A MONOGRAPH OF THE CRETACEOUS *INOCERAMUS* OF JAPAN

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With 34 Plates

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PART I.

With 12 Plates

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I. INTRODUCTION AND ACKNOWLEDGMENTS

Although species of *Inoceramus* are very frequently found in the Cretaceous deposits of Japan(1), they have not been much studied, having been described rather sparingly in the following papers:

1) SCHMIDT, F., 1873: Ueber die Petrefakten der Kreideformation von der Insel Sachlin. (Mém. l'Acad. Imp. Sci., St. Pétersbourg, VII ser., XIX, no. 3.)

(1) The species from North Saghalien which belongs to U. S. S. R., are included here from the geological standpoint.

2) YOKOYAMA, M., 1890: Versteinerung aus der japanischen Kreide. (Palaeontographica, 36.)
3) JIMBO, K., 1894: Beiträge zur Kenntnis der Kreideformation von Hokkaido. (Palaeont. Abhandlung, N. Ser., III, no. 3.)
4) MICHAEL, R., 1899: Ueber Kreidefossilien von der Insel Sachalin. (Jahrbuch der königl. preuss. geologischen Landesanstalt, XIX.)
5) SOKOLOW, D. W., 1914: Kreideinoceramen des russischen Sachalin (Mémoires du Comité géologique. N. Sér., Liv. 83.)
6) YABE, H., 1915: Note on some Cretaceous Fossils from Anaga on the Island of Awaji and Toyajo in the province of Kii. (Sci. Rep. Tôhoku Imp. Univ., 2nd ser., IV, no. 1.)
7) YEHARA, S., 1924: On the Izumi Sandstone group in the Onogawa Basin and the same group in Uwajima. (Jap. Jour. Geol. & Geogr., III, no. 1.)
8) YABE, H. and T. NAGAO, 1925: New or Little Known Cretaceous Fossils from North Saghalin (Lammellibranchiata and Gastropoda). (Sci. Rep. Tôhoku Imp. Univ., 2nd ser., VII, no. 4.)
9) YABE, H. and T. NAGAO, 1928: Cretaceous Fossils from Hokkaidô: Annelida, Gastropoda and Lamellibranchiata. (Ibid. IX, no. 3.)

Among these publications that of SOKOLOW dealt systematically with excellent material from North or Russian Saghalien.

Besides those specimens of *Inoceramus* described in these publications, many additional ones have been collected and studied by a number of Japanese geologists. Valuable unpublished manuscripts on these fossils are not rare, among which those by Messrs. Y. INAI, M. ITÔ, K. OTATUME, R. SAITO and K. SUGAI are the most important.

About ten years ago, the senior author of the present paper began to study the specimens stored in the Institute of Geology and Palaeontology, Tôhoku Imperial University, under the guidance of Prof. H. YABE; but his investigation was suspended for unavoidable reasons. Since his appointment to the Department of Geology and Mineralogy, Hokkaidô Imperial University, he has been able to begin a reexamination of the specimens together with additional rich material from various localities in Hokkaidô. On the other hand, the junior author, since 1935, has been examining the Cretaceous *Inoceramus* in the Institute of Geology, Tôkyô Imperial University. The necessity of dealing with very rich and extensive material in

order to go deep into the subject needed the cooperation of the two authors.

The material treated in the present paper comprises specimens of a very large number collected from various parts of the Japanese Islands, including not only those preserved in the Department of Geology and Mineralogy, Hokkaidô Imperial University (Hk), and the Institute of Geology, Tôkyô Imperial University (Tk), but also those belonging to the Institute of Geology and Palaeontology, Tôhoku Imperial University in Sendai (Sd) and the Institute of Geology and Mineralogy, Kyôto Imperial University (Ky). It includes may important specimens formerly collected or studied by Dr. JIMBO, Prof. YABE and others, and numerous other specimens recently obtained by many geologists of Japan. The names of the main collectors in each of the districts where the specimens have been derived are enumerated below:

Near Alexandrovsk, North Saghalien: H. YABE, S. SHIMIZU, etc.
Keton-Aton-Hoe district in Japanese Saghalien (South Karahuto): S. OISHI and T. MATSUMOTO.
Nisisakutan district, Japanese Saghalien: M. KAWASAKI and W. MUROI.
Naibuti and its adjacent district, Japanese Saghalien: M. KAWADA, S. SHIMIZU, etc.
Towada district, Japanese Saghalien: Y. ISHIZAKI and K. SAKAKURA.
Various localities in Hokkaidô: K. JIMBO and H. YABE.
Abesinai district, province of Tesio, Hokkaidô: Y. MORITA and T. NAGAO.
Obirasibe district, province of Tesio, Hokkaido: K. URABE.
Ikusyubetu and adjacent districts, province of Isikari, Hokkaidô: R. SAITO, T. NAGAO, etc.
Yûbari and Oyûbari districts, province of Isikari, Hokkaidô: R. SAITO and K. OTATUME..
Hobetu and Hetonai districts, province of Iburi, Hokkaidô: K. OTATUME and T. NAGAO.
Urakawa district, province of Nemuro, Hokkaidô: Y. IGARASHI and T. NAGAO, etc.
Nemuro district, Hokkaidô: Y. SASA and S. ENDO.
Kuzi district, province of Rikutyû: Y. SASA.
Hutaba district, province of Iwaki: S. TOKUNAGA, S. SHIMIZU, etc.
Toyazyo district, province of Kii: J. INOUE, etc.
Awazi: H. SASAI.

Uwazima district, province of Iyo: I. MATSUZAWA, K. SUGAI, S. SHIMIZU and S. NAKAMURA.
Onogawa district, province of Bungo: Y. INAI and T. MATUMOTO.
Amakusa Islands: T. NAGAO, T. MATUMOTO, and S. OMATI.

Besides these gentlemen, the names of numerous other collectors who contributed to the present matrial, as far as are known to the present writers, are given in a separate catalogue(1).

This monograph, as may be seen from the above statements, owes very much to the investigations of a large number of geologists and palaeontologists for many years, and it is the pleasure of the present writers to record here a debt of gratitude to all these gentlemen. The specific nams given by some of these scholars in their manuscripts are used in this paper, as far as possible, with some emendation. The writers desire to express their particular thanks to Prof. T. KATÔ and Dr. T. KOBAYASHI of Tôkyô Imperial University, and to Dr. S. TOKUNAGA of Waseda University; these gentlemen suggested their cooperation and much encouraged them during the preparation. They are also greatly indebted to Prof. H. YABE of Tôhoku Imperial University and Prof. S. NAKAMURA of Kyôto University for kind permission freely to use the library and the specimens of their respective Institutes. They must likewise thank Dr. S. YEHARA in Kyôto for permission to examine his original specimens. The photographs contained in this paper, have been prepared by Messrs. C. UEKI, T. TAKEDA, K. KUMAGAI and N. TAKAHASI, to whom thanks are due.

In the present monograph it is intended to classify and describe the Japanese Cretaceous species of *Inoceramus*. The classification of this genus is at present very complicated, and the writers can not enter far into it, having no opportunity to examine foreign specimens. However, the wealth of material at hand enables the classification of the Japanese *Inoceramus* and throws light on their variations. The writers wish, furthermore, to elucidate the geological and geographical distribution of the species in order to correlate the Cretaceous deposits of Japan.

II. STRATIGRAPHICAL NOTES

As has been already stated, the material dealt with in the present paper comprises specimens from the Cretaceous deposits of Japan,

(1) This catalogue is not published.

distributed from Russian or North Saghalien to the Islands of Kyûsyû. In this chapter the stratigraphy of the rocks from which the examined specimens have been derived is briefly referred to; the *Inoceramus* bearing strata are marked with the sign "※" in the following outline[1].

Regarding the general outline of the Cretaceous Stratigraphy of Japan, the reader is requested to refer to the following papers:

YABE, H., Cretaceous Stratigraphy of the Japanese Islands. Sci. Rep. Tôhoku Imp. Univ. Sec. Ser. (Geol.), XI, 1927.

YABE, H. and MATUMOTO, T., chapter Cretaceous in "Geology and Palaeontology of Japan" in preparation.

(Cf. Pl. I).

(1) Near Alexandrovsk, North Saghalien.

YABE, H. & SHIMIZU, S., 1924: Stratigraphical Sequence of the Lower Tertiary and Upper Cretaceous Deposits of Russian Saghalin. Jap. Jour. Geol. & Geogr., III, no. 1.

Cape de la Jonquière group	Upper division	Sandstone and shale in thin alternation, with plant remains and coal seams
	Middle division	1. Dark shale with marly nodules containing marine fauna
		2. Greenish sandstone with marine fauna (※)
		3. Dark gray sandy shale with marly nodules and marine fauna (※)
	Lower division	Sandstone and shale in thin layered alternation with plant remains and coal seams
Werblude group	Upper division	Conglomerate
	Middle division	Sandstone with marine fauna (Cape Khoi beds (※)
	Lower division	Sandstone and shale in alternation, with plant remains and coal seams

(2) Northern part of the west coast of Japanese Saghalien.

KAWASAKI, M., 1935: Report on the geological survey of coal fields in Karafuto, no. 2, Karafuto Government. (in Japanese).

Only a part of the Cretaceous deposits is distributed in the surveyed area, and the deposits, the Oyau Series, consist of the following three members:

1. Sandstone and shale with coal-seams.
2. Shale with Parapachydiscus (※)
3. Green sandstone (※)

(1) The strata are arranged in descending order, unless otherwise stated.

(3) The drainage areas of the Keton, the Aton, and the Hoe, tributaries of the Horonai-gawa, northern part of Japanese Saghalien.

ÔISHI, S. and MATUMOTO, T., 1937: Geology of the area between Keton and Hoe, S. Karahuto. Jour. Geol. Soc. Japan, vol. 44. (in Japanese)

Division D. { Mudstone with Neopachydiscus (※).
Sandstone and conglomeratic sandstone, with coal-seams (※).
Siltstone and mudstone (※).
Division C. Sandstone containing marine fauna (※).
Division B. Shale with occasional intercalations of thin sandstone (※).
Division A. Mainly tuffaceous sandstone, associated with conglomerate and shale (in the upper part).

(4) Naibuti district, Japanese Saghalien.

KAWADA, M., 1929: On some new species of Ammonites from the Naibuti district. Jour. Geol. Soc. Tôkyô, vol. 36.

SHIMIZU, S., 1929: Cretaceous Deposits of North and South Saghalien; A Comparison. Ann. Rep. Saito Hô-on-Kai, no. 5.

Most of the specimens examined by the present writers are the collection of the former author, but some are of the latter. The horizons of *Inoceramus* are not exactly labeled.

KAWADA's divisions are as follows:

3. Simaiwa Beds. Mainly black shale with some layers of green sandstone.
2. Ryugase Beds. Green glauconitic sandstone with thin intercalating layers of dark shale and conglomerate (※)
1. Miho Beds. Gray shale, a few thin layers of hard sandstone intercalating (※)

After the present work had been nearly completed, the junior author visited the district and undertook a precise survey. The result has been concisely reported in the following paper:

T. MATUMOTO, 1938: A Biostratigraphic Study on the Cretaceous Deposits of the Naibuti Valley, South Karahuto. Proc. Imp. Acad., XIV, no. 6.

In brief, the revised stratigraphic succession is as follows:

3. Ryugase Formation (emended), with subdivisions Rfy, Rey. ..... Ray and Ry-Mh in descending order. The first three subdivisions approximetely correspond to the Simaiwa Bed, and the remaining ones to the Ryugase Beds.

2. Miho Formation, including faunal zones denominated as Mh_7, Mh_6 ....Mh_1 and Mh_0 in descending order.
1. Kawakita Formation, containing subdivisions K_3, Ky, Kx, Ka and Kv.

The stratigraphic distribution of the species of *Inoceramus* has been shown in table 4 of that paper.

(5) Towada district, Japanese Saghalien.

ISHIZAKI, M. and K. SAKAKURA, 1937: Geology of the Nisi-Notoro Peninsula, S. Karahuto. (Journ. Geol. Soc. Japan, vol. 44) (in Japanese).

2. Upper Togusi Bed. Sandstone or sandy shale (※)
1. Lower Togusi Bed. Shale ( )

N.B. Specimens have been collected from various other localities in Karahuto, but the stratigraphy is not accurately known.

Cretaceous Deposits of Hokkaidô.

The general subdivision of the Cretaceous deposits of Hokkaidô proposed by H. YABE, is as follows:

YABE, H., 1926: A New Scheme of the Stratigraphical Subdivision of the Cretaceous Deposits of Hokkaidô. (Proc. Imp. Acad. Japan, II.)

3. Upper Ammonite Beds.
   - Hakobuti Sandstone
   - *Parapachydiscus* Beds
   - *Yezoites* Beds
   - *Mammites* Beds

   } Mainly dark gray shale
2. *Trigonia* Sandstone.
1. Lower Ammonite Beds.

Recently detailed stratigraphical studies of various districts in Hokkaidô have been undertaken. (6) to (14) indicate the present state of knowledge:

(6) Abesinai district, province of Tesio.

Geological reconnaissance of this district was carried out in 1930 by Y. MORITA: the senior author of the present paper visited there with him. The stratigraphy is briefly informed in the following paper:

SHIMIZU, S., 1932: On a new type of Senonian Ammonite, *Pseudobarroisiceras nagaoi* SHIMIZU gen. et sp. nov. from Tesio Province, Hokkaidô. (Jap. Jour. Geol. & Geogr., X, nos. 1–2.)

3. Abesinai group	Upper.	Coarse grained sandstone and shale with thin coal-seams
	Lower.	Blackish standstone and black shale with marly nodules (※)
2. Sibunnai-tôge group	Upper.	Green or blackish shale and green sandstone (※)
	Lower.	Greenish sandstone with grey shale beds.
1. Kamizi group		Tuffaceous shale, gray hard sandstone and shale with limestone bands

(7) Obirasibe district, province of Tesio.

The equivalent beds to the *Trigonia* Sandstone, (※), the Scaphites beds (※) and a part of the *Parapachydiscus* beds (※) are developed. (Recently K. URABE studied the geology of the district, but his report has not been published.)

(8) Ikusyunbetu district, province of Isikari.

NAGAO, T., SAITÔ, R., and MATUMOTO, T., 1938: Preliminary note on the succession of Cretaceous strata along the valley of the Ikusyunbetu, Hokkaidô. (Jour. Geol. Soc. Japan, 45.) (in Japanese).

Along the valley of the Ikusyunbetu, the succession of the Cretaceous strata is typically shown, and a large number of fossil *Inoceramus* are found in each of the horizons. Stratigraphy of this place is summarized as follows:

Division VI. Sandstone
Div. V. *Parapachydiscus* beds (※)
Div. IV. *Polyptychoceras* beds (※)
Div. III. *Scaphites* beds { IIIu (※), IIIm (※), IIIl (※) }
Div. II. *Trigonia* Sandstone (※)
Div. I. Lower Ammonite beds.

(9) Near Yûbari, province of Isikari.

In the neighbourhood of the Yûbari Colliery, the Lower Ammonite beds, the *Trigonia* Sandstone, and a part of the *Parapachydiscus* beds are developed. Most of the specimens examined are from the upper part of the *Trigonia* Sandstone.

(10) Oyubari district, province of Ishikari.

The specimens derived from the upper and middle course of the Yûbari and its tributaries are also numerous. Recently the stratigraphy was reinvestigated by R. SAITO.

(11) Noborikawa-Hobetu district.

The stratigraphical study by K. ÔTATUME revealed the detailed succession which is similar to that of the next district.

(12) Hetonai district, province of Iburi.

According to K. ÔTATUME, the stratigraphic succession is as follows:

(UWATOKO, K. and OHTATSUME, K., 1933: The Upper Cretaceous Oil-bearing Sedimentary Rocks of Hokkaidô. (Jour. Fac. Sci. Hokkaidô Imp. Univ. Ser. IV, vol. 2.)

(Also ÔTATUME's lecture in the 5th meeting of the Palaeontological Society of Japan.)

4. Upper Hetonai group
   - d. Sanusibe sandstone
   - c. Upper sandy shale
   - b. Fukausi sandstone (※)
   - a. Lower sandy shale (※)

   Lower Hetonai group — Mainly sandstone, with sandy shale, conglomerate and coaly shale (※)

3. *Parapachydiscus* beds. Black shale or black marly shale (※)
2. *Scaphites* beds. Black shale and sandy shale, occasionally intercalating sandstone.
   - b. Zone of *Inoc. hobetsensis* (※)
   - a. Zone of *Inoc. concentricus* (s. 1.) (※)
1. Zone of *Desmoceras japonicum* YABE. Dark grey shale with thin sandstone.

(13) Urakawa district, province of Hidaka.

Inoceramus is collected chiefly from the *Parapachydiscus* beds which are intercalated here by lenticular layers of sandstone.

(14) Nemuro peninsula, and Sikotan Island of South Kurile Islands.

SASA, Y., 1934: A Preliminary Notes on the Geology of the Island of Sikotan, South Tisima. (Proc. Fifth Pan-Pacific Sci. Congr., Canada.)

Upper Cretaceous deposits called the Sikotan beds are known.

Upper Cretaceous deposits of the Kitakami Mountainland

Species of *Inoceramus* are known only from the Upper Cretaceous of the Kuzi district.

(15) Kuzi district, province of Rikuzen.

SASA, Y., 1932: Geology of Kuzi district, Iwate prefecture. (Jour. Geol. Soc. Tokyo, vol. 39.) (in Japanese)

3. Kadonosawa formation
2. Kunitan formation { b. Kunitan sandy shale (※)
   a. Asige sandstone (※)
1. Tamagawa formation

Cretaceous deposits of the Abukuma Mountainland

(16) Hutaba district, province of Iwaki.

Through the investigation of S. TOKUNAGA, numerous specimens of *Inoceramus* have been collected, besides other important fossils already described.

TOKUNAGA, S., and SHIMIZU, S., 1926: The Cretaceous Formation of Futaba in Iwaki and its Fossils. Jour. Fac. Sci., Imp. Univ. Tokyo, Ser. II, vol. 1, pt. 6.

3. Upper Hutaba beds. Hard coarse sandstone and conglomerate with local intercalation of shale and sandy shale
2. Middle Hutaba beds. Very soft bluish mudstone, locally with mudstone and coarse sandstone in alternation
1. Lower Hutaba beds. Alternation of sandy shale and hard sandstone (※) (basal part arenaceous and locally conglomeratic and upper part is occupied chiefly by sandy shale)

Cretaceous deposits of South-west Japan

Specimens of *Inoceramus* from the upper Cretaceous deposits of South-west Japan are not infrequent. But, unfortunately, their preservation is often faulty.

(17) The Izumi Sandstone Group in the province of Izumi.

KOBAYASHI, T., 1931: The Izumi Sandstone formation in the Izumi Mountain Range. Jour. Geol. Soc. Tokyo, vol. 38. (in Japanese with English résumé)

5. Kuzuhata Sandstone and Conglomerate
4. Warazuhata Sandstone and Shale
3. Kintaizi Sandstone and Conglomerate
2. Asenotani Shale (※)
1. Kasayama basal conglomerate

(18) The Izumi Sandstone Group in Awazi Island.

The examined specimens depend chiefly on the recent investigation of H. SASAI.

SASAI, H., 1936: The Izumi Sandstone Series in Awazi. Jour. Geol. Soc. Japan, vol. 43. (in Japanese)

6. Nada Sandstone and Conglomerate (※)
5. Kitaama Sandstone
4. Siti Shale containing the second fossil-zone (※)
3. Yoroizaki Sandstone
2. Minato Shale containing the first fossil-zone (※)
1. Tui basal conglomerate

(19) Izumi Sandstone Group in the Inner Zone of the Island of Sikoku.

Systematic collection has not yet been carried out in the Izumi Sandstone Series from the provinces of Sanuki and Iyo, and only a few fossils derived from this district have been examined.

(20) Near Yuasa, Province of Kii.

Almost all the fossils have been collected from the Upper Cretaceous Toyazyo Formation.

(21) Miyakura district, province of Awa.

Upper Cretaceous deposits, called the Miyakura Sandstone, yield *Inoceramus*.

(22) Kunimi district, province of Tosa.

According to YAGI, 1899 (Jour. Geol. Soc. Tokyo, vol. 6), dark coloured fine sandstone containing *Inoceramus* is exposed at Kunimi in the southwestern part of Nakamura, Hata-gun, province of Tosa. But, due to the complicated structure, the stratigraphy of the Mesozoic strata of this district is not yet known sufficiently.

(23) Uwazima district, province of Iyo.

