JURASSIC INOCERAMIDS IN JAPAN*

By

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With Plates XV-XVIII

Abstract

Jurassic inoceramids occur fairly commonly at various localities in Japan. They seem important for domestic and international correlation, but no comprehensive palaeontological study was published, and accordingly, their stratigraphical application was unsatisfactory. In this paper I describe 26 Japanese forms including 10 new species based on the collections of the Geological Institute, University of Tokyo, which came from various horizons in Nagato, Kitakami and Hida regions, and show a provisional classification of the Jurassic Inoceramidae. My available material can be classified into the following groups.

Parainoceramus VORONETZ, 1936 (upper Triassic—Bajocian)
Inoceramus SOWERBY, 1814 (upper Lias—upper Cretaceous)
Group of *I. polyplocus* ROEMER (Aalenian—Bathonian)
Group of *I. fuscus* QUENSTEDT (Toarcian—Oxfordian)
Group of *I. lucifer* VON EICHWALD (Bajocian)
Group of *I. retrorsus* KEYSERLING (Bathonian—Oxfordian)
Group of *I. galoi* BOEHM (Callovian—? Cretaceous)
Group of *I. neocomiensis* D'ORBIGNY (? Oxfordian—Albian)
Incertae sedis

Since many of the famous European species were established very early, specific identification of inoceramids in other continents often meets with much difficulty. Nevertheless, several Japanese specimens are certainly comparable with European, Arctic or Australasiatic species. In most cases their occurrences agree well with the chronology hitherto shown by ammonites, and it is concluded that inoceramids constitute an important pelecypod group for biostratigraphy not only in the Cretaceous but also in the Jurassic.

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Introduction

Japan seems an important field for the study of the Inoceramidae, since they are fairly common not only in the Upper Cretaceous but also in the Jurassic strata at various localities. Since KOBAYASHI (1926) had described *Inoceramus utanoensis* and *Inoceramus ogurai* from the Dogger-Malm Utano formation of the Toyora group in West Japan, the occurrences of *Inocerami* at various horizons of Japanese Jurassic were announced by many stratigraphers. In the Toyora area INOUYE, KOBAYASHI, TORIYAMA (1938), MATSUMOTO and ONO (1947) collected rich material through their field works. In Kitakami region of Northeast Japan various Lias and Dogger species were known by KOBAYASHI, FUKADA, YAMASHITA, MORI (1949) and SATO's fossil-hunting. In the Hida plateau of Central Japan, OGASAWARA, MAEDA (1952b), HAMADA and others found some characteristic *Inoceramus*-bearing strata in the Jurassic and Cretaceous Tetori group. These collections are now mostly preserved in the Geological Institute, University of Tokyo. KUDO intended to classify and describe them, but did not accomplish the work.

Inoceramids bear special importance for Jurassic and Cretaceous stratigraphy, but their classification is not easy and now somewhat confused. The Jurassic species, though not so numerous as the Cretaceous ones, are invaluable for the phylogeny of the Inoceramidae, but they are unfortunately insufficiently investigated. In this paper I describe the following 26 forms including 10 new species in the institute collection which may cover most Jurassic inoceramids hitherto known in this country.

Parainoceramus lunaris HAYAMI, new species
Parainoceramus matsumotoi HAYAMI, new species
Parainoceramus cf. *matsumotoi* HAYAMI
Parainoceramus sp. ex gr. *matsumotoi* HAYAMI
Parainoceramus sp. indet.
Inoceramus (*Mytiloceramus*) *karakuwensis* HAYAMI, new species
Inoceramus morii HAYAMI

Inoceramus sp. ex gr. *fuscus* QUENSTEDT
Inoceramus cf. *nitescens* ARKELL
Inoceramus hamadae HAYAMI, new species
Inoceramus hashiurensis HAYAMI, new species
Inoceramus cf. *lucifer* VON EICHWALD
Inoceramus utanoensis KOBAYASHI
Inoceramus ogurai KOBAYASHI
Inoceramus sp. ex gr. *galoi* BOEHM
Inoceramus maedae HAYAMI, new species
Inoceramus maedae HAYAMI, var. a
Inoceramus maedae HAYAMI, var. b
Inoceramus furukawensis HAYAMI, new species
Inoceramus (s. l.) *kudoi* HAYAMI, new species
Inoceramus (s. l.) *fukadae* HAYAMI, new species
Inoceramus (s. l.) a sp. indet.
Inoceramus (s. l.) b sp. indet.
Inoceramus (s. l.) c sp. indet.
Inoceramus (s. l.) d sp. indet.
Inoceramus (?) *naganoensis* HAYAMI, new species

Since I am not in a position to examine the type-specimens of foreign species, I find it difficult to classify them systematically on a firm basis. The taxonomic notes discussed in this paper are, therefore, provisional.

Acknowledgements

I intend to express my most sincere thanks to Prof. Teiichi KOBAYASHI of the University of Tokyo for his constant encouragements, placing the collection of the institute at my disposal and kind supervision of this manuscript, and to Prof. Tatsuro MATSUMOTO of the Kyushu University for the permission to examine his collection kept in the Kyushu University and kind reading of this manuscript. Thanks are also due to Dr. Leslie R. COX of the British Museum (Natural History) for his kind informations concerning this pelecypod group, and to Prof. Ryuzo TORIYAMA of the Kyushu University, Assist. Prof. Shiro MAEDA of the Chiba University and many other gentlemen for the privilege of describing their collections.

Distribution of Domestic Jurassic Inoceramids

Before taxonomic discussions, previous studies and distribution of Jurassic inoceramids are briefly reviewed. Japanese Jurassic inoceramids are so far known in three regions, namely Nagato region of West Japan, Kitakami mountainland of Northeast Japan and Hida plateau of Central Japan. In the first and second regions upper Lower and Middle Jurassic primitive species are well represented, while Upper Jurassic species seems to be confined properly to the last region. (Table 1).

1) Nagato region

According to MATSUMOTO and ONO (1947) and ARKELL (1956) the Toyora group in western Yamaguchi Prefecture can be biostratigraphically divided into the following beds.

Utano formation	upper part (Bajocian—? Callovian)	
	Ut *Holcophylloceras* bed	(Bajocian)
	Uz barren	
	Uh *Hammatoceras* bed	
	Ub *Haugia* bed	(Toarcian)
	Up *Posidonia* bed	
Nishinakayama formation	Na *Dactylioceras* bed	
	Nd *Dactylioceras-Hidoceras* bed	
	Ng *Protogrammoceras* bed	
	Ne *Fontanelliceras* bed	(up. Pliensbachian)
Higashinagano formation	(Hettangian—Sinemurian)	

It has long been known that the Nishinakayama shaly formation yields some small inoceramids, which were once considered as mytilids, altogether with upper Liassic ammonites. MATSUMOTO and ONO (1947) listed *Inoceramus* spp. from Ne, Ng and Nd beds. Among TORIYAMA's and my collections *Parainoceramus lunaris*, n. sp. from Ne and *P. matsumotoi*, n. sp. and some allied forms from Nd bed are distinguished. This fauna may bear some alliances to those of the Toarcian and Aalenian of Europe and Caucasus. Large forms of *Inoceramus* appear in this area at first in Uh bed of the Utano formation, and they are obviously different from Nishinakayama forms. *Inoceramus* sp. ex gr. *fuscus* QUENSTEDT from this horizon is apparently similar to the Bajocian species from Europe. *Inoceramus utanoensis* and *I. ogurai* were described by KOBAYASHI from the upper part of the Utano formation. The fauna is not exactly dated, but its age is probably Bathonian or later, considering that the formation is fairly thick and that the occurrence of *Onychiopsis elongata* was reported from the horizon. A small specimen of an indeterminable inoceramid belonging to the old collection of this institute is labelled that it came from "Yoshimo". The Yoshimo beds must be, as clarified by KOBAYASHI and SUZUKI (1939), Wealden brackish deposits, and its exact locality is unknown at present.

2) Kitakami region

The Jurassic of the western belt of the south Kitakami mountainland in Miyagi Prefecture is best typified by the sequence of Shizukawa area (MABUTI, 1933; INAI, 1939; MATSUMOTO, 1953; ONUKI, 1956; SATO, 1957).

Hashiura group	Sodenohama formation (? Kimmeridgian—Tithonian)
	Arato formation (Bajocian—Kimmeridgian)
	Aratozaki formation (Bajocian)
Shizukawa group	Hosoura formation (Sinemurian—Aalenian)
	Niranohama formation (Hettangian)

The Hosoura formation consists mainly of arenaceous shales of the first innundation phase, and yields *Inoceramus* (s. l.) *kudoi*, n. sp. altogether with *Hammatoceras*, *Tmetoceras* and *Graphoceras* in the upper part (Hh zone by SATO, 1957). The basal part of the Bajocian Aratozaki sandy formation contains some lenticular fossil beds where *Inoceramus morii* HAYAMI and *Parainoceramus* sp. coexist with *Trigonia sumiyagura* KOBAYASHI and KASENO, *Camptonectes* cf. *auritus*

(SCHLOTHEIM) and *Ludwigia*-like ammonite, as I noted elsewhere (HAYAMI, 1959a). The Arato shaly formation showing the second innundation facies bears *Inocerami* at several horizons in Shizukawa and Hashiura areas. Most specimens are too fragmental to be determined specifically, but I distingnished *Inoceramus hashiurensis*, n. sp. and *I.* sp. ex gr. *galoi* BOEHM in MORI's collection. Because of the scarceness of guide fossils and well defined key beds, the biostratigraphy of this formation is still obscure, but the sedimentation is considered to have continued from Bajocian to Kimmeridgian in view of the occurrences of *Cadomites* (BANDO, 1958) and *Idoceras* (ARKELL, 1956). MATSUMOTO (1953) listed *Inoceramus* sp. from the overlying Sodenohama formation whose age is presumed Kimmeridgian to Tithonian.

The eastern belt of the Kitakami Jurassic comprises the Ojika group in Ojika peninsulà and the Karakuwa and Shishiori groups in Kesen area. FAKADA (1947, MS)* distinguished "*Inoceramus* bed" in the Kodaijima sandy formation at the neck of the peninsula. The inoceramid is somewhat aberrant and named here *Inoceramus* (s. l.) *fukadae*. The age is probably upper Lias or Bajocian since the bed is adjacent to the *Trigonia sumiyagura* bearing sandstone. Besides, FUKADA collected a specimen at the west of Momonoura, whose mother rock is correlative to the Tsukinoura formation (probably Bajocian) according to ONUKI (1956). In Kesen area SHIIDA (1940) listed *Inoceramus* sp. from the Kosaba formation which may be identical with *Inoceramus morii* from the Bajocian Aratozaki formation. *Inoceramus karakuwensis*, n. sp. and *Inoceramus* cf. *lucifer* VON EICHWALD occur in the overlying Tsunakizaka shaly formation. SHIIDA referred its age to Lias, but later SATO (1956) ascertained with *Stephanoceras* that the black shales are correlated to the lower part of the Arato formation. The large dimensions of the two *Inocerami* and their resemblances respectively with *Inoceramus polyplocus* from the Bajocian of Europe and *I. lucifer* from the Bajocian of Arctic region may support SATO's opinion. Besides, an *Inoceramus*-like pelecypod is found in the Tithonian-Berriasian Kogoshio formation of the Shishiori group.

3) Hida region

No inoceramid was ever collected from the Liassic Kuruma group. The stratigraphy of the Jurasso-Cretaceous Tetori group has been recently promoted by MAEDA (1954a, b, etc.) and some others, and the occurrences of *Inocerami* were announced at various localities. According to MAEDA the succession of the Tetori group is typified in Kuzuryu and Makito areas as follows:

Kuzuryu area in Fukui Prefecture

Akaiwa subgroup	
Itoshiro subgroup	Nochino formation
	Izuki formation
	Ofuchi formation
	Ashidani formation
	Yambara formation

* FUKADA's result was briefly cited by KOBAYASHI (1948, p. 213).

Kuzuryu subgroup	Yambarazaka formation Kaizara formation Tochimochiyama formation Oidani formation Shimoyama formation

Makito area in Gifu Prefecture

"Akaiwa subgroup"	
"Itoshiro subgroup"	Amagodani formation Daikokudani formation Otaniyama formation
"Kuzuryu subgroup"	Mitarai formation Nonomata (formerly Akaboke) formation Ushimaru formation

The Kaizara formation composed of transgressive black silty shales contains *Inoceramus hamadae*, n. sp. at Shimoyama and *Inoceramus* cf. *nitescens* ARKELL and *I.* (?) *naganoensis* at Nagano. Its age has been considered to be Callovian or Oxfordian on the basis of *Seymourites* and perishinctids (YOKOYAMA, 1904; KOBAYASHI, 1947; ARKELL, 1956). *Inoceramus* cf. *nitescens* is similar to the type specimens from the Corallian of England. The Mitarai shaly formation, which is a solitary marine formation in Makito area, has been correlated to the Kaizara formation. But the pelecypod fauna of the Mitarai, as I reported before (HAYAMI, 1959b, c) contains some allied forms to Lower Cretaceous as well as Upper Jurassic ones in Europe and boreal regions. The inoceramid fauna is composed of different species from Kaizara. *Inoceramus maedae*, n. sp. and its varietal forms from its lower part are much larger than Kaizara forms, and have strikingly inequivalve shells, developed prismatic layers and prominent umbones. The species may remind one of a Cretaceous form. Although the exact age of this fauna should be determined by means of associated ammonites, I am now inclined to consider that it is more or less younger than the Callovian Kaizara fauna. *Inoceramus furukawensis*, n. sp. found by OGASAWARA et al. (1949, MS) from the Sugizaki sandy formation near Furukawa resembles the Makito species. Besides, MAEDA (1957) and MAEDA and TAKENAMI (1958) announced the occurrences of *Inocerami* respectively at Shimohambara of the Upper Kuzuryu and at Arimine area.

Inoceramus morii and *I.* (s. l.) *fukadae* occur in more or less coarse littoral sandstones of the Aratozaki and Kodaijima formations, but they are rather exceptional cases. Most other specimens dealt with in this paper were obtained from fine sandstones or black shales which are characteristically distributed in the Kitakami mountainland and Inner zone of Southwest Japan. In such fine rocks inoceramids are frequently accompanied by ammonites, aptychi, posidoniids and some other thin-shelled pelecypods but scarcely by trigoniids and hexacorals. It is concluded that the inoceramids have been generally fond of somewhat deep, muddy and fairly stagnant condition of inland sea or embayment. In the Outer zone of Southwest Japan and Soma area of Northeast Japan, the Upper Jurassic Torinosu group or its comparable calcareous forma-

Table 1. Distribution of Jurassic Inoceramids in Japan.

Age	West Japan			Central Japan			Northeast Japan					
	Toyora area			Kuzuryu and Makito areas			Shizukawa and Hashiura areas			Ojika and Kesen areas		
Neocomian	Toyonishi group	Yoshimo fmt.	*I.* d sp.	Tetori group	represented but no inoceramid		Jusanhama group		no inoceramid			
		?					?					
Tithonian				Tetori group	?		?			Shishiori group	Kogoshio fmt.	*I.* (?) sp.
Kimmeridgian				Tetori group	Mitarai fmt.	(*I. furukawensis*) *I. maedae* *I.* c sp.	Hashiura group	Sodenohama fmt.	*I.* sp.	Shishiori group	represented but no inoceramid	
Oxfordian		?		Tetori group	Mitarai fmt.	?	Hashiura group	Sodenohama fmt.			?	
Callovian	Toyora group	Utano fmt.	*I. utanoensis* *I. ogurai*	Tetori group	Kaizara fmt.	*I.* ? *naganoensis* *I.* cf. *nitescens* *I. hamadae*	Hashiura group	Arato fmt.	*I. hashiurensis* *I.* sp. ex gr. *galoi*			
Bathonian	Toyora group	Utano fmt.	no inoceramid	Tetori group	represented but no inoceramid	?	Hashiura group	Arato fmt.		Karakuwa group	Tsunakizaka fmt.	*I. karakuwensis* *I.* cf. *lucifer* *I.* b sp.
Bajocian	Toyora group	Utano fmt.	no inoceramid	?			Hashiura group	Aratozaki fmt.	*I. morii* *P.* sp.	Karakuwa group	Kosaba fmt.	*I. morii*
											?	
Aalenian	Toyora group	Utano fmt.	*I.* sp. ex gr. *fuscus*	Kuruma group		no inoceramid	Shizukawa group	Hosoura fmt.	*I.* (s. l.) *kudoi*		Kodaijina fmt.	*I.* (s. l.) *fukadae* *I.* (s. l.) a sp.
											?	
Toarcian	Toyora group	Nishinakayama fmt.	*P. matsumotoi* *P.* cf. *matsumotoi*	Kuruma group		no inoceramid	Shizukawa group	Hosoura fmt.	no inoceramid			
Pliensbachian	Toyora group	Nishinakayama fmt.	*P. lunaris*	Kuruma group		no inoceramid	Shizukawa group	Hosoura fmt.	not represented			
Sinemurian	Toyora group	not represented		Kuruma group		no inoceramid	Shizukawa group	Hosoura fmt.	no inoceramid			
Hettangian	Toyora group	Higashinagano fmt.	no inoceramid	Kuruma group		no inoceramid	Shizukawa group	Niranohama fmt.	no inoceramid			

tions, whose fauna is characterized by the abundant stromatoporoids, hermatypic hexacorals, *Cidaris*, *Nerinea* and many neritic or even pelagic pelecypods, are extensively distributed, but no specimen of *Inoceramus* have ever been found. The fact seems to imply something on palaeogeography and palaeoclimatology.

Distribution of Foreign Jurassic Inoceramids

Compared with Cretaceous species, Jurassic inoceramids so far reported in the world are not so numerous (see the synoptic list in this paper), and the distribution is restricted properly to the following four provinces.

1) **Europe—Western Tethys province** (England, France, Germany, Swiss, Italy, Morocco, Czechoslovakia, Poland, Turkey and Caucasus).

In Europe Jurassic inoceramids were described by SCHLOTHEIM (1813), SOWERBY (1825, 1826), ZIETEN (1830), GOLDFUSS (1836), DUNKER (1851), MORRIS and LYCETT (1853), QUENSTEDT (1856), OPPEL (1862), OOSTER (1869), DUMORTIER (1874), BLAKE (1875), BLAKE and HUDLESTON (1877), ROLLIER (1914), ARKELL (1933) and some others. ROLLIER published a list of European species in which he discussed their occurrences and synonimies, but so far as I know, there is no comprehensive revision on this group in recent papers. Since most of European species were established very early, the specific identification of inoceramids in other areas with such European species may be frequently difficult, unless one has a chance examining the type specimens or those species are redescribed with better illustrations on the basis of lectotypes. *Inoceramus pinnaeformis* (DUNKER) from the lower Lias is probably the earliest inoceramid in Europe. Upper Liassic and Aalenian small mytiliform species such as *Inoceramus dubius* SOWERBY, which were referred by some Russsian authors to *Mytiloides* BRONGNIART, seem to be well represented, and some of them were reported also from Carpathia by ANDRUSOV (1932), from Anatolia by STCHEPINSKI (1942) and OTKUN (1942) and from Caucasus by PČELINČEV (1928, 1933, 1937) and LEONTJEW (1950). In these areas inoceramids occur in black argillaceous rocks belonging to the Alpine geosynclinal facies. Bajocian species are also very common, and may be represented by orbicular *Inoceramus polyplocus* ROEMER and subrhomboidal *Inoceramus fuscus* QUENSTEDT. Some allied species to the latter are found also in the Great Oolite series. Malm species appear comparatively rare in Europe, but some occur in the lower and upper calcareous grits of the Corallian and in the Kimmeridge clay of England.

