286K$_{o}$1 (×3).

Fig. 8. A part of the brachial exterior. 100KA3 (×5).

Spiriferid gen. et sp. indet. ..... page 81

Fig. 9. A fragmentary pedicle exterior showing the multicostellate shell and alate form. 229K$_{\zeta}$1 (×1.5).

Figs. 10a, b. Another pedicle valve showing the internal impression (b) and its latex replica (a). Note the alate shell outline with a broad, smooth median sinus, and the widely open delthyrium. 192KZ1 (×1.5).

"Howellella" amurensis HAMADA, sp. nov. ..... page 75

Figs. 11a, b, 12. Two pedicle interiors showing the well-developed incurved dental lamellae and a deep sinus. 167KQ1 (×1.5), 063HH1 (×1).

Figs. 13, 14. Latex replicas of two pedicle valves showing the interarea with open delthyrium, thick teeth (13) and a small ventral process that extends toward anterior to form a low, short median septum (14). 352KnJ1 (×1.5), 283K$_{\xi}$1 (×1).

Figs. 15a–d. Another pedicle valve showing the triangular interarea with open delthyrium. Note the well-developed dental lamellae. 271K$_{\mu}$1 (×1.5).

Figs. 16, 17. Two pedicle valves showing the exterior (16a) and the interiors. 089KA2 (16a ×1.5), 089KA3 (16b, c), 050HF1 (17a–c ×1.25, 17d ×2.5).