As the Cretaceous deposits of the Uwazima district are imperfectly known, the horizon from which the examined fossils have been derived, is not exactly recorded. Quite recently, I. MATUZAWA and K. SUGAI investigated this district to elucidate the complicated structure. Their conclusions will be published in the near future.

(24) Ônogawa Basin, Kyûsyû.

The junior writer reinvestigated the stratigraphy of the district, which was formerly surveyed by Y. INAI and S. YEHARA. The revised table of the Cretaceous succession of this district is as follows:

MATUMOTO, T., 1936: Geology of the Onogawa Basin, Kyûsyû. (Journ. Geol. Soc. Japan, vol. 43.) (in Japanese, with English résumé)

Upper group	Amabe formation	Upper member	(fossil zone)	Eastern part
		Lower member	0_{10} (※)	
	Yosinoturu formation	Conglomerate, sandstone and shale		
		Shale with sandstone	$0_7, 0_8, 0_9$. (※)	
		Conglomerate, snndstone with siltstone	0_6 (※)	
	Tonoe formation	Sandstone with shale		
		Conglomerate		
		Sandstone, siltstone and shale, with conglomerate.	0_5 (※)	
	fault			
	Inukaimati beds	. . . . .	0_4.	Western part
	Sibakita beds			
Lower group	Nakawarauti beds			
	Okukawarauti formation	Siltsonte		
		Sandstone, with conglomerate and shale	0_2 (※)	
		Conglomerate with sandstone and shale		
	Ryôzen formation	Transitional beds		
		Shale	0_1 & $0_1'$ (※)	
		Conglomerate		

(25) Amakusa Island, Kyûsyû.

NAGAO, T., 1930: On some Cretaceous Fossils from the Islands of Amakusa, Kyûshû, Japan. (Jour. Fac. Sci. Hokkaidô Imp. Univ., Ser. IV, vol. 1, no. 1.)

The examined specimens are those from the Upper Cretaceous Himenoura Group, which has the following three members:

Himenoura group	Upper Division	Thin bedded shale with intercalating sandstone layers with a fauna.
	Middle Division	Dark shale, with a rich fauna (※).
	Lower Division	Sandstone and basal conglomerate (※).

III. ON THE STUDY OF THE JAPANESE *INOCERAMUS* AND ITS CLASSIFICATION

The genus *Inoceramus* is one of the most important Cretaceous fossils, the species of this genus being found abundantly in various parts of the world. The invetigation of this fossil is not easy, since specimens are very frequently deformed after burial in sediments due to thin-tested shells, and the species themselves, as described, are very widely variable. The writers have examined as many specimens from Japan as are available especially those whose stratigraphical occurrence is more or less well determined. On the other

hand, it was not deemed wise to give names to the forms represented by ill-preserved specimens, though some of them have distinctive features.

Extremely numerous species of *Inoceramus* have hitherto been described by foreign paleontologists, and the classification of them is at present very complicated, a number of new names having been proposed for imperfect specimens, and the types being sometimes inadequate for determination.

As has been stated before, the purpose of the present paper is not a criticism of previous works, but a study of the rich material from Japan in order to get an adequate conception of the characters, variations, and mutual relations of the Japanese species and to classify them.

In the course of the present study, the writers have intended to examine all the characters available, distinguishing those which are observable relatively constantly in various species from those easily subject to variation. It was very useful for this purpose to compare numerous specimens collected from one locality or from one bed.

The Japanese Cretaceous species are classified into groups, species and varieties or subspecies as will be seen below. It may be adequate to offer at this place some general considerations on the variations shown in the characters of the shell. One character is not constantly persistent in all species of the genus: (a) in some forms, the outline of the shell is rather constant and the sculpture shows considerable variation, differentiation and multiplication (e.g., the group of *I. naumanni*); (b) in others, the ornamentation seems to be fairly constant and the outline and inflation of the shell are variable (e.g., the group of *I. uwajimensis*, although this group is represented by insufficient material), and (c) also in some others, the form of the shell and the sculpture are equally variable (e.g., the groups of *I. ezoensis* and *I. concentricus*).

The shell form is one of the important characters to consider in classifying this genus; the general outline, the features of equivalve- or inequivalveness, and the character of the hinge-line and the wing. Moreover, the primary sculptural element shown in the earlier stage of growth is usually one of the most useful features.

In each group of *Inoceramus*, the form[1] which appeared geologically earlier, has a simpler or more primitive ornamentation, and

(1) Such a form did not always disappear first, but has sometimes a rather long geological range.

such sculptural characters as concentric ridges, radial ribs and oblique ribs seem to be features which have possibly developed later as a result of specialization.

It seems to appear somewhat inadequate to include under a single genus, *Inoceramus*, all the forms, so varied and different. In the present state of knowledge, it would be advisable to establish some subgenera. The writers are not in a position to examine the type specimens of the genera and subgenera established by foreign paleontologists. However, it is undeniable that there are intimate relationships to one another among the groups in the available material, so these groups are placed for the present under the one genus, *Inoceramus*.

SUMMARIZED CLASSIFICATION OF THE CRETACEOUS *INOCERAMUS* OF JAPAN

I. The group *Inoceramus concentricus*

- *I. concentricus* PARKINSON var. *nipponicus* var. nov.
- *I. concentricus* PARKINSON var. *costatus* var. nov.
- *I. tenuistriatus* sp. nov.
- *I. teshioensis* sp. nov.
- *I. pedalionoides* sp. nov.
- *I.* sp.

II. The group of *Inoc. hobetsensis*

- *I. hobetsensis* sp. nov.
- *I. hobetsensis* var. *nonsulcatus* var. nov.
- *I. uwajimensis* YEHARA emend.
- *I. uwajimensis* var. *yeharai* var. nov.
- *I. iburiensis* sp. nov.
- *I.* sp. nov.? (*I. mukawaensis* MS)

III. The group of *Inoc. yabei*?

- *I. yabei* sp. nov. (s. str. and *I.* cfr. *yabei*, including deformed specimens)
- *I.* sp. aff. *I. yabei*
- *I.* sp.
- *I.* sp.

IV. The group of *Inoc. ezoensis*

I. incertus JIMBO emend.
I. incertus JIMBO var. *yubariensis* var. nov.
I. ezoensis YOKOYAMA
I. sp. nov.? (*I. vanuxemiformis* MS.)
I. balticus J. BÖHM
I. balticus BÖHM var. *toyajoanus* var. nov.
I. balticus BÖHM var. (nom. indet.)
I. balticus BÖHM var. *kunimiensis* var. nov.
I. sp. (*"Endocostea"* sp.)
I. shikotanensis sp. nov.
I. japonicus sp. nov. (including forma α, β, γ)

V. The group of *Inoc. naumanni*

I. naumanni YOKOYAMA emend.
I. orientalis SOKOLOW emend.
I. orientalis SOKOLOW var. *ambiguus* var. nov.
I. schmidti MICHAEL
I. yokoyamai sp. nov.
I. sachalinensis SOKOLOW emend.
I. sachalinensis SOKOLOW var. *ventriformis* var. nov.
I. pseudosulcatus sp. nov.
I. pseudosulcatus var. *elegans* SOKOLOW

VI. *Incerta sedis*

I. pilvoensis SOKOLOW
I. kusiroensis sp. nov.
I. akamatsui YEHARA emend.

IV. NOTES ON DESCRIPTION

It will be convenient to describe here in brief notes some important points in order to understand the descriptions of the species to be given in the next chapter.

(1) Descriptive terms. The terms employed in the descriptions of *Inoceramus* by many authors are not always the same. Some of them used in the present paper will be shortly stated:

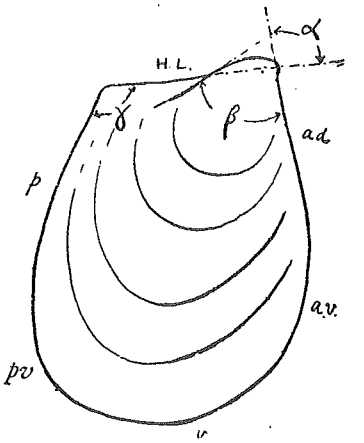
Terms for the description of the outline of the shell. (text-fig. 1)

beak angle: angle between the hinge-line and the antero-dorsal margin
(This cannot always be accurately measured.)

apical angle: angle between the antero-dorsal margin and the boundary line of the wing and the flank

postero-dorsal angle: angle between the hinge-line and the posterior margin

H.L. hinge-line
a.d. antero-dorsal margin
a.v. antero-ventral margin
v. ventral margin
p.v. postero-ventral margin
p. posterior margin



Text-fig. 1.

The nomenclature of the surface sculpture is especially varied. In this paper the following terms are used:

(a) Primitive or simple sculptures

Concentric lines: Surface of the test is always marked by regular concentric lines which are a trifle coarser than growth-lines. These surface markings are here called concentric lines and have often been called growth-lines or striae (Anwachslinie) by some authors. This type of sculpture is observable only when the outer layer of the test is preserved or when it is impressed on external casts.

Concentric rings: In many cases, there is a small elevation on each concentric line. These elevations are here denominated as concentric rings, though they are sometimes called growth-rings, minor concentric ribs, or concentric ribs or elevations of the third order. This sculpture is not usually preserved on the internal moulds. The concentric rings show various profiles according to their height, breadth and shape, but these characters will be better expressed by using respective adjectives in accordance with each feature.(1)

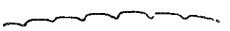
A distinctive sculpture is shown in certain forms in which two adjacent concentric rings unite with each other near the margins of the flank, or the summit of a concentric ring is distinctly divided. These rings are called concentric double rings.

(1) Such terms as "Anwachsring" and "Anwachskämme" defined by *Heintz* are sometimes convenient for description, but cannot always be decisively distinguished in the sculpture actually in existence in the forms at hand.

Concentric bands: This sculpture is represented by concentric undulations illustrated diagramatically in text-fig. 2, and is confined to certain forms only.

(b) *Concentric ridges*:

Comparatively large concentric sculptures, which are called concentric ribs, concentric ridges, major concentric ribs or elevations, or concentric ribs or elevations of the first order, are called concentric ridges in this paper. But when they are very low and weak, the term *concentric undulations* is employed.



Text-fig. 2.

The concentric ridges vary in shape, regularity, strength, etc. These features are expressed by adequate adjectives(1). In fossil state, the sculptures are often modified or obliterated by secondary deformation, and those preserved on internal moulds are distinguished from those of the external ornamentation impressed on external casts.

Concentric depressions: In some forms, the shell is concentrically constricted, i.e. the shell shows an abrupt change in convexity. These furrows are called *concentric depressions*, (e.g. *I. sachalinensis* and *I. yokoyamai.*)

(d) *Non-concentric sculptures*

The following five terms defined by HEINTZ are used, in English.

oblique ribs = Querungsrippen
divergent ribs = Divergenzrippen
radial ribs = Radialrippen
radial riblets = Radialrippeln
radial depression = Radialfurche

Besides these sculptures, when the preservation is favourable, fine *radial striae* are discernible on the inner surface of the shell.

The sculpture which characterizes *Endocostea* is here called *internal rib*. (HEINTZ's Diagonalleiste)

(2) *Measurements*

No great stress is put on the measurements of shell, for the writers have not examined them from the standpoint of biometry. Only it is aimed to help an understanding of the general idea of the size and to supplement the description of the shell-form.

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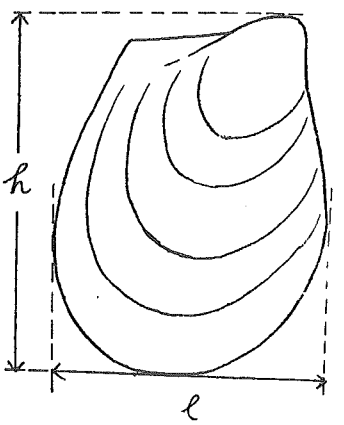
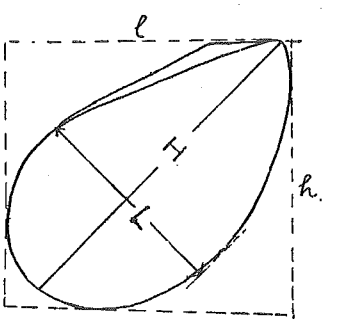
(1) HEINTZ's terms, "Anwachsreifen" and "Anwachswelle" are appropriate.

In very oblique valves, the measurements of height (h) and length (l) are usually inadequate or insufficient to show the size; the dimensions may be expressed by the scales measured along the line from beak to the postero-ventral extremity (H) and along the line perpendicular to it (L). (text-figs. 3a, 3b) In the present paper, thickness (th) means that of one valve, unless otherwise stated.



Text-fig. 3a.



Text-fig. 3b.

(3) *Type specimens*

So far as the species of *Inoceramus* are concerned, it is difficult and inadequate to select a single holotype specimen for description, because of the shell having considerable variations, and because the specimens possessing all characters of the species are very rare. Consequently, a few or numerous comparatively good specimens serve for this purpose (under the title of Typical specimens, Types or Syntypes).

(4) *On the occurrences*

In the following descriptions "Occurrences" represents the geographical and stratigraphical distributions of the examined specimens. As to the detailed localities, reference should be made to the separate tables in the separate catalogue, in which the examined specimens are listed almost completely together with the localities, horizons and collectors.

V. DISTRIBUTION OF THE JAPANESE CRETACEOUS *INOCERAMUS* AND THE CORRELATION OF THE UPPER CRETACEOUS DEPOSITS OF THE JAPANESE ISLANDS

The localities and horizons which have yielded specimens of forma, varieties or species of the Cretaceous *Inoceramus* of our country are listed in a separate catalogue(1). The stratigraphical and geographical occurrences are recorded in a summarized form in the description of each species. The occurrences of fossils are naturally influenced by various factors, not representing the direct influence of *time* only. In as much as the extent of most of these influences except time, is not accurately known, the geological ranges of species or groups of *Inoceramus* can not be determined with certainty. A simultaneous consideration of the correlation of the fossil-bearing strata, depending upon multiple working hypotheses, is very desirable. Based upon all the facts hitherto obtained, the tentative conclusion arrived at is represented in the accompanying tables concerning "the geological range of the Cretaceous *Inoceramus* of Japan" and "the correlation of the Upper Cretaceous deposits of Japan chiefly by means of *Inoceramus*"(2).

Inoceramus flourished in Japan from the Middle Cretaceous and ranges from the beginning of the Gyliakian epoch to the end of the Urakawa, being almost unknown from the Monobegawa Series. In the course of the history of this large genus, there have been prosperity and decay of the groups and species. By means of this genus the later half of the Cretaceous period may be divide into three epochs G, GU, and U, and the last one can be subdivided into three ages' Ul, Um and Uu. (G corresponds almost, but not exactly, to Gyliakian, and U to the Urakawa epoch defined by H. YABE.)

The brief history of the Japanese *Inoceramus* is here summarized:

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(1) This catalogue is not published, but is preserved in Geological Institute, Tokyo Imp. Univ. and Dept. Geol. & Mineral. Hokkaidô Imp. Univ.

(2) *Inoceramus* is not always yielded continuously or universally from the deposits in various districts. The defect of data is supplemented by the researches of the previous investigations on ammonites and other fossils. The correlation of the Upper Cretaceous deposits of Japan proposed by SASA with respect to the Kuzi Cretaceous, the opinion of TOKUNAGA and SHIMIZU as to the geological age of the Hutaba formation, and that of SASAI on the age of the Izumi Sandstone Series agree with the present conclusion.

(a) The group of *I. concentricus* flourished in G, and various kinds of forms, which have appeared in the later part of G, ranged to GU, but completely disappeared before U.
(b) *I. hobetsensis* (s.l.), *I. iburiensis,* and their allies are characteristic to GU. But isolated from them, a small number of individuals of a species belonging to this group (viz., *I. "mukawaensis"*) are found from the deposits of Um.
(c) *I. uwajimensis* YEHARA emend. and var. *yeharai,* which seem to be related to the group of *I. hobetsensis* (s. str.) experienced prosperity in Ul and are found neither earlier nor later than this age. *I. akamatsui* YEHARA is associated with the above two forms but appears earlier, in GU.
(d) The group of *I. yabei* has a similar history to that of the *I. concentricus* group, being found in G and GU. But a doubtful representative of this group is known from the earlier half of U.
(e) In the history of the group of *I. naumanni,* the probably primitive form of this group, *I. naumanni* YOKOYAMA emend., persisted in the almost the whole period of U; during Um multifarious forms were differentiated(?) and the number of individuals was very large. Among them *I. orientalis* (s. str.) ranged up into the earliest part of Uu, and *I. pseudosulcatus,* the probable last representative of this group, occurred, with its peculiar form, near the boundary of Um and Uu.
(f) Though *I. incertus* (s. str.) lived in GU, the other members of the group of *I. ezoensis* flourished in Ul, and most of them had their range in Um. The last representative, *I. shikotanensis* lived in Uu, presumably together with another peculiar form *I. kusiroensis.* A peculiar form (*"Endocostea"*) is represented by a few individuals in the deposits of Um and associated with *I. balticus* (s.l.).

Shortly, the history of each group has the following general aspects: (1) the appearance or advent of the primitive form; (2) the rapid (at least apparently) and multifarious differentiation and prosperity of the group; and (3) the apparently abrupt disappearance of the members of the groups, with the survival of a few representatives.

Each age or epoch, is defined generally as follows:

G is defined by the considerable existence of the members of (a)[1] and (d), and by the absence of other forms;

(1) (a) The group mentinoed in (a) of the just preceding articles;

GU, by the acme of (b), existence of various forms belonging to (a) and (d), and the appearance of the forerunners of (c) and (f);
U is the age of (c), (e), and (f), and is free from (a), (b) and (d) except for some survivors and doubtful forms;
Ul is characterized by the remarkable prosperity of (c);
Um may be defined as the age of various forms belonging to (e) and (f);
Uu is characterized by the existence of the last representatives[1] of (e) and (f), while the other forms disappeared in this age.

Concerning the correlation of the proposed time scale with the standard divisions of Europe, the writers cannot yet come to an accurate conclusion; a further investigation of ammonites is necessary for this purpose[2]. But evidenced by the present knowledge on ammonites and also the occurrences of some forms of *Inoceramus* allied to foreign ones, the following general correlation seems to be established:

G: Cenomanian
GU: Turonian
U: Senonian (s.l.)
Ul: Coniacian (Emscher)
Um: Santonian-Campanian
Uu: Maestrichtian (and possibly Danian)

It is noteworthy that the following facts have become apparent as to the relation between foreign *Inoceramus* and Japanese forms of this genus.

Almost all the species of Japanese *Inoceramus* have respectively their allied forms in the Atlantic or other realms, but there is found hardly any quite identical form. Also the stratigraphic occurrences are not always identical between our forms and the foreign equivalents. For example, *I. concentricus* and its allies are found in Europe from Albian and Cenomanian, while the Japanese representatives of this group range in G and GU (Cenomanian and Turonian) and are not yet discovered in the deposits which are correlated to Albian on the evidence of ammonites and other fossils. On the other hand, the group of *I. inconstans* flourished in the European Turonian and seems to range somewhat later; but in our country, the group

(1) *I. shikotanensis* is confined to this age.
(2) The junior author is at present carrying out the re-investigation of the Cretaceous chronology.

of *I. yabei,* the probable equivalent of that foreign group, lived in G and GU. Such forms as *I. iburiensis* and *I. uwajimensis,* (s. str. and var. *yeharai*), have contemporaneous foreign representatives. Moreover, *I. naumanni-ambiguus* and *I. lingua-lobatus* are in a close relation. But the group of *I. naumanni* seems to have its domain chiefly in the Japanese province, or in the northern Pacific region.

The "European standard" has been often applied to the Cretaceous deposits of the Indo-Pacific realms, but there is no doubt that this application for the deposits in these provinces needs some modification.

The above mentioned general conclusions on the geological age of species and groups of *Inoceramus* and the correlation of the Cretaceous deposits, are of course somewhat provisional; hitherto obtained data are obviously insufficient, owing to the lack of accurate knowledge on the stratigraphy of some districts and also to the incomplete collection of fossils.

Within the Japanese province, differences in the distribution due to a geographical factor do not seem to exist. A number of forms are found with a wide geographical distribution in each age; for example, *I. hobetsensis* in GU, *I. uwajimensis* in Ul, *I. naumanni* in U, and *I. schmidti* and *orientalis* in Um. At the same time, it is also a fact that certain forms are known from restricted areas, or are represented by a small number of specimens. Such differences in distribution as described next can be found.

(1) *I. balticus* (s. l.) is known only from Southwest Japan, while *I. ezoensis* only from Hokkaidô and Saghalien.