2) **Eastern Tethys—Australasia province** (Himalaya, Cutch, Borneo, Timor, Moluccas, New Guinea, New Caledonia and New Zealand).

In this province Upper Jurassic (especially Oxfordian) inoceramids appear fairly common. *Inocerami*, mainly regularly ribbed species such as *Inoceramus everesti*, are important constituents in the fauna of the Spiti shales (HOLDHAUS, 1913). In Spiti the fossiliferous rocks are limited in a narrow area, but similar shales are extensive in Tibet without any striking facies change. Moluccas and its surrounding seem an important field for a study of this kind. Since BOEHM (1907) had described several Oxfordian species from Sulu, *Inoceramus galoi* and some other coarse-ribbed species were announced also in Misol and Timor. A comprehensive study of the Upper Jurassic *Inocerami* in this regions was undertaken by WANDEL (1936), who distinguished four species and discussed the classification and synonymy. Upper Jurassic species are also rich in New Caledonia and New Zealand. Since HOCHSTETTER (1863) had erected *Inoceramus haasti*, ZITTEL (1864), TRECHMANN (1923), MARWICK (1953), ROUTHIER (1953) and AVIAS (1953) contributed to the palaeontology. According to them, the Upper Jurassic inoceramids of Spiti, Moluccas, New Caledonia and New Zealand are fairly similar to one another in the assemblage of species. In this province Liassic and Dogger species are quite rare. Only two unnamed inoceramids were reported from the Lias of Madagascar and New Caledonia.

3) **Boreal province** (Greenland, Prince Patrick, Alaska, Alberta, Petschola, Yenisei, Franz Joseph Land and the greater part of North Siberia).

KEYSERLING (1848) described *Inoceramus retrorsus** from Siberia, which was later reported also from the Bathonio-Callovian in Jameson Land of East Greenland (SPATH, 1932; DONOVAN, 1953) and lower Lena (LAHUSEN, 1886). VON EICHWALD (1865, 1871) erected 4 species based on the collections from European Russia and Alaska. He described Alaskan forms as "Neocomian or Gault species", but NEUMAYR (1885), MARTIN (1926) and many others are of opinion that they are Jurassic. Among VON EICHWALD's species *Inoceramus lucifer* was redescribed from the Bajocian of North Alaska by IMLAY (1955) and Prince Patrick by FREBOLD (1958) as a guide fossil. *Inoceramya* proposed by ULRICH (1910) on the basis of *Posidonia*-like specimens from the Yaktat group of Alaska may imply something on the phylogeny. Besides, MCLEARN (1924) and WARREN (1932) described some new species from the Fernie shales of Alberta, but their occurrences appear somewhat sporadical.

4) **Andine province** (Peru, Neuquén, Mendoza and Patagonia).

In the South Andes occur several species from the Lias of Peru and Neuquén (LEANZA, 1942, etc.) and the Tithonian-Neocomian of Patagonia (FERUGLIO, 1936), though the occurrences seem to be somewhat sporadical. According to BEHRENDSEN (1891) and JAWORSKI (1926), some Argentina specimens, though they were not illustrated, are comparable with some species from the European Lias and Moluccan Malm.

Surverying the distribution of foreign and domestic Jurassic inoceramids, it is noticed that they occur more commonly in the shaly or muddy facies than in the sandy or limy facies. A few species such as *Inoceramus fittoni* MORRIS and LYCETT occur exceptionally in calcareous rocks. Striking is the distribution forming two belts in temperate and tropical zones. One is the Alpine-Caucasus geosynclinal region, where Liassic and lower Dogger primitive species occur more or less commonly in Pre-Alps, East Alps, Carpathia, Anatolia and Cauca-

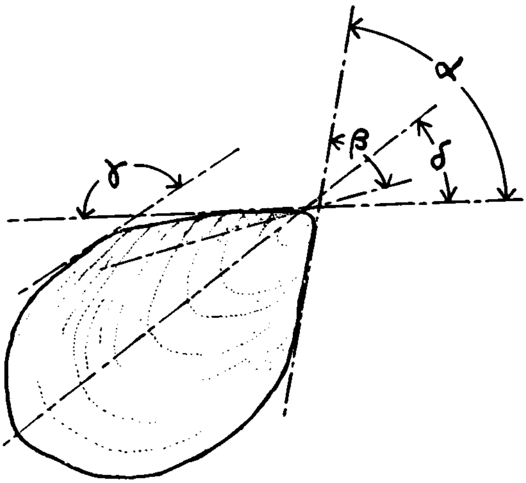
* Its age was lately discussed by VORONETZ and LAPTINSKAJA (1954).

sus. In the adjacent areas of Western Europe and Northern Africa contemporaneous inoceramids are comparatively uncommon, notwithstanding the fact that other neritic pelecypods are better represented. The other belt is the Himalaya-Moluccas-New Zealand region where Oxfordian and later regularly ribbed species are common. The Spiti shales are overlain by the Cretaceous "Flysch" of the Himalayan geosyncline and bear also geosynclinal characters, though the thickness is comparatively small. Cutch is a classical Jurassic locality and considered to have been situated on a stable continental shelf of Gondwana. Although its Upper Jurassic rocks contain rich ammonites and neritic pelecypods, inoceramids are unknown but for an indeterminable species represented only by one specimen (COX, 1940). A similar fact is also seen in East Africa or Ethiopian province. The pelecypod faunas of that province are well characterized by *Eligmus* and *Gryphaea*, being somewhat allied to the Torinosu-Soma fauna of Japan. The southeastern part of the belt coincides with the Papuan geosyncline or the inner margin of Neo-Australia from Moluccas through New Caledonia to New Zealand where the thickness of Jurassic sediments approaches 5,000 meters. These two belts roughly form the greatest mobile zones of the Cretaceous or later ages.

In the boreal region, on the contrary, the distribution of the Jurassic inoceramids does not form such a belt. Sediments are generally not so thick as in the above two regions. The Fernie shales in West Canada show fairly slow deposition which took place under off-shore condition in Early Jurassic times (FREBOLD, 1953; IMLAY, 1957). Middle and Upper Jurassic inoceramids were reported often with arctic ammonites and *Aucella*. But according to IMLAY's observation in North Alaska (1955), "The absence of almost ubiquitous *Inoceramus* in *Aucella* beds and its rarity even in the same formations suggest that two genera lived under different environmental conditions, that is, *Aucella* may have lived in waters that were too agitated or too shallow for *Inoceramus* to exist". Though *Aucella* has not been ever found in Japan, the statement seems to agree to a certain extent with my observation on the Jurassic ecology of this country. The black shales of the Kitakami mountainland and the Inner Zone of Southwest Japan are not geosynclinal sediment, but most inoceramids, as ascertained from many stratigraphical columns, seem to have been fond of more muddy, stagnant and probably deeper sea bottoms than most other pelecypods. The Japanese Jurassic inoceramid fauna is apparently composed of the mixture of Tethyan and Arctic elements. For example, some of the species of the Bajocian to Kimmeridgian Arato formation and its comparable strata are comparable to *Inoceramus polyplocus* (an European element), *I. galoi* (a Moluccan element) and *I. lucifer* (a boreal element). But the greater part of the available specimens is obviously different from the species hitherto described in the above mentioned provinces.

Descriptive Terms and Diagnostic Characters

Descriptive terms used by NAGAO and MATSUMOTO (1939-1940) are mostly applied also to the Jurassic species in this paper. Because most specimen at hand are more or less deformed secondarily owing to the thin tests and fissile mother rocks, I could not put great stress on the biometry. But the dimensions, if many specimens are measurable, are important to clarify the evolution of this family especially Jurassic species. The Lower Jurassic species are always small, scarcely in excess of 5 cm. in maximum length, while the Upper Jurassic species are often as large as the Cretaceous ones. I use the following terms to indicate the size (maximum length of shall); very small, less than 19.5 mm.; small, 20.0-39.5 mm.; medium, 40.0-69.5 mm.; large, 70.0-99.5 mm.; very large, more than 100.0 mm.



Text-fig. Measurement of angles.

α: Apical angle between hinge and anterior margin.
β: Beak angle of umbonal inflation.
γ: Postero-dorsal angle between hinge and postero-dorsal margin.
δ: Obliquity between hinge and the line from umbo to the most distant point on ventral margin.

The outline is regarded here as the most important criterion for the distinction among species and groups of higher category, although attention must be paid against the secondary deformation and the individual variation. In the Jurassic species the anterior margin is usually not differentiated into antero-dorsal and antero-ventral and very prosocline. The obliquity, which is indicated by the angle between the hinge and the line from the beak to the most distant point on ventral margin (Text-fig.), is generally smaller than in the more advanced species. Posterior wing is absent or undeveloped except for a few species, but the postero-dorsal part is often angulated, flattened or defined clearly from the remaining surface in Jurassic species. The prominence of umbonal region is one of distinctive characters of inoceramids from isognomonids. The umbones of the Jurassic species are, however, generally less prominent than the Cretaceous ones, and its state may be important for the consideration of phylogeny. The apical angle between hinge and anterior margin (antero-dorsal margin, if differentiated) is comparatively small in the Jurassic species, but the beak angle between the beak inflation exclusive of postero-dorsal area, though it is often immeasurable in accurary, is not always smaller than the more advanced species, because of the less prominent umbones. Inequivalveness is often observed in the Cretaceous inoceramids, especially *Actinoceramus*, *Volviceramus* and many species of *neocomiensis*- and *concentricus*-groups. The careful study on the trend from equivalve to inequivalve (or from inequivalve to equivalve) in each inoceramid group may be important for the phylogeny. The Jurassic species in Japan are always equivalve or subequivalve except for *Inoceramus maedae*, and the major trend of the family appears the morphological transformation from equivalve to inequivalve. The tendency probably suggests a change of habit from vertical to subhorizontal situation against sea floor, and agrees with those of the Bakevelliidae and Isognomonidae. Judging from the absence of byssal gape and the muddy facies, inoceramids probably had not strong byssi.

Most species of inoceramids are edentulous. But the presence of *Bakevellia*-like dentition, i. e. two small cardinal (or anterior) and one or two elongated lateral (or posterior) teeth, seems one of ancestral features of the family. Such a dentition is often observed in the Liassic species. The denticles of *Parainoceramus matsumotoi*, n. sp. and more other related forms remind at a glance one of mytilid's hingement; that is, the cardinals resemble *Mytilus*' umbonal teeth and laterals a tooth-like ridge for adherence of a ligament running subparallel to the dorsal margin in most species of the Mytilidae. But such umbonal teeth do not appear in the Jurassic or earlier species of the Mytilidae, and the posterior teeth are frequently two in number in the present specimens. The similarity can be regarded as superficial.

Numerous pits arranged along a narrow ligament area are fairly characteristic of inoceramids. As stated by COX (1940, p. 125), HEINZ's distinction between *Inoceramus* and *Isognomon* on the basis of ligament structure may be not always applicable, but the ligament pits of inoceramids are generally less elongated vertically and more numerous than contemporaneous isognomonid. Though some Recent species of *Isognomon* have comparatively thin tests, Mesozoic species of the genus have usually much thicker shells (lamellar layer) than *Inoceramus*. The ligament characters in primitive inoceramids seem especially important to solve the phylogeny, but the area of small forms is tolerably narrow and often difficult to examine in detail. Musculature is an important criterion for pelecypod classification, but it has been scarcely observed in *Inoceramus*.

The shell structure of inoceramids is famous for the developed prismatic calcite layer. The character may be also essential for the classification, but it is fairly difficult at present to apply the shell structure to the subdivision of the family, since investigators are required to consider carefully the different state of preservation, size and maturity among individuals and also the orientation of thin sections. In the greater part of the present material, the shells are exfoliated, eroded out or displaced by other material than carbonates, and some forms are represented only by "Steinkern". The microscopic observation could be carried out only on two species, *Inoceramus morii* and *I. maedae.* The prismatic layer of *morii* is very thin and composed of minute crystals, while the calcite prisms of *maedae* are fairly large, elongated and comparable in the dimensions with those of some Upper Cretaceous species.

Ornamentation is regarded as one of the diagnostic criteria for the classification of Cretaceous *Inocerami.* But non-concentric (oblique, divergent or radial) sculptures scarcely appear in the Jurassic species. In *Parainoceramus* and the primitive groups of *Inoceramus,* prominent concentric lamellae, if present, are somewhat irregular and sometimes difficult to be demarcated from growth-lines. However, in some large Upper Jurassic species (ex. *I. galoi*) concentric sculpture is fairly regular and distinctly plicated. Strong constrictions are sometimes observable in the Middle and Upper Jurassic species (ex. *I. lucifer*).

Provisional Classification of Jurassic Inoceramids

No comprehensive study on the classification of Jurassic inoceramids has as yet been published. *Inoceramus* (sensu lato) is in fact a large but difficult group to classify. As to Cretaceous species attempts have been done to separate them into several groups or genera by MEEK (1864), STOLICZKA (1871), WOODS (1911, 1911-1912), BOEHM (1915), NAGAO and MATSUMOTO (1939-1940) and others, and the phylogenetical development of the family is partly clarified. But diverge opinions were expressed as to the taxonomy and nomenclature. Many authors consider that Jurassic and Cretaceous species belong to one genus, *Inoceramus,* but HEINZ (1932, etc.) showed his scope of "Neue Systematik" and splitted Cretaceous species into 63 genera and 28 subgenera in 2 families and 24 subfamilies as the result of his observation on the surface ornamentation and other characters. However, each category in his mind seems evidently out of proportion to other lamellibranch genera and families, and the diagnostic characters of the groups are not always clear. His classification has been repeatedly criticised by COX (1940, 1954), ARKELL and MOY-THOMAS (1941) and some others. Since the phylogeny of Jurassic and Early Cretaceous inoceramids has not been sufficiently clarified to make a natural classification, their separation into many genera is inevitably apt to become artificial.

Putting aside HEINZ's classification, the following names were proposed for various groups of the Inoceramidae on the basis of the deviated morphological characters from typical *Inoceramus* SOWERBY, 1814.

Mytiloides BRONGNIART, 1822
Anopaea VON EICHWALD, 1861
Actinoceramus MEEK, 1871
Volviceramus STOLICZKA, 1871
Cucullifera CONRAD, 1875
Haploscapha CONRAD, 1875
Endocostea WHITFIELD, 1885
Neocatillus FISCHER, 1887
Neoinoceramus IHERING, 1903

Inoceramya ULRICH, 1910
Mytiloceramus ROLLIER, 1914
Sphenoceramus BOEHM, 1915
Haenleinia BOEHM, 1915
Sergipia MAURY, 1925
Parainoceramus VORONETZ, 1936

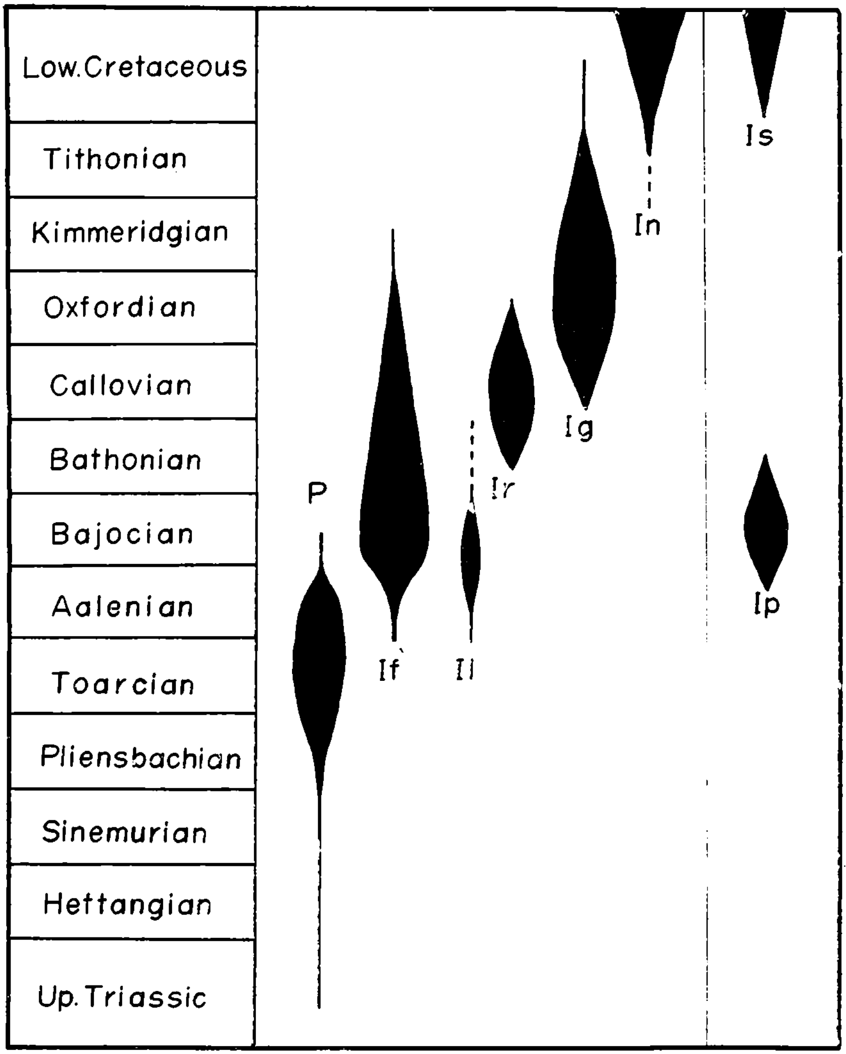
These groups except for *Inoceramya*, *Mytiloceramus* and *Parainoceramus* are founded on somewhat specialized Cretaceous species. But before they are accepted as generic or subgeneric names, one must examine carefully their type-species. WOODS (1911, 1911-1912), who carefully studied the phylogeny of the Cretaceous inoceramids of England, did not recognize the type-species of *Mytiloides*, *Actinoceramus* and *Volviceramus* as subgenerically distinct from *Inoceramus*, since they are allied to typical species of *Inoceramus*. Since I am not in a position to examine the type-species of these Cretaceous groups, I do not intend here to evaluate their validities, but apply the group-names proposed by WOODS (1911) and NAGAO and MATSUMOTO (1939-1940).