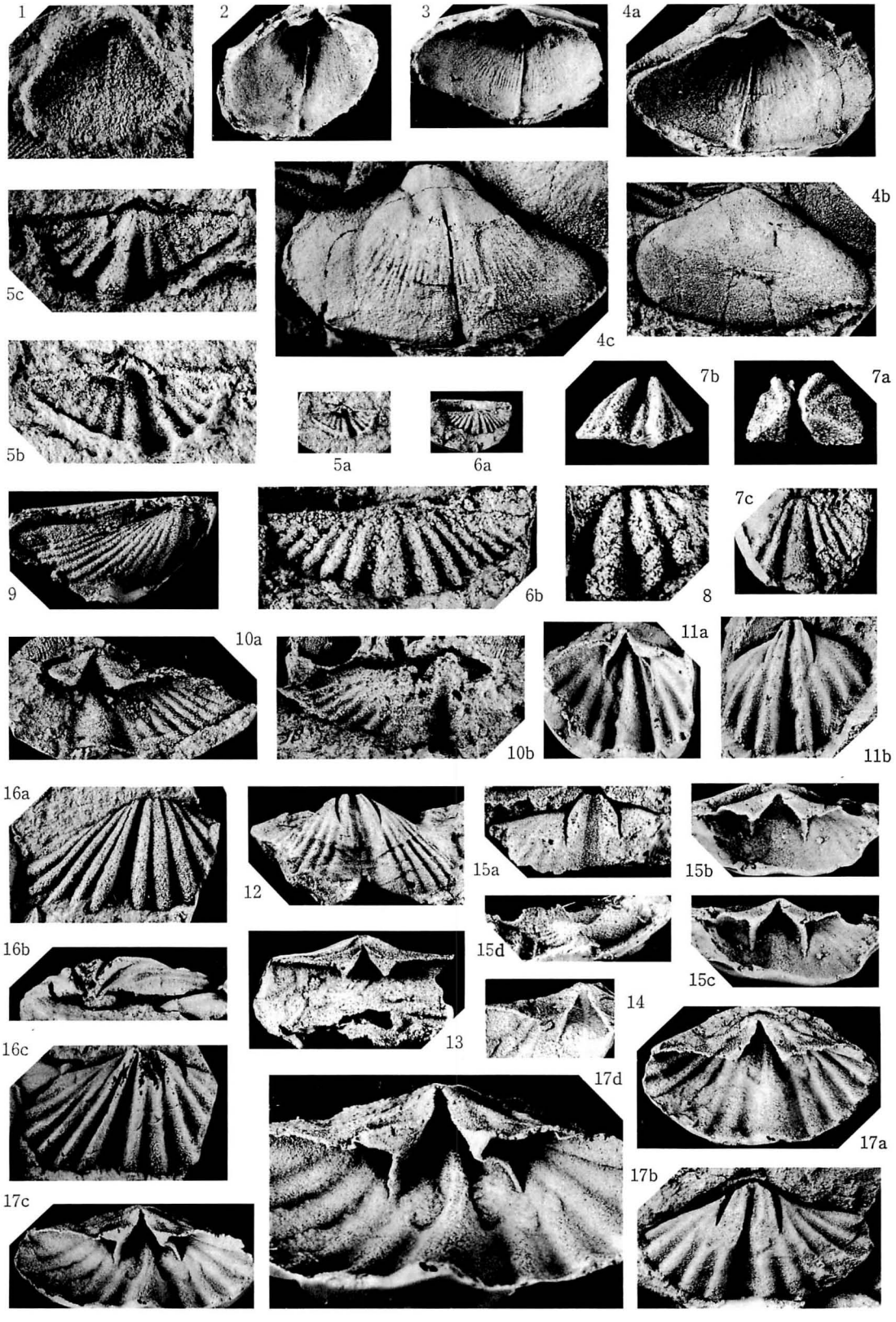

1
2
3
4a
4b
4c
5a
5b
5c
6a
6b
7a
7b
7c
8
9
10a
10b
11a
11b
12
13
14
15a
15b
15c
15d
16a
16b
16c
17a
17b
17c
17d

Plate 26

Explanation of Plate 26

"*Howellella*" *amurensis* HAMADA, sp. nov. ..... page 75

Figs. 1a–c. A laterally compressed pedicle valve showing the exterior and a Steinkern. 230K$_{\zeta}$1 (a, b ×1.5), 230K$_{\zeta}$1′ (c ×1.5).

Figs. 2, 3. Two pedicle interiors showing somewhat straight dental lamellae. 222K$_{\gamma}$1 (a, b ×1.25, c×2.5), 044HF1 (a–c ×1.25, d ×4). The latter specimen was illustrated by NONAKA on his plate 27 as *Spirifer tonkinensis* MANSUY. *Vide* Plate 30 of this paper.

Figs. 4a, b. A pedicle interior showing the anterior portion of the ventral process and a low median septum as the anterior extension. 4b illustrates a lateral view of a tooth and the supporting dental lamellae. 049HF1 (×1.25).

Fig. 5. A small brachial interior showing the narrow interarea with widely open notothyrium, sockets and the divergent crural plates. 041HF1 (×1.25).

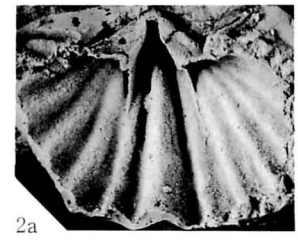
Figs. 6a–f. The holotype brachial specimen showing an impression of interior (a–c) and its latex replica (d, e) and the exterior (f). 019HA7 (a, b, d ×1.5, c, e ×2.5), 019HA3 (f ×1.5).

Figs. 7a–d. Another brachial interior showing the presence of a low median ridge. 340 KnF1 (a–c ×1.25, d ×2.5).

Fig. 8. A brachial interior showing a interior with the widely divergent notothyrium. Note the narrow, deep sockets. 338KnE1 (×1.25).

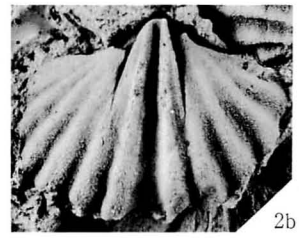

1b


1a


2a


2c


1c

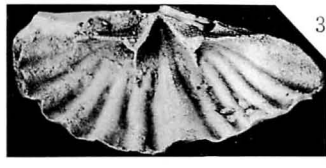

2b


4a


4b


3a


3b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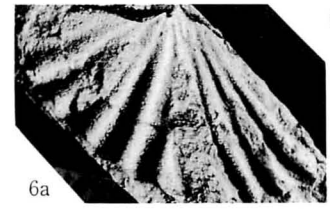
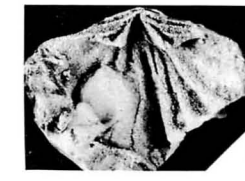