(2) *I. sachalinensis* is not found in SW Japan, but is very abundant in the northern half of the Yezo-Saghalien belt of deposition.

(3) *I. shikotanensis* is yielded from Uu of the eastern part of Hokkaidô and the Izumi sandstone belt of SW Japan.

(4) *I. concentricus* and *I. tenuistriatus* are not known from SW Japan, while it is fairly abundant in Hokkaidô and Saghalien.

At the end, so far as the examined material is concerned, the occurrences of the *Inoceramus*-species seem scarcely to be influenced by such a difference in rock-facies as represented chiefly by the coarseness of sediments. These fossils are yielded not only from mudstone and marl together with some pelagic ammonites, but also from sandstone and conglomerate of shallow sea.

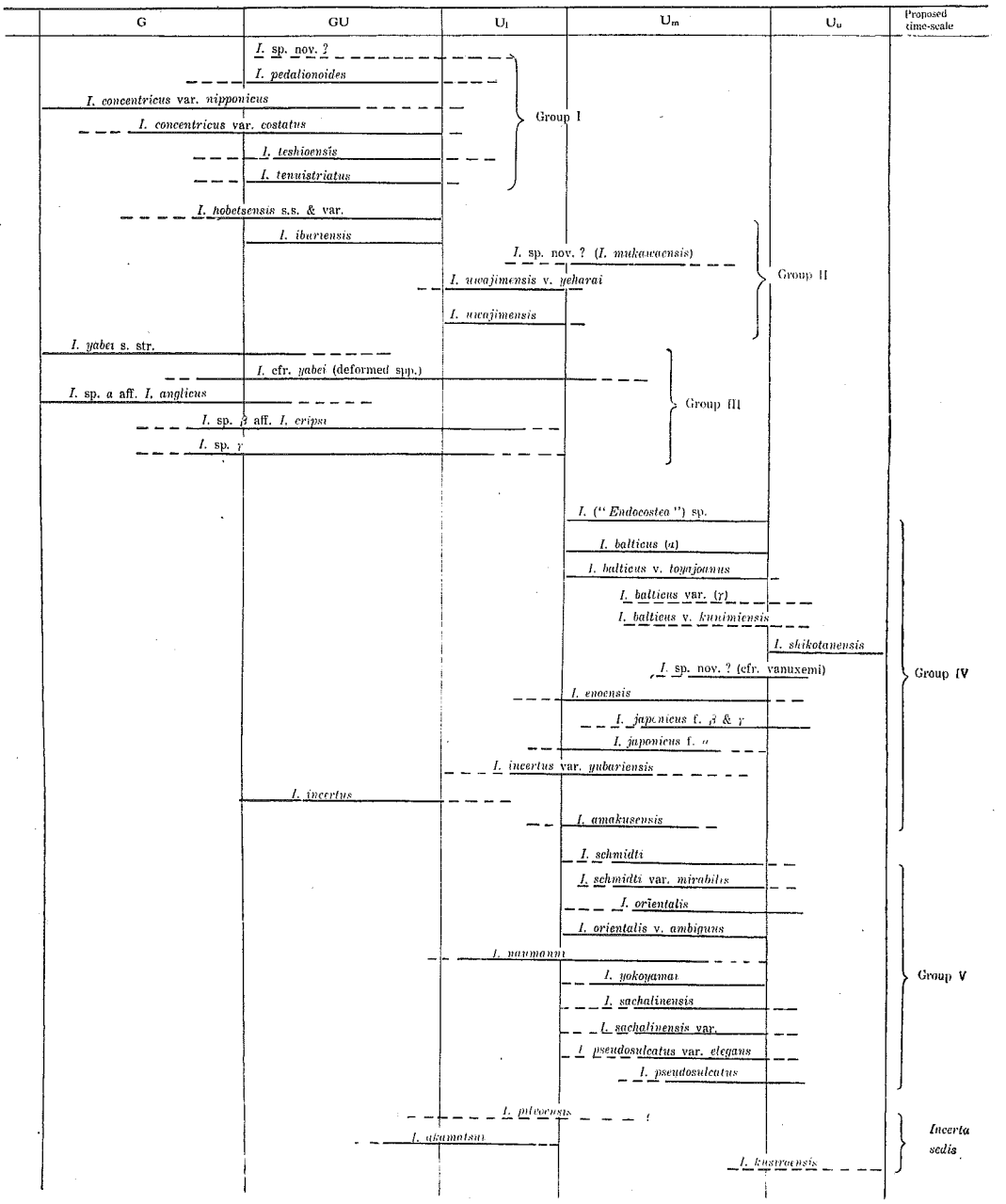
TABLE 2.

TENTATIVE CORRELATION OF THE IMPORTANT UPPER CRETACEOUS DEPOSITS OF JAPAN
(chifly by means of *Inoceramus*)
(×) indicates *Inoceramus*—bearing formation.

	Proposed geological time-scale	G	GU	U l	U m	U u
	Presumed European equivalent	Cenomanian	Turonian	Coniacian	Santonian-Campanian	Maestrichtian-Danian
	Series-name proposed by YABE 1927.	Gyliak Series		**Urakawa Series**		
Karahuto or Saghalien	The Western Range near Alexandrofsk	? Lower Werblud Group Middle (×) Upper		Lower Cape de la Jonquière Group Middle (×)		Upper
	Keton-Hoé district	Division A Low. Mid. Up. (×)	Division B (×)	Division C (×)	Division D α(×) β(×) γ(×)	
	N. W. coast				Oyau Beds (×)→?	
	Naibuti district		Miho (×)	Group (×)	(×)	Ryugase Beds (×) / Simaiwa Beds
		No. II Group (×)	Lower (×)	No. III Group Middle (×)	Upper (×)	No. IV Group / No. V Group
	Towada district				Togusi Shale (×)	Togusi s.s. (×)
	Kitasiretoko Pen.			Low. Tirie Form.	Mid. Tirie Form. (×)	Up. Tirie Form.
Hokkaido	YABE'S standard division	*Trigonia* Sandstone	Upper *Scaphites* Beds	Ammonite Beds *Parapachydiscus* Beds		Hakobuti Sandstone
	Abesinai district	Sibunnaitoge Beds Lower Upper (×)	(×)	Lower Abesinai Group (×)	(×)	Up. Abesinai Group
	Obirasibe district		*Scaphites* Beds (×)			
	Ikusyunbetu district	Div. II (*Trigonia* Sandstone) (×)	Div. III l (×) (*Scaphites*	Div. III u (×) Beds)	Div. IV (×) (*Polyptychoc.* B.) / Div. V (×) (*Parapachy.* B.)	Div. VI. (Hakobuti s.s.)
	Near Yubari	*Trigonia* Sandstone (×)		*Parapachydiscus* Beds (×)		
	Oyubari district	*Desmoc. japonicum* Beds (×)	*Scaphites* Beds (×)	*Parapachydiscus* Beds (×)		Hakobuti s.s.
	Hobetu-Hetonai district	*Desmoc. japonicum* & *I. concentricus* Beds (×)	*I. hobetsensis* Beds (×)	*Parapachydiscus* Beds (×) (×)		Hetonai Group Low. (×) Up. (×)
	Urakawa	(×)		(× ?)	(×)	
	Near Nemuro				Sikotan Formation (×)	
Kitakami Mtl.	Kuzi district			Tamagawa Form.	Kunitan Form. (×)	Kadonosawa Form.
Abukuma Mtl.	Hutaba district			Low. Hutaba B. (×)	Mid. & Up. Hutaba Beds	
Southwest Japan	Izumi Mts.				Kasayama conglom. / Asenotani shale (×) / Kintaizi s.s.-sh.	Warazuhata s.s.-sh. / Kuzuhata s.s.-congl.
	Awazi Island				Tui conglom. / Minato shale (×) / Yoroizaki s.s.	Siti sh. (×) / Kita-ama s.s. (×) / Nada s.s.
	North Iyo			s.s.-cgl. (×)	s.s.-sh. (×) / s.s. cgl. / sh.	
	Amakusa Islands	Gosyonoura Group Middle (×) Upper		Himenoura Group Lower (×) Middle (×) Upper		
	Ônogawa Basin W.	Ryozen Formation O1 (×)	Naka- & Oku-kawarauti Form.	Sibakita & Inu-kaimati Beds		
	Ônogawa Basin E.			Tonoé Formation O5 (×)	Yosinoturu F. O6-9 (×) / Amabe F. O10 (×)	
	Yuasa district	Kanaya Beds		Toyazyo Series (×) (×)		
	Katuragawa valley				Miyakura Beds (×)→?	
	Uwazima district		s.s.-cgl. / s.s.-sh.-	Hurusiroyama sh. (×)	s.s.-sh. (×)	
	Nakamura (Tosa)				? *Inoc.* Beds (×)→?	

TABLE 1.

THE GEOLOGICAL RANGE OF THE CRETACEOUS *INOCERAMUS* OF JAPAN



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VII. DESCRIPTION OF SPECIES

The group of *Inoceramus concentricus*

Inoceramus concentricus PARKINSON var. *nipponicus* NAGAO et MATUMOTO var. nov.

Pl. XXIV (II), fig. 2; Pl. XXV (III), figs. 1–6.

Shell rather small, very inequivalve, thin-tested. Left valve much higher than long, very inflated, convex both antero-posteriorly and dorso-ventrally, with the antero-dorsal marginal area steep and concave and the posterior part slightly convex. Right valve higher than long, less inflated than the left, with the antero-dorsal marginal area truncated, flattened, and perpendicular to the plane of the valve.

Outline of the valve ovate and inequilateral; antero-dorsal margin long and concave in the left valve and nearly straight in the right; anterior margin broadly rounded, the ventral one rather narrowly curved, and the posterior one long and broadly arched.

Umbo of the left valve rather long and narrow, high, pointed, and curved considerably inwards and forwards; that of the right valve small, with less conspicuous bending. Hinge-line short.

Surface almost smooth, being covered with numerous, regular and fine concentric lines; faint (i.e. low) concentric rings occur and very weak concentric major undulations discernible.

Types (Syntypes)

1) Sp. rg. no. (Sd), from No. II group of the Naibuti Cretaceous Series, on the Ugoizawa, a tributary of the Naibuti (an internal mould of both valves). (Pl. XXV, figs. 1, a–d)
2) Sp. rg. no. 7167a (Hk), contained in a rolled pebble collected from the Yûbari-gawa, Hokkaidô.
3) Sp. rg. no. 58017 (Sd), from No. II group(?) of the Naibuti Cretaceous.
4) Sp. rg. no. 5965 (Hk), from the "zone of *I. concentricus*" along the upper course of the Hobetu-gawa, province of Iburi, Hokkaidô.
5) Sp. rg. no. I-687 (Tk), from the middle course of the Obirasibe, province of Tesio.

Measurements: (mm.)

Specimen	H	h	L	l	th	HL
I-687 (left valve) (Tk)	54	50	32	32	ca. 20	19
do. (juvenile stage)	32		23			
I-682 (preserved latest part ot the left valve) (Tk)	27		23			
7163 (Hk) (left)	37		26			
do. (juvenile stage)	26		19			
7167 (Hk) (left)	55		40+		15	
do. (mature stage)	34		27			
(Sd) (left)	50		34		15+	
do. (right) (mature stage)	39		32+		13	
22785 (Sd) (outline somewhat nearer to that of *I. tenuistratus* nov.)	31		23		12	
do. (mature stage)	22		18			

Variations and Remarks:

1) Shell is rather variable in the proportion of height (or H) and length (or L), and the feature of the umbonal region. For example, a specimen [sp. rg. no. 7163 (Sd)] from the Naibuti Cretaceous has a longer umbo and a larger ratio of H:L, than another one from the same district [sp. rg. no. I-682 (Tk)]. The latter is rather globose in outline. [Cf. fig. 3 on Pl. XXV (III)] This feature is fairly common(1), showing a close relationship with *I. tenuistriatus* nov. The present species is however, distinguished from the latter in having a less prominent posterior flattened area and a longer umbo.

2) Size of the shell is rather constant among the specimens examined, height being in general 4 or 5 cm., although one of the larger examples attains about 10 cm. in height [sp. rg. no. 13 (Hk)].

3) Surface sculpture:

(a) The valves are quite smooth in a few specimens [e.g., sp. rg. no. I-676 (Tk)], but the development of very weak concentric undulations is a characteristic feature of this Japanese form.

(b) In certain forms, these low concentric elevations are developed to more or less elevated ridges which are occasionally rather rounded on summit [e.g., sp. rg. no. I-686 (Tk), Pl. XXIV (II), fig. 5], but in other cases they are relatively sharp(2) [e.g., spp. rg. no. I-695 (Tk) and no. 7170 (Hk)]. Such a form with weak concentric ridges

(1) Also spp. rg. no. 5971 (Hk) and no. 22803 (Sd).

(2) This last feature may possibly be due to a state of preservation.

as sp. rg. no. 22783 (Sd) [Pl. XXV (III), fig. 4], is intermediate in the sculpture between the costate form and the smooth one.

(c) The elevation corresponding to each concentric line is very weak or absent in the typical form. It becomes a relatively distinct concentric ring with the development of the concentric ridge. The rings are generally uniform in size and distance from one another.

(d) However, in a few specimens of the costate forms [e.g., sp. rg. no. I-691 (Tk)], the concentric ring on the summit of the ridge is more marked than the remaining ones.

(e) Those with distinct concentric rings but without any notable development of concentric ridges or undulations, are not rare. [e.g., spp. rg. no. I-690 (Tk) (Pl. XXIV (II), fig. 1) and no. 7173 (Hk)]. A transition between this form and the smooth one is represented by those specimens with weak concentric rings [e.g., rg. no. 1095 (Hk)].

Thus these costate forms, though distinct, have a quite intimate relation with the typical one (i.e., *I. concentricus* var. *nipponicus*). Therefore this costate form is taken as another variety (viz., *I. concentricus* var. *costatus*, see p. 270).

4) There is no doubt that the present form is closely akin to *I. concentricus* PARKINSON. But the following minor differences are discernible between these two forms and it is warrantable to regard the Japanese one as a variety (probably a geographical variety) of the European. The typical form from the Gault of England (Woods, fig. 11 on Pl. XLV, fig. 1–7 on Pl. XLVI) seems to have a more prominent umbo and a more expanded ventral portion than the Japanese one(1). Furthermore, the Japanese form, is characterized by the presence of major concentric undulations, showing a close relation with the costate variety(2).

Some specimens of our form [e.g., sp. rg. no. I-685 (Tk)] seem to be identical in the outline of the shell with the type of *I. tenuis* MANTELL(3); the umbo of the latter is less prominent than in *I. con-*

(1) In the shape of the valve, a few specimens from Japan may be identical with some foreign specimens included in *I. concentricus*.

(2) Woods stated: "When the outer layer of the shell is wanting, concentric undulations or ribs having an unsymmetrical curvature are seen, and are separated by concentric furrows."

(3) The specimen figured on Pl. XLVII in WOODS' monograph, which has a moderately long hinge-line, is quite distinct from the present form, although WOODS stated that the hinge-line of *I. tenuis* is nearly as long as two-thirds of the height, and the text figure (type) seems to indicate a shorter hinge line.

centricus. But most of the Japanese specimens have a slightly more prominent umbo, with stronger inward curvature, especially in the left valve. Furthermore *I. tenuis* is stated to have less conspicuous surface sculpture than *I. concentricus*, and is quite distinct from the Japanese species.

Occurrences:

1) No. II group (S. SHIMIZU) or the eastern part of the Miho beds (M. KAWADA) of the Naibuchi Cretaceous deposits, South Karahuto.
2) "*Scaphites* beds" and an unknown horizon in the Obirasibe district, province of Tesio.
3) Lower part of the Upper Ammonite beds (or MORITA's Upper Sibunaitôge beds) in the Abesinai district, province of Tesio.
4) Divisions II and III_1 along the main course of the Ikusyunbetu, the *Trigonia* Sandstone and the lower part of the overlying Upper Ammonite beds along the Pombetu, province of Isikari.
5) Part of "*Scaphites* bed" or "zone of *I. concentricus*" of ÔTATUME in the Yûbari-Hobetu district.
6) Unknown horizon (possibly the lower part of the Upper Ammonite beds) of the Cretaceous, province of Hidaka.

2–6 all in Hokkaidô.

Geological range. In Japan this species is characteristic to G(1), and extends upwards to GU(1), but is not informed from the upper part of the Monbegawa Series, i.e., an equivalent part of European Albian. From outside of Europe, *I. concentricus* (s.l.) is known to occur in South America, New Zealand, Africa, Southern India, and on the Pacific Coast of Canada. From Japan, this species is represented by the present variety, showing a world wide distribution, though the geological age is not always quite identical.

Inoceramus concentricus PARKINSON
var. *costatus* NAGAO et MATUMOTO var. nov.

Pl. XXIV (II), figs. 1, 4, 5; Pl. XXVII (V), fig. 2.

All the features of the shell, except the surface sculpture, identical with or quite similar to those of *I. concentricus* PARKINSON

(1) G—Gyliak Series. GU—Gyliak-Urakawa Series. U—Urakawa Series. See H. YABE: Cretaceous Stratigraphy of the Japanese Islands.. T. NAGAO and T. MATUMOTO: On the Japanese Cretaceous *Inoceramus* (Preliminary report). Jour. Geol. Japan., Vol. 44, 1937, pp. 1222–1223. (In Japanese).

var. *nipponicus*. Surface ornamented with more or less elevated concentric ridges or concentric rings.

Types (Syntypes)

1) rg. no. I-691 (Tk) from the eastern part of the Miho beds, Karahuto.
2) rg. no. I-695 (Tk) from "*Scaphites* beds" of the Obirasibe district, province of Tesio.
3) rg. no. 22725 (Sd) from an unknown locality.
4) rg. no. I-689 (Tk) from the Pombetu, province of Isikari.
5) rg. no. 7178 (Hk) from the *Trigonia* Sandstone of the Ikushunbetu district, province of Isikari.
6) rg. no. I-690 (Tk) from Div. II (*Trigonia* Sandstone) along the Ikusyunbetu.
7) rg. no. 7173 (Hk) from the *Trigonia* Sandstone along the Ikusyumbetu.

Measurements: (mm.)

Specimen	H	h	L	l	th
I-690 (Tk) (left valve)	42		29		17
do. (right valve)			29		
no. 22725 (Sd) (left valve)	49	50	37	37	16

Remarks:

To the surface sculpture of this form reference is made above in article (3) in the description of *I. concentricus* var. *nipponicus*. The variation observed in the outline of the shell in the preceding form, is also shown in the present one. The tendency to decrease the proportion between height and length is, however, more conspicuous in the latter(1).

As has already been mentioned, the present form evidently has an intimate relation with *I. concentricus* var. *nipponicus*, these forms being connected by some transitional specimens in many features.

I. concentricus PARKINSON var. *porrectus* WOODS from New Zealand, and also probably *I.* aff. *concentricus* SPEGLER from the Lower Utatur group of India, are very akin to the present form, in having less convex valves, less prominent umbones and occasional stronger ornamentation than *I. concentricus*. These foreign forms seem to have the posterior part more extended than in the Japanese one.

(1) Consequently its outline is apparently more closely similar to that of certain specimens belonging to *I. tenuistriatus* nov. and *I. teshioensis* nov. (See the descriptions of those species.)

The specimen of *I. concentricus* of WHITEAVES from Div. C of the Queen Charlotte Series, which is stated to have coarse concentric plications, may possibly belong to the present form, but the absence of figures and detailed description prevents a decisive conclusion.

Occurrences:

1) Upper part of Div. A of the Cretaceous deposits exposed along the Hoé, northern part of South Karahuto.
2) Eastern part of the Miho beds in the Naibuti district, S. Karahuto.
3) "*Scaphites* beds" of the Obirasibe district, province of Tesio, Hokkaidô.
4) Upper part of Div. II and Div. III_1 along the Ikusyunbetu, and the lower part of the Upper Ammonite beds along the Pombetu. Unknown horizon of the Bibai district, Hokkaidô.
5) "*Scaphites* beds" in the Oyûbari district, and the upper part of the Trigonia Sandstone near the Yûbari Coal-mines, Hokkaidô.

Geological range. This form is common in GU and extends downward to G.

Inoceramus tenuistriatus NAGAO et MATUMOTO sp. nov.

Pl. XXIV (II), fig. 8; Pl. XXVI (IV), figs. 1–4.