Most Jurassic inoceramids, on the contrary, have been referred to *Inoceramus*. Jurassic species seem, however, to be generally distinguished from Cretaceous ones by many primitive or less specialized features such as the undeveloped prismatic layers, equivalve or subequivalve shells, less prominent umbones, prosocline outlines and absence of radial plications. PČELINČEV (1937) and some Russian authors assigned *Inoceramus dubius* SOWERBY, *I. amygdaloides* (SCHLOTHEIM), *I. cinctus* GOLDFUSS, *I. gryphoides* (SCHLOTHEIM) and *I. quenstedti* PČENINČEV from the Lias and Aalenian of Europe, Asia Minor, Caucasus, Western Siberia and Madagascar to *Mytiloides* BRONGNIART, 1822. *Mytiloides* was, however, founded on *Ostracites labiatus* SCHLOTHEIM, 1813 (by monotypy), a well-known Upper Cretaceous species, and its essential characters, if the obliquely elongated outline is ignored as a specific character, are seemingly not so deviated from those of typical *Inoceramus* that no generic distinction is required for the species. As stated by WOODS (1911-1912) the species may not be much apart from some varietal forms of *Inoceramus crippsi*. Such small Liassic and Aalenian species are, I think, anyhow different from the type-species of *Inoceramus* and *Mytiloides* at generic level. On the other hand VORONETZ (1936) proposed *Parainoceramus* from the Upper Triassic of North Siberia. KIPARISOVA (1938) did not recognize *Parainoceramus* as a distinct genus, and assigned it congeneric with "*Mytiloides*" in her mind. Recently COX (1954, p. 47), however, selected its type-species and included *Crenatula ventricosa* SOWERBY and *Inoceramus substriatus* MÜNSTER in GOLDFUSS from the Lias of Europe in the genus. The generic characters were more or less clearly expressed by him. So far as I can judge from foreign literatures and a few European specimens kept in this institute, most other Liassic small species are considered to belong to *Parainoceramus*. Several species belonging to the genus are found also in the middle and upper Lias of Japan, Neuquén and (?) New Caledonia. It is certain that such primitive inoceramids have flourished universally in Early Jurassic times prior to large species. *Parainoceramus* is generally characterized by the small size (rarely exceeding 5 cm. in maximum length), mytiliform prosocline outline, comparatively improminent umbonal area, weak concentric ornamentation thin prismatic layer and sometimes posessing a small anterior wing and weak cardinal and lateral teeth.

Generic distinction of Dogger and Malm inoceramids from typical Cretaceous *Inoceramus* seems difficult, because of the absence of any striking distinctive characters. ROLLIER (1914) proposed *Mytiloceramus* for *Inoceramus polyplocus* ROEMER from the Bajocian. According to GOLDFUSS (1836), BENECKE (1905) and SCHMIDTILL (1926) the species shows a somewhat *Posidonia*-like orbicular outline, and may form a distinct group, probably a subgenus of *Inoceramus*, since most other Dogger and Malm species have mytiliform or subrhomboidal shells with very prosocline anterior margins. Mytiliform (or subrhomboidal) large inoceramids appeared in Aalenian-Bajocian in many areas of the world, and flourished until Callovian-Oxfordian. *Inoceramus lucifer* VON EICHWALD having inflated shells and strong surface constrictions appear in the Bajocian of the Arctic region (group of *I. lucifer*). The group may be phylogenetically connected with *Inoceramus propinquus* MÜNSTER in GOLDFUSS, 1836, from the Lower Cretaceous. In Europe *Inoceramus fuscus* QUENSTEDT and some other related species, which have rhomboidal outline and comparatively weak ornamentation, occur in Dogger (group of *I. fuscus*), and a few species of this group are found also until Oxfordian. The group is at a glance similar to *Parainoceramus* from the Lias, but generically separable by the larger dimensions, more prominent umbo and absence of anterior wing and hinge-teeth. Certain species such as *Inoceramus quenstedti* PČELINČEV and *I. falgeri* MERIAN seem intermediate between the two groups, but it may suggest at the same time that at least a part of Jurassic subrhomboidal *Inoceramus* was derived from *Parainoceramus*. Coarse-ribbed large inoceramids flourished chiefly in the Callovian and later stages of Himalaya, Moluccas-New Zealand (group of *I. galoi*). This group shows variable outlines from mytiliform to subtrapezoidal, and may have been connected with some Cretaceous *Inocerami*. Some arctic species such as *Inoceramus retrorsus* KEYSERLING show irregular ribbing and more or less developed posterior wing (group of *I. retrorsus*). *Inoceramus utanoensis* and *I. ogurai* from the upper Toyora group in West Japan may belong to the group. All the above groups are characterized by the equivalve shells, and the antero-dorsal and antero-ventral margins are not clearly differentiated. A strikingly inequivalve inoceramid was, however, found in the Upper Jurassic of Japan. Judging from the ornamentation, large obliquity of shell and prominent umbones, the species is fairly different from the hitherto reported Jurassic ones and seems to be connected with the group of *I. neocomiensis* from the Lower Cretaceous.

Although there are some intermediate species between the two groups and several aberrant forms, my provisional classification of Japanese Jurassic inoceramids can be summerized as follows:

Parainoceramus		Late Triassic—Bajocian
Inoceramus	Group of *I. polyplocus* (Subgenus *Mytiloceramus*)	Aalenian—Bathonian
	Group of *I. fuscus*	Toarcian—Oxfordian
	Group of *I. lucifer*	Bajocian
	Group of *I. retrorsus*	Bathonian—Oxfordian
	Group of *I. galoi*	Callovian—? Cretaceons
	Group of *I. neocomiensis*	? Oxfordian—Albian



Text-figure 1. Stratigraphical Distribution of Jurassic Inoceramids.

P : *Parainoceramus;* If : Group of *Inoceramus fuscus;* Il : Group of *I. lucifer;* Ir : Group of *I. retrorsus;* Ig : Group of *I. galoi;* In : Group of *I. neocomiensis;* Ip : Group of *I. polyplocus* (subgenus *Mytiloceramus*) ; Is : Group of *I. salomoni.*

Phylogeny

The ancestry of the Inoceramidae has not been clarified. It is possible to consider that Dogger and later *Inocerami* at least in part are originated from Liassic *Parainoceramus*, but if one traces the stock into the Triassic, the phylogeny becomes much obscure. Only several species of *Parainoceramus* described by VORONETZ (1936) from the "Upper Triassic"* of North Siberia are referable to the family with a certain confidence. As stated by many authors, *Inoceramus* is sometimes akin to *Isognomon* in Jurassic times. The prismatic layer is still undeveloped and the umbo is generally less prominent than Cretaceous species. Therefore, the Inoceramidae, if not all groups, are regarded as allied to the Isognomonidae: both families may have been derived from similar stocks.

Multivincular pelecypods appeared in the Permian, represented by *Bakevellia* KING, 1848, which is generally considered as the main trunk of the Bakevelliidae and is persistent until Cretaceous. Since *Isognomon* has not been known in the Palaeozoic and Lower Triassic, I (1957b) suggested that the Isognomonidae may have been derived from the Bakevelliidae. However, a newly collected specimen from the *Parafusulina matsubaishi* bed of the Kanokura group (Middle Permian) of North Japan shows similar characters to Jurassic and later *Isognomon* (s. s.), i. e. fairly large dimensions, five or more ligament pits, linguiform outline, more or less gaped and sinuated anterior margin, as described in the supplement of this paper. The ligament area is elongated along the hinge-line and not trigonal as in early representatives of *Bakevellia*. The anteriorly projected umbo, weak inflation and presence of an elongated tooth on the interior of posterior area may remind one of *Cuneigervillia* COX, 1954, from the Lias. But it is plausible to consider that *Isognomon* or its allied pelecypods appeared already in the Middle Permian and since then form an independent trunk of the Isognomonidae from that of the Bakevelliidae.

COX (1940, p. 126) and some other authors suggested the possibility that two or more stocks of independent origin may exist in the Jurassic inoceramids. Other candidates for the ancestors of the Inoceramidae are the Posidoniidae and Myalinidae. GUILLAUME (1928) stated that multivincular ligament structure exists in *Posidonia bronni* VOLTZ in ZIETEN, 1930, from the Toarcian for which FISCHER (1887) proposed *Steinmannia*. But the exterior of that species is of typical *Posidonia*, and *Inoceramus*-like appearance cannot be felt. On the other hand ULRICH (1910) described *Inoceramya concentrica* as a new genus and new species from the Yaktat group, undated "Mesozoic" formations on the Pacific coast of Alaska. He assumed the genus to be transitional between *Posidonia* ane *Inoceramus*, suggesting that it is an ancestral form of inoceramids. In fact, its multivincular ligament structure and regular concentric ornamentation resemble those of *Inoceramus* especially the group of *I. polyplocus*. But in the

* VORONETZ noted that *Parainoceramus* was accompanied by *Trigonodus* and an ammonite with a ceratitic suture, though similar inoceramids of other areas occur always from the Lias or Bajocian.

Alaskan species the umbo is not subterminal and the preumbonal margin is fairly long and almost horizontal, and the external features are more similar to *Posidonia* than *Inoceramus*. *Posidonia revelata* KEYSERLING, 1846, from the Jurassic of Petchola shows also large dimensions for Mesozoic *Posidonia*, multivincular pits of inoceramid-type (fig. 12) and *polyplocus*-like outline (fig. 13). I am now inclined to consider that some species of *Inoceramus* may have originated in the Posidoniidae, but its greater part may have been derived from the Isognomonidae through *Parainoceramus* or some primitive inoceramids such as *fuscus*-group. Myalinids are probably not directly ancertral to inoceramids, but it is possible that isognomonids are descendants from the Myalinidae instead of the Bakevelliidae or *Pteria*-like families.

It is concluded that the development of the Inoceramidae is roughly divided into four steps. The first period is the stages from the Upper Triassic to upper Lias when *Parainoceramus*, showing small size, dentitions and other primitive features, is well represented. Large inoceramids, if present, are very rare in this period. The second period from the lower Dogger to lower Malm or thereabout is characterized by the differentiation and somewhat rapid transformation. Many groups of *Inoceramus* appeared in early Dogger times. Bajocian species are especially common. If *Posidonia*-like *polyplocus*-group is ignored, most inoceramids in this period were probably derived from *Parainoceramus*. The *fuscus*-group includes many species and is regarded as a main trunk of the Inoceramidae. Near the end of this period the *galoi*-group and the *retrorsus*-group appeared respectively in the Australasia and boreal provinces. *Inoceramus* is relatively uncommon in the third period from the upper Malm through Neocomian to Albian, but the period is characterized by the first appearance of inequivalve and polygonal species. The *neocomiensis*-group and *salomoni*-group constitute the main trunks in this period (WOODS, 1911; GILLET, 1924). The fourth period is the rest of the Cretaceous (from Albian up to Maestrichtian) when the development of the family attained the climax. There are many aberrant and specialized inoceramids for which many generic and subgeneric names were hitherto proposed.

Description of Jurassic Inoceramids in Japan

Family **Inoceramidae** ZITTEL

Genus ***Parainoceramus*** VORONETZ, 1936

Type-species:—Parainoceramus bulkurensis VORONETZ, 1936, Upper Triassic, North Siberia (by COX, 1954).

Diagnosis:—Shell equivalve, of moderate convexity, rectangular or rhomboidal, sometimes posteriorly subalate; umbones not inflated, level with or not rising much above hinge-margin; beaks subterminal; no byssal gape; anterior surface of shell more or less impressed; ligament area flat, pits numerous; surface smooth or with weak concentric folds; prismatic layer thin except along hinge-line. according to COX, 1954)

Remarks:—Besides *bulkurensis* and three other Siberian species by VORONETZ (1936), this genus seems to include the greater part of Liassic small species from Western Europe, Alps, Carpathia, Anatolia, Caucasus, Siberia, Neuquén and New Caledonia as follows:

Inoceramus amygdaloides GOLDFUSS, 1836
Inoceramus apollo LEANZA, 1942
Inoceramus cinctus GOLDFUSS, 1836
Inoceramus depressus MÜNSTER in GOLDFUSS, 1836
Inoceramus dubius SOWERBY, 1826
Mytilus gryphoides SCHLOTHEIM, 1813
Inoceramus pernoides GOLDFUSS, 1836
Gervillia pinnaeformis DUNKER, 1851
Inoceramus substriatus MÜNSTER in GOLDFUSS, 1836
Perna thermarum MOESCH, 1867
Crenatula ventricosa SOWERBY, 1825
Inoceramus (?) sp. in AVIAS, 1953

Faint radial striations were drawn in the original figures of *substriatus*, *pernoides* and *ventricosa*, and also are seen on the surface of a specimen of "*I. dubius*" preserved in this institute (M 288). But they are very weak and tolerably different from the broad plications of Cretaceous species. In Japan five forms of *Parainoceramus* are found in the Domerio-Toarcian Nishinakayama and Bajocian Aratozaki formations, They have frequently weak cardinal and posterior lateral teeth of *Bakevellia*-type which have been reported also in young individuals of *Isognomon* and *Cuneigervillia*. COX (1954) stated the presence of two internal tooth-like ridges in the angle of the rudimentary anterior wing of *substriatus*, and such a feature is regarded as a primitive character in early representatives of the Inoceramidae.

Parainoceramus lunaris HAYAMI, new species

Plate XV, Figure 1.

Description:—Shell very small to small, equivalve, inequilateral, gibbose to linguiform, probably not strongly inflated, much higher than long; hinge-line fairly long, occupying about two-thirds of shell-length; anterior margin long, straight or even slightly concave, prosocline, meeting hinge-line with an apical angle of about 85 degrees; posterior and ventral margins gently arcuate; anterior wing small; beak angle not measurable owing to ill-defined postero-dorsal area; postero-dorsal corner much rounded, not forming posterior wing; umbo subterminal, improminent; two strong subhorizontal cardinal teeth present at anterodorsal angle; lateral teeth two in number, elongated, subhorizontal or slightly oblique to hinge-line; surface smooth except for many irregular concentric lamellae and numerous faint growth-lines.

Measurement in mm.	Lenght	Height	Thickness	Obliquity
Holotype (MM 3582) right in. mould	15. 5	19. 0	2. 5	70°
Paratype (MM 3583) left valve	16. 0	18. 0	2. 0	75°

Observation and comparison:—Represented by three flattened specimens. The *Bakevellia*-like dentition is clearly seen on the internal surface of the holotype. Although the ligament structure is unknown, this is referable to *Parainoceramus* by the similarity of other essential characters to the next species, *P. matsumotoi*. In the outline *Parainoceramus bulkurensis* VORONETZ, the type of the genus, resembles this species, but the absence of posterior wing and presence of strong lateral teeth prevent me from comparing it to the Siberian species.

Occurrence:—Rare in the *Fontanelliceras* bed (Ne zone in ARKELL, 1956, p. 420) of Nishinakayama formation at Sakuraguchi, southwest of Ishimachi, Toyoda town, Toyora County, Yamaguchi Prefecture. Upper Pliensbachian. This species is usually accompanied by small ammonites, aptychi and an aulacomyellid (*Amonotis* ?) in highly fissile shales.

Parainoceramus matsumotoi HAYAMI, new species

Plate XV, Figures 2-8.

Description:—Shell very small to small, equivalve, inequilateral, submytiliform, to linguiform, slightly broadened downwards, more or less higher than long, not strongly inflated; test thin; anterior wing very small, not clearly demarcated from main body; posterior area not alate but somewhat depressed; hinge-line moderate in length, occupying about a half of shell; anterior margin nearly straight, not gaped, not differentiated into antero-dorsal and antero-ventral, forming an apical of about 70 degrees with hinge-line, passing gradually into ventral margin; posterior margin sligetly convex, truncated, forming a postero-dorsal angle of about 130 degrees; umbo subterminal, improminent, rising scarcely above hinge-margin; hinge composed of one or two small granular cardinal teeth and an elongated posterior tooth of *Bakevellia*-type in each valve; cardinals seen only in small specimens and probably obsolete in adult; lateral tooth never disappears but becomes gradually more oblique to hinge-line; ligament area very narrow, nearly flat, provided with numerous pits surface marked with irregularly spaced concentric folds and numerous growth-lines.

Measurement in mm.	Length	Height	Thickness	Obliquity
Holotype (MM 3584) left in. mould	7.0	8.0	1.5	65°
Paratype (MM 3585) left in. mould	19.5	25.5	4.0	65°
Paratype (MM 3586) right in. mould	8.5	9.5	1.5	60°
Paratype (MM 3587) right ex. mould	8.0	9.0	1.0+	65°

Observation and comparison:—Nine specimens are at hand. Though the outline varies to a certain extent, they belong to one species, since the variation is continuous. A small anterior wing is observed in most specimens. The holotype specimen composed of small left external and internal moulds has numeous ligament pits, two weak oblique minute cardinal teeth and an elongated posterior lateral tooth. Such a lateral tooth is observable also in other specimens but the cardinals are not always double and apparently obscure in adult individuals. The lateral tooth is subhorizontal in small specimens but fairly oblique to the hinge-line in large ones. The tendency agrees with my observation (1957) on *Bakevellia trigona* (YOKOYAMA). This is similar to *Parainoceramus lunaris* in many respects, but differs in the weaker and smaller cardinal teeth, a solitary and less elongated lateral tooth, narrower shell, smaller apical angle, shorter hinge-line and more angulated postero-dorsal corner. This is readily distinguishable from *Parainoceramus bulkurensis* VORONETZ and *P. nikolaiewi* VORONETZ, 1936, from the Upper Triassic of Siberia by the absence of posterior wing (or more rounded postero-dorsal angle) and slightly more elongated outline. Some specimens resemble *Inoceramus* (*Mytiloides*) *amydaloides* GOLDFUSS in PČELINČEV, 1937, from the Toarcian of Caucasus. But GOLDFUSS' original figure of that species (1836) has more horizontally elongated outline (smaller obliquity) and more rounded anterior margin than PČELINČEV's and my specimens. *Inoceramus quenstedti* PČELINČEV, 1933, from the Aalenian of Caucasus, Germany and ? Madagascar is also similar to this in outline, but the dimenfions of *quenstedti* are somewhat larger, suggesting that species is transitional between *Parainoceramus* and the group of *I. fuscus*. Such hinge-teeth as seen in *matsumotoi* are unknown in PČELINČEV's.

Occurrence:—Common in the *Dactylioceras-Hildoceras* bed (Nd zone in ARKELL, 1956, p. 420) of Nishinakayama formation at Ishimachi, Toyoda town, Toyora County, Yamaguch Prefecture. Toarcian. Most of the materials collected by YOKOYAMA and TORIYAMA. MATSUMOTO's collection of the inoceramids from this horizon kept in the Kyushu University may belong also to this species.

Parainoceramus cf. *matsumotoi* HAYAMI

Plate XV, Figure 9.

Description:—Shell very small, equivalve, mytiliform, not strongly inflated, nearly as long as high, not auriculate; hinge-line moderate in length, passing gradually into posterior without any angulations; anterior margin nearly straight, forming an apical angle of about 55 degrees; posterior margin subparallel to anterior but gradually bent down into ventral; umbo subterminal, improminent, not rising above hinge; a weak subhorizontal lateral tooth present in left valve; surface marked with irregular concentric folds.

Measurement in mm.	Length	Height	Thickness	Obliquity
(MM 3591) left in. mould	8. 0	6. 5	1. 0	45°
(MM 3592) right in. mould	8. 5	7. 5	1. 0	50°

Observation and comparison:—Represented by two specimens. Although it is not improbable that this form is actually conspecific with *matsumotoi* from the same fossil bed in view of the similar surface-markings and dentition, the outline is more mytiliform with much smaller obliquity and a more rounded postero-dorsal angle. This is somewhat similar to *Inoceramus dubius* SOWERBY, 1826, from the upper Lias. Because SOWERBY's type illustration is somewhat obscure, many authors' references of small inoceramids to *dubius* are now confused and cumbersome. GOLDFUSS's figure (1836, pl. 109, fig. 1) is more clearly drawn, but ROEMER, 1857, established *Inoceramus polyplocus* on it. In comparison with DUMORTIER's figures (1874, pl. 42, figs. 5, 6), this has weaker convexity and a straight and more prosocline anterior margin which is not differentiated into antero-dorsal and antero-ventral. *Inoceramus amygdaloides* GOLDFUSS shows also smaller obliquity but differs from this in the more elongated outline and stronger curvature of the anterior margin.