6a


6b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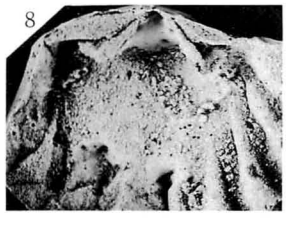
3d


7a


6c


6e


7b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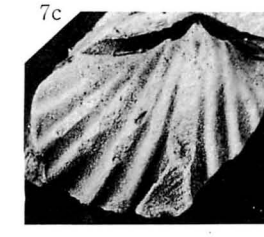
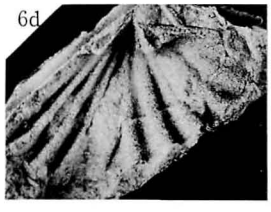

7c


6d


7d

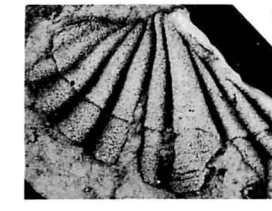

6f

Plate 27

Explanation of Plate 27

"*Howellella*" *amurensis* HAMADA, sp. nov. ..... page 75

Figs. 1a-e. Dorsal (a), lateral (b) and posterior (e) views of impression of a large brachial interior and its latex replica (c, d) showing the interarea, sockets and crural base. Note the medianly separated cardinal process like projection in the notothyrial cavity. 188 KX1 (a-c ×1.25, d, e ×2.5).

Paraspirifer aff. *cultrijugatus* (ROEMER) ..... page 78

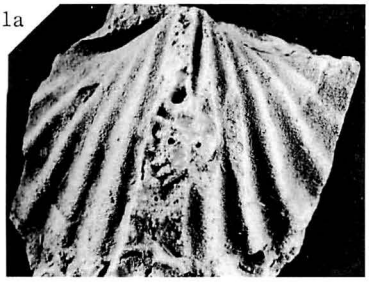
Figs. 2a-c. A pedicle valve with thick test showing the general outline and the radial ribs. Note the strong sinus that begins at the beak area and the grooved boundary rib at the anterior periphery. 176KS1 (×1).

Fig. 3. A compressed brachial exterior showing a broad median fold that is neighboured by the anteriorly grooved boundary ribs. 174KR1 (×1.25).

Figs. 4a-d. Impression of a pedicle interior (a, b) and its latex replica (c, d) showing the well-developed incurved dental lamellae, teeth, triangular interarea with widely open delthyrium. Note the spindle shaped ventral process in the delthyrial cavity. 272K$_{\mu}$1 (×1.25).

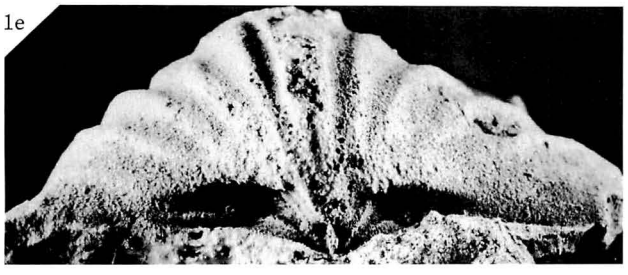
Fig. 5. Interior of another fragmentary pedicle valve. 004HA1 (×1).

Figs. 6, 7. Two small pedicle exteriors showing the sinus and narrow interspaces of the costation. 350KnI1 (×1.5), 351KnJ1 (×1.5).


1a


1b

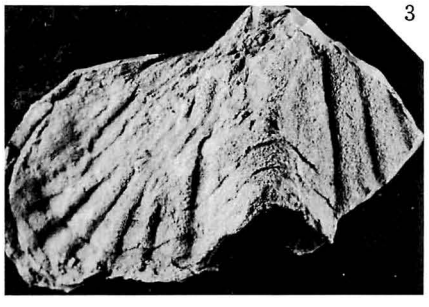

1d


1e


1c


2b


2c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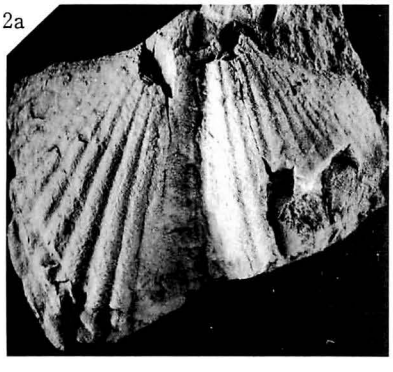
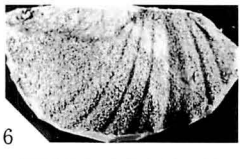