Shell small, with very thin test, moderately inflated, inequilateral, and roughly pentagonal in outline. Left valve only slightly higher than long, inflated and gibbous; umbo rather short, with moderate height, and curved considerably inwards and forwards. Right valve nearly as high as long, less inflated, with an inconspicuous subterminal umbo. Antero-dorsal marginal area steep and more or less concave. Antero-dorsal margin concave in the left valve and slightly so in the right. Antero-ventral margin rounded, more or less produced; ventral margin, with an asymmetric curvature, passing gradually into the long posterior one. Posterior margin forms an obtuse angle of medium length(1) with the hinge line. Beak angle nearly rectangular or slightly obtuse. Postero-dorsal flattened area (or wing) small, but distinctly defined. Surface almost smooth, except for very fine concentris lines(2).

(1) It is larger than a half of the length of the valve.

(2) On internal moulds, very low and narrow concentric rings are frequently discernible, each corresponding to a concentric line.

Types (Syntypes):

(1) Sp. rg. no. 7192 (Hk), (2) no. 22751 (Sd), (3) no. 7187 (Hk), (4) no. 7185 (Hk), (5) no. I-700 and I-701 (Tk), (6) no. 22769 (Sd), all from the lowest part of the Upper Ammonite beds along the Pombetu, province Isikari.

Variations and *Remarks*:

1) Outline of the valve is somewhat variable. As observed in *I. concentricus* var. *nipponicus*, the proportion between height and length is not constant also in this form. Besides the typical specimens, some are higher than long [e.g., rg. no. 7182 (Hk)], and some others are slightly longer than high (e.g., sp. rg. no. I-700). In the last specimens, the umbo is not terminal and the left valve is very inflated and rather orbicular in outline [Pl. XXIV (II), fig. 8][(1)].

Measurements: (mm.)

Specimens	H	h	L	l	th	HL
I-700 (Tk) (left valve)	29?	25	26	27	11	10
do. (juvenile stage)	18		18			8?
I-701 (Tk) (right)	31	30	26+	26+	9-	
7187 (Hk) (right)	24	22	21	19	8	13
7192 (Hk) (left)	27?	24	23	21	12-	14
7192 (Sd) (left)	33	30-	27	25+	11	16
do. (right) (deformed)	30	27	25	24	9+	17
7185 (Hk) (right)	40	37	34+	32	12	
do. (juvenile stage)	27	25	24	23	9?	12

2) The present species has a tendency to bear concentric elevations. Low and broad concentric undulations and weak concentric rings are observable in some specimens [e.g., sp. rg. no. 7185 (Hk) figured]. This feature connects this form with *I. teshioensis* nov. which is characterized by distinct concentric ridges. A specimen described by YABE and NAGAO (1925) [sp. rg. no. 22643 (Sd) Pl. XXVI (IV), fig. 5] represents a transitional form[(2)].

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(1) The specimens belonging to this category are not rare, possibly due to the state of preservation.

(2) Although this small specimen has lost its ventral portion, its outline is quite identical with that of the left valve of typcal *I. tenuistraitus*. Its surface is sculptured, besides fine concentric striae, by low and rather small concentric undulations even in its earlier part. The specimen is here provisionally included in *I. teshioensis*.

3) Among foreign species, *I. etheridgei* WOODS is most closely akin to the present species, and that the latter may be a geographical variety of that foreign form, is suggested. Both are identical in the contour and inflation of the valve, the umbonal region, the length of the hinge-line and the surface ornamentation. But the antero-dorsal margin is long and straight in *I. etheridgei*, while it is shorter and concave in the Japanese species. Furthermore, the postero-dorsal wing seems more distinct in the latter.

Occurrences:

1) Lower part of the Upper Ammonite beds along the Pombetu and Div. III_l and III_m? along the Ikusyunbetu, province of Isikari.
2) "*Scaphites beds*" of the Obirasibe district, province of Tesio.
3) Unknown horizon along the Yûparo-gawa, 1–3, province of Isikari.
4) A certain horizon in the Uwazima district, province of Iyo.

Geological range. This species characterizes GU.

Inoceramus teshioensis NAGAO et MATUMOTO sp. nov.

Pl. XXIV (II), figs. 6, 7, 9; Pl. XXVI (IV), figs. 5, 6, 7.

Shell rather small, subequivalve, somewhat inequilateral, and slightly oblique. Valves slightly higher than long, considerably inflated with a moderate curvature both along the axis of growth and from anterior to posterior; antero-dorsal part steeply inclined and concave, near the umbo, the postero-dorsal more or less compressed, passing into the wing.

Antero-dorsal margin concave, the antero-ventral one rounded, the ventral one nearly semi-circular, passing upwards to the broadly curved posterior margin which forms an obtuse angle with the hinge-line. Hinge-line of medium length(1).

Umbo subcentral; that of the left valve considerably curved inwards and moderately forwards.

Surface sculpture consisting of combination of rather regular concentric ridges and concentric rings, the ridges being narrow, relatively low and separated by wider interspaces.

(1) Slightly more than a half of the length of the shell.

Types (Syntypes)

1) Sp. rg. no. I-711 (Tk) from the Abesinai district, province of Tesio.
2) no. 5961 (Hk) from Kamihobetu, province of Iburi.
3) no. 22642 (Sd) from the *Trigonia* Sandstone exposed along the Horomui, province of Isikari. (*I.* sp. indet., aff. *I. concentricus* of YABE & NAGAO).
4) no. I-720a, b from the Obirasibe district, province of Tesio.

Measurements: (mm.)

	H	h	L	l	th	HL
Sp. rg. no. I-711 (left) (Tk)	29	28	25	24	8	14
,, ,, no. 7170b (Hk) (left)	40		40		13-14	
do. (juvenile stage)	26		21			

Remarks:

The present species is somewhat variable in the outline and the sculpture of the valves.

1) Comparison with *I. tenuistriatus*:

As has already been mentioned in the description of *I. tenuistriatus,* this species has an antero-ventral part which tends to be more or less produced and an umbo which is almost central. These specimens of *I. tenuistriatus* with these features fairly coincide in the outline of the shell with the present species, especially with the young forms. It is, moreover, observable that the degree of extension of the anterior part is somewhat variable in the latter.

Weak concentric undulations are discernible in *I. tenuistriatus,* and consequently there is a gradual transition in this feature from this species to some individuals of *I. teshioensis,* in which, also a relatively weak sculpture occurs. (See also remark (2) regarding the preceding species.)

Sometimes the concentric rings are rather coarse; those on the summit of the major concentric elevations are stronger and irregularly multicostated (e.g., sp. rg. no. I-714).

Thus, the relation of *I. teshioensis* with *I. tenuistriatus* seems to be almost parallel with that of *I. concentricus* var. *costatus* to *I. concentricus* var. *nipponicus.* However, it seems to be reasonable to separate *I. teshioensis* specifically from *I. tenuistriatus* after a close comparison.

2) It is noteworthy that there is a specimen at hand which shows a connection among the following three intimate species, *I. concentricus* var. *nipponicus*, *I. tenuistriatus* and *I. teshioensis*.

The description of this specimen follows:

I. aff. *teshioensis* NAGAO et MATUMOTO Pl. XXIV (II), figs. 7, 8.

Sp. rg. no. 7170a (Hk) from the Upper Ammonite beds of the Abesinai district. H:37.5 L:30 th:14

Left valve similar to that of *I. concentricus* var. *nipponicus*, but with a much shorter umbo. In this respect, it stands near the typical form of *I. tenuistriatus*, but in the marginal outline of its ventral half, it is rather akin to the first species than the second. Right valve, which is only partly visible, is identical with that of the two above cited species(1). In the shape of the valves, this species most closely resembles *I. teshioensis*, though it is not identical. The concentric ridges are developed on the ventral part of the shell, although they are hardly discernible on the dorsal part.

In the present state of knowledge, the specimens of this kind should be referable to *I. teshioensis*.

3) On the apparent affinity with *I. yabei* nov.

The shell of the present species somewhat resembles that of *I. yabei* nov. to be described below, in its rough outline, moderate inflation and sculptural elements. The important differences between these two fossils are in the bending of the umbo(2), the different nature of the postero-dorsal part, smaller inflation of the right valve in *I. teshioensis*, and in the distribution of the concentric ridges(3). As will be described later, *I. yabei* has probably an intimate relation with *I.* sp. aff. *I. anglicus* WOODS, a more primitive form of the "group of *I. yabei*", which is very different from *I. tenuistriatus*. And if the above mentioned relation between *I. tenuistriatus* and *I. teshioensis* is true, the resemblance of the latter to *I. yabei* is inferred to be only superficial.

But in practice, the distinction is sometimes difficult, especially in fragmental or deformed specimens. There are doubtful speci-

(1) The difference in the marginal outline of the right valve between *I. concentricus* var. *nipponicus* and *I. tenuistriatus* is less conspicuous.

(2) Left umbo of *I. tenuistriatus* bends much inward.

(3) *I. yabei* has in general rather irregular and stronger concentric ridges.

mens referable either to *I. yabei* or to *I. teshioensis*. The true relation must be solved by study of better material(1).

4) Comparison with allied foreign forms:

The present species somewhat resembles *I. geinitzianus* STOLICZKA from the Utatur and Trichinopoly groups of India. The left valve from the Trichinopoly group figured by STOLICZKA (Pl. XXVII as fig. 5) is closely akin to some forms of Japan (e.g., sp. rg. no. I-711 (Tk) which is nearer to *I. tenuistriatus* in outline). But in general, comparing, with *I. geinitzianus*, the Japanese species includes some specimens with less inequilateral individuals, less difference between height and length, and no flexuosity of ribs on the posterior part.

Occurrences:

1) Lower Abesinai beds in the Abesinai district, province of Tesio.
2) Uncertain horizon in the Obirasibe district, province of Tesio.
3) *Trigonia* Sandstone of the Horomui, province of Ishikari.
4) Lowest part of the Upper Ammonite beds along the Pombets, province of Ishikari.
5) A certain horizon in the Hobetu district, province of Iburi.

1–5, all in Hokkaidô.

A comparatively small number of specimens have been collected from each of these districts.

Inoceramus pedalionoides (INAI MS) NAGAO et MATUMOTO nov. sp.

Pl. XXVI (IV), figs. 8, 9.

Shell medium in size, subequivalve, with a very thin test. Valves moderately convex along the axis of growth, especially in the left valve; umbonal region and the anterior part most convex; anterior

(1) On a possible relation to *I. iburiensis*.

In the cource of his preliminary study on a recent large collection from the Naibuti district, South Karahuto, the junior author once suggested a possibility of the present species having a close affinity with the juveniles of *I. iburiensis* nov.

But judging from all the features available at present, these two forms are to be specifically separated, though the decisive conclusion should be led by a further investigation.

marginal part steep and almost perpendicular to the plane of the valve, and more or less excavated; postero-dorsal part compressed, flat and broad, forming a wing-line area which is not sharply defined from the flank. Valves *Pedalion*-like, being rectangular in rough marginal outline, inequilateral and much higher than long. Anterior margin very long and nearly straight or broadly concave outward; antero-ventral end forms a narrowly rounded angle; ventral margin in very asymmetric curvature, passing gradually upwards into the long and broadly arched posterior one. Hinge-line of considerable length, forming nearly a right angle with the anterior margin and an obtuse one with the posterior. Umbo terminal, curved moderately inwards and forwards, more prominent in the left valve, projecting a little beyond the hinge-line.

Surface ornamentation coinciding with that of *I. tenuistriatus*, except for the curvature. Concentric lines run continuously, but with decreasing prominence, toward the wing-like portion.

Types (Syntypes)

1) Sp. rg. no. 22720 (Sd) from the lowest part of the Upper Ammonite beds exposed along the Pombetu, province of Isikari. (Postero-ventral part of the left valve is lost.)
2) Sp. rg. no. 5969 (Hk) from the "zone of *I. concentricus*" exposed along a tributary of the Pankemoyûparo, province of Isikari. Left valve.

Measurements: (mm.)

Specimen	h	l	th	HL
no. 22720 (medium-sized specimen) (left)	36	25	12	21
do. (right)	30	24	10	24
do. (juvenile stage)	20	17		16
no. 5969 (left)	54	37	15	21
do. (juvenile stage)	26	21		11

Variations:

The following points shown among the specimens are considered as variations:

1) Outline of the earlier portion of the shell is less high, resembling that of *I. tenuistriatus*.
2) In not a few specimens, the antero-ventral end tends to be more produced outward, and the curvature of the anterior margin and the obliqueness of the shell are different from the typical

specimens. For example, 22756 (Sd), which is very oblique antero-ventrally, is to be included in the present species.

3) Convexity of the valve is variable, although this feature has been modified frequently by secondary deformation. Specimen rg. no. 22756 (supra cit.) has no doubt suffered deformation, but rg. no. 7165 (Hk) is very inflated near the umbonal region.

4) The surface is almost smooth in the typical forms. The concentric elevation corresponding to each concentric line is very low, narrow and inconspicuous. Sometimes, however, very low concentric major undulations tend to appear. [e.g., sp. rg. no. 5969 (Hk), Pl. XXVI (IV), fig. 9]. The presence of a more strongly costate "variety" is not known, except for some doubtful specimens to be described later (*I.* sp. nov.? p. 279).

Remarks:

Shortly, from the above described diagnosis and variations, the present species has without doubt a close morphological similarity to *I. tenuistriatus*(1) on the one hand, and apparent affinity with *I. amakusensis* nov.(2) on the other.

I. fragilis HALL and MEEK from the Turonian of North America is somewhat akin to the present species. Generally, the Japanese form is relatively a bit higher with a straighter and longer posterior margin. The typical form of *I. fragilis* is less inequivalve than the present species, but the more inequivalve representative, *I. howelli* WHITE included in *I. fragilis* by STANTON, has a somewhat different shape. The resemblance is very likely superficial.

Occurrences:

1) Ikusyunbetu district, the same horizon as that of *I. tenuistriatus*.
2) Lower part of the Upper Ammonite bed in the Obirasibe district, province of Tesio.
3) Sandstone at Miruto along the Horomui-gawa, province of Isikari.
4) "*I. concentricus* zone" along the Yûbari-gawa.

All in Hokkaidô.

Geological range. GU.

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(1) The similarity consists of a small inequivalveness, inflation of umbonal region, marginal outline of dorsal part, more or less developed definite wing, and quite identical surface ornamentation. The stratigraphic occurrences are also coincident. The present species are different from *I. tenuistriatus* in being more elongated dorsoventrally, with a longer and broadly arched posterior margin.

(2) Cf. the description of *I. amakusensis*.

Inoceramus sp. indet. (sp. nov.?)
(belonging to the group of *I. concentricus*)

Pl. XXVII (V), fig. 1; Pl. XXVIII (VI), fig. 1.

Shell presumably inequivalve or subequivalve, with medium size: inequilateral, rather oblong in marginal outline, higher than long, but in the middle age of growth, almost as high as long and rather orbicular. Antero-dorsal margin long, nearly straight or slightly concave outward, the antero ventral one more or less broadly rounded; ventral margin with asymmetrical curvature, passing gradually upward into the comparatively long and broadly arcuated posterior margin. Umbonal portion moderately inflated, especially in the left valve, the remaining portion rather convex. Antero-dorsal margin steep, slightly concave near the umbo; posterior part more or less flattened, but not forming a notable wing. Hinge-line very long. Umbo of the left valve prominent, bent considerably inward and forward(1).

Surface sculptured with rather irregularly spaced, low and broad concentric undulations(2), and fine concentric lines and rings. A faint sinuosity(3) is discernible at the postero-ventral part in the curvature along the concentric sculpture.

The description is based upon two fairly well preserved specimens.

1) Sp. rg. no. I-710 (Tk) from a picked pebble found in the Obira-sibe-gawa, between the mouth of the Sankesyomappu and the Porosan-utoromappu silty marl with sand grains.
2) Sp. rg. no. 22709 (Sd) from the same district, in a rock similar to the preceding.

Measurements: (mm.)

Specimens	H	h	L	l	th	HL
I-710 (adult)	72	73	65	64	16	33+?
do. (medium sized stage)	34	31	31	30		21
22709 (adult, left)	130		95		25	
do. (medium size stage)	73		70			

(1) The umbo is not preserved in the right valve.
(2) Undulations are discernible even in the earlier part of the valve.
(3) This is always present in the examined valves, both left and right, and certainly is not a character due to secondary deformation.

The present form would well be called a costate variety of *I. pedalionoides*. But there are considerable differences in outline and in size. As compared with the latter species, it has a a more broadly rounded antero-ventral margin, a shorter posterior margin, forming an obtuse angle with the hinge-line, and is without a notable wing. In the shape of the earlier part of the shell, this form is akin to some specimens of *I. tenuistriatus* or *I. teshioensis*, but in the adult stage it is easily distinguished by outline, by sculpture and by size.

Although this form shows some affinity with the members of *I. concentricus*-group, it is not identical with any species of that group; it may be new, but the material available at present is insufficient to errect a new name and, moreover, its stratigraphic occurrence is unfortunately uncertain.

The group of *Inoceramus hobetsensis*

Inoceramus hobetsensis (NAGAO et OTATUME MS) NAGAO et MATUMOTO sp. nov.

Pl. XXIX (VI), fig. 3; Pl. XXX (VII), figs. 1–6; Pl. XXXI (VIII), figs. 2, 3.

I. cfr. *percostatus* YABE et NAGAO; 1925 (op. cit.) p. 115, pl. XXVIII, figs. 7, 8; pl. XXIX, figs. 10, 10a.

Shell of medium size, or attaining huge size, subequivalve. Valves moderately convex from the umbo to the ventral margin and from the anterior to the posterior; umbonal region considerably inflated. Anterior part relatively thick; antero-dorsal marginal part steep and almost perpendicular to the plane of the valve, flat or slightly concave; postero-dorsal part compressed, passing gradually into the moderately broad wing.

Outline of the shell inequilateral, a little oblique postero-ventrally; higher than long, elongate pentagonal or oval in general aspect. Antero-dorsal margin nearly straight, or slightly concave, the anterior broadly convex, the ventral or posteroventral narrowly rounded, passing gradually upward into the broadly arcuate posterior one which forms an obtuse angle with the hinge-line.

Hinge plate comparatively long, almost as long as two thirds of the length of the shell, forming a right angle or a slightly obtuse one with the antero-dorsal margin. Umbo subterminal, small, prominent especially in the left valve, curved inwards and somewhat forward.

Flank sculptured with regular concentric ridges and numerous concentric rings; the concentric ridges on the main part of the valve moderately strong, and symmetrically wavy in cross section, with rounded summit, regular in size and distance, and separated from one another by wider interspaces; those on the earlier stage of growth low, wavy, undulated and comparatively crowded. Wing ornamented with fine parallel striae. A broad and shallow radial depression runs from behind the umbo to the postero-ventral extremity (parallel to and behind the axis of growth).

Types (syntypes).

Spp. rg. no. 442 (Hk), no. I-813 (Tk), no. I-793 (Tk), no. 8057 (Sd), no. 7143 (Hk), no. 37285 (Sd).

var. *nonsulcatus* NAGAO et MATUMOTO var. nov.

Pl. XXVII (V), fig. 3; Pl. XXVIII (VI), fig. 4; Pl. XXXI (VIII), fig. 1.

All the characters same as those of the typical species, except for the entire absence of the radial depression.

Types: Spp. rg. no. I-817 (Tk), no. 5645 (Hk).

Remarks:

1) On the relation between *I. hobetsensis* and var. *nonsulcatus*: The radial depression, one of the characteristic features of *I. hobetsensis*, is in general shallow and comparatively broad. But there is some variation in its strength; it is sometimes very distinct, but in other cases, it is weak, being represented only by interruptions or diminishing in the strength of the concentric ridges [e.g., sp. rg. no. 7143 (Hk)]. It is, furthermore, sometimes very weak and hardly visible, except for the sinuousity of the concentric sculpture shown on the ventral part [e.g., sp. rg. no. 5957 (Hk), no. I-796 (Tk)]. Thus a gradual transition is traceable from the specimens with a distinct depression to those quite free from it, and since these various forms occur almost always in equivalent beds, the writers are warranted to regard the nonsulcate form as a variety(1).

N.B. In some ill-preserved specimens and in case the radial depression is absent, it is almost impossible to distinguish whether it was original or secondary.

(1) Withouth any stratigraphical or geographical meaning. The manuscript name once proposed, *I. hobetsensis* var. *bungoensis* (T. MATUMOTO, 1936, Geol. of Onogawa Basin, p. 763 the list) is here abandoned.