Occurrence:—The same as *P. matsumotoi.* Toarcian. TORIYAMA coll.

Parainoceramus sp. ex gr. *matsumotoi* HAYAMI

Plate XV, Figure 10.

An internal mould of a small left valve closely resembles *matsumotoi* in outline but different in the stronger convexity and more prominent umbo. Two granular cardinals at the antero-dorsal angle suggest that it is intimate to *matsumotoi,* though the posterior lateral is much weaker. The difference of shell-convexity may be attributed to the different state of preservation, considering that the matrix of this specimen is more massive. This is at a glance similar to *Inoceramus morii* HAYAMI, 1959a, from the Bajocian Aratozaki formation of Northeast Japan, but differs in the presence of the weak cardinal and lateral teeth of *Bakevellia*-type, less prominent umbonal area and less steep anterior slope. Specimen, MM 3593, 12.5 mm. long, 15.0 mm. high, 5.0 mm. thick. Obliquity ca. 60 degrees.

Occurrence:—Rare in Nd (?) zone at Yasudadani, Nishinakayama, Toyoda town, Toyora County, Yamaguchi Prefecture. Toarcian. TORIYAMA coll.

Parainoceramus sp. indet.

1959. *Inoceramus* (?) sp. indet., HAYAMI, *Japan. Jour. Geol. Geogr., Vol. 30,* p. 60, pl. 5, fig. 15.

I intend here to included the *Isognomon*-like small indeterminable species from the Bajocian Aratozaki formation in *Parainoceramus* on the basis of a distinct posterior lateral tooth, improminent umbo and the similar outline to *Parainoceramus lunaris.* But the shell is more broadly inflated and lateral tooth much weaker than *lunaris.*

Genus ***Inoceramus*** SOWERBY, 1814

Type-species:—*Inoceramus cuvieri* SOWERBY, 1814, Cretaceous, England (defined by COX's lectotype designation). The decision of the International Commission on Zoological Nomenclature related to genus *Inoceramus* and its type species was published as Opinion 473 in 1957, in response to COX's application (1955).

Remarks:—Other Jurassic inoceramids than *Parainoceramus* are here referred to *Inoceramus*. In Japan tne groups of *I. polyplocus, fuscus, lucifer, retrorsus, galoi* and *neocomiensis* are represented by one or a few species in each. Besides, several aberrant forms may belong to the other groups.

Group of *Inoceramus polyplocus* ROEMER

(Subgenus *Mytiloceramus* ROLLIER, 1914)

Diagnosis:—Shell medium to large, suborbicular, equivalve, not strongly inflated; umbo subterminal, not very prominent; a small anterior wing-like area usually present; anterior margin nearly acline, broadly arcuate; apical angle generally larger than contemporaneous inoceramids; surface marked with fairly regular concentric plications which sometimes die out in flattened postero-dorsal area.

Remarks:—This group seems to be restricted to the Dogger (mainly Bajocian) and distinguishable from other groups by the suborbicular outline, subvertical anterior margin and regular concentrics on the surface. As noted before, it is not improbable that this group was derived from *Posidonia*-like pelecypods and has a different origin from other inoceramid groups. ROLLIER (1914) proposed *Mytiloceramus* for *I. polyplocus*, though the outline of the species is rather orbicular than mytiliform, and it is accepted here as a subgeneric name of *Inoceramus*.

Inoceramus (*Mytiloceramus*) *karakuwensis* HAYAMI, new species

Plate XV, Figure 17.

Description:—Only right valve known. Shell medium to large, probably suborbicular, not strongly inflated, hinge-line occupying about a half of shell-length; anterior margin subvertical, gently arcuate; apical angle not accurately measured but about 85 degrees or slightly more; posterior margin truncated with an angle of 140 degrees or less; umbo subterminal, risihg slightly above hinge; small anterior wing-like area present; beak angle about 70 degrees; a distinct post-umbonal sulcus defining flattened postero-dorsal area; surface marked with somewhat irregular concentric plications which are much weakened towards umbonal and postero-dorsal areas; hinge apparently edentulous; ligament structure unknown.

Measurement in mm.	Length	Height	Thickness	Obliquity
Holotype (MM 3597) right in. mould	76.0	68.5	9.5	55°
Paratype (MM 3598) right ex. mould	48.5	33.0	5.5	50°

Observation and comparison:—Represented by two specimens which show subtrapezoidal outline. However, seeing that they are compressed secondarily in antero-ventral to postero-dorsal direction, their original outline must be more orbicular. The post-umbonal sulcus and concentric ornaments in part may be somewhat emphasized in the holotype specimen. This species may be allied to *Inoceramus polyplocus* ROEMER, 1857, from the Bajocian of Europe (BENECKE, 1905 ; SCHMIDTILL, 1926) in the imaginable original outline. Because of the strong deformation of the present material, a detailed comparison of outline seems difficult, but the dimensions are larger and the postero-dorsal area of this species is probably more flattened, better defined and more weakly sculptured than *polyplocus*. The scuptures on the remaining part are apparently coarser, stronger and more irregular.

Occurrence:—Rare in black shales of Tsunakizaka formation (ONUKI, 1956) at the southeast of Tsunakizaka-pass, Shishiori, Kesennuma City, Miyagi Prefecture. SATO (1956) reported *Stephanoceras* sp. ex gr. *plicatissimum* QUENSTEDT from its adjacent horizon. Middle Bajocian or thereabout. YAMASHITA coll.

Group of *Inoceramus fuscus* QUENSTEDT

Diagnosis:—Shell small to medium for genus, equivalve, subrhomboidal and sometimes obliquely elongated, moderately or fairly strongly inflated; both wing absent or undeveloped; postero-dorsal area not flattened, illdefined from remaining part; anterior margin straight, prosocline, not differentiated into antero-dorsal and antero-ventral; posterior margin usually straight, subparallel to anterior; umbo terminal, sometimes fairly prominent; hinge edentulous; prismatic layer usually thin; surface marked with many irregular concentric lamellae which are comparatively weak and not clearly distinguishable from growth-lines.

Remarks:—The group of *Inoceramus fuscus* in my classification is composed of *I. fuscus* and many other subrhomboidal species and regarded as the main trunk of the Inoceramidae during Middle Jurassic and lower Upper Jurassic. Sometimes this group shows similar outline to *Parainoceramus*, but readily distinguished from the genus by the much larger dimensions, absence of hinge-teeth and wings, more prominent umbo and less mytiloid aspect.

Inoceramus morii HAYAMI

Plate XV, Figures 11-12.

1959. *Inoceramus* (s. l.) *morii* HAYAMI, *Japan. Jour. Geol. Geogr., Vol. 30*, p. 59, pl. 5, figs. 12-14.

After the original description of this species had been published, several specimens were further amplified from the Bajocian Aratozaki and Kosaba formations. As I referred then this species provisionally to *Inoceramus* (s. l.), it is not a typical *Inoceramus* and seems to belong to the group of *I. fuscus* QUENSTEDT, 1856, from the Bajocian of Europe, especially Alpine form of the species described by OOSTER (1869). But if compared with QUENSTEDT's original figure (1856, pl. 48, fig. 18), the surface concentric lamellae seem stronger and the outline is somewhat different. OOSTER and SCHMIDTILL's specimens of *fuscus* may have larger size and weaker inflation than this species. *Inoceramus quenstedti*

PČELINČEV resembles this in the dimensions and surface markings, but the convexity is probably weaker and the umbo less prominent. It is also similar to *Inoceramus dubius* in DUMORTIER (1874, pl. 42, figs. 5, 6) from the upper Lias of Rhône basin, but the anterior margin is nearly straight and more prosocline. In the several transverse thin sections prepared from the Aratozaki specimens, it was known that the prismatic layer is quite thin and undeveloped. The prisms are much smaller than those of *I. maedae* from the Malm and normal Cretaceous species.

Occurrence:—Common in the *Trigonia sumiyagura* bed of the lower Aratozaki formation at Akaiwazaki, southwest of Hosoura, Shizukawa town, Motoyoshi County, Miyagi Prefecture, and rare in the basal sandstone of the Kosaba formation at Shibitachi, Karakuwa town, the same county. SATO (1954a, b) described *Hammatoceras* and *Tmetoceras* from the underlying Hosoura formation, and BANDO (1959) *Cadomites* from the overlying Arato formation. Bajocian.

Inoceramus sp. ex gr. *fuscus* QUENSTEDT

Plate XV, Figure 13.

ex gr.
1856. *Inoceramus fuscus* QUENSTEDT, Der Jura, p. 355, pl. 48, fig. 18.
? 1867. *Inoceramus fuscus* LAUBE, Bivalv. Braun. Jura Balin, p. 26, pl. 2, fig. 1 (=*Inoceramus balinensis* ROLLIER, 1914).
1869. *Inoceramus fuscus* OOSTER, Jura. Inoceramen Alpen, p. 38, pl. 13, figs. 1-6.
? 1874. *Inoceramus fuscus* DUMORTIER, Études pal. Depôt jura. Bassin Rhône, Vol. 4, p. 307, pl. 61, figs. 6, 7 (=*Inoceramus dumortieri* ROLLIER, 1914).
1926. *Inoceramus fuscus* SCHMIDTILL, *Palaeontogr., Vol. 68,* p. 17, pl. 3, fig. 3.
1950. *Inoceramus fuscus* WETZEL, *Ibid., Vol. 99, Abt. A,* p. 108.

Description of Japanese specimens:—Shell small to medium, equivalve, subrhomboidal, obliquely elongated, not strongly inflated, more or less higher than long (MM 9087, right ex. mould, 35.5 mm. long; 38.5+mm. high; 3.5+mm. thick; obliquity ca. 55 degrees); anterior and posterior margins subparallel to each other, prosocline, forming respectively an apical angle of about 65 degrees and postero-dorsal angle of about 115 degrees with hinge-line; both wings absent; postero-dorsal area ill-defined; surface marked with about 15 irregular concentric foldings and numerous growth-lamellae.

Observation and comparison:—Four external moulds adhered to a slab of black shale. They must be compressed secondarily, because their valve-margins are subparallel to the bedding plane. Although the hinge and original shell-convexity are unknown, this form seems to be closely allied to *Inoceramus fuscus* QUENSTEDT from the Bajocian of Europe in the subrhomboidal outline and weak ornamentation. The surface concentrics seem very similar to DUMORTIER's figure but somewhat coarser than QUENSTEDT and SCHMIDTILL's. ROLLIER (1914) proposed *Inoceramus dumortieri* on DUMORTIER's figure, but the specific distinction seems not clear. It is different from *Inoceramus morii* in the larger dimensions and slightly less prosocline and more elongated shell.

Occurrence:—Rare in *Hammatoceras* bed (Uh zone by ARKELL, 1956, p. 420) of Utano formation at Todani valley, west of Nishinakayama, Toyoda town, Toyora County, Yamaguchi Prefecture. Aalenian. TORIYAMA coll.

Inoceramus cf. *nitescens* ARKELL

Plate XV, Figure 15.

cf. 1933. *Inoceramus nitescens* ARKELL, Monogr. Coral. Lamell., p. 218, pl. 28, figs. 2, 3.

Description of Japanese specimen:—Only left valve known. Shell large, highly inequilateral, roundly subrhomboidal, moderately inflated, higher than long (MM 3600, left valve, 62.5 mm. long; 71.5 mm. high; 13.0 mm. thick; obliquity ca. 55 degrees); both wings undeveloped; hinge-line as long as three-fifths of shell length, straight; anterior margin straight, not differentiated into antero-dorsal and antero-ventral, overlapped by inflated anterior part but not gaped, forming an apical angle of about 75 degrees; posterior margin broadly arcuate but forms postero-dorsal angle of about 120 degrees with hinge; umbo fairly prominent, slightly rising above hinge-line; hinge probably edentulous; ligament structure unknown; surface shining, smooth but for several subequidistant weak concentric lines; growth-lines apparently very weak.

Observation and comparison:—Represented only by a left valve. The test partly preserved on the internal surface is shiny. In view of the outline, shiny surface and weak concentric sculpture, it may be a close ally to *Inoceramus nitescens* ARKELL from the Corallian of England. The anterior margin seems slightly longer than ARKELL's type specimens, but no specific distinction can be based on any other characters.

Occurrence:—Rare in the "Nagano formation", which is correlative to Kaizara formation of the lower Tetori group, at Nagano, Izumi village, Ono County, Fukui Prefecture. Callovian or Oxfordian. Material belonging to the old collection of this institute.

Inoceramus hamadae HAYAMI, new species

Plate XV, Figures 14a, b.

Description:—Only left valve is known. Shell small, roundly subtrapezoidal, not strongly inflated, higher than long (holotype, MM 3601, left in. mould, 25.5 mm. long; 28.0 mm. high; 6.5 mm. thick; obliquity ca. 50 degress); test thin; both wings absent; postero-dorsal area not flattened, not clearly defined from remaining part; hinge-line comparatively short, passing gradually into posterior without any angulations; anterior margin straight, not gaped, turned somewhat abruptly into ventral; apical angle about 75 degrees; umbo very terminal, pointed but scarcely rising above hinge-line; hinge apparently edentulous; surface marked with about 12 irregular concentric narrow ridges and numerous growth-lines; ridges roof-shaped, clearly impressed on internal surface.

Observation and comparison:—Represented by a well preserved specimen composed of left internal and external moulds. This resembles the preceding form, *I.* cf. *nitescens* ARKELL from the coeval rock in the weak ornamentation and general outline. But the dimensions are much smaller, umbo less prominent, hinge-line shorter, concentrics more irregular and the postero-dorsal corner more rounded without forming a distinct postero-dorsal angle than that form and typical *nitescens*. *Inoceramus everesti* OPPEL in HOLDHAUS (1913) from the Upper Jurassic Spiti shales is also similar in the outline, but the concentrics of that species are denser and more regular.

Occurrence:—Rare in Kaizara formation at Shimoyama, Izumi village, Ono County, Fukui Prefecture. Callovian. HAMADA coll.

Inoceramus hashiurensis HAYAMI, new species

Plate XV, Figure 16.

Description:—Only left valve known. Shell small, roundly trapezoidal, obliquely elongated, only weakly inflated, much higher than long (holotype, MM 3602, left in. mould, 26.0 mm. long; 31.0 mm. high; 4.0 mm. thick; obliquity ca. 60 degrees); both wings absent; postero-dorsal area not defined from remaining part; anterior margin prosocline, slightly concave but not gaped, forming an apical angle of about 70 degrees; umbo terminal, improminent; postero-dorsal corner rounded; hinge apparently edentulous; weak irregular concentric lamellae and numerous radial capillary threads impressed on internal surface.

Observation and comparison:—Only a left internal mould is at hand. It is similar to *Inoceramus hamadae* from the lower Tetori group, but distinct in the more obliquely elongated outline, weaker concentrics and presence of faint radial impressions on the internal surface. Such internal radials have been probably unknown in Jurassic inoceramids, but known in some Cretaceous species as "internal ribs" by NAGAO and MATSUMOTO and "Diagonalleiste" by HEINZ. But it cannot be warranted here for the radials to be homologous with those of Cretaceous species, because of the inadequate preservation of the present material.

Occurrence:—Rare in Arato formation (Nagao formation by MORI, 1949) at Kuromorizawa, Kitakami village, Monou County, Miyagi Prefecture. The age is not exactly determinable at present but must be somewhere from Bajocian to Kimmeridgian. MORI coll.

Group of *Inoceramus lucifer* VON EICHWALD

Diagnosis:—Shell medium to large, equivalve, mytiliform to subtrapezoidal, moderately or strongly inflated; umbo terminal, fairly prominent; spicial and beak angle very small; posterior wing flattened, narrow but clearly defined from remaining part; surface marked with many irregular concentric lamellae and usually also with a few strong constrictions.

Remarks:—This group may have been derived from Liassic *Parainoceramus* or certain primitive members of *fuscus*-group, and includes several Bajocian forms from Alaska, Canada and Japan. *Inoceramus propinquus* MÜNSTER in GOLDFUSS, 1836, from the Lower Cretaceous of Germany shows similar outline and surface constrictions and may be a derivative of this group.

Inoceramus cf. *lucifer* VON EICHWALD

Plate XVI, Figure 1.

cf. 1871. *Inoceramus lucifer* VON EICHWALD, Geogn. Pal. Bemerkungen Mangischlak und Aleutischen Inseln, p. 194, pl. 18, figs. 5-7.
cf. 1955. *Inoceramus lucifer* IMLAY, *U.S. Geol. Surv., Prof. Paper, 274-D*, p. 86, pl. 8, figs. 1, 5-10.
cf. 1958. *Inoceramus lucifer* FREBOLD, *Geol.Surv. Canada, Bull. 41*, p. 15, pl. 14, figs. 1, 2; pl. 15, fig. 2; pl. 16, figs. 1, 2.

Description of Japanese specimen:—Shell large, mytiliform, obliquely elongated, much longer than high, moderately inflated (MM 3603, left in mould, 89.0 mm. long; 51.5 mm. high; 10.5 mm. thick; obliquity ca. 30 degrees); anterior margin slightly concave, forming an apical angle of 45 degrees or slightly more; hinge-line occupying about a half shell-length; postero-dorsal angle about 150 degrees; beak angle very small, about 32 degrees; small anterior wing-like area defined from umbonal area by a shallow sulcus; posterior wing narrow, flattened, clearly defined from main body by a deep post-umbonal sulcus; surface marked with many irregular concentric lines and four distinct constrictions which become stronger towards ventral periphery.

Observation and comparison:—Represented only by a left internal mould which shows mytiloid elongated outline, small apical and beak angles and a strong constriction near ventral periphery. The specimen may be compressed secondarily in transverse direction to shell-elongation, but these characters agree with those of *Inoceramus lucifer* recently redescribed by IMLAY (1955) and FREBOLD (1958) from the Bajocian of North Alaska and Prince Patrick Island. Compared with IMLAY's plesiotypes of that species, the anterior wing seems more distinctly separated from umbonal area but other essential characters are quite similar. VON EICHWALD (1871) originally established the species as a "Neocomian or Gault one", but NEUMAYR (1885), MARTIN (1926) and many other authors shared the opinion that it is a Jurassic species. Though no clear constriction is drawn and the posterior wing seems broader in VON EICHWALD's figures, I compare this specimen with *lucifer* on the basis of the similarity to IMLAY's plesiotypes. *Inoceramus karakuwensis*, n. sp. from the adjacent horizon may be specifically different from this in view of the more orbicular outline, larger apical angle (ca. 90 degrees), absence of strong constrictions and broader postero-dorsal area. According to IMLAY and FREBOLD, *Inoceramus lucifer* is accompanied by *Pseudolioceras, Emileia, Sonninia, Stemmatoceras, Otoites* and *Arkelloceras*, and can be treated as a guide fossil of lower and middle Bajocian.