2a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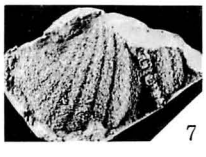
4c


4b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4a


5

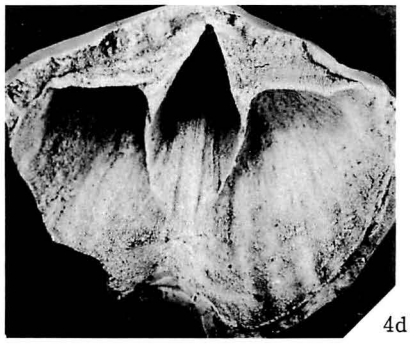

4d

Plate 28

Explanation of Plate 28

Fimbrispirifer cf. *divaricatus* (HALL) ..... page 80

Figs. 1, b. An incomplete pedicle interior showing the rounded and striated muscle fields bordered by the low dental plates, a narrow and short median ridge, and the multicostellate broad sinus. 153KN1 (×1.25).

Paraspirifer aff. *cultrijugatus* (ROEMER) ..... page 78

Figs. 2a-e. Impression of a large incomplete pedicle interior (b, c) and its latex replica (a) and two views of the exterior (d, e). Note the high, incurved interarea with an open delthyrium, thick cardinal teeth and the strongly developed dental lamellae. 260 $K_{\kappa}1$ (a-c ×1.25), 260$K_{\kappa}2$ (d, e ×1.25).

Acrospirifer sp. indet. ..... page 74

Figs. 3a-d. A brachial valve showing the interior (a-c) and the exterior (d). Note the narrow interarea with widely open notothyrium, narrow sockets and a short median ridge, somewhat thickened crural base (c) and the round- or flat-topped radial costae (d). 046HF1 (a, c ×1.25, b ×2.5), 046HF2 (d ×1.25).

Figs. 4, 5. A lateral flank of an exterior (4) and an interior (5). Note the blunt costation similar to 3d. 281$K_{\xi}1$ (×1), 339KnE1 (×1.25).

Figs. 6a-c. Dorsal (a), lateral (b) and posterior (c) views of a pedicle exterior showing the faint costation on the flank. 315$K_{\phi}1$ (×1.25).

Figs. 7a, b. A large brachial interior showing the interarea, notothyrium, sockets, narrow socket ridges and a high fold. 282$K_{\xi}1$ (a ×1.25, b ×2.5).


1a

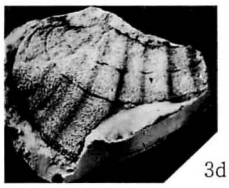

1b


2a


3b


2b


3a

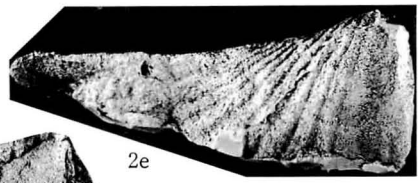

3d


2c

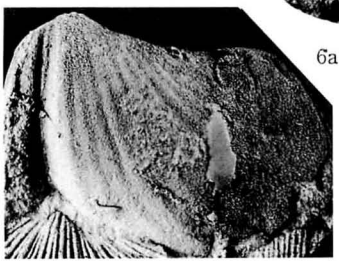

2d


3c


5


2e


6b


6a


4


6c


7a


7b

Plate 29

Explanation of Plate 29

Megastrophia (*Protomegastrophia*) *manchurica* HAMADA, sp. nov. ..... page 47

Figs. 1a-c. Impression of interior of a young brachial valve (a) and its latex replica (b, c) showing the postero-dorsally projecting cardinal process lobes, widely divergent socket ridges, hinge crenulation and the faintly impressed muscle fields divided by a low but long median myophragm. 236K$_7$1 (a, b ×1.5, c ×3).