2) Comparison with the costate forms belonging to the group of *I. concentricus*:

a) Specimens of this species with both valves preserved are compartively rare. However, as far as the observed specimens are concerned, there is shown some variation among the individuals in the equivalveness of the shell. A few individuals [e.g., sp. rg. no. 145 (Hk)] are almost equivalve, the left umbo being generally only a trifle more prominent than in the right. But the difference between the two opposite valves in often considerable [e.g., spp. rg. no. I-796, no. I-797, no. I-830 (Tk), no. 7146, no. 7176, no. 7210 (Hk), no. 22725 and no. 22809 (Sd)], especially the last cited specimen (Pl. XXVII (V), fig. 3).

b) In the last specimen the left valve is more inflated and has a more prominent and more strongly incurved umbo than the right. In the marginal outline and the convexity of the shell, it is very similar to the *I. concentricus-tenuistritus-pedalionoides* group. In its general shape and surface sculpture, however, it is identical with *I. hobetsensis* var. *non-sulcatus*, consequently regarded as an extreme variation of *I. hobetsensis*(1).

c) In this species the surface sculpture is simple(2) in the earlier stage of growth, resembling some specimens of *I. concentricus* which tend to bear a strong ornamentation(3).

d) In short, there is practically no sharp boundary in respect to external features between the two forms cited above.

3) The ratio between height and length (or H:L) and the beak-angle are somewhat variable.

Those specimens nearly equal in height and length, with a comparatively large beak-angle show an affinity to *I.* sp. belonging to the group of *I. yabei.* [e.g., sp. rg. no. 491 (Hk)].

On the other hand, the shell is sometimes very elongated from the beak to the ventral(4), being characterized by the tongue-like

(1) The anterior side is long and nearly straight, with a concave antero-dorsal margin. Its general outline is rectangular or *Pedalion*-like rather than pentagonal, and resembles that of *I. pedalionoides*. The left valve is much inflated, and the slope between the wing and the flank is comparatively steep.

(2) In some specimens [rg. no. I-793, no. I-808, no. I-808 (Tk), etc.], the earlier part of the valve is sculptured with numerous fine concentric rings and very weak concentric undulations.

(3) As has already remarked, certain specimens [e.g., sp. rg. no. 5969 (Hk)] of *I. pedalionoides* have low and broad concentric ridges on the ventral part, thus standing near the above mentioned specimen [no. 22809 (Sd)].

(4) Accordingly, the hinge-line is relatively short; the posterior and anterior sides are long and nearly straight.

course of the concentric sculpture. [e.g., specimens rg. nos. I-800, 826, 830 (Tk), no. 5645 (Hk), no. 7145 (Hk)] (cf. Pl. XXX (VII), fig. 4; Pl. XXXI (VIII), figs. 1, 3). It is noteworthy that these specimens superficially resemble *I. labiatus*(1).

The above cited varied forms are found together with or in the equivalent formations with the typical one.

Dimensions: (mm.)

Specimen rg. no.	H	h	L	l	th	HL
I-793 (posterior border partly broken) (Tk)	54	53	36+	36+	13	
do. (middle age)	39	34	29	28		19
I-? (Tk)	58+	53+	44	43	17	30
I-817 (Tk)	63	60	44	45		24+
491 (Hk) (right v.)	130	120	ca. 100	97	37±	55 (?)
7143 (Hk) (r.v.)	78	75	58	60	25	30+
5645 (Hk) (r.v.)	50	44	30+	35	12	20+

4) Size: As is shown in the above table, the present species, though usually five or six cm. in height, sometimes attains large size (Pl. XXX (VII), fig. 3). These huge specimens do not differ from the common examples in the essential points and should be included within one and the same species. (*I. hobetsensis* s. s.) There are at hand no large individuals referable to var. *nonsulcatus*.

5) Supplemental notes on the surface sculpture.

a) Concentric rings become weaker and lower in the later stage of growth, sometimes with no marked concentric elevation. Some other specimens have the concentric rings with distinct elevation even in the comparatively older stage.

N.B. Concentric rings are only partially discernible on internal moulds.

b) Near the ventral margin, the concentric ridges rarely run a little obliquely across the concentric rings.

c) Concentric ridges are variable in height, shape in cross section (roundness or sharpness of the summit) and in distance.

d) The sculpture is in general stronger on the anterior half of the valve, but sometimes, especially in the higher individuals, it is stronger on the middle portion.

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(1) In some cases, the concentric ring is very low and almost unrecognizable, resembling that of *I. labiatus*, though likely due to a different state of preservation.

6) Comparison with some foreign species:

a) As YABE and NAGAO have already pointed out, *I. percostatus* MÜLLER from the Emscher and Upper Turonian of Europe, is an allied form to *I. hobetsensis* s.s., both with a more or less distinctly impressed radial furrow. The Japanese species is much less inflated than the European one and has its wing less sharply defined from the flank.

b) *I. flaccidus* WHITE, from America, which attains huge size, may be an allied form, but it is represented by specimens insufficient for a specific comparison.

c) *I. subpercostatus* ANDERT from the European Turonian is rather dissimilar to *I. hobetsensis* s.s. in the position of the radial depression(1), in the features of the wing and in the outline and inflation of the valve.

d) Var. *nonsulcutus* somewhat resembles, but is not identical with, *I. annulatus* GOLDFUSS (the Turonian of Germany, South Africa and South America), *I. lusatiae* ANDERT (the Upper Turonian of Europe), *I. marathonensis* ETHERIDGE (Australia), *I. stantoni* SOKOLOW (or *I. acuteplicatus* STANTON 1899).

Among those foreign species the first is inequilateral. The second, which is regarded by ANDERT as a derivative of *I. lamarcki* PARK., and resembles the present species in general outline and the surface sculpture, is more inflated. The wing of the German form is much larger.

I. stantoni SOKOLOW, from the Cretaceous of North Saghalien, has a close resemblance with *I. hobetsensis* var. *nonsulcatus*. The specimen of SOKOLOW is, however, unfortunately ill-preserved.

Occurrences:

1) Near Alexandrovsk: Werblud group.
2) Along the Keton-gawa in the northern part of South Karahuto; Division B.
3) Naibuti district, S. Karahuto; horizon uncertain (No. III group?)
4) Abesinai district, province of Tesio: Upper Sibunnaitôge beds or the lower part of the lower Abesinai group.
5) Obirasibe district, province of Tesio; "*Scaphites* beds" and other uncertain horizons.

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(1) It runs along the anterior side of the highest axis of the valve.

6) Ikusyunbetu district, province of Isikari; Division III_1 and upper part of Div. II.
7) Yûbari Colliery, province of Isikari; upper part of the Trigonia Sandstone.
8) Oyûbari district, do.; "*Scaphites* beds".
9) Hobets-Hetonai district, province of Iburi; "*I. hobetsensis* zone".
10) Ônogawa Cretaceous deposits; zones O_1' and 0_1.

Inoceramus uwajimensis YEHARA emend.

Pl. XXXIV (XI), figs. 1, 3, 4, 6; Pl. XXXV (XII), figs. 1–3.

1923. *Inoceramus uwajimensis* YEHARA, Jap. Journ. Geol. and Geogr., Vol. II, p. 36, Pl. III, fig. 2.

Shell small or of moderate size, rarely attaining fairly large size; equivalve, with thin test. Outline of the shell oval, trigonal dorsally and semicircular ventrally, *only slightly inequilateral,* higher than long, much elongated from the beak to the ventral margin. Antero-dorsal margin nearly straight, slightly concave beneath the umbo, passing gradually into the broadly arched anterior one. Ventral margin evenly and narrowly rounded, with a subsymmetrical curvature. Posterior margin broadly arched, *usually without forming any distinct angle with the hinge line.*

Convexity of the valve moderate and regular from the anterior to the posterior and along the growth-axis. Antero-dorsal marginal part steep, truncated and somewhat concave, postero-dorsal part not flattened distinctly, apparently *without a wing.* Umbo prominent, slightly curved forward and inward, projecting beyond the *short hinge line.*

Surface of the umbonal region sculptured with very fine concentric lines, rings, or[1] low concentric undulations; concentric ridges are present on the most part of the shell and they are low, sharp, usually subequal with one another in distance and strength, separated by broad and slightly concave interspaces.

In many specimens the concentric rings almost absent, or sometimes a few of them developed in the interspaces. Moreover, distinct concentric lines cover the summit of the concentric ridges.

(1) That is to say, in some cases, rather crowded, low, shap concentric ridges are developed in the ventral region, but in others, the ridges are less prominent, giving their place to fine concentric rings or lines.

Typical specimens:

Sp. rg. no. I-842 (Tk)	Lower Hutaba beds; prov. Iwaki.
no. 22728 (Sd)	Upper Ammonite bed of Bibai Colliery, Isikari Coal-field.
no. 22733 (Sd)	Zone 0_5 of the Cretaceous deposits of Ônogawa basin.
no. 57823 (Sd)	Division III of the Ponbetu, Ishikari Coal-field.

Measurements: (mm.)

Specimen	H	h	L	l	th	Hl
I-842 (Tk)	40		25+		ca. 13	
I-846 (,,)	71+		50		17	16
I-878 (,,)	84		63		23±	
22703 (Sd)	71		49		20	
7142 (Hk)	62		47			
do. (young part)	30		25			

Inoceramus uwajimensis YEHARA em. var. *yeharai* NAGAO et MATUMOTO var. nov.

Pl. XXXIV (XI), figs. 2, 5; Pl. XXXV (XII), fig. 4.

Shell small or moderate in size, sometimes attaining fairly large size; nearly equivalve. Outline of the shell pentagonal in general aspect, inequilateral, higher than long. Antero-dorsal margin rather long, nearly straight or slightly concave, passing gradually into the more or less distinct antero-ventral end. Ventral margin evenly rounded, with a subsymmetrical curvature. Posterior margin broadly arcuated, forming a slightly obtuse angle with the hinge-line and continuing gradually with the ventral. Hinge-line of moderate length, passing into the antero-dorsal margin over a slightly obtuse angle.

Valves with moderate and rather uniform inflation; antero-dorsal marginal part steep, nearly perpendicular to the flank of the valve. Postero-dorsal part flattened, forming a wing-like area. Umbo short, with a slight curvature.

Surface of the umbonal region sculptured with very fine concentric lines, rings, or low, distinct concentric undulations. Concentric ridges, low, *rather sharp*, generally regular in strength and distance, separated by broad and slightly concave interspaces. Sharply defined concentric lines decorate the summit of the concentric ridges. Faint concentric rings are developed on the interspaces. Postero-dorsal flattened area usually free from concentric ridges.

Typical specimens:

I-1209, 1207 (Tk) from Division C of the Cretaceous deposits of the Keton-Aton-Hoe district.
I-939 a, b (Tk) from zone O_5 of the Ônogawa group.

Measurements: (mm.)

Specimens (Tk)	H	h	L	l	th	HL
I-1209 (right valve)	63	60	54	51	ca. 17	29
I-1208 (akin to *I. uwajimensis*)	35		30			13
I-220 (compressed specimen)		95		90		53
I-927	75		55			

Remarks:

1) YEHARA in 1923 described several specimens of *Inoceramus* from the Cretaceous deposits of the Uwazima district and the Ônogawa Basin under the name of *I. uwajimensis*. But, unfortunately their state of preservation is bad. YABE, in 1927, pointed out that *I. uwajimensis* is a composite name, including at least two or three forms. In the course of the present study, the writers have recognized a distinct form, to which they once gave the name *I. futabaensis* MS. This species is represented by a number of good specimens collected from various localities in Japan, including the above cited two districts. Fortunately, the junior author had an opportunity to observe YEHARA's original specimens and found that the specimen figured, fig. 2 on Pl. III of YEHARA, is without doubt identical to "*I. futabaensis*." Although the specimens from Uwazima are not good, those illustrated by YEHARA in fig. 1, Pl. III and fig. 2, Pl. IV are to be referred to var. *yeharai*, and those in fig. 1 and 3, Pl. IV, to *I. hobetsensis*. YEHARA's specific name, *I. uwajimensis* with emendation, is here adopted in place of *I. futabaensis*.

2) Relation between *I. uwajimensis* em., var. *yeharai* and *I. hobetsensis*.

Through examination of numerous specimens collected from various places, the writers came to the conclusion that *I. uwajimensis* s.s. is usually constant in its characters, though sometimes variable, with var. *yeharai* as the extreme example.

The following points are recognizable for separation of the typical representatives of *I. uwajimensis* from var. *yeharai*: in the former, the hinge line is very short, the outline of the valve oval and the apical angle small, while in the latter, the hinge line is moderately

long, the outline of the valve rather pentagonal with the posterior margin forming a slightly obtuse angle with the hinge line, and with a well developed postero-dorsal area, and the apical angle is large.

On the other hand, there are many specimens with features transitional between these two forms. (cf. Pl. XXXIV (XI), figs. 4, 6) Moreover, the above variations may suggest some affinity of *I. uwajimensis* (s.l.) to *I. hobetsensis* described before.

The surface sculpture also is very similar between *I. uwajimensis* s.s. and var. *yeharai,* both forms having acute-topped concentric ridges, covered by strongly impressed concentric lines on the summit (a typical example of HEINTZ's Anwachswellen). The concentric rings are very weak and almost absent in *I. uwajimensis,* while they are a little better developed in the variety. Thus there occurs a gradual transition between typical *I. uwajimensis* (s.s.), var. *yeharai,* and *I. hobetsensis* (var. *nonsulcatus*). The last one from a somewhat lower horizon is, however, morphologically easily distinguished from the first, but less distinctly, from the second.

In short, *I. uwajimensis* and its variety *yeharai* are very closely similar to each other in the external features.

The differences between the two are, although sometimes considerable, to be regarded as variations in one and the same species. The variety has always been found together with the typical form.

3) On the resemblance between *I. uwajimensis* var. *yeharai* and *I. amakusensis.*

I. uwajimensis var. *yeharai,* especially a compressed specimen, apparently resembles *I. amakusensis.* But as will be described later, the concentric sculpture is essentially different, and the latter species has a longer hinge-line and posterior margin than the former. The concentric ornamentation is present also on the postero-dorsal part in *I. amakusensis.*

4) Additional notes on surface sculpture:

Though the concentric ridges are usually regular in their elevation and distance, sometimes they are irregular, and their number (or distance) is not always constant.

It should be noted that *faint divergent ribs* are developed in certain specimens. [e.g., rg. no. I-939 a, b, I-940, I-941 (Tk), etc.] But as they have no other difference from the normal form and are more or less secondarily compressed, they are here provisionally included within the same species.

5) Comparison with some foreign allies:

Several allied forms are found in Europe from rocks of nearly equivalent age (viz., Emscher and Upper Turonian). They are *I. kleini* MÜLLER, *I. frechi* FLEGEL, *I. glatziae* FLEGEL, *I. stillei* HEINTZ, and *I. gürichi* HEINTZ. These forms seem to have more or less intimate relation to one another. And the two Japanese forms above described very likely belong to the same group.

I. kleini MÜLLER (em. SCUPIN, HEINE, ANDERT, etc.) agrees well with *I. uwajimensis* (s.s.) in its general outline and inflation of the valve, and "ribbing"; but in that German species, a distinct and often broad wing is present, while in the type Japanese species, it is absent. The variety, *yeharai* has a less distinctly separated wing than *I. keini.* The faint concentric rings, which are frequently observable in the two Japanese forms, seem to be wanting in *I. kleini.*

In comparison with *I. uwajimensis* var. *yeharai, I. frechi* FLEGEL is considerably inequivalve and seems to be more inflated. *I. glatziae* FLEGEL, (less inequivalve than the foregoing species) closely resembles, and is very likely identical with var. *yeharai.* But the following minor(?) differences are to be pointed out: Anterior margin of *yeharai* is somewhat shorter than that of the German one, and passes down to the antero-ventral corner. In the Euripean species, the wing is more sharply defined and usually is covered with the concentric ridges which run continuously from the flank in an arcuated curvature.

I. stillei HEINTZ, 1928 (*I. frechi* FLEGEL, ANDERT pars) agrees well with the lower individuals of *I. uwajimensis* var. *yeharai.* But as HEINTZ's species is based upon only a few specimens, the writers cannot compare *yeharai* with it.

The divergent sculpture, which tends to be developed in certain specimens of *I. uwajimensis* var. *yeharai,* is quite absent in the above foreign species. *I. gürichi* HEINTZ has many radial riblets, instead of a few, faint divergent ribs present in the Japanese form. It has also a posterior radial groove accompanied with a sigmoidal curvature on the wing.

Occurrences: (var. *yeharai* is marked by *)

1) *Keton-Aton-Hoe district, C beds.
2) Kawakami district, horizon uncertain.
3) Ikusyunbetu-Bibai district, Division III m+u, superjacent horizon above the beds with *I. hobetsensis,* in the lower part of the upper Ammonite beds (* rarely found).

4) Yûbari district, horizon uncertain.
5) Hobetu district, lower part of "*Parapachydiscus* beds"
6) A few localities in the province of Hidaka, horizon uncertain.
7) Hutaba district in Iwaki, Lower Hutaba beds.
8) Toyazyo district, Toyazyo series, but exact horizon uncertain.
9) *Cretaceous deposits of the Onogawa Basin, zone O_5, and rarely zone O_7.
10) Uwazima district, "Furushiroyama shale" and other localities.

Inoceramus iburiensis NAGAO et MATUMOTO nov. sp.

Pl. XXXII (IX), figs. 1, 2; Pl. XXXIII (X), fig. 2.

Shell large, sometimes attaining huge size; presumably subequivalve; inequilateral, higher than long, elongated trapezoidal in marginal outline. Anterior and posterior borders long and almost straight, with a slight curvature, antero-ventral and postero-ventral ends narrowly rounded; ventral margin more or less rounded, and in older stage it has a broad curvature and a sinuosity.

Hinge-line considerably long, forming nearly a right angle with the posterior margin.

Valves very inflated, especially near the umbonal region, moderately convex along the axis of growth and also from front to back; antero-dorsal marginal part steep, flat, very thick, broad, perpendicular to the plane of the valve; posterior side of the flank also fairly steep, while the convexity on the main part of the flank is comparatively gentle.

Posterior wing very broad, flat, and distinctly depressed from the steep posterior side of the flank.

Flank sculptured with strong, regular, fold-like concentric ridges(1), and a submedian radial depression(2), which becomes broader and more conspicuous toward the ventral margin; concentric ridges decrease in strength, and have a slight sinuosity at the intersection with the radial depression. Besides these, narrow and very low concentric rings or concentric lines cover the surface. Wing with numerous, fine, slightly sinuous parallel lines.

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(1) Concentric ridges are subequal in size and distance, asymmetrically wave-like in cross-section, their ventral slope being steeper, with narrowly rounded or partly sharp summit. The interspaces are broadly concave and wider than the ridges.

(2) Situated slightly posteriorly to the middle. Along the posterior side of this depression, a low radial elevation runs parallel to it.

Types (Syntypes)

Specimens from the *Scaphites* beds of the Obirashibe district, rg. no. 7260 (Hk), no. 7207 (Hk), no. 5968 (Hk), no. 57829 (Sd).

Measurements: (cm.)

Specimen rg. no.	H	h	l	th
7260 (Hk)	46	40	29	8-9
do. (middle age)	21	16	14	
7207 (Hk)	19	11	8	5
7208 (Hk)	12	9	7	4

Remarks:

1) This species is rather distinct in its features, but variable in details(1). In general, the juvenile specimens are nearly as high as long, more rounded along the ventral margin, and more oblique than the grown individuals. Consequently, the high-trapezoidal aspect is shown only in the full grown forms. A similar variation is recognizable also among the individuals of about the same size; some [e.g., sp. rg. no. 7207 (Hk)] are subequal in height and length, more rounded, and more inflated than some others [e.g., sp. rg. no. 5968 (Hk)], the former being more gibbous.

The inflation of the valve is more conspicuous in the umbonal region and less so in the ventral portion. This feature is not always constant; in sp. rg. no. 57829 (Sd), the maximum convexity along the axis of growth is in the middle.

The submedian depression appears at the same distance from the beak among the individuals; in sp. rg. no. 7207 (Hk) (left valve), it appears at the middle of the preserved portion of the valve and increases its breadth rapidly, being very deep in the ventral part. On the other hand, in sp. rg. no. 5968 (Hk) (right valve) the depression is inconspicuous; the presence of a very weak one is suggested by sinuosity and slightly decrease in strength of the concentric ridge. A huge specimen [rg. no. 7260 (Hk)] (right valve) has a radial depression, intermediate in size or in strength.