Occurrence:—Rare in the black shales of the *Stephanoceras*-bearing Tsunakizaka formation at the southwest of Tsunakizaka-pass, Shishiori, Kesennuma City, Miyagi Prefecture. Middle Bajocian or thereabout.

Group of *Inoceramus retrorsus* KEYSERLING

Diagnosis:—Shell medium for genus, equivalve, subtrapezoidal to cuneiform in outline; umbo terminal; apical angle comparatively small; postero-dorsal area well-defined from remaining part by post-umbonal sulcus, flattened, more or less auriculate; strong constrictions not appear; concentric ornamentation and other characters similar to those of the group of *I. fuscus.*

Remarks:—This group composed of a few arctic and two Japanese species chiefly from the Bathonian and Callovian is probably related to the group of *I. fuscus,* but characterized by the more cuneiform outline and better defined and more developed posterior wing.

Inoceramus utanoensis KOBAYASHI

Plate XVI, Figures 3–5.

1926. *Inoceramus utanoensis* KOBAYASHI, *Jour. Geol. Soc. Tokyo, Vol. 33,* p. 7, pl. 11, figs. 1–2.

Description:—Shell small to large, equivalve, subrhomboidal to cuneiform, as long as or slightly longer than high; anterior wing absent, while posterior one is large, flattened and clearly defined from remaining surface by a post-umbonal sulcus; anterior margin straight, long, not differentiated into antero-dorsal and antero-ventral; posterior margin of wing sometimes slightly sinuated but passing gradually into broadly arcuate ventral margin; umbo narrow, fairly prominent but scarcely rising above hinge-line; hinge occupying about two-thirds of shell-length; apical angle somewhat variable among individuals but usually 55 to 65 degrees in cotypes; postero-dorsal angle about 120 degrees; ligament area apparently narrow; pits numerous; hinge edentulous; surface marked with several concentric ribs which are flattened at bottoms and fairly irregular in interval and prominence, and numerous slightly imbricated growth-lamellae; concentric ribs much weakened towards postero-dorsal area.

Measurement in mm.			Length	Height	Thickness	Obliquity
Lectotype	(MM 9081)	bivalved in. mould	45.0	43.5	11.0	50°
Cotype	(MM 9085)	left valve (juv.)	23.0	19.5	6.5	45°
Cotype	(MM 9084)	left ex. mould	44.5	47.0	9.0	45°

Observation and comparison:—Among KOBAYASHI's cotypes I select here a bivalved internal mould (fig. 1 in KOBAYASHI, 1926) as the lectotype. Though the outline is variable to a certain extent among individuals, this species can be generally characterized by the small beak angle (ca. 30 degrees) and clearly defined and well developed posterior wing. These characters remind me at a glance of those of *Cuneigervillia* COX, 1954, which was established as a substitute of *Edentula* WAAGEN, 1907, non NITSCH, 1820, but considered to be distinct from WAAGEN's by TOKUYAMA (1959)*. However, this is anyhow different from *Cuneigervillia* in the thin test, narrower ligament area with more numerous pits and concentric sculpture of *Inoceramus*-type. As noted by KOBAYASHI (1947), this species may be similar to *Inoceramus retrorsus* KEYSERLING, 1848, (LAHUSEN 1886), but the more cuneiform outline and developed posterior wing prevent me from referring this to *retrorsus*. A small specimen, which must be conspecific with the lectotype from the same bed, has less cuneiform outline and may suggest that this species is related also to the group of *I. fuscus*.

Occurrence:—Common in the upper part of Utano formation at Utano, Okaeda village, Toyora County, Yamaguchi Prefecture. Callovian or thereabout. KOBAYASHI coll.

Inoceramus ogurai KOBAYASHI

Plate XVI, Figure 2.

1926. *Inoceramus ogurai* KOBAYASHI, *Jour. Geol. Soc. Tokyo, Vol. 33*, p. 7, pl. 11, fig. 3.

Description:—Shell medium, subtrapezoidal, not strongly inflated, higher than long (holotype, MM 9086, 58.0 mm. long; 63.0 mm. high; 10.5 mm. thick; obliquity ca. 60 degrees); anterior margin fairly convex, forming apical angle of about 90 degrees or slightly less with hinge-line; hinge fairly long, occupying about two-thirds of length; posterior wing large, triangular, flattened, sharply defined from remaining part; posterior margin behind it slightly sinuated, forming a postero-dorsal angle of about 110 degrees; beak angle about 50 degrees; umbo terminal, slightly projecting above hinge; surface but for posterior wing about 30 or more concentrics.

Observation and comparison:—Besides the holotype specimen, two fragmental moulds showing similar surface sculpture are referrable to this species. The developed posterior wing and general outline are similar to *Inoceramus utanoensis* KOBAYASHI, but distinguishing characters from that species are the larger apical angle and shell-obliquity, more convex anterior margin and more delicate surface sculpture. The resemblance of outline between this species and *Cuneigervillia* cannot be overlooked, but in all species of that genus listed by COX (1954) the umbo is more anteriorly projected and more prosogyrous.

Occurrence:—The same as the preceding species. Callovian or thereabout. KOBAYASHI coll.

Group of *Inoceramus galoi* BOEHM

Diagnosis:—Shell medium to large for genus, eqivalve, variable in outline but usually subovate and sometimes elongated, moderately inflated; anterior margin very prosocline, ill-differentiated into antero-dorsal and antero-ventral; apical angle comparatively small (45-80 degrees); beak angle usually im-

* TOKUYAMA proposed *Waagenoperna* as a substitute name of *Edentula* WAAGEN and included it in the Isognomonidae.

measurable, because of the ill-defined postero-dorsal area; both wings absent; postero-dorsal angle rounded and very large; surface marked with wide-spaced regular concentric foldings.

Remarks:—This group, which seems common in the Oxfordian and later of Himalaya, Moluccas, New Caledonia and New Zealand, is charcterized by the subovate outline and coarse concentric ribs. Certain species such as *Inoceramus everesti* OPPEL seems intermediate between *fuscus*- and this group in many respects. This group can be subdivided into *galoi*-subgroup with small apical angle (ca. 50 degrees) and *haasti*-subgroup with large apical angle (ca. 75 degrees), as pointed out by WANDEL (1936).

Inoceramus sp. ex gr. *galoi* BOEHM

Plate XVI, Figure 6.

ex gr.

1907. *Inoceramus galoi* BOEHM, *Palaeontogr., Supple. 4, Lief. 2*, p. 68, pl. 9, figs. 10-14; pl. 10, figs. 1, 2.
1923. *Inoceramus* cf. *galoi*, TRECHMANN, *Quart. Jour. Geol. Soc. London, Vol. 79*, p. 274, pl. 15, figs. 1, 2.
1926. *Inoceramus* sp. ex gr. *galoi*, JAWORSKI, *Actas Acad. Noc. Cienc., Vol. 9, Nos. 3-4*, p. 158.
1936. *Inoceramus galoi* WANDEL, *Neues Jahrb. f. Min. usw., Beil.-Bd. 75B*, p. 467, text-fig. 2.
1953. *Inoceramus galoi* MARWICK, *N. Z. Geol. Surv., Pal. Bull. 21*, p. 92, pl. 12, fig. 2.
1953. *Inoceramus* sp. (aff. *I.* cf. *galoi* BOEHM in TRECHMANN), AVIAS, *Univ. Nancy, Fac. Sci., Thesis No. 91*, p. 169, pl. 23, figs. 1, 2, 7.
1959. *Inoceramus* cf. *galoi*, MILLIGAN, *N. Z. Jour. Geol. Geoph., Vol. 2, No. 1*, p. 197, text-fig. 2.

Represented by a fragmental external mould. Judging from the concentric ribs, this form is fairly large and has somewhat obliquely elongated outline. MORI (1949, p. 319) compared this specimen with *Inoceramus haasti*, but I presume that it may be more close to *Inoceramus galoi* BOEHM in view of the mode of round-topped concentric ribs.

Occurrence:—Rare in the black shale of Arato formation (Nagao shales in MORI, 1949) at Kuromorizawa, north of Ookami, Kitakami village, Monou County, Miyagi Prefecture. The age is exactly indeterminable but somewhere from Bajocian to Kimmeridgian. MORI coll.

Group of *Inoceramus neocomiensis* D'ORBIGNY

Diagnosis:—Shell medium to very large, subequivalve to pronouncedly inequivalve, variable in outline but usually subovate or polygonal and not much elongated, more or less higher than long; left valve frequently more strongly inflated than right, provided with more prominent umbo; anterior margin often differentiated into antero-dorsal and antero-ventral, subvertical or even opisthocline; apical angle 90 degrees or more; postero-dorsal area not auriculate, sometimes fairly wide but not clearly defined; prismatic layer fairly thick; hinge edentulous; ligament area comparatively long; pits isolated from one another; surface marked with numerous densely and sometimes slightly imbricated concentric wrinkles; strong concentric and radial plications absent.

Remarks:—WOODS (1911) stated that the species of Gault, upper Greensand and Chalk *Inoceramus* appear to be originated from two lower Greensand stocks, one being *Inoceramus salomoni* D'ORBIGNY and the other belonging to the type of *Inoceramus necomiensis* D'ORBIGNY. According to GILLET (1924), *Inoceramus ewaldi* SCHLÜTER, *I. quatsioensis* WHITFIELD, *I. ovatus* STANTON, *I. montezumae* FELIX, *I. plicatus* D'ORBIGNY, *I. picteti* MAYER-EYMAR and *I. sebianus* BUCHAUER belong to the group of *I. neocomiensis.* Besides, *Inoceramus anglicus* WOODS from the upper Greensand and Gault seems to belong also to the group. *Inoceramus tenuis* MANTELL, 1822, from the Albio-Cenomanian resembles some species of this group, but WOODS regarded it as a descendant of *Inoceramus salomoni,* which has a fairly striking sulcus on the middle surface and short triangular ligament area with divergent pits from beak. The ligament structure which reminds me of a primitive multivincular pelecypod, is quite different not only from Cretaceous but also from Jurassic species, and may imply that it was derived directly from other family than the Inoceramidae. *Salomoni* is generally considered as ancestral to the group of *Inoceramus concentricus* PARKINSON from the Middle and Upper Cretaceous, but I presume that the former species is somewhat deviated from the main trunk of the family which was persistent from the Jurassic. This group is characterized by the large and regular and delicate surface sculpture, and readily distinguishable from above mentioned Jurassic groups. So far as I am aware, no inquivalve inoceramid has been reported from the Jurassic. However, the following species show very inequivalve shells, prominent umbones and large apical angles, and are referable to *neocomiensis*-group.

Inoceramus maedae HAYAMI, new species

Plate XVII, Figures 1-3; Text-figure 2.

1952. *Inoceramus* spp., MAEDA, *Jour. Geol. Soc. Japan, Vol. 58, No. 679,* p. 150 (pars).

Description:—Shell large to very large, inequivalve, subquadrate or polygonal in outline, more or less higher than long; test thin; left valve strongly inflated, while convexity of right valve is moderate; anterior margin differentiated into slightly concave opisthocline antero-dorsal and prosocline antero-ventral of similar length; anterior wing absent but anterior area fairly protruded forwards beyond umbo; apical angle between antero-dorsal and hinge-margins about 115 degrees in right valve and probable slightly larger in left; posterior wing absent; posterior margin broadly arcuate from posterior part of hinge-margin; posterior area not defined and beak angle immeasurable in left valve, but in right valve a weak post-umbonal sulcus present and forming an beak angle of about 90 degrees with antero-dorsal; hinge-line occupying

Text-figure 2. Right valve of *Inoceramus maedae* HAYAMI, n. sp. (MM 9069) from the Mitarai formation. ×3/4. MAEDA coll.

about a half of little more of shell-length; umbo terminal but situated at about a fifth of shell-length from anterior extremity of shell, very prominent, recurved and rising highly above hinge in left valve, but less prominent and scarcely protruded in right valve; hinge edentulous; ligament area occupying greater part of hinge-margin, comparatively narrow, slightly concave and forming a certain angle against commissure plane in right valve, provided with numerous pits which are much broader than their interspaces; surface marked with numerous subequidistant concentric lamellae which are slightly imbricated externally and weakly impressed on internal surface; mode of ornamentation equal between two valves; strong plication and constriction absent; test occupied mostly by developed prismatic calcite layer; prisms about 0.1 mm. in diameter, interfingering from outer and inner margins, showing very irregular extinction under cross nicol.

Measurement in mm.	Length	Height	Thickness	Obliquity
Holotype (MM 9076) right valve	104.0	114.5	17.5	70°
Paratype (MM 9077) right in. mould	68.0	77.0	11.5	75°
Paratype (MM 9078) left valve	62.5	72.0	29.0	70°

Observation and comparison:—Three well preserved specimens and many fragments are at hand. The remarkable inequivalveness is ascertained between the holotype (right) and paratype (left) specimens which show similar surface markings and outlines. The holotype specimen is composed of nearly complete internal and broken external moulds. The test is partly but well preserved on the latter mould. The microscopic observation was carried out on several thin sections prepared from the holotype and some other fragmental specimens (Pl. XVII, Figs. 3b, c). In all rectangular sections to shell-surface, the test is occupied by developed calcite prisms, and lamellar layer cannot be observed, though it is unknown whether the layer is very thin or not preserved by unfavourable preservation. In parallel sections to shell-surface, the test is filled by numerous polygonal prisms which show very irregular extinction under cross nicol. The concave and narrow ligament area is impressed on the internal surface of the paratype. In view of the strong inequivalveness, large dimensions and large apical angle, this species is different from hitherto known Jurassic inoceramids and more similar to the group of *Inoceramus neocomiensis* chiefly from the Neocomian and Gault. Specifically it resembles *Inoceramus anglicus* WOODS, 1911, from the Albian in the outline of right valve, but the shell is more inequivalve and the umbo of left valve much more prominent than the Albian species. The concentric ornamentation is seemingly weaker and denser. The inequivalveness may remind one of some varietal forms of *Inoceramus concentricus* PARKINSON, 1819, from the Middle and Upper Cretaceous, but the umbonal region of each valve is less prominent and broader, hinge-line longer and the dimensions are much larger. *Inoceramus tenuis* MANTELL, 1822 (WOODS, 1911) from the Albio-Cenomanian shows similar inequivalve outline and delicate concentrics. According to WOODS, *I. tenuis* resembles *I. concentricus* but the left umbo is less prominent, the length of shell is relatively greater and concentric rings less prominent. Such differences are found also between *concentricus* and this species. Compared with WOODS' figures (1911-1912, p. 272-273, text-figs. 31-32) the outline seems more trapezoidal and postero-dorsal area is broader, but another figure (pl. 48, fig. 1) shows broader outline and more projected postero-dorsal area. Though it may be difficult that the specific distinction can be based on the outline and ornamentation, this is, I think, not conspecific with *tenuis* in view of the broadly sinuated antero-dirsal margin and more developed anterior area which projected forwards beyond umbo. *Inoceramus neocomiensis* D'ORBIGNY, 1842, from the Neocomian of Europe and South America differs from this in the gibbose outline and ill-differentiated anterior margin. The species includes two varietal forms which are probably conspecific but somewhat different in morphology.

Occurrence:—Common in the lower part of Mitarai formation (M_1 member by MAEDA, 1952a and HAYAMI, 1959b) at Mitarai, Shokawa village, Ono County, Gifu Prefecture. MAEDA suggested that this formation is as a whole correlative with the Callovio-Oxfordian Kaizara formation in Kuzuryu area. But my palaeontological result shows that the Mitarai fauna comprises several pelecypods akin to some Uppermost Jurassic and Lower Cretaceous foreign species. This inoceramid is, as noted above, more similar to some Neocomian and Gault species than any Upper Jurassic ones. The age is exactly indeterminable at present, but concluded to be more or less younger than the Kaizara fauna. Some inoceramids from Kaizara are less inflated, smaller, subrhomboidal, more primitive and properly belong to *fuscus*-group. It is interesting that the marine invasions, whose sediments are represented in the Tetori group, appear to have occurred at different stages among Kuzuryu, Makito and Kiritani areas. MAEDA coll.

Inoceramus maedae HAYAMI, var. a

Plate XVI, Figure 7; Plate XVIII, Figure 2.

Description:—Only left valve is known. Shell medium to very large, subrectangular, moderately inflated, much higher than long; test thin; umbo fairly prominent but rising slightly above hinge-line; surface marked with several irregular concentric foldings and numerous slightly imbricated lamellae of *maedae*-type.

Measurement in mm.	Length	Height	Thickness	Obliquity
(MM 9070) left valve	110.5	152.5	31.0	70°
(MM 9078) left ex. mould	50.0	51.0+	19.5	70°

Observation and comparison:—This form represented by two specimens is probably conspecific with *Inoceramus maedae* from the same locality, judging from the large obliquity and similar concentric lamellae, but it is somewhat different in the less prominent umbo and the presence or more elevated concentric ribs and weak constrictions. Since the anterior marginal areas of the two specimens, which seem at a glance nearly acline, are broken, the umbonal angle may be larger than 90 degrees. The precise comparison of outline with typical *maedae* is, therefore, difficult.

Occurrence:—The same as *Inoceramus maedae*. MAEDA coll.

Inoceramus maedae HAYAMI, var. b

Plate XVIII, Figure 1.

An intact specimen has also inequivalve shells and prominent umbo of left valve, but shows exceptionally small apical angle (about 75 degrees) and ill-developed anterior area. Judging from the somewhat emphasized concentrics in antero-ventral area, this specimen (MM 9071) is probably compressed seconarily in diagonal direction, and it may be merely a varietal form of *Inoceramus maedae*.

Occurrence:—The same as *Inoceramus maedae*. MAEDA coll.

Inoceramus furukawensis HAYAMI, new species

Plate XVI, Figure 8.

Description:—Shell medium, scborbicular, well inflated, slightly higher than long (holotype, MM 3604, left in. mould, 46.5 mm. long ; 52.0mm. high ; 13.5mm. thick ; obliquity ca. 75 degrees) ; anterior margin slightly concave, slightly opisthocline, forming an apical angle of about 115 degrees ; hinge-line occupying about three-fourths of shell-length, gradually bent down into posterior without sharp angulation ; both wings absent ; postero-dorsal area weakly defined but narrow ; umbo terminal, recurved, fairly prominent, rising highly above hinge-margin ; ligament area comparatively wide, provided with numeous pits along greater part of hinge-line ; inner surface smooth but for several obscure concentric foldings.

Observation and comparison:—Represented only by an internal mould of left valve which shows the internal characters prominent and thickened umbonal area. The test may be thick for *Inoceramus*, but the prominent umbo and multivincular ligament structure are typical of the genus. Although the inequivalveness cannot be ascertained, the strong inflation, concave and opisthocline antero-dorsal margin, large apical angle and weak ornamentation show that this is akin to *Inoceramus maedae* from Makito. The ligament structure is also very similar. However, the dimensions of this specimen are much smaller and the hinge-margin somewhat longer and thicker than that species.