Fig. 2. Another brachial valve showing the cardinal process lobes and the moderately concave shell with blunt radial costae. An enlarged figure of the hinge portion is on Plate 8, fig. 2. 110KB1 (×1.5).

Dalejina kinsuiensis HAMADA, sp. nov. ..... page 41

Figs. 3-8. Enlarged figures of the cardinal portion of the brachial valves to show the development of the cardinal process lobe, sockets and the brachial processes.

Fig. 3. 097KA4 (×4)

Fig. 4. 177KT1 (×4) *Vide* Plate 3, figs. 10a, b.

Fig. 5. 125KC1 (×4) *Vide* Plate 3, figs. 7a, b.

Figs. 6a, b. 088KA3 (×4)

Fig. 7. 253K$_1$1 (×3) *Vide* Plate 3, figs. 9a, b.

Fig. 8. 186KW1 (×3) *Vide* Plate 4, figs. 5a-d.

Paraspirifer aff. *cultrijugatus* (ROEMER) ..... page 78

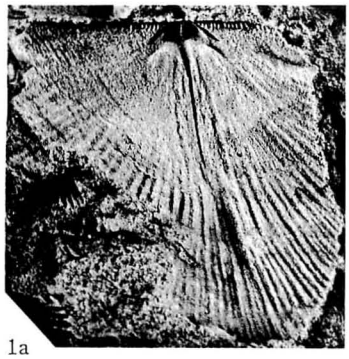
Figs. 9a, b. A small fragmentary pedicle valve showing the exterior (a) and interior (b). Note the narrow interspace of the costation and the strongly impressed muscle field. 354KnK1, 1′ (×1.25).

Mucrospirifer cf. *paradoxiformis* HOU ..... page 83

Figs. 10a-f. Internal (a, b) and external (c-f) views of latex replicas of an incomplete pedicle valve. Note the alate shell outline and the strongly incurved dental lamellae. The median sinus is faintly ornamented by a narrow ridge. 355MA1, 1′ (×1.5).

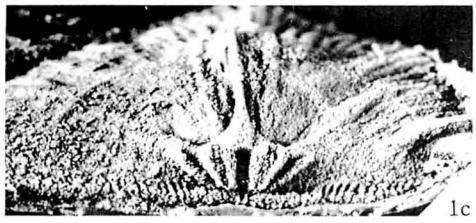
Leptaena "rhomboidalis" (WILCKENS) ..... page 82

Fig. 11. Latex replica of a pedicle exterior showing the shell outline and the surface ornamentation. 356MA1 (×1.5).


1a


1b


2


1c


3


4


5


7


6a


9a


9b


8


6b

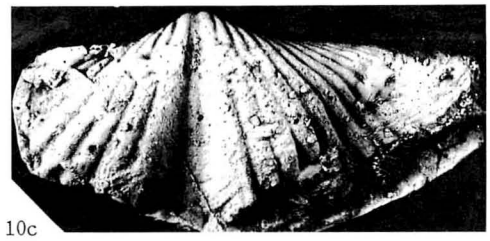

10a


10e


11


10d


10b


10c


10f

Plate 30

Explanation of Plate 30

(This plate is reproduced from NONAKA's plate 27, 1944 in original size)

The original designation is followed by the revised identification, and the collated illustration in this paper in the parentheses.

Fig. 1. *Stropheodonta* (*Leptostrophia*), new species (*Leptostrophia nonakai* HAMADA, sp. nov., Plate 9, fig. 5a for the larger specimen; *Sinostrophia kondoi* HAMADA, gen. et sp. nov., Plate 11, fig. 5: latex replica for the smaller specimen).

Fig. 2. *Stropheodonta*, new species (*Sinostrophia kondoi* HAMADA, gen. et sp. nov., Plate 13, fig. 1c).

Fig. 3. *Stropheodonta*, new species (*Sinostrophia kondoi* HAMADA, gen. et sp. nov., Plate 13, fig. 1b).

