IMPERIAL GEOLOGICAL SURVEY OF JAPAN

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Mollusca from the Oil-Field of the Island of Taiwan

By

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I. General Remarks

The island of Taiwan, generally known under the name of Formosa among Westerners, when geologically considered, was almost a *terra incognita* prior to its occupation in 1895 by the Japanese, brief references made on its coal-field and the fossils found therein by Corner, Guppy, Kleinwächter, Tyzack and Lebour[1] having been insufficient to form any adequate idea about the geology of the whole island. Since then many of our geologists have travelled through it, and at present its geology is tolerably well known.

Concerning the fossils, however, very little has been written until now. What the above named authors have written are only enumerations of the names of some corals, echinoids and molluses. In 1900 Newton and Holland published a short note[2] on the results of the examination of microscopic sections of some

1) About the writings of these authors, I refer to the paper of Newton and Holland named below.

2) R.B. Newton and R. Holland. Notes on Microscopic Sections of Limestones from Formosa: Collected by Dr. Koto of Japan. Jour. Geol. Soc. Tokyo, Vol. 7, 1900.

limestones from the island sent by Professor Koto and two years later a more lengthy paper[1] on the Foraminifera, Bryozoa and Nullipora contained in limestones collected in the island as well as in Ryukyu by Professor S. Tokunaga of the Waseda University, then a student of the University Hall of the Imperial University of Tokyo. The fossils of the island treated in these two papers are very few, although they are very valuable, giving hints to the age of the rocks containing them. About the higher Invertebrates, no important paper has appeared until present.

In 1927 our Imperial Geological Survey, at the request of the Department of Navy, undertook the investigation of the oil-field of the island. For this purpose four geologists were sent. They are Messrs. Y. Ōinouye, Y. Iizuka, H. Sato and K. Murayama who brought back a large number of fossils, mostly Mollusca, collected in the field. These fossils I was entrusted to examine, the results of which are laid in the following pages.

The rock-layers constituting the oil-field of Taiwan are grouped by the above geologists into several beds which in descending order are as follows:

I. *Shokkōsan Beds.* Mainly composed of conglomerate with subordinate layers of sandstone, shale and limestone. Fossils present.

II. *Upper Byoritz Beds.* Consisting either of sandstone alone or of alternations of sandstone and shale. Rich in fossils.

III. *Lower Byoritz Beds.* Made up of shale and shaly sandstone with some limestone. Rich in fossils and also oil-bearing.

1) On Some Fossils from the Islands of Formosa and Ryukyu (Loochoo). Jour. Coll. Sci., Imp. Univ. Tokyo, Vol. XVII, Art. 6, 1902.

IV. *Upper Arisan Beds.* Chiefly made up of sandstone and shale, but also intercalating some limestone layers, coal-seams and basalt-sheets. Fossiliferous as well as oil-bearing.

V. *Middle Arisan Beds.* Consisting of alternating layers of sandstone and shale with some coal-seams. Oil-bearing. Fossils absent.

VI. *Lower Arisan Beds.* Also called *Karisan Beds* and composed of slaty shale and sandstone. Fossiliferous.

Above the uppermost or Shokkōsan Beds there are layers of gravel and clay of the Pleistocene and Holocene epochs unconformably overlying them, whilst below the lowest, the Lower Arisan Beds, there are the so-called *Hori Beds* which consist of black slates intercalating some sandstone layers and are separated from the Arisan Beds, usually by a fault. But geologists assume the presence of a line of unconformability between. Between the Shokkōsan and Upper Byoritz Beds, there is a distinct and undoubted one.

As to the thickness of the respective beds, some estimations have been made. The figures ran very high, though differing at places. For the Shokkōsan Beds 1300 metres to 1900 meters were obtained, for the Upper and Lower Byoritz together 3000 metres to 4000 metres, and for the whole Arisan 2500 metres to 5000 metres.

The fossils treated in this paper are from all of the fossiliferous beds. Their names and distribution are given in the following table :

I. Gastropoda	Shokkōsan	Upper Byoritz	Lower Byoritz	Upper Arisan	Lower Arisan	Geological Occurrence
Fam. Ringiculidae						
1. Ringicula foveolata n. sp.		+				
2. Ringicula globulifera n. sp.			+			
Fam. Terebridae						
3. Terebra lischkeana Dkr.			+			Recent (C.W. Japan). Up. Musashino, Pliocene
4. Terebra naumanni Yok.		+				Rec. (C. Japan). Up. Musashino
5. Terebra subvariegata n. sp.		+				
6. Terebra formosana n. sp.		+				
7. Terebra sp.		+				
Fam. Conidae						
8. Conus sinensis Sow. var.		+				Rec. (China, Philippines, South Sea)
9. Conus kikaiensis Pils.			+			Pliocene
10. Conus comatosaeformis n. sp.			+			
11. Conus oinouyei n. sp.			+	?		
Fam. Pleurotomidae						
12. Pleurotoma oxytropis Sow.		+				Rec. (C.W. Japan, China). Up. Musashino
13. Pleurotoma carinata Gr. var. woodwardi Mart.		+				Pliocene of Java. Miocene of Philippines
14. Drillia pseudoprincipalis Yok.		+				Up. Musashino
15. Surcula javana (L.)		+	+			Rec. (W. Japan, China, Java)

I. Shokkōsan Beds.

From the Shokkōsan Beds we have only four species, namely: *Pecten* (*Chlamys*) *aurantiacus* Ad. et Reeve., *