Occurrence:—Rare in fine sandstone of Sugizaki sandy formation at Wakidani, Kawai village, Yoshiki County, Gifu Prefecture. MAEDA (1958) reported *Nipponitrigonia* sp. from this horizon. The age cannot be exactly determined but presumed to be almost contemporaneous with the Oxfordian Kiritani formation. AMAFUJI, OGASAWARA and TAKAGI coll. The tribal name in their manuscript (1949) is applied in the present specific denomination.

Incertae sedis

Several other Jurassic inoceramids in Japan are more or less aberrant and cannot be included in the above mentioned groups.

Inoceramus (s. l.) *kudoi* HAYAMI, new species

Plate XVI, Figure 9; Plate XVIII, Figures 3-4.

Description:—Shell medium to very large, equivalve, mytiliform, elongated postero-ventrally, not strongly inflated, much longer than high ; anterior margin straight, unusuall long, forming an apical angle of about 45 degrees with hinge ; hinge-line occupying about a half length, passing gradually into posterior margin which is subparallel to anterior ; both wings absent ; postero-dorsal area not defined ; umbo terminal, pointed but improminent, not rising above hinge ; hinge edentulous ; ligament area narrow, provided with 10 or more pits ; surface smooth except for faint concentric lines of growth.

Measurement in mm.	Length	Height	Thickness	Obliquity
Holotype (MM 9088) left in. mould	114.0	84.5	12.0	30°
Paratype (MM 9089) right in.mould	110.0	91.0	14.5	30°
Paratype (MM 9090) left in. mould	50.0+	44.0+	9.0	35°
Paratype (MM 9093) right ex. mould	35.0	25.5	4.5	30°

Observation and comparison:—Seven specimens at hand have similarly mytiliform and elongated outline. Although the outline reminds at a glance one of the Mytilidae or Pinnidae rather than Inoceramidae, the multivincular ligament structure shows this to belong to the Isognomonidae or Inoceramidae. Mesozoic isognomonids have usually thick tests, broad ligament area with subvertically elongated pits and more or less gaped anterior margin, while this species is characterized by the thin shell and narrow ligament. Mytiliform isognomonids are generally referred to subgenus *Mytiloperna* ROLLIER, which is, however, characterized by the comparatively small dimensions and also thick test. Some specimens of *Waagenoperna triangularis* (KOBAYASHI and ICHIKAWA, 1952) from the Upper Triassic Nariwa and Mine groups (TOKUYAMA, 1959) resembles this, but the outline is more mytiliform and more elongated than that species. In view of the improminent umbo and weak ornamentation, this is anyhow not a typical inoceramid, and the generic reference is provisional. So far as I am aware, there is no comparable species with this in Japanese and foreign Jurassic.

Occurrence:—Common in the upper part of Hosoura shaly formation (*Hammatoceras*-bed or Hh zone by SATO, 1957) at Jaou and some other localities, Hosoura, Shizukawa town, Motoyoshi County, Miyagi Prefecture. Aalenian. KOBAYASHI, KUDO and SATO coll.

Inoceramus (s. l.) *fukadae* HAYAMI, new species

Plate XVI, Figure 10; Text-figure 3.

Description:—Only left valve known. Shell small to medium, elliptical, moderately inflated, much longer than high; both wings absent; anterior margin broadly convex, passing gradually into venter without any angulations; apical angle obtuse but accurately inmeasurable; hinge-line long, occupying about three-fourths of shell-length; postero-dorsal angle about 130 degrees; postero-dorsal area narrow, ill-defined; umbo fairly prominent, rising above hinge-line; hinge apparently edentulous; ligament area fairly wide, provided with somewhat roughly spaced ligament pits;

Text-figure 3. Left internal mould of *Inoceramus* (s. l.) *fukadae* HAYAMI, u. sp. (MM 3606), paratype, from the Aalenian or Bajocian at Kodaijima, ×3/4. FUKADA coll.

surface marked with several concentric foldings.

Measurement in mm.	Length	Height	Thickness	Obliquity
Holotype (MM 3605) left in. mould	31.5	25.5	8.0	45°
Paratype (MM 3606) left in. mould	69.0	53.5	17.0	45°

Observation and comparison:—Represented by three specimens. Although they may be more or less deformed secondarily, the elliptical outline and long hinge-line occupying almost the shell-length are fairly unique for Jurassic inoceramids. The prominent umbo, concentric sculpture and multivincular ligament imply this species to belong to *Inoceramus* of a wide sense, but its taxonomic position is uncertain, since I could not refer to any intimate species.

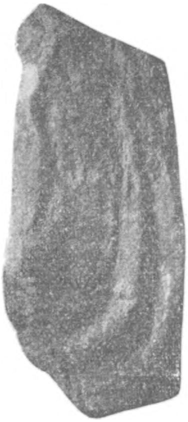
Occurrence:—Rare in the *Inoceramus*-bed of Kodaijima sandy formation at the southern coast of Kodaijima (an island at the neck of the Ojika peninsula), Ishinomaki City, Miyagi Prefecture. Aalenian or Bajocian. FUKADA coll.

Inoceramus (s. l.) a sp. indet.

Text-figure 4.

A fragment of a large inoceramid (MM 3607) differs from *Inoceramus* (s. l.) *fukadae* in the much larger dimensions and broadly plicated concentric ribs. The mode of ornamentation is somewhat similar to that of *galoi*-group.

Occurrence:—The same as *Inoceramus* (s. l.) *fukadae*. FUKADA coll.



Text-figure 4. *Inoceramus* (s. l.) a sp. (MM 3607) from the Aalenian or Bajocian at Kodaijima, ×1/2. FUKADA coll.

Text-figure 5. *Inoceramus* (s. l.) b sp. (MM 3608) from the Bajocian at the southeast of Tsunakizaka, ×3/4. YAMASHITA coll.

Inoceramus (s. l.) b sp. indet.

Text-figure 5.

A fragment of right valve (MM 3608) has similarly irregular concentrics to *Inoceramus utanoensis* KOBAYASHI from Utano formation, but the apical angle is apparently larger. Judging from the deformation of associated fossils, this specimen is also compressed secondarily. It may belong to a different species from *Inoceramus karakuwensis* from the same horizon, since the posterior area is worse defined and concentrics less prominent.

Occurrence:—Rare in the *Stephanoceras*-bearing Tsunakizaka formation at the southeast of Tsunakizaka-pass, Shishiori, Kesennuma City, Miyagi Prefecture. Middle Bajocian or thereabout. YAMASHITA coll.

Inoceramus (s. l.) c sp. indet.

Plate XVI, Figure 11.

A small external mould (MM 3609), though specifically indeterminable, is referable to *Inoceramus* of a wide sense in the thin test, concentric ornaments and developed prisms which are fairly characteristic of the genus.

Occurrence:—Rare in tuffaceous siltstone (M_2 by MAEDA, 1952a and HAYAMI, 1959b) of Mitarai formation at the west of Mitarai, Shokawa village, Ono County, Gifu Prefecture. Upper Jurassic or Lower Cretaceous.

Inoceramus (s. l.) d sp. indet.

Plate XVIII, Figure 5.

Only a left valve is available. Shell very small, mytiliform, obliquely elongated, moderately inflated, higher than long (MM 3610, left valve, 15.0mm. long; 18.0 mm. high; 3.5 mm. thick); anterior margin long, nearly straight; apical angle about 80 degrees; postero-dorsal angle about 135 degrees; hinge-line occupying about three-fifths of shell-length; umbo subterminal, slightly rising above hinge; postero-dorsal area not defined; surface smooth except for fine concentric growth-lamellae; hinge and ligament structure unknown.

The outline is similar to some species of *Parainoceramus* instead of Upper Jurassic and Lower Cretaceous developed species. *Inoceramus* cf. *amygdaloides* GOLDFUSS in SCHMIDTILL (1926) resembles this, but the shell-obliquity and apical angle are larger than that form. This may be a new form, but the specific name is not given here, since the occurrence of this specimen is exactly unknown.

Occurrence:—This specimen belongs to an old collection of this institute, labelled to have been collected from "Yoshimo". As stated KOBAYASHI and SUZUKI (1939) and MATSUMOTO (1953), the Yoshimo beds of West Japan must be Lower Cretaceous (or Wealden) and included in the Toyonishi group. All the fossils of Yoshimo beds appear brackish and the location of this specimen is now uncertain.

Inoceramus (?) *naganoensis* HAYAMI, new species

Plate XVIII, Figure 6.

Description:—Shell medium, *Isognomon*-like in outline, weakly inflated, much higher than long (holotype, MM 3611, 49.5 mm. long; 64.5 mm. high; 9.0 mm. thick; obliquity ca. 60 degrees); anterior margin broadly sinuated, forming an apical angle of about 80 degrees; posterior margin broadly convex, subparallel to anterior margin; hinge-line fairly long, occupying about three-fourths of shell-length; umbo terminal, projected forwards, situated at the anterior extremity of shell; internal surface marked with some irregular concentric foldings.

Observation and comparison:—Represented by two specimens. Since the test is exfoliated and ligament structure not observable, it cannot be determined whether it is actually an inoceramid or a member of *Isognomon*. The improminent umbo projected forwards is similar to some species of Mesozoic *Isognomon*, but the surface markings remind me of *Inoceramus*. This is somewhat similar to *Inoceramus* aff. *everesti* OPPEL in MARWICK, 1953, from the Ohauan (≒Kimmeridgian) of New Zealand, but the concentrics seem more irregular.

Occurence:—Rare in the black shale of the "Nagano formation" which is correlative with Kaizara formation, at Nagano, Izumi village, Ono County, Fukui Prefecture. Callovian or Oxfordian.

Synoptic List of Jurassic Inoceramids

Abbreviations:

P : *Parainoceramus*
Ip : Group of *Inoceramus polyplocus* (subgenus *Mytiloceramus*)
If : Group of *Inoceramus fuscus*
Il : Group of *Inoceramus lucifer*
Ir : Group of *Inoceramus retrorsus*
Ig : Group of *Inoceramus galoi*
In : Group of *Inoceramus neocomiensis*
Io : Other groups of *Inoceramus*

Inoceramus ambiguus VON EICHWALD, 1865, p. 493, pl. 21, f. 8a, b, Moscow; VON EICHWALD, 1871, p. 189, pl. 20, f. 1-5, Alaska; aff., SPATH, 1932, p. 109, text-fig. 7, mid. Greenland. (Ir) Bathonian-Callovian.

Inoceramus amygaloides GOLDFUSS, 1836, p. 110, pl. 115, f. 4, Germany; ROEMER, 1836, p. 83; OPPEL, 1856-1858, p. 416, (=*I. ellipticus* ROEMER, 1836, according to ROLLIER, 1914); SEEBACH, 1864, p. 108, do.; PČELINČEV, 1933, p. 12, pl. 2, f. 20-23, Caucasus; PČELINČEV, 1937, p. 50, 70, pl. 3, f. 53-58, do.; aff., BODYLEVSKI and SHULGINA, 1958, p. 61, Yenisei. (?=*Mytilites elongatiformis* SCHLOTHEIM, 1820). (P) Toarcian-Aalenian.

Inoceramus anomiaeformis FERUGLIO, 1936, Patagonia. Tithonian or Neocomian.

Inoceramus apollo LEANZA, 1942, p. 157, pl. 2, f. 1, Neuquén. (P) Pliensbachian.

Inoceramus aucella TRAUTSCHOLD, 1865, p. 4, pl. 1, f. 2-3, Ssimbirsk. ? Jurassic.

Inoceramus balinensis ROLLIER, 1914, p. 423, Germany. (=*I. fuscus* LAUBE, 1867, non QUENSTEDT, 1856). (If) Callovian.

Inoceramus brownei MARWICK, 1953, p. 92, pl. 13, f. 17, pl. 14, f. 5, New Zealand. (Io) Bajocian-Bathonian.

Inoceramus brunneri OOSTER, 1869, p. 38, pl. 13, f. 7-14, Alps. (→*I. oosteri* FAVRE, 1876). (If or In) Oxfordian.

Parainoceramus bulkurensis VORONETZ, 1936, p. 34, pl. 1, f. 2, 8, 10, North Siberia; COX, 1954, p. 47, do. (P) Upper Triassic.

Inoceramus cinctus GOLDFUSS, 1836, p. 110, pl. 115, f. 5, Germany; ROEMER, 1836, p. 82, do.; DUMORTIER, 1874, p. 185, France; JENENSCH, 1902, p. 24, pl. 10, f. 2, Germany; ROLLIER, 1914, p. 420, listed; PČELINČEV, 1937, p. 51, 71, pl. 3, f. 59, Caucasus. (P) Toarcian.

Inoceramya concentrica ULRICH, 1910, p. 134, pl. 12, f. 1, 2, pl. 13, f. 1, Alaska. (non *Inoceramus concentricus* PARKINSON, 1819). (*Inoceramya*) Yaktat group (Jurassic ?).

Inoceramus cor MÜNSTER in GOLDFUSS, 1836, p. 111, pl. 109, f. 7, Germany; VON EICHWALD, 1865, p. 485, Crimea. (If ?) Jurassic.

[*Inoceramus corfinianus* FUCINI, Italy; MARINO, 1934, do. Lias.

Inoceramus depressus MÜNSTER in GOLDFUSS, 1836, p. 109, pl. 109, f. 5, Germany; ROLLIER, 1914, p. 417, listed. (=*I. ventricosus* SOWERBY according to BRAUNS, 1871). (P) Hettangian-Sinemurian.

Inoceramus dubius SOWERBY, 1826, p. 162, pl. 584, f. 3, England; ZIETEN, 1830, p. 96, pl. 72, f. 6, Germany; GOLDFUSS, 1836, p. 108, pl. 109, f. 1, Germany (→ *I. polyplocus* ROEMER, 1857); QUENSTEDT, 1856, p. 260, Germany; DUMORTIER, 1874, p. 186, pl. 42, f. 5-6, France; ROLLIER, 1914, p. 419, listed; JAWORSKI, 1926, p. 158, Argentian; PČELINČEV, 1928, p. 1117, pl. 56, f. 13-14, Caucasus; PČELINČEV, 1933, p. 11, pl. 2, f. 15-19, do.; PČELINČEV, 1937, p. 50, 70, pl. 3, f. 48-52, do.; GILLARD, 1940, p. 609, France; cf., THEVENIN, 1908, p. 24, pl. 3, f. 10, Madagascar; cf., FREBOLD, 1957, p. 11, Alberta. (P) Toarcian-Aalenian.

Inoceramus dumortieri ROLLIER, 1914, p. 421, France. (=*I. fuscus* DUMORTIER, 1874, non QUENSTEDT, 1856). (If) Aalenian.

Inoceramus ellipticus ROEMER, 1836, p. 82, Germany; QUENSTEDT, 1856, p. 355, Germany; ROLLIER, 1914, p. 421, listed. Aalenian-Bajocian.

Inoceramus everesti OPPEL, 1862, p. 298, Himalaya; HOLDHAUS, 1913, p. 415, pl. 98, f. 12-14, Himalaya; aff., MARWICK, 1953, p. 92, pl. 12, f. 4, New Zealand. (If ?) Tithonian.

Inoceramus eximius VON EICHWALD, 1871, p. 192, pl. 18, f. 1-4, pl. 19, f. 3-4, Alaska. (Ir) Jurassic.

Inoceramus expansus BLAKE, 1875, p. 229, pl. 12, f. 3-4, England. (non *I. expansus* BAILY from Cretaceous). (If) Kimmeridgian.

Inoceramus faberi OPPEL, 1856-1858, p. 101, Germany; ROLLIER, 1914, p. 417, listed. Hettangian.

Inoceramus falgeri MERIAN, 1853, p. 7, pl. 1, Alps; OOSTER, 1869, p. 36, pl. 12, f. 1-5, do.; ROLLIER, 1914, p. 418, listed. (P or If) Pliensbachian.

Inoceramus ferniensis WARREN, 1932, p. 15, pl. 2, f. 1-3, Alberta. (Ir ?) Dogger ?.

Inoceramus fittoni MORRIS and LYCETT, 1853, p. 24, pl. 3, f. 14, England; MOESCH, 1874, p. 38, Swiss; ROLLIER, 1914, p. 423, listed; COX and ARKELL, 1948, p. 11, England. (If) Bathonian-Callovian.

Inoceramus (s. l.) *fukadae* HAYAMI, n. sp., p. 313, pl. 16 f. 10, Japan. (Io) Aalenian.

Iuoceramus furukawensis HAYAMI, n. sp., p. 311, pl. 16, f. 8, Japan. (In) ? Oxfordian.

Inoceramus fuscus QUENSTEDT, 1856, p. 355, pl. 48, f. 18, Germany; MOESCH, 1867, p. 73, Swiss; LAUBE, 1867, p. 26, pl. 2, f. 1, Germany (→*I. balinensis* ROLLIER, 1914); OOSTER, 1869, p. 38, pl. 13, f. 1-6, Alps; DUMORTIER, 1874, p. 307, p. 61, f. 6-7, France (→*I. dumortieri* ROLLIER, 1914); ROLLIER, 1914, p. 422, listed; SCHMIDTILL, 1926, p. 17, pl. 3, f. 3, Germany; WETZEL, 1950, p. 108, Germany; ex gr., HAYAMI, 1960, p. 301, pl. 15, f. 13, Japan. (If) Calenian-? Bajocian.

Inoceramus galoi BOEHM, 1907, p. 68, pl. 9, f. 10-14, pl. 10, f. 1-2, Sulu; WANDEL, 1936, p. 467, text-figs., Sulu; MARWICK, 1953, p. 92, pl. 12, f. 2, New Zealand; cf., TRECHMANN, 1923, p. 274, pl. 15, f. 1-2, New Zealand; ex gr., JAWORSKI, 1926, p. 158, Argentian; aff. I. cf. galoi TRECHMANN, AVIAS, 1953, p. 169, pl. 23, f. 1, 2, 7, New Caledonia; cf., MILLIGAN, 1959, p. 197, f. 2, New Zealand; ex gr., HAYAMI, 1960, p. 107, pl. 16, f. 6, Japan. (Ig) Callovian-Oxfordian? Tithonian.

Parainoceramus? gervillia VORONETZ, 1936, p. 34, pl. 1, f. 11, North Siberia. (P ?) Upper Triassic.

Inoceramus gracilis HOLDHAUS, 1913, p. 417, pl. 98, f. 15, Himalaya. (Ig) Tithonian.

Mytilus gryphoides SCHLOTHEIM, 1820, p. 296, Germany; *Inoceramus gryphoides* GOLDFUSS, 1836, p. 109, pl. 115, f. 2, Germany; QUENSTEDT, 1856, p. 260, pl. 37, f. 11, 12, up. Lias, Germany; PČELINČEV, 1933, p. 14, pl. 1, f. 7, Caucasus; PČELINČEV, 1937, p. 51, 71, pl. 4, f. 7, 8, Caucasus. (P) Pliensbachian-Toarcian.

Inoceramus gryphaeoides (SCHLOTHEIM), VON EICHWALD, 1865, p. 496, Tambov and Lithuania. (? misspelling of *gryphoides*) "Oxfordian".