2) The present species has many features common with *I. hobetsensis,* but differs in the inflation and outline of the valve, the breadth of the wing and the nature of the concentric rings. It should be noted that these differences are sometimes less distinct. Specimen rg. no. 7208 (Hk), which is to be included in *I. iburiensis,* has a more oblique shape with a somewhat narrower wing than the

(1) The original feature of the variation is often obliterated by modifications due to secondary deformation.

typical form, apparently nearer to a specimen of *I. hobetsensis*, recently collected by INAI from Okukawakami in Saghalien. Still its very convex valve, with low and narrow concentric rings and a broad wing, separates it from *I. hobetsensis*.

3) Comparison with some foreign allies:

The general outline and inflation of the valve, nature of the wing, and concentric sculpture bring the present species near the group of *I. lamarcki* PARKINSON (s.l.).

The presence of a median radial depression separates it from *I. lamarcki* s.s.

I. gibbosus (SCHLÜTER) HEINE, 1929, from the Emscherian of Europe, and the almost contemporaneous *I. bilobatus* MÜLLER are other forms closely allied to the present one. These two species have close relationship with *I. percostatus* MÜLLER, as *I. iburiensis* has a morphological affinity with *I. hobetsensis*. *I. gibbosus* is provided with a radial groove which is very deep and accompanied on either side by a nodulous elevation, besides weak radial riblets. Compared with *I. bilobatus*, the Japanese form is in general large, a little more inflated, and has one radial depression instead of two.

Among the species known from the Indo-Pacific region, *I. australis* WOODS em. HEINTZ (WOODS, 1917, Pl. 13 fig. 3) is most akin to the present species, but is less convex. Furthermore, it is free from radial depression.

Occurrence:

1) Obirasibe district, province of Tesio; *Scaphites* beds.
2) Abesinai district, province of Tesio; Upper Sibunaitôge beds, and lowest part of the Lower Abesinai beds?
3) *Scaphites* beds along the Yûbari-gawa, province of Isikari.
4) Hobets-Hetonai district, province of Iburi; "*I. hobetsensis* zone".
5) Some referable specimens from the Naibuti district and the Motodomari district in S. Karahuto, horizon uncertain.

Inoceramus sp. nov.?

(*Inoceramus mukawaensis* OTATUME MS.)

Pl. XXXI (VIII), figs. 1, 3.

There are a few specimens at hand which represent a peculiar form; the number of the specimens is too small to establish a new species.

Shell small in size, slightly inequivalve. Outline of the shell much higher than long, inequilateral; anterior margin long and with a gentle curvature; the posterior one also long, probably with a slight sinuosity near the wing. Antero-dorsal margin slightly concave; ventral margin nearly straight or with broad curvature, showing a sinuosity at the end of the radial depression; antero-ventral and postero-ventral ends narrowly rounded.

Valves inflated, moderately [e.g., sp. rg. no. 5972 (Hd)] or strongly [e.g., no. 7204 (Hd)] convex in the umbonal region; the great part of the valve rather thick, flattened, the antero-dorsal marginal area and the posterior border being steep to the plane of the valve. Flank provided with a shallow and broad radial depression, which begins at some distance from the beak, running along the axis of growth and increasing its breadth towards the ventral margin.

Hinge-line relatively long, forming a right angle with the posterior margin and a slightly obtuse angle with the antero-dorsal. Left umbo more conspicuous than the right. Wing broad and flat, separated by a shallow depression.

Surface sculptured with concentric ridges of the second order and radial riblets; concentric ridges narrow and low, acute-topped, regular in disposition, separated by interspaces broader than the ridges, and continuous on the wing, showing a sinuosity. Radial riblets numerous, fine, narrow, and distinctly shown on the ventral slope of the concentric ridges.

Specimens:

Sp. rg. no. 7204 (Hk) from the *Parapachydiscus* beds of the Kikumenzawa, Ikushumbets district.

Sp. rg. no. 5972 (Hk) from the lowest part of *Parapachydiscus* beds in the Hetonai district.

Measurements: (mm.)

Sp. rg. no. 5972 (Hk)	Height	Length	Thickness	HL
(left valve)	50	41	15–16	?
(right valve)	30	25	13	20

Remarks: The present species is allied to *I. iburiensis* nov. in shape and in the presence of the radial depression, but is much smaller and has a different type of sculpture. It closely resembles *I. seitzi* ANDERT, 1934, from the Upper Turonian of Europe, especially in

shape and in the concentric sculpture, but it has a distinct radial depression[1] and radial riblets.

Inoceramus sp. indet.

cf. "*I. mukawaensis* MS".

Pl. XXXI (VIII), figs. 4–7.

In the material there are a few deformed specimens referable to the preceding form. They have been collected from South-west Japan, in a rock almost equivalent to the lower part of *Parapachydiscus* beds of Hokkaidô.

As the specimens have been somewhat deformed, details of the outline and inflation of the valve, and the relation between the wing and the flank are not accurately known. Apparently the shell is very oblique antero-ventrally with an undefined wing. The median radial depression is sometimes preserved, sometimes unrecognizable. The surface sculpture is identical with that of the preceding species.

Occurrence: Zone O_8 of the Ônogawa Cretaceous Group.

(To be continued)

EXPLANATION OF THE PLATES

Plate XXIII (I)

Map showing the distribution of the *Inoceramus*-bearing Cretaceous deposits in the Japanese Islands.

Figs. 1–5. Saghalien or Karahuto:

1. Near Alexandrofsk.
2. Northern part of the west coast of South Karahuto.
3. Drainage area of the Keton, the Aton and the Hoe, tributaries of the Horonai.
4. Naibuti district.
5. Towada district.

Figs. 6–14. Hokkaidô:

6. Abesinai district, prov. Tesio.
7. Obirasibe district, prov. Tesio.
8. Ikusyunbetu district, Isikari coal field.
9. Near Yûbari, Isikari coal field.

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(1) In ANDERT's figure (fig. 2a on Pl. 16), the rib and the ventral margin are shown to have a slight flexousity.

10. Oyûbari district, prov. Isikari.
11. Noborikawa-Hobets district, Isikari coal field.
12. Hetonai district, prov. Iburi.
13. Urakawa district, prov. Hidaka.
14. Nemuro Peninsula and Island of Sikotan.
15. Kuzi district, prov. Rikutyû.
16. Hutaba district, prov. Iwaki.

Figs. 17–25. South-West Japan:

17. The Izumi Mountainrange.
18. Island of Awazi.
19. Near Matuyama, prov. Iyo.
20. Near Yuasa, prov. Kii.
21. Katuragawa basin, prov. Awa.
22. Kunimi district, prov. Tosa.
23. Uwazima district, prov. Iyo.
24. Onogawa basin, prov. Bungo.
25. The Islands of Amakusa.

PLATES XXIV (II)—XXXV (XII)

The figures are of natural size, unless otherwise stated.

Plate XXIV (II)

Figs. 1. a, b, c, *Inoceramus concentricus* PARKINSON var. *costatus* var. nov. Ikusyunbetu district, Tk. no. I-690. a. left valve, b. right valve, c. anterior view of both valves.

Fig. 2. *I. concentricus* PARK. var. *nipponicus* var. nov. Obirasibe, Tk. no. I-687. left valve.

Fig. 3. *I. tenuistriatus* sp. nov. Ponbetu, Tk. no. I-701, right valve.

Fig. 4. *I. concentricus* PARK. var. *costatus* var. nov. Obirasibe, Tk. I-695, left valve.

Figs. 5. a, b. *I. concentricus* PARK. var. *costatus* var. nov. Ponbetu, Tk. no. I-689, left valve.

Fig. 6. *I. teshioensis* sp. nov. Tk. no. I-715, left valve.

Fig. 7. *I. teshioensis* sp. nov. Tk. no. I-721, left valve.

Figs. 8. a, b, c. *I. tenuistriatus* sp. nov. Ponbetu, Tk. no. I-700, left valve of a subequilateral form.

Figs. 9. a, b. *I. teshioensis* sp. nov. Tk. no. I-714.

Plate XXV (III)

Figs. 1. a–d. *Inoceramus concentricus* PARKINSON var. *niponicus* var. nov. Naibuti district, Sd. (without rg. no.) a, b. left valve. c. posterior view of both valves. d. right valve.

Figs. 2. a, b. *I. concentricus* PARK. var. *nipponicus* var. nov. Kamihobetu, Hk. no. 5965, left valve.

Fig. 3. *I. concentricus* PARK. var. *nipponicus* var. nov. Naibuti district, Hk. no. 7163, left valve of a higher form.

Fig. 4. *I. concentricus* PARK. var. *nipponicus* var. nov. Bibai, Sd. no. 22783, left valve of a lower form.

Fig. 5. *I. concentricus* PARK. var. *nipponicus* var. nov. Kamihobetu, Hk. no. 5971, left valve of a lower form.

Figs. 6. a, b, c. *I. concentricus* PARK. var. *nipponicus* var. nov. Hakkinzawa in Ôyûbari, Hk. no. 7167, left valve of the typical form.

Figs. 7. a, b. *I.* aff. *teshioensis*, Abesinai district, Hk. no. 7170a.

Figs. 8. a, b. *I.* aff. *teshioensis*, Abesinai district, Hk. no. 7170b.

Plate XXVI (IV)

Figs. 1–4. *Inoceramus tenuistriatus* sp. nov. Ponbetu.
1. a, b, c. Hk. no. 7192, left valve.
2. a, b. Hk. no. 7187, right valve.
3. a, b. Sd. no. 22751, left valve.
4. Hk. no. 7185, right valve, with weak concentric undulations.

Figs. 5. a, b. *I. teshioensis* sp. nov. Miruto, Sd. no. 22643. (= *Inoc.* sp. indet. YABE and NAGAO 1928), left valve, a juvenile specimen showing an intermediate character between *I. teshioensis* and *I. tenuistriatus*.

Fig. 6. *I.* cfr. *teshioensis*. Tk. no. I-709, left valve.

Figs. 7. a, b. *I. teshioensis* sp. nov. Kamihobetu, Hk. no. 5961, left valve.

Figs. 8. a, b, c. *I. pedalionoides* (INAI MS.) sp. nov., Ponbetu, Sd. no. 22720. a. anterior view of a right valve, b. lateral view of a left valve, c. lateral view of a right valve.

Fig. 9. *I. pedalionoides* (INAI MS.) sp. nov. Penkemoyûparo, Hk. no. 5969.

Plate XXVII (V)

Figs. 1. a, b. *Inoceramus* sp. nov. ?belonging to the group of *I. concentricus*. Obirasibe, Sd. no. 22709, left valve. × ½.

Figs. 2. a, b. *I. concentricus* PARKINSON var. *costatus* var. nov. Obirasibe, Sd. no. 22725. a. left valve, b. right valve.

Figs. 3. a, b, c. *I. hobetsensis* sp. nov. var. *nonsulcatus* var. nov. Hobetu district, Sd. no. 22809. A somewhat inequivalve form. a. anterior view of both valves, b. left valve, c. right valve.

Plate XXVIII (VI)

Fig. 1. *Inoceramus* sp. nov. ? belonging to the group of *I. concentricus*. Obirasibe, Tk. no. I-710, left valve.

Fig. 2. *I. iburiensis* sp. nov. Kamihobetu, Hk. no. 5968, right valve. × ½.

Figs. 3. a, b, c. *I. hobetsensis* sp. nov. Hakkin-zawa, in Oyûbari, Hk. no. 7143. A specimen in which the radial depression is very weak, lateral, dorsal and anterior views of a right valve.

Fig. 4. *I. hobetsensis* var. *nonsulcatus* var. nov. Abesinai, Hk. no. 491, right valve. × ½.

Plate XXIX (VII)

Fig. 1. *Inoceramus hobetsensis* sp. nov. Obirasibe, Tk. no, I-793, internal mould of a right valve.

Figs. 2. a, b. *I. hobetsensis* sp. nov. Onogawa basin, Tk. no. I-817, a. internal mould (slightly reduced), b. external artificial cast of the same specimen.

Fig. 3. *I. hobetsensis* sp. nov. Hobetu, Hk. (without rg. no.) A huge example, ca. × 1/3.

Fig. 4. *I. hobetsensis* sp. nov. Onogawa basin, Tk. no. I-830, a very high example, × 1½.

Fig. 5. *I. hobetsensis* sp. nov. Onogawa basin, Tk. no. I-818.

Fig. 6. *I. hobetsensis* sp. nov. Onogawa basin, Tk. no. I-816.

Plate XXX (VIII)

Figs. 1. a, b. *Inoceramus hobetsensis* var. *nonsulcatus* var. nov. Oyûbari, Hk. no. 5645.

Fig. 2. *I. hobetsensis* sp. nov. Penkemo-yûparo, Tk. no. I-1369, × ½ .

Fig. 3. *I. hobetsensis* sp. nov. Hakkin-zawa, Hk. no. 7145.

Figs. 4–7. *I.* sp. indet. aff. *I.* sp. nov.? (*I. mukawaensis* OTATSUME MS.), Onogawa basin. 4. Tk. no. I-953, 5. Tk. no. I-948, 6. Tk. no. I-951, × ½, 7. Tk. no. I-954.

Plate XXXI (IX)

Figs. 1. a, b, c. *Inoceramus iburiensis* sp. nov. Hakkin-zawa, in Oyûbari, Hk. no. 7208. a. lateral, b. anterior, and c. dorsal view of a right valve.

Figs. 2. a, b. *I. iburiensis* sp. nov. Hakkin-zawa, in Oyûbari, Hk. no. 7207. a. lateral view, b. anterior view.

Plate XXXII (X)

Figs. 1. a–d. *Inoceramus* sp. nov.? (*I. mukawaensis* OTATSUME MS.), the Mukawa, Hk. no. 5972. a, b. left valve. c. dorsal view of both valve. d. right valve.

Fig. 2. *I. iburiensis* sp. nov. Obirasibe, Hk. no. 7270. Typical form, right valve. × 2/5.

Figs. 3. a, b. *I.* sp. nov.? (*I. mukawaensis* OTATSUME MS.) Kikumen-zawa, Hk. no. 7204. a. lateral, b. dorsal view, of a right valve.

Plate XXXIII (XI)

Figs. 1. a, b, c. *Inoceramus uwajimensis* YEHARA emend. Bannosawa, Sd. no. 22773. a. dorsal, b. lateral and c. anterior views of a left valve.

Fig. 2. *I. uwajimensis* var. *yeharai* var. nov. Onogawa basin, Tk. no. I-927. An external artificial cast of a left valve.

Figs. 3. a, b. *I. uwajimensis* YEHARA em. Hutaba district, Tk. no. I-842.

Fig. 4. *I. uwajimensis* YEHARA em. Aton district, Tk. no. I-1058. A transitional form to var. *yeharai*.

Fig. 5. *I. uwajimensis* var. *yeharai* var. nov. Onogawa basin, Tk. no. I-939a. An external artificial cast.

Fig. 6. *I. uwajimensis* YEHARA em. Aton, Tk. no. I-1208. A transitional form to var. *yeharai*.

Plate XXXIV (XII)

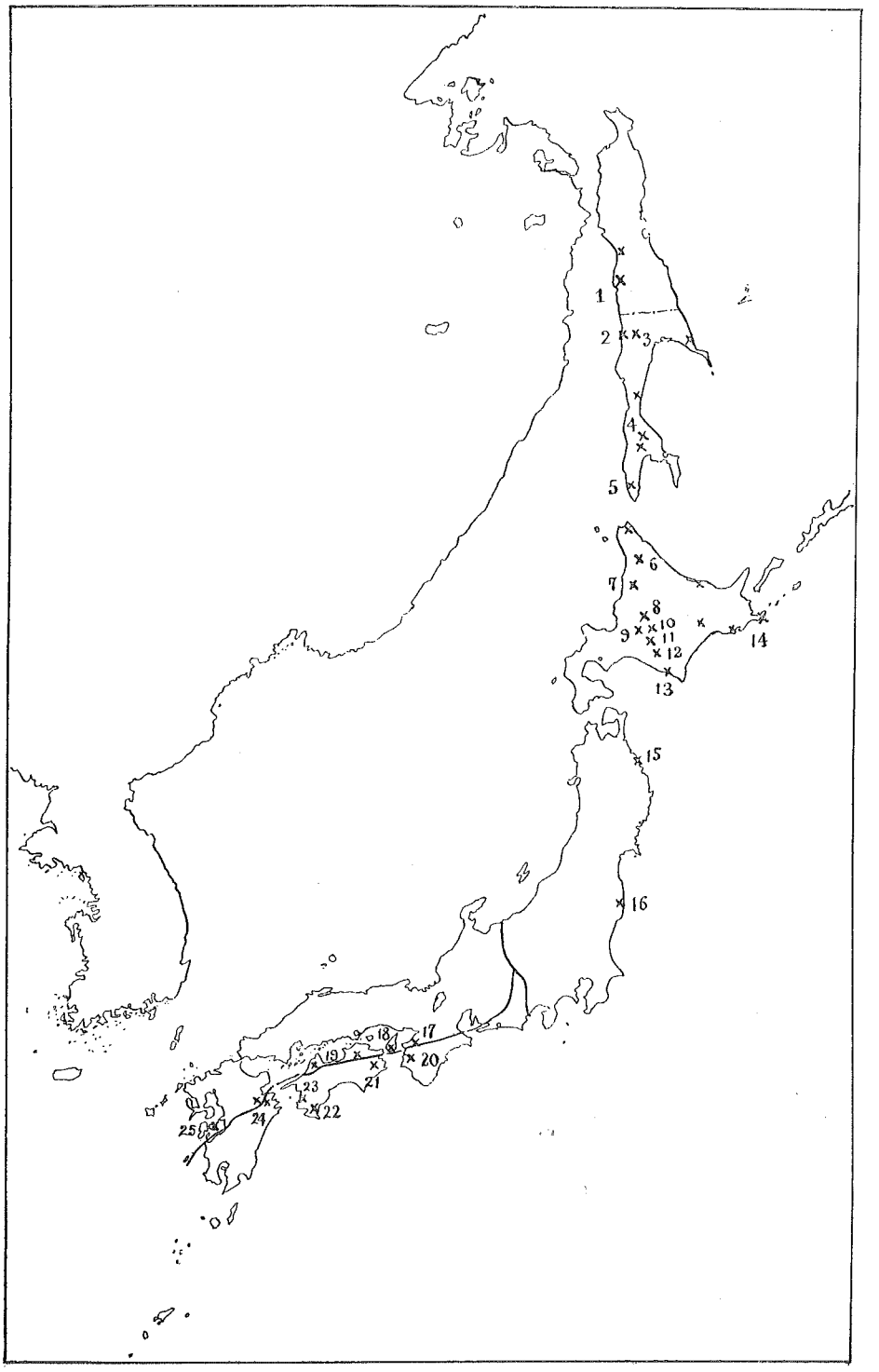
Figs. 1, 2, 3. *Inoceramus uwajimensis* YEHARA emend,
1. Bibai, Sd. no. 22728b, right valve.
2. Ponbetu, Hk. no. 7142, left valve.
3. Bibai, Sd. no. 22728c, right valve.

Fig. 4. *I. uwajimensis* var. *yeharai* var. nov. Aton, Tk. no. I-1209, right valve of a typical form.