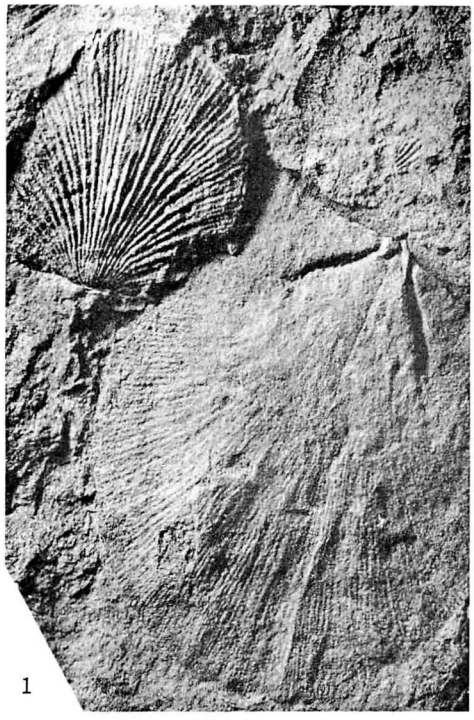
Fig. 4. *Stropheodonta*, new species (*Sinostrophia kondoi* HAMADA, gen. et sp. nov., Plate 13, fig. 2b).

Figs. 5, 6. *Gypidula* cf. *mansuyi* GRABAU (*Proschizophoria kobayashii* HAMADA, sp. nov., Plate 2, figs. 1a, b).

Fig. 7. *Camarotoechia* sp. indet. ("*Camarotoechia*" sp. indet., Plate 24, fig. 2a).

Fig. 8. *Atrypa desquamata* SOWERBY ("*Atrypa*" sp. indet., Plate 24, fig. 9a).

Fig. 9. *Spirifer tonkinensis* MANSUY ("*Howellella*" *amurensis* HAMADA, sp. nov., Plate 26, fig. 3b for the spiriferid; *Sinostrophia kondoi* HAMADA, gen. et sp. nov., Plate 11, fig. 4: latex replica for the strophomenid).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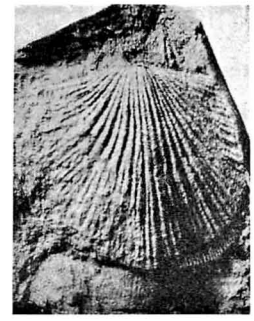
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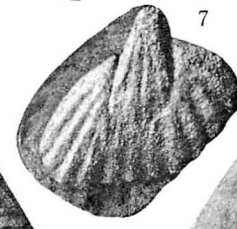
3


4


5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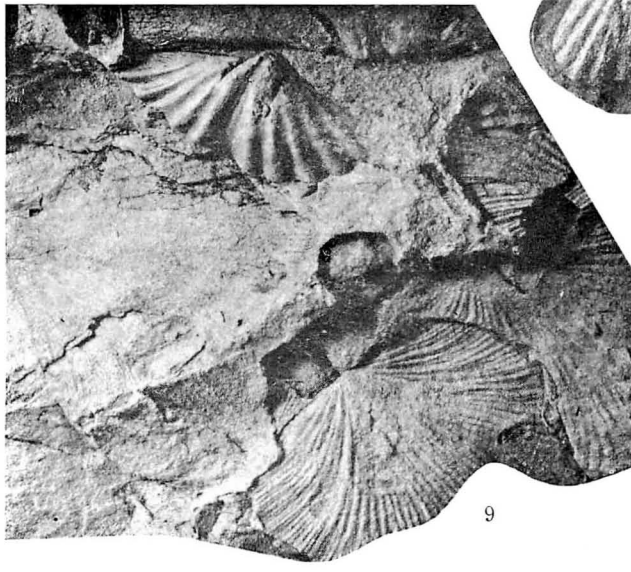
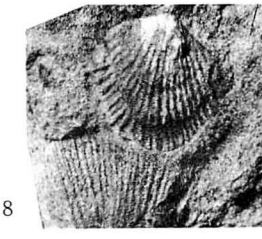
6


9


8

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