Inoceramus haasti HOCHSTETTER, 1863, p. 190, New Zealand; ZITTEL, 1864, p. 33, pl. 8, f. 5, New Zealand; BOEHM, 1911, p. 14, Sulu; WANDEL, 1936, p. 473, pl. 19, 20, text-fig. 4, 5, Misol; BARTRUM, 1937, p. 458, f. 1, New Zealand; MARWICK, 1953, p. 91, pl. 12, f. 1, up. New Zealand; cf., TRECHMANN, 1923, p. 275, pl. 15, f. 3, New Zealand; cf., KRUMBECK, 1923, p. 78, pl. 173, f. 13, low. Timor. (Ig) Oxfordian.

Inoceramus hamadae HAYAMI, n. sp., p. 302, pl. 15, f. 14, Japan. (If) Callovian.

Inoceramus hashiurensis HAYAMI, n. sp., p. 303, pl. 15, f. 16, Japan. (If) ? Callovian.

Inoceramus hookeri SALTER, 1865, p. 95, pl. 23, f. 2, Himalaya; STOLICZKA, 1875, p. 89. (=*I. everesti* OPPEL, 1862, according to HOLDHAUS, 1913). (If ?) Tithonian.

Inoceramus inconditus MARWICK, 1953, p. 93, pl. 12, f. 5, pl. 13, f. 13, New Zealand. (If or Ig) Bajocian-Bathonian.

Perna inoceramoides HUDLESTON, 1878, p. 489, England; *Inoceramus inoceramoides* ARKELL, 1933, p. 217, pl. 28, f. 1, do. (If) Oxfordian.

Inoceramus intermedius VON EICHWALD, 1865, p. 494, pl. 21, f. 7, Tambov. Jurassic?

Inoceramus ischeri ROLLIER, 1914, p. 414, pl. 25, f. 2, Swiss. (If) Oxfordian.

Inoceramus (*Mytiloceramus*) *karakuwensis* HAYAMI, n. sp., p. 299, pl., 15 f. 17, Japan. (Ip) Bajocian.

Inoceramus (s. l.) *kudoi* HAYAMI, n. sp., p. 312, pl. 16, f. 9, pl. 18, f. 3-4 Japan. (Io) Aalenian.

Inoceramus laevigatus MÜNSTER in GOLDFUSS, 1836, p. 111, pl. 109, f. 6, Germany; GREPPIN, 1870, p. 29, Swiss; ROLLIER, 1914, p. 420, listed; Wetzel, 1950, p. 108, Germany. (If) Aalenian-? Bathonian.

Parainoceramus lenaensis VORONETZ, 1936, p. 34, pl. 1, f. 5, 7, 9, North Siberia. (P) Upper Triassic.

Inoceramus lucifer VON EICHWALD, 1871, p. 194, pl. 18, f. 5-7, Alaska; IMLAY, 1955, p. 86, pl. 8, f. 1, 5-10, Alaska; FREBOLD, 1958, p. 15, pl. 14, f. 1, 2, pl. 15, f. 2, pl. 16, f. 1, 2, Prince Patrick; cf. HAYAMI, 1960, p. 304, pl. 16, f. 1. (Il) Bajocian.

Parainoceramus lunaris HAYAMI, n. sp., p. 295, pl. 15, f. 1, Japan. (P) Pliensbachian.

Inoceramus maedae HAYAMI, n. sp., p. 308, pl. 17, f. 1-3, pl. 16, f. 1-2, pl. 14, f. 7, Japan. (In) ? Oxfordian.

Parainoceramus matsumotoi HAYAMI, n. sp., p. 296, pl. 15, f. 2-8, Japan; cf., HAYAMI, 1960, p. 297, pl. 15, f. 9, do.; ex gr., HAYAMI, 1960, p. 298, pl. 15, f. 10, do. (P) Toarcian.

Myoconcha ? meyrati FISCHER-OOSTER, 1869, p. 74, 98, pl. 3, f. 12, Germany; ROLLIER, 1914, p. 417, listed. (*Inoceramus* ?) Rhaetic.

Inoceramus morii HAYAMI, 1959, p. 59, pl. 5, f. 12-14, Japan; HAYAMI, 1960, p. 300, pl. 15, f. 11-12, do. (If) Bajocian.

Inoceramus ? naganoensis HAYAMI, n. sp., p. 315, pl. 16, f. 6, Japan. (*Inoceramus* ?) Callovian or Oxfordian.

Parainoceramus nikolaiewi VORONETZ, 1936, p. 34, pl. 1, f. 4, 6, 12, 13, North Siberia; *Inoceramus ? nikolaiewi*, KIPARISOVA, 1938, p. 45, pl. 6, f. 16, do. (P) Upper Triassic.

Inoceramus nitescens ARKELL, 1933, p. 218, pl. 28, f. 2, 3, England; cf., HAYAMI, 1960, p. 302, pl. 15, f. 15, Japan. (If) ? Callovian-Oxfordian.

Inoceramus nobilis MÜNSTER in GOLDFUSS, 1836, p. 109, pl. 109, f. 4, Germany. Lias (Cretaceous according to BOEHM, 1911, p. 400).

Inoceramus obliquiformis McLEARN, 1924, p. 41, pl. 3, f. 9, FREBOLD 1957, p. 21), Alberta. (Ig ?) Callovian.

Inoceramus obliquus MORRIS and LYCETT, 1853, p. 24, pl. 6, f. 12, England; WOODWARD, 1887, p. 313, do.; ROLLIER, 1914, p. 422, listed; QUENSTEDT, 1856, p. 355, Germany. (If) Bajocian-Bathonian.

Inoceramus ogurai KOBAYASHI, 1926, p. 7, pl. 11, f. 3, Japan; HAYAMI, 1960, p. 406, pl. 16, f. 2, do. (Ir) Callovian or thereabout.

Inoceramus oosteri FAVRE, 1876, p. 64, pl. 6, f. 2, Alps. (=*I. bruneri* OOSTER). (If or In) Oxfordian.

Inoceramus pernoides GOLDFUSS, 1836, p. 109, pl. 109, f. 3, Germany. (non *I. pernoides* ETHERIDGE, 1872). (=*I. ventricosus* SOWERBY, 1825, according to ROLLIER, 1914). (P) Pliensbachian.

Gervillia pinnaeformis DUNKER, 1851, p. 179, pl. 25, f. 10-11, Germany; *Inoceramus* *pinnaeformis* BRAUNS, 1871, p. 361, do., PHILIPPI, 1897, p. 437, do., ROLLIER, 1914, p. 416, listed. (P) Hettangian.

Inoceramus polyplocus ROEMER, 1857, p. 624, Germany (=*I. dubius* GOLDFUSS, 1836, non SOWERBY, 1826); BENECK, 1905, p. 145, pl. 8, f. 1-5, Germany; ROLLIER, 1914, p. 421, listed; SCHMIDTILL, 1926, p. 16, pl. 4, f. 3, Germany; cf. HORWITZ, 1937, p. 212, Poland; ex gr., PČELINČEV, 1937, p. 52, pl. 4, f. 2, Caucasus. (Ip) Aalenian-Bajocian.

Inoceramus porrectus VON EICHWALD, 1871, p. 191, pl. 19, f. 1, 2, Alaska. (Io) Jurassic (according to MARTIN, 1926).

Mytilus psilonoti QUENSTEDT, 1856, p. 48, pl. 4, f. 14, Germany (?=*I. pinnaeformis* DUNKER, 1851). (P ?) Hettangian.

Inoceramus quenstedti PČELINČEV, 1933, p. 13, pl. 1, f. 6; pl. 2, f. 2, Caucasus; PČELINČEV, 1937, p. 50, 70, pl. 4, f. 3-6, Caucasus; aff., BODYLEVSKI and SHULGINA, 1958, p. 60, Yenisei. (If) Aalenian.

Inoceramus retrorsus KEYSERLING, 1848, p. 12, pl. 4, f. 4, 5, Siberia; LAHUSEN, 1886, p. 3, pl. 1, f. 1, Lena; SPATH, 1932, p. 110, text-fig. 8, Greenland; VORONETZ, 1936, p. 22, pl. 1, f. 1; pl. 3, f. 38, North Siberia; DONOVAN, 1953, p. 70, Greenland; ex gr., VORONETZ, 1936, p. 23, pl. 3, f. 37, North Siberia. (Ir) Bathonian-Callovian.

Posidonia revelata KEYSERLING, 1846, p. 302, pl. 14, f. 12-15, Petchora. (*Inoeeramya* ?) Jurassic.

Inoceramus rostratus GOLDFUSS, 1836, p. 110, pl. 115, f. 3, Germany; ROLLIER, 1914, p. 418, listed. (If ?) Pliensbachian.

Inoceramus secundus MÉRIAN, 1853; MÜLLER, 1862, p. 56; MOESCH, 1867, p. 73; GREPPIN, 1899, p. 109, pl. 15, f. 1, Swiss; ROLLIER, 1914, p. 417, listed. (Ip) Bajocian.

Inoceramus stoliczkai HOLDHAUS, 1913, p. 418, pl. 98, f. 10-11, Himalaya. (Io) Tithonian.

Inoceramus subhaasti WANDEL, 1936, p. 469, pl. 15, f. 1, 2, pl. 16, f. 5, pl. 18, f. 1-3, text-fig. 3, Sulu (including *lateplicata*, *intermedia* and *denseplicata* as varieties); AVIAS, 1953, p. 169, pl. 23, f. 3, New Caledonia; cf., ROUTHIER, 1953, p. 56, pl. 2, f. 9, New Caledonia. (Ig) Oxfordian.

Inoceramus substriatus MÜNSTER in GOLDFUSS, 1836, p. 108, pl. 109, f. 2, pl. 115, f. 1, Germany; ROEMER, 1836, p. 83, do.; OPPEL, 1853, p. 81, do.; FUCINI, 1893, p. 88, pl. 5, f. 10-11, Italy; ROLLIER, 1914, p. 418, listed; *Parainoceramus substriatus*, COX, 1954, p. 47, Germany; cf., BEHRENDSEEN, 1891, p. 387, Argentina. (P) Pliensbachian.

Inoceramus sularum BOEHM, 1907, p. 70, pl. 11, f. 1, Sulu; cf., HOLDHAUS, 1913, p. 420, text-fig., Himalaya. (Ig) Oxfordian-Tithonian.

Inoceramus taliabuticus BOEHM, 1907, p. 69, pl. 11, f. 2, Sulu. (Ig) Oxfordian.

Perna thermarum MOESCH, 1867, p. 308, pl. 3, f. 2, Swiss. (P) Lias.

Inoceramus undulatus ZIETEN, 1830, pl. 72, fig. 7, Germany; OOSTER, 1869, p. 37, pl. 12, f. 6, Alps; DUMORTIER, 1874, p. 185, France; ROLLIER, 1914, p. 420, listed. (non *I. undulatus* MANTELL). (If ?) Toarcian.

Inoceramus utanoensis KOBAYASHI, 1926, p. 7, pl. 11, f. 1-2, Japan; HAYAMI, 1960,

p. 305, pl. 16, f. 3-5, do. (Ir) Callovian or thereabout.

Crenatula ventricosa SOWERBY, 1825, p. 64, pl. 443, 2 figs., England; *Inoceramus ventricosus* DUMORTIER, 1869, p. 134, pl. 21, f. 5-6, France; ROLLIER, 1914, p. 417, listed; *Parainoceramus ventricosus*, COX, 1954, p. 47, England. (P) Pliensbachian.

Inoceramus weissmanni OPPEL, 1856-1858, p. 101, Germany; MÖSCH, 1867, p. 47, 49; ROLLIER, 1914, p. 46. (P ?) Hettangian.

Inoceramus sp., ZIETEN, 1830, p. 96, pl. 72, f. 5, Germany. Lias.

Inoceramus sp., EVEREST, 1863, pl. 2, f. 29, Himalaya (→*Inoceramus everesti* OPPEL). (Ig ?) Tithonian.

Inoceramus sp., KRAUSE, 1896, p. 157, Borneo. Lias.

Inoceramus sp., NEWTON and TEALL, 1898, p. 650, pl. 29, f. 4, Franz Joseph Land. Jurassic.

Inoceramus sp., POMPECKJ, 1901, p. 271, Alaska. Jurassic.

Inoceramus sp., HOLDHAUS, 1913, p. 421, Himalaya. Tithonian.

Inoceramus sp., TILMANN, 1917, p. 674, Peru. ? Sinemurian.

Inoceramus sp., SCHLÜTTER, 1928, p. 59, New Guinea. Jurassic.

Inoceramus sp., SPATH, 1932, p. 112, pl. 4, f. 12, Greenland. (Ir ?) Bathonian-Callovian.

Inoceramus sp., WANDEL, 1936, p. 475, Misol. Oxfordian.

Inoceramus sp., COX, 1940, p. 127, pl. 7, f. 8, Cutch. (If) Oxfordian.

Inoceramus sp., GARDET and GÉRARD, 1946, p. 39, pl. 8, f. 5, Morocoo. (If ?) Bajocian.

Inoceramus sp., AVIAS, 1953, p. 169, pl. 23, f. 6, New Caledonia. (Ig) Oxfordian.

Inoceramus sp., AVIAS, 1953, p. 170, pl. 23, f. 8, New Caledonia. (Ig) Oxfordian.

Inoceramus ? sp., AVIAS, 1953, p. 151, pl. 23, f. 5, New Caledonia. (P ?) Hettangian.

Inoceramus sp., ROUTHIER, 1953, p. 56, pl. 2, f. 7, New Caledonia. (Ig) Upper Jurassic.

Inoceramus sp., ROUTHIER, 1953, p. 56, pl. 2, f. 10, New Caledonia. (Ig) Upper Jurassic.

Inoceramus subhaasti or *Inoceramus galoi* (juv.), ROUTHIER, 1953, p. 56, pl. 2, f. 8, New Caledonia. (Ig) Upper Jurassic.

Inoceramus sp., FREBOLD, 1958, p. 16, pl. 14, f. 3, pl. 15, f. 1, 4, pl. 16, f. 3, pl. 17, f. 1, 3, Prince patrick. (Il ?) Bajocian.

Inoceramus ? sp., HAYAMI, 1959, p. 60, pl. 5, f. 15, Japan; *Parainoceramus* sp., HAYAMI, 1960, p. 298, do. (P) Bajocian.

Inoceramus (s. l.) sp., HAYAMI, 1960, p. 314, f. 4, Japan. (Io) Aalenian.

Inoceramus (s. l.) sp., HAYAMI, 1960, p. 314, f. 5, Japan. (Io) Bajocian.

Inoceramus (s. l.) sp., HAYAMI, 1960, p. 315, pl. 16, f. 11, Japan. (Io) ? Oxfordian.

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Appendix

Occurrences of an Isognomonid in the Japanese Permian

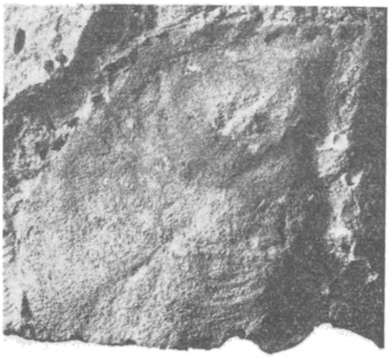
Genus *Isognomon* SOLANDER, 1786

"*Isognomon*" n. sp. indet.

Text-figure 6.

Description:—Shell medium, linguiform, nearly as long as high, not strongly inflated (right internal mould, PM 3612, 33.0 mm. long; 29.5+mm. high; 5.5 mm. thick; obliquity ca. 45 degrees); anterior wing small, triangular, clearly demarcated from remaining surface; anterior margin deeply sinuated at median part; apical angle about 50 degrees; postero-dorsal part flattened but not auriculate; hinge-line moderate in length, occupying about three-fifths of shell-length; umbo terminal, pointed anteriorly; hinge nearly edentulous except a weak posterior lateral tooth which runs subparallel to posterior hinge-margin; ligament area moderate in breadth, provided with five distinct pits of *Isognomon*-type byssal gape observable in front of anterior wing; surface striated with fine concentric lamellae besides numerous growth-lines.

Observation and comparison:—Represented only by a specimen of right valve composed of internal and external moulds. Though such a distinct anterior wing is unknown in *Isognomon*, the weakness of dentition, developed multivincular ligament structure, byssal gaping and other principal characters are more similar to Mesozoic and Recent *Isognomon* (s. s.) than other genera. Some species of *Cuneigervillia* COX, 1954, from the Lias resembles this in the general outline, but byssal gape and anterior wing are absent in that genus. This is anyhow different from *Bakevellia*, since coeval *Bakevellia* seems to be characterized by the smaller dimensions, smaller number of ligament pits, distinct cardinal teeth and more *Pteria*-like outline (developed posterior wing). This form, though I do not give it a name, may be the first



Text-figure 6. Right in. mould of "*Isognomon*" n. sp. (PM 3612) from the Middle Permian Kanokura group at Omotematsukawa, Kesennuma City, ×1.5. KOJIMA coll. Numerous holes are the external moulds of *Parafusulina matsubashi* FUJIMOTO.

Palaeozoic isognomonid, and bears importance for the phylogeny of the Isognomonidae.

Occurrence:—Rare in the *Parafusulina matsubaishi* FUJIMOTO bearing sandstone of the middle Kanokura series (Kamiyatsuse formation by SHIIDA, 1940) at Omotematsukawa, Kesennuma City, Miyagi Prefecture. Middle Permian. Collected by Mr. Keiji KOJIMA whom I acknowledge for his donation of the material.

Postscript

1. After the manuscript of this paper was completed, I read C. A. FLEMING'S paper (Upper Jurassic Fossils and Hydrocarbon Traces from the Cheviot Hills, North Canterbury. *N. Z. Jour. Geol. Geophysics, Vol. 1, No. 2, 1958*), where he described *Inoceramus* n. sp. A ? aff. *everesti* OPPEL and *I.* n. sp. B ? aff. *gracilis* HOLDHAUS from the Tithonian of South New Zealand and referred another species to *Anopaea* VON EICHWALD, 1861. *Anopaea* was originally founded on *Inoceramus lobatus* AUERBACH and FREARS, 1846, non MÜNSTER in GOLDFUSS, 1836, from "the Neocomian of Russia", which has a rib-like internal tooth below the beak of left valve and a deep "lunule". Some Uppermost Jurassic inoceramids from European Russia, Spiti and Taliabu, which were assigned to *Anopaea* by BOEHM (1904) and FLEMING, have oval outline and developed anterior part with excavated byssal sinus, and may be generically distinct from typical *Inoceramus*. But further informations on the stratigraphical occurrence and diagnostic characters of the type-species are desirable for the application of the generic name.

2. Recently VORONETZ and some other Russian authors described and listed many inoceramids, such as *Inoceramus formosulus, I. ussuriensis, I. skorochodi, I. rhomboideus, I. porrectiformis, I. aequicostatus, I. subambiguus* and *I. lucifer* from the Aalenian of Eastern Siberia and Sichota Alin Mountains. Though I cannot at present refer to their detailed descriptions and illustrations, their precise comparison with Japanese inoceramids seems necessary to promote the biostratigraphy and palaeobiogeography.
(June 23, 1960)

3. In the midst of printing of this paper, I could recognize the specific characters of some Siberian inoceramids through the courtesy of Dr. L. D. KIPARISOVA who kindly sent me a book, entitled "New species of palaeo-plants and invertebrates in USSR, Vol. 2. *Moscow*, 1960". So far as judged from the illustrations, *Inoceramus subambiguus* PČELINCEVA, 1960, from the Aalenian of Okhotsk region is, if not identical with, very close to *Inoceramus morii* HAYAMI, 1959, and *Inoceramus kystatymensis* KOSCHELKINA, 1960, from the Bathonian of Lena region is hardly distinguishable from *Inoceramus utanoensis* KOBAYASHI, 1926. *Inoceramus menneri* KOSCHELKINA, 1960, from the Bajocian of Lena is referable to the group of *I. lucifer* in my classification. (July 19, 1960)

I. Hayami

Jurassic Inoceramids in Japan.