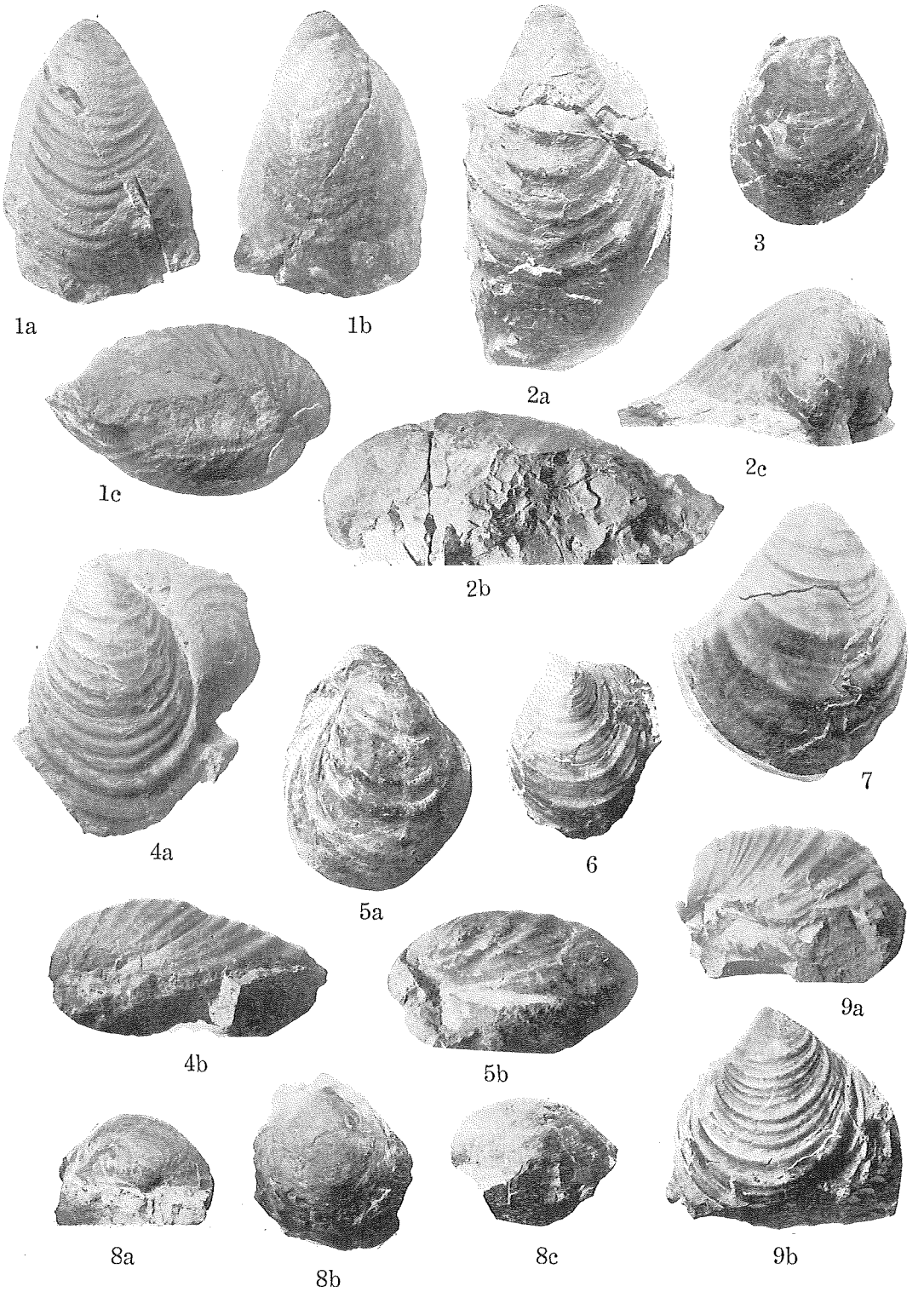
Figs. 5. a, b, c. *I. yabei* sp. nov. (typical form) Yubari, Hk. no. 7276. a. right valve, b. left valve, c. anterior view of both valves. (internal mould).

Figs. 6. a, b. *I. yabei* sp. nov. (typical form), Ikusyunbetu, Sd. no. 22685. a, left valve, b. right valve.

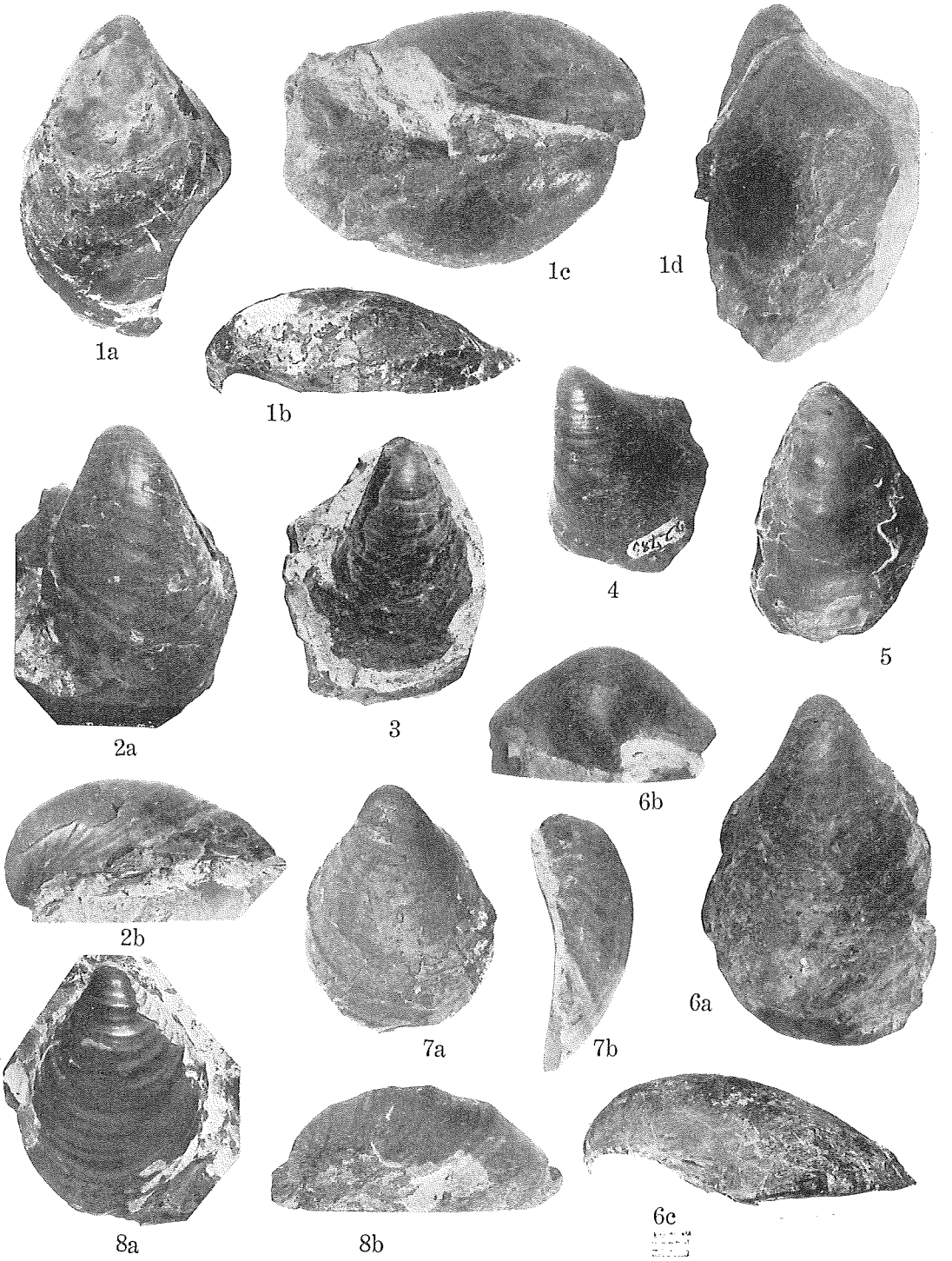
Fig. 7. *I. yabei* sp. nov. (deformed specimen), Hutaba district, Tk. no. I-750, lateral view.



T. Nagao and T. Matumoto: Cretaceous Inoceramus.



T. Nagao and T. Matumoto: Cretaceous Inoceramus.



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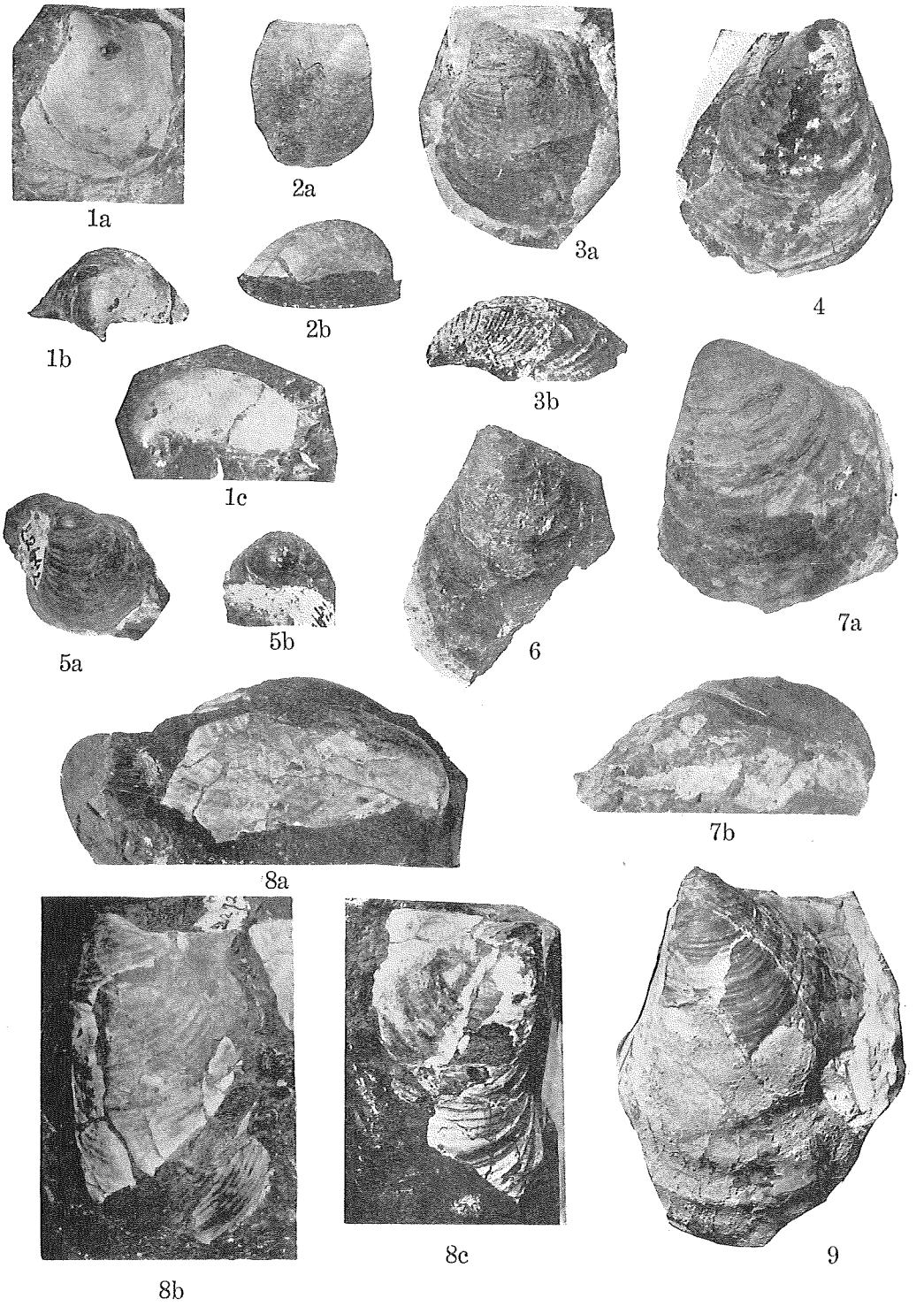

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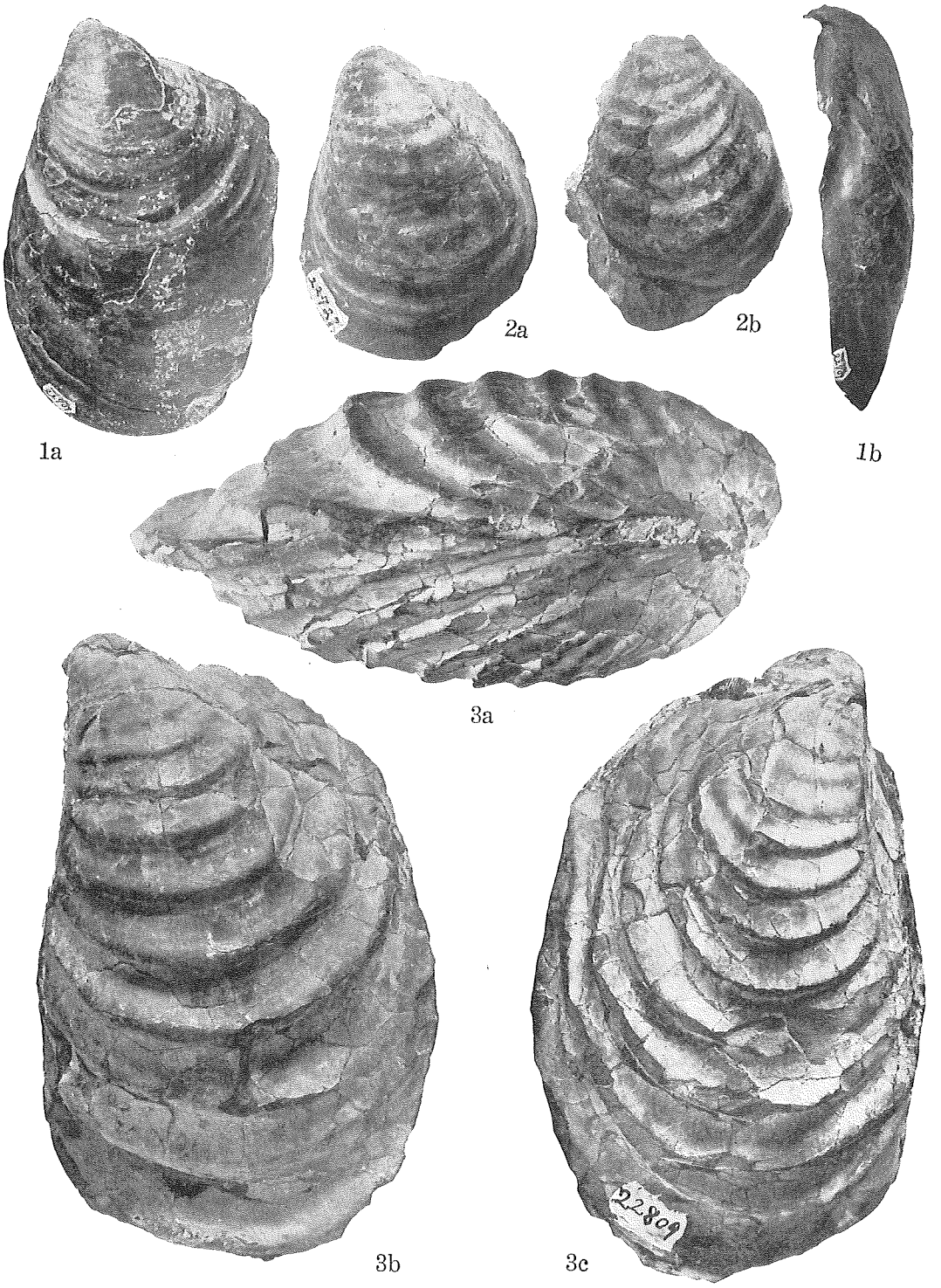

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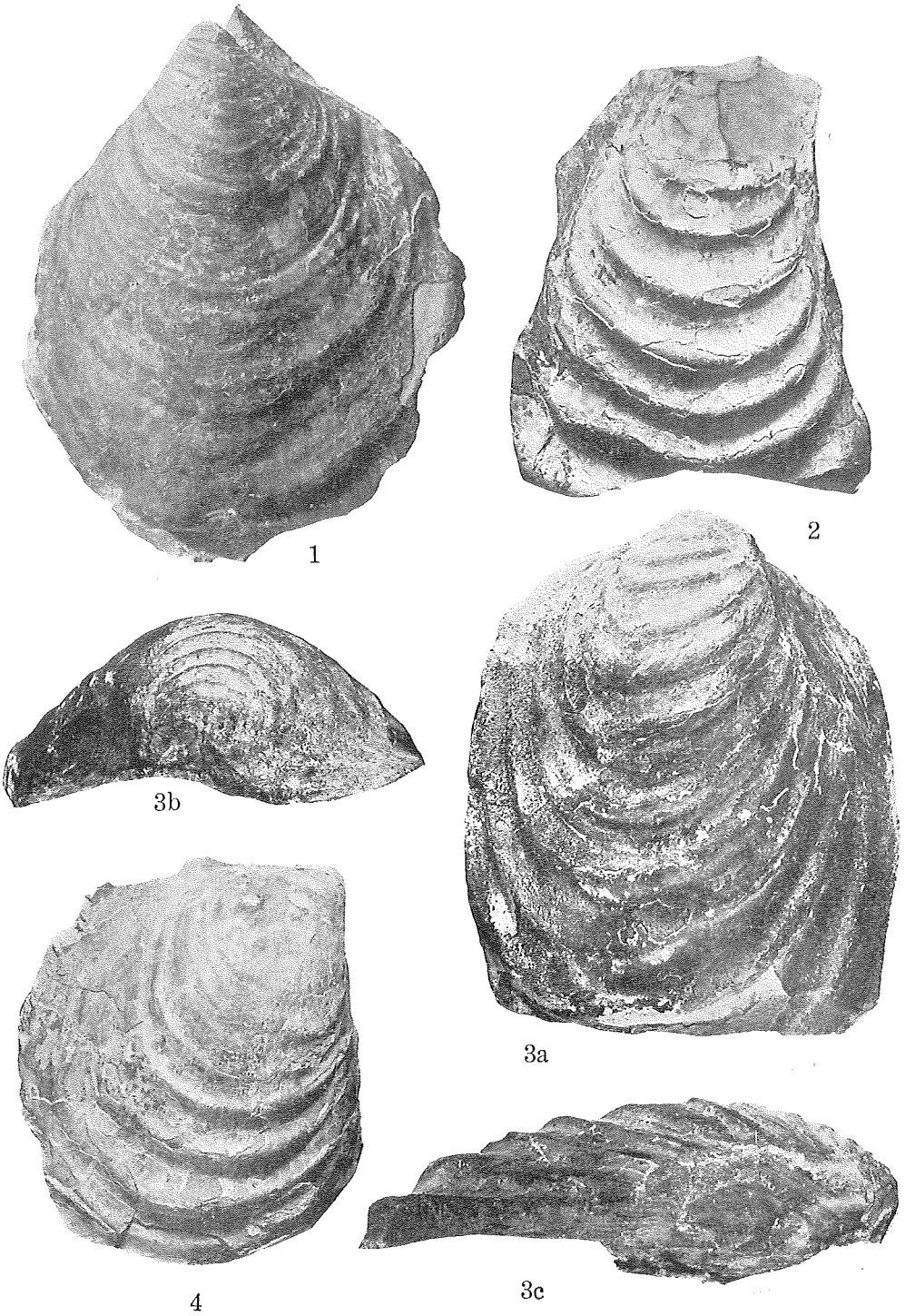

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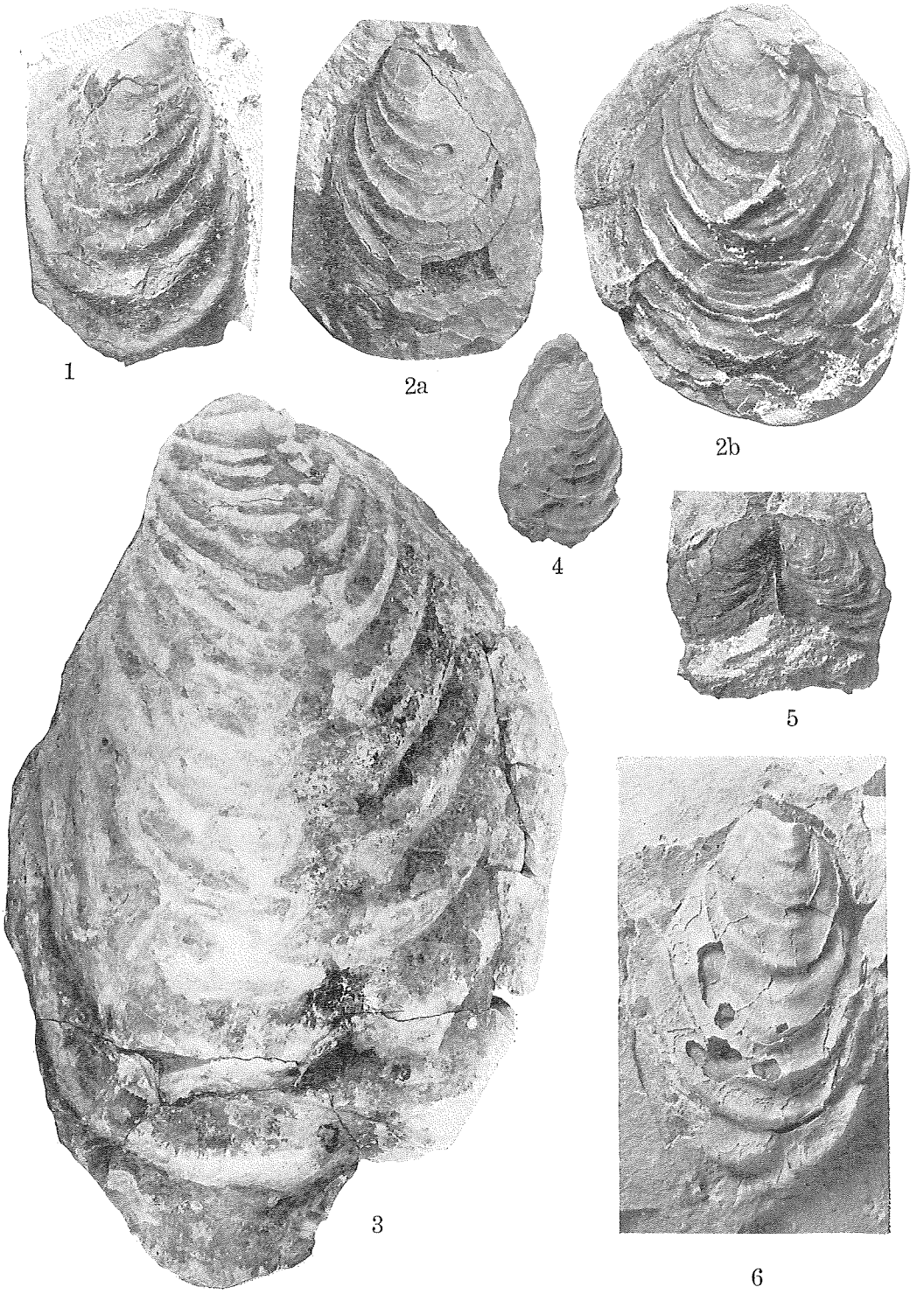

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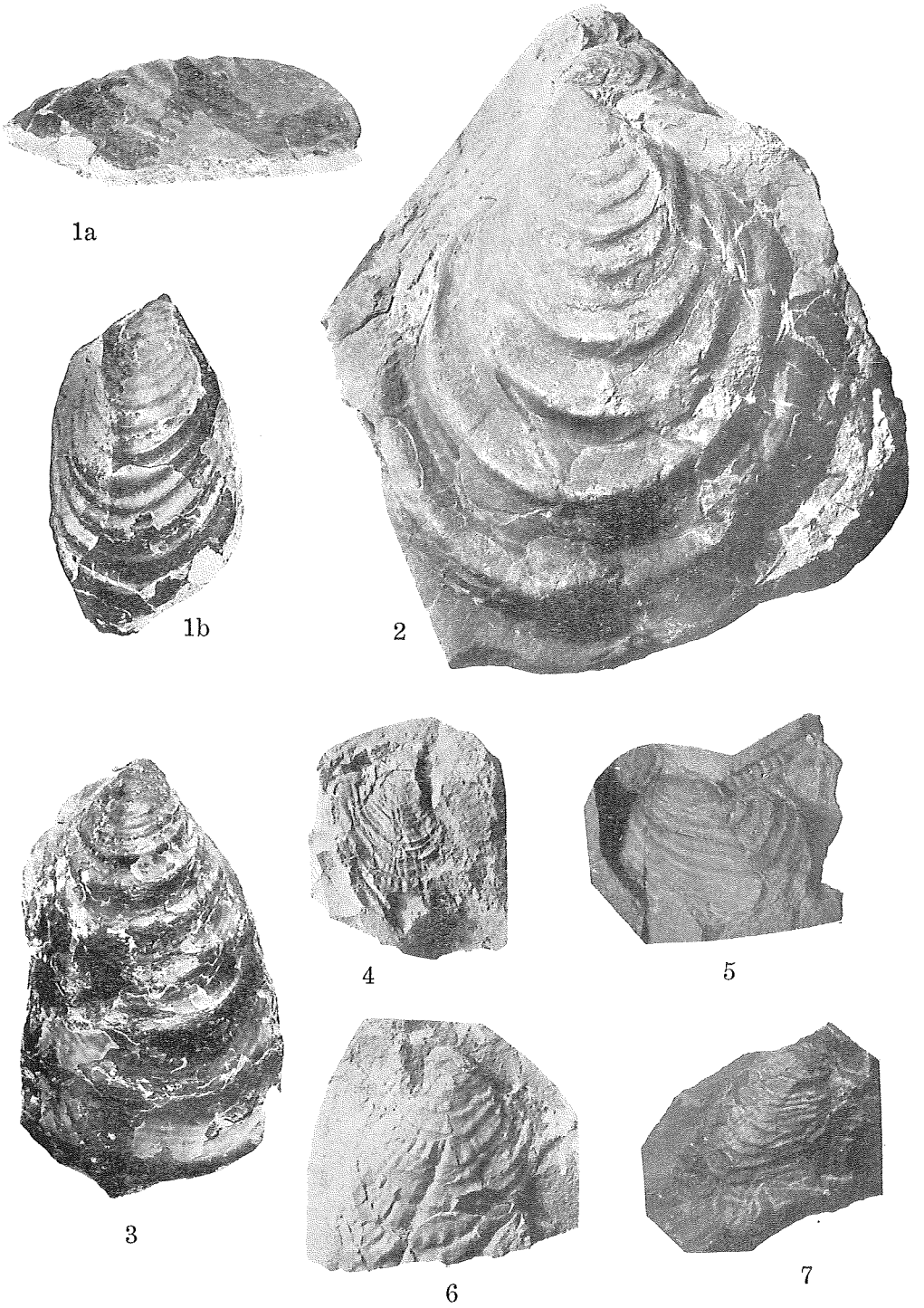

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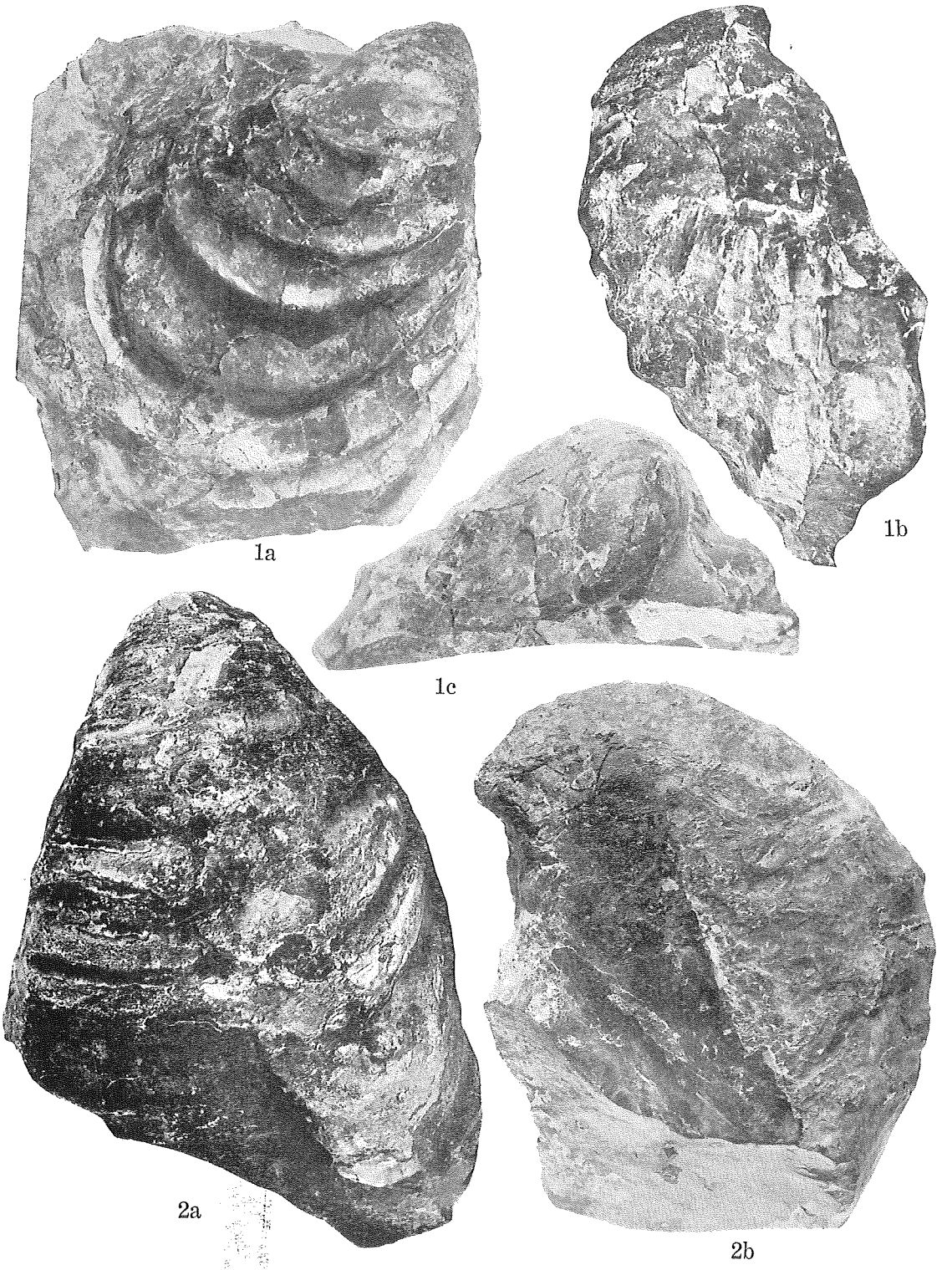
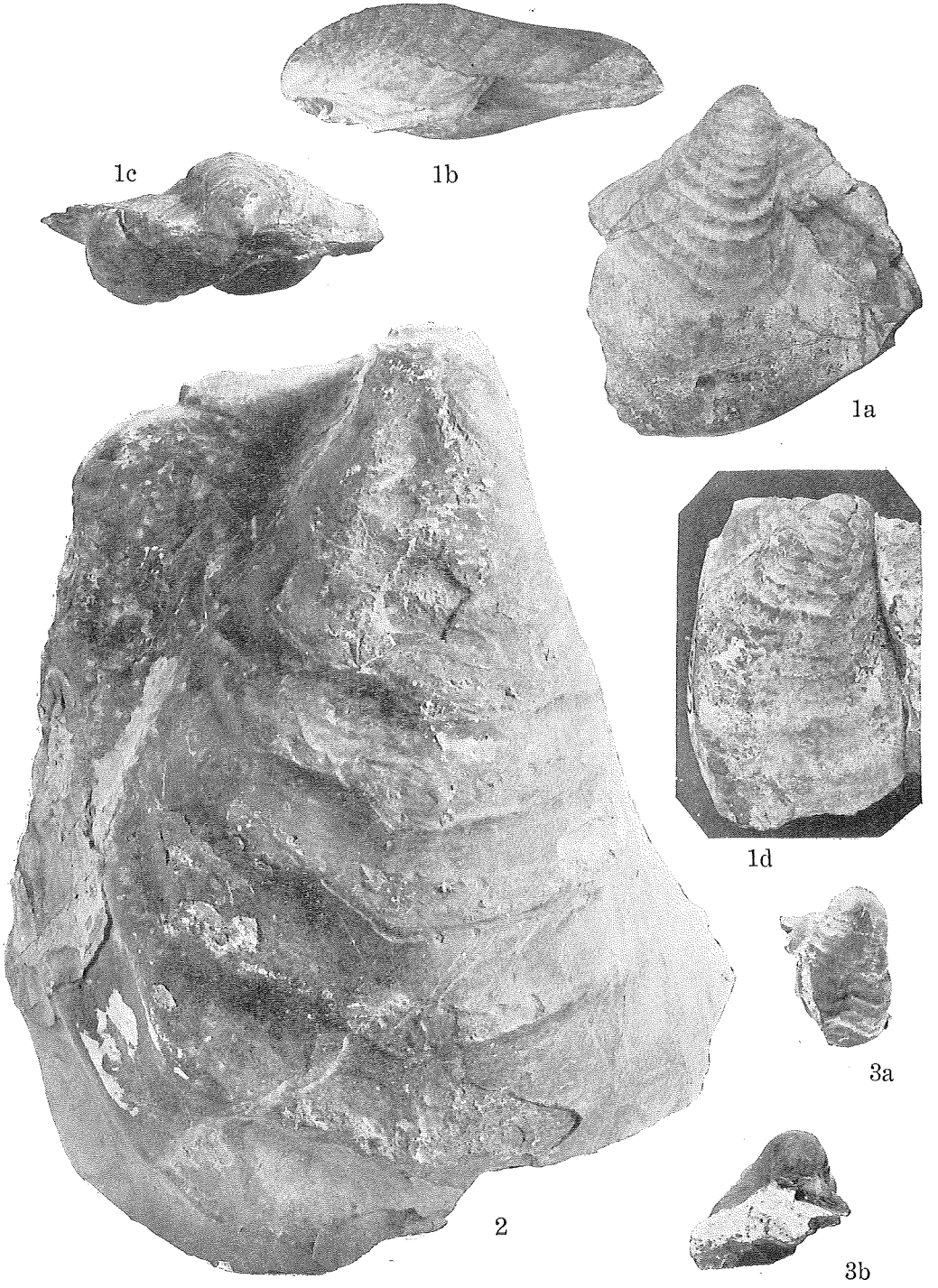
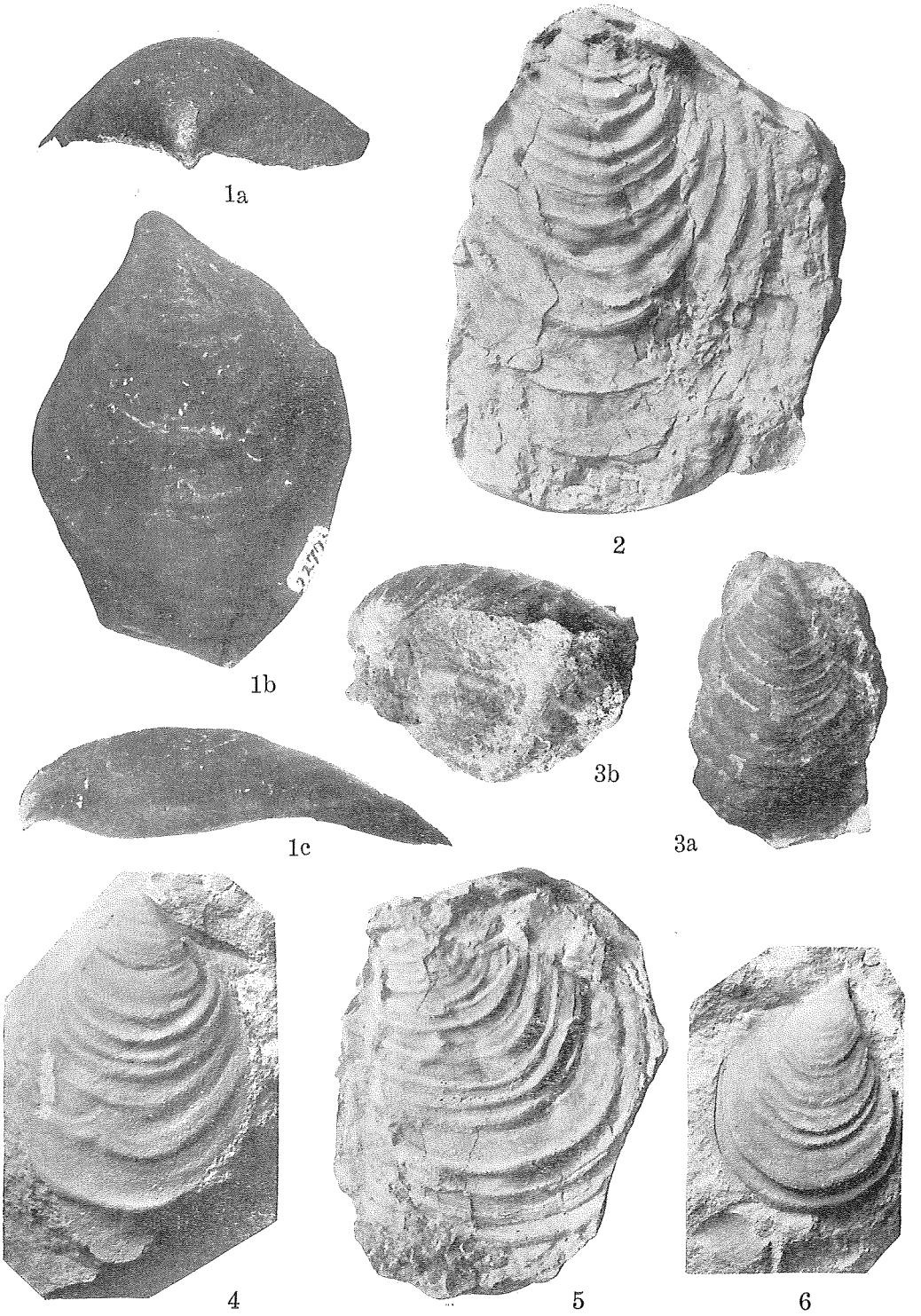


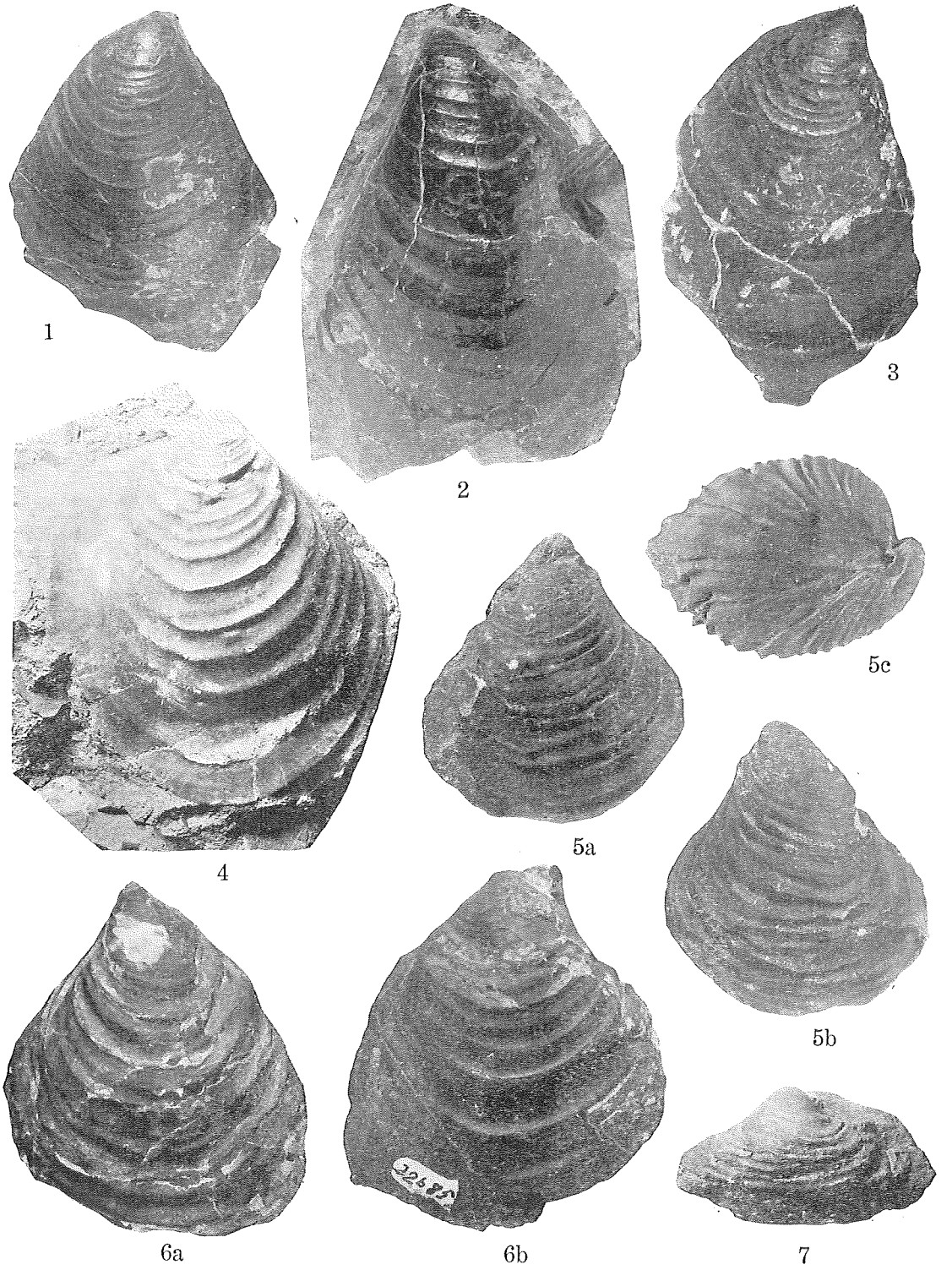
T. Nagao and T. Matumoto: Cretaceous Inoceramus.



T. Nagao and T. Matumoto: Cretaceous Inoceramus.



T. Nagao and T. Matumoto: Cretaceous Inoceramus.



T. Nagao and T. Matumoto: Cretaceous Inoceramus.