Plate XV

Explanation of Plate XV

Parainoceramus lunaris HAYAMI, n. sp. .... p. 295

Fig. 1. Right internal mould (MM 3582), holotype, ×2. Upper Pliensbachian at Sakuraguchi, southwest of Ishimachi, Yamaguchi Pref.

Parainoceramus matsumotoi HAYAMI, n. sp. .... p. 296

Figs. 2a-b. Left internal mould (MM 3584), holotype, ×1.5 ann clay cast of the same external mould, ×2. Toarcian at Ishimacii.

Fig. 3. Right internal mould (MM 3586), paratype, ×1.5 Do.

Fig. 4. Left internal mould (MM 3585), Paratype, ×1. Do.

Fig. 5. Left internal mould (MM 3588), ×1.5. Do.

Fig. 6. Clay cast of right external mould (MM 3587), paratype, ×1.5. Do.

Fig. 7. Gypsum casts of two external moulds (MM 3589), ×1. Do.

Fig. 8. Left valve (MM 3590), ×1. Do. Material coll. by TORIYAMA.

Parainoceramus cf. *matsumotoi* HAYAMI. .... p. 297

Fig. 9. Right internal mould (MM 3592), ×2. Do. TORIYAMA coll.

Parainoceramus sp. ex gr. *matsumotoi* HAYAMI .... p. 298

Fig. 10. Left internal mould (MM 3593), ×2. Toarcian at Yasuda-dani, Nishinakayama, Yamaguchi Pref. TORIYAMA coll.

Inoceramus morii HAYAMI .... p. 300

Fig. 11. Left internal mould (MM 3596), ×1. Bajocien at Akai-wazaki, Southwest of Hosoura, Miyagi Pref. MORI coll.

Fig. 12. Left valve (MM 3595), ×1.5. Do.

Inoceramus sp. ex gr. *fuscus* QUENSTEDT .... p. 301

Fig. 13. Gypsum cast of right external mould (MM 9087), ×1. Bajocian at Todani, west of Nishinakayama. TORIYAMA coll.

Inoceramus hamadae HAYAMI, n. sp. .... p. 302

Figs. 14a-b. Left internal mould (MM 3601), holotype, ×1.5, and clay cast of the same external mould (MM 3601), Callovian or Oxfordian at Shimoyama, Fukui, Pref. HAMADA coll.

Inoceramus cf. *nitescens* ARKELL. .... p. 302

Fig. 15. Left valve (MM 3600), ×1. Callovian or Oxfordian at Nagano, Fukui Pref.

Inoceramus hashiurensis HAYAMI, n. sp. .... p. 303

Fig. 16. Left internal mould (MM 3602), holotype, ×1.5. Dogger or Malm at Kuromorizawa, Hashiura, Miyagi Pref. MORI coll.

Inoceramus (*Mytiloceramus*) *karakuwensis* HAYAMI, n. sp. .... p. 299

Fig. 17. Right internal mould (MM 3597), holotype, ×1. Bajocian at southeast of Tsunakizaka, Kesennuma City, Miyagi Pref. YAMASHITA coll.

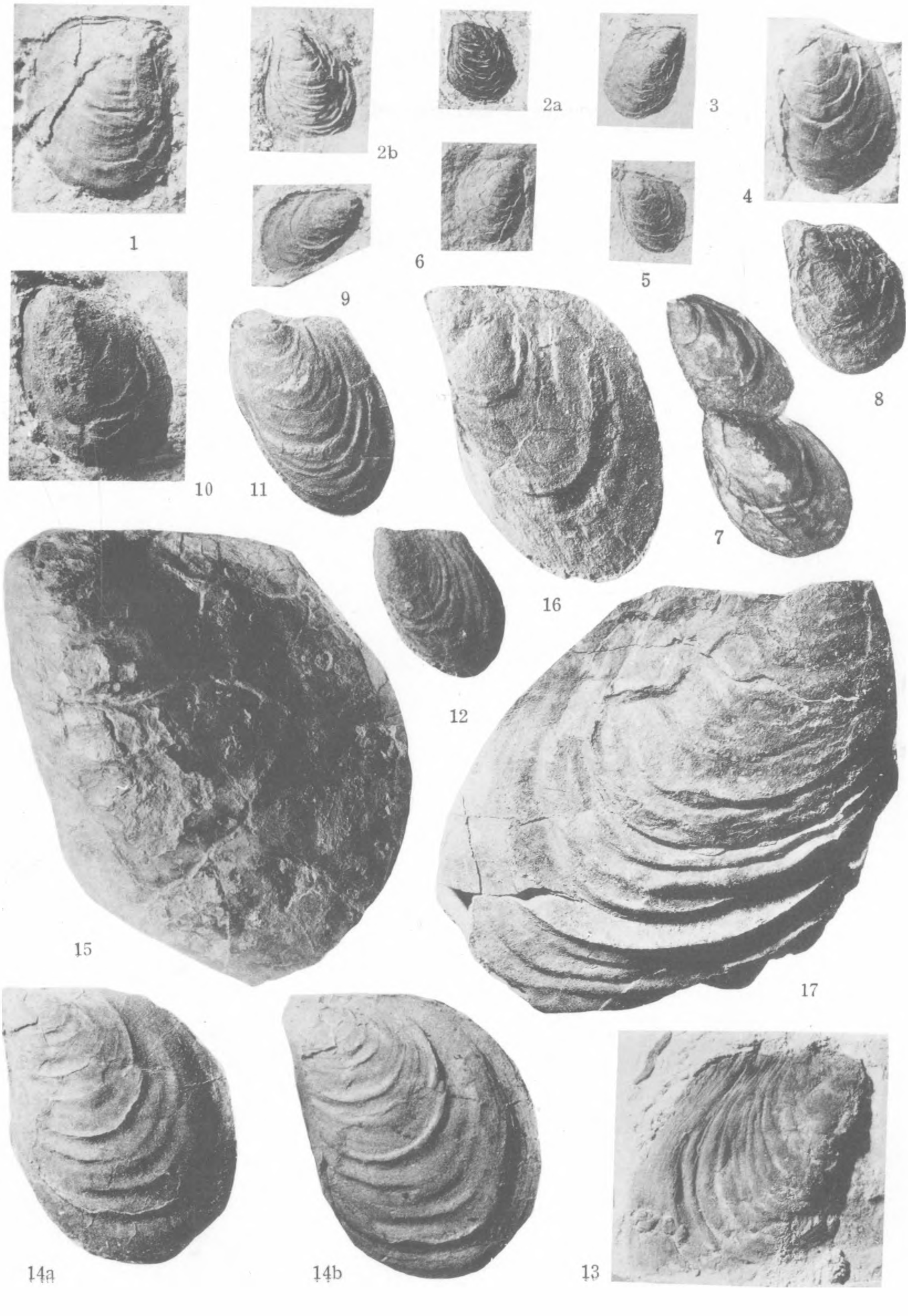

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Plate XVI

Explanation of Plate XVI

Inoceramus cf. *lucifer* von Eichwald....................................p. 304

Fig. 1. Left internal mould (MM 3603), ×1. Bajocian at southwest of Tsunakizaka, Kesennuma City, Miyagi Pref.

Inoceramus ogurai Kobayashi. ....p. 306

Fig. 2. Left internal mould (MM 9086), holotype, ×1. Callovian (?) at Utano, Yamaguchi Pref. Kobayashi coll.

Inoceramus utanoensis Kobayashi ....p. 305

Fig. 3. Right internal mould (MM 9081), lectotype, ×1. Do. Kobayashi coll.

Fig. 4. Bivalved internal mould (MM 9085), cotype, ×1. Do. Kobayashi coll.

Fig. 5. Gysum cast of left external mould (MM 9084), cotype, ×1. Do. Kobayashi coll.

Inoceramus sp. ex gr. *galoi* Boehm. ....p. 307

Fig. 6. Fragmental left external mould (MM 9079), ×1. Dogger or Malm at Kuromorizawa, Hashiura, Miyagi Pref. Mori coll.

Inoceramus maedae Hayami, var. a. ....p. 311

Fig. 7. Left valve (MM 9078), ×1. Malm at Mitarai, Shokawa, Gifu Pref. Maeda coll.

Inoceramus furukawensis Hayami, n. sp. ....p. 311

Fig. 8. Left internal mould (MM 3604), holotype, ×1. Malm at Wakidani, Kawai, Gifu Pref. Ogasawara coll.

Inoceramus (s. l.) *kudoi* Hayami, n. sp. ....p. 312

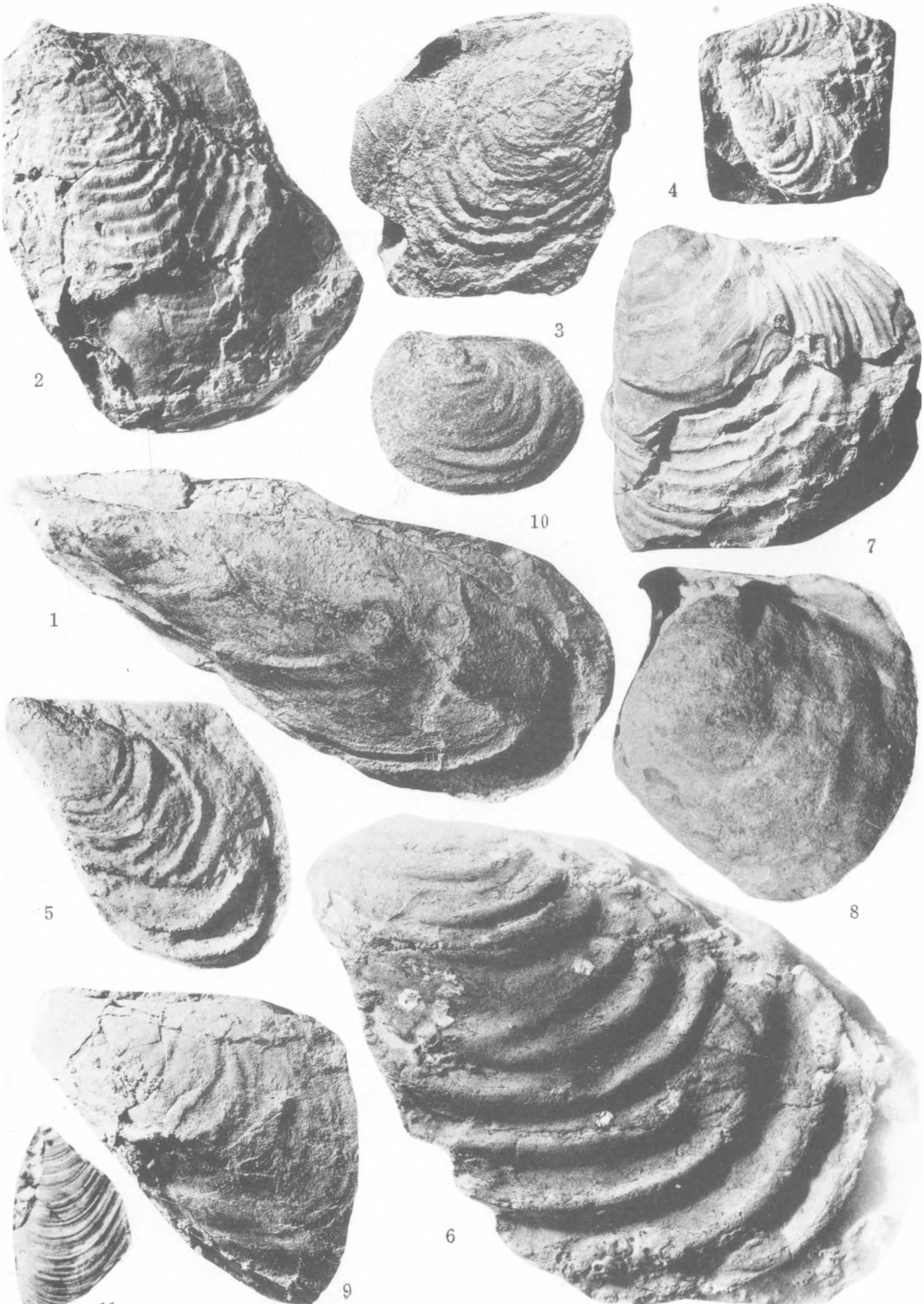
Fig. 9. Left internal mould (MM 9090), paratype, ×1. Aalenian at Hosoura, Miyagi Pref. ,Kobayashi coll.

Inoceramus (s. l.) *fukadae* Hayami, n. sp. ....p. 313

Fig. 10. Left internal mould (MM 3605), holotype, ×1. Aalenian or Bajocian. Fukada coll.

Inoceramus (s. l.) c sp. indet. ....p. 315

Fig. 11. Rubber cast of left (?) external mould (MM 3609), ×1. Malm at Mitarai, Shokawa, Gifu Pref.



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Jurassic Inoceramids in Japan.

Plate XVII

Explanation of Plate XVII

Inoceramus maedae HAYAMI, n. sp. ....p. 308

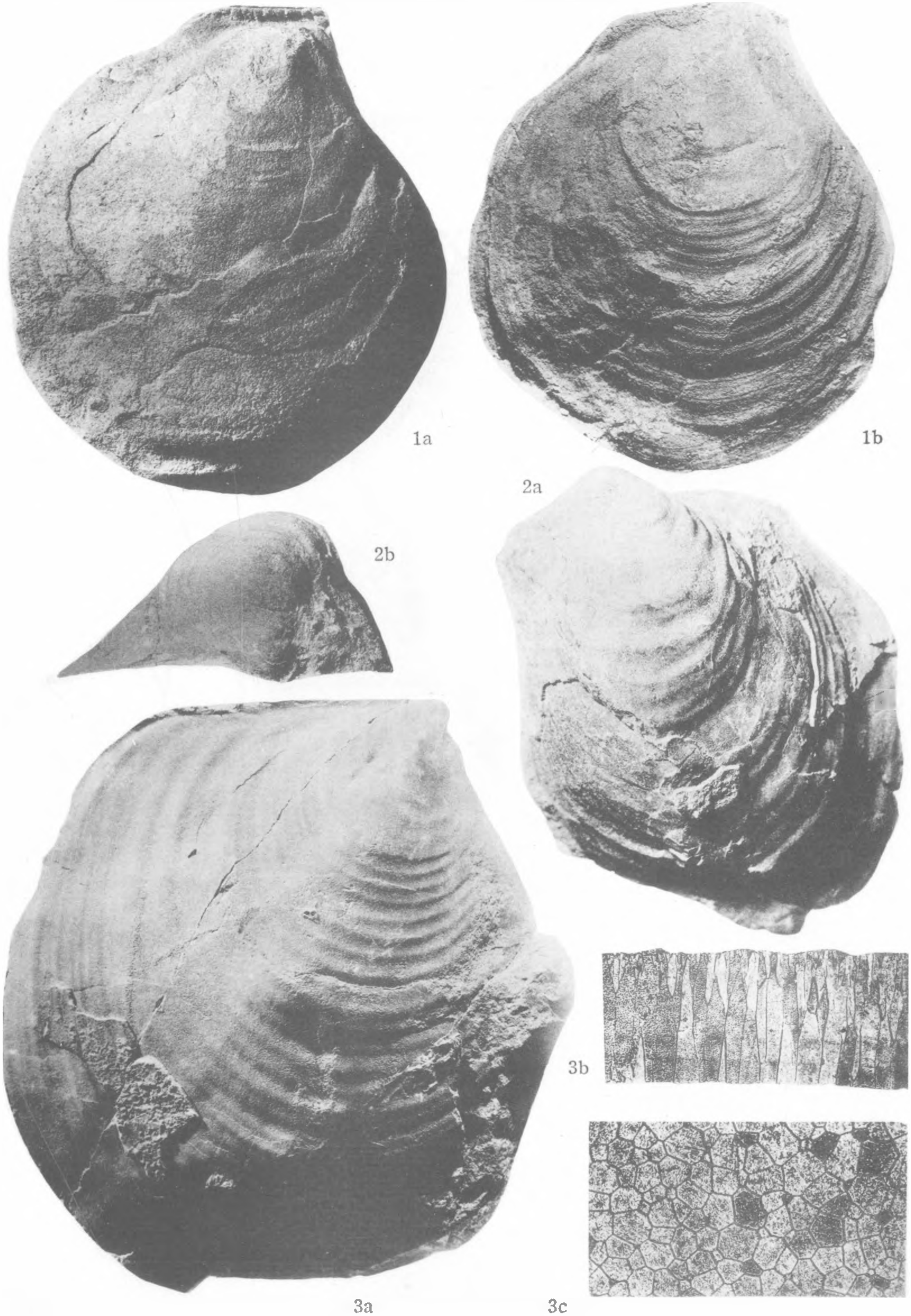
Figs. 1a-b. Right internal mould (MM 9077), paratype, ×1, and gypsum cast from the same external mould, ×1. Malm at Mitarai, Shokawa, Gifu Pref. MAEDA coll.

Figs. 2a-b. Left valve (MM 9078), paratype, ×1, and its upper view, ×1. Do. MREDA coll.

Fig. 3a. Right internal mould (MM 9076), holotype, ×3/4. Do. MAEDA coll.

Fig. 3b. Vertical section of the prismatic calcite layer of the holotype, prepared from the ventral part of the shell adhered to the external mould, ×22, (under open nicol).

Fig. 3c. Horizontal section of the prismatic calcite layer of the holotype, prepared from the middle part of the shell adhered to the external mould, ×66, (under open nicol).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2b
3a
3b
3c

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Jurassic Inoceramids in Japan.

Plate XVIII

Explanation of Plate XVIII

Inoceramus maedae HAYAMI, var. b. ....p. 311

Fig. 1. Bivalved internal mould (MM 9071), ×1. Malm at Mitarai, Shokawa, Gifu Pref. MAEDA coll.

Inoceramus maedae HAYAMI, var. a. ....p. 311

Fig. 2. Gypsum cast of left external mould (MM 9070), ×3/4. Do. MAEDA coll.

Inoceramus (s. l.) *kudoi* HAYAMI, n. sp. ....p. 312

Fig. 3. Left internal mould (MM 9088), holotype, ×1. Aalenian at Hosoura, Miyagi Pref. KOBAYASHI coll.

Fig. 4. Clay of right external mould (MM 9093), paratype, ×1. Do. KOBAYASHI coll.

Inoceramus (s. l.) d sp. indet. ....p. 315

Fig. 5. Left valve (MM 3610), ×1.5. "Wealden at Yoshimo" but exact locality unknown.

Inoceramus (?) *naganoensis* HAYAMI, n. sp. ....p. 315

Fig. 6. Left internal mould (MM 3611), ×1. Callovian or Oxfordian at Nagano, Kuzuryu, Fukui Pref.

All specimens illustrated in this paper are kept in the Geological Institue, University of Tokyo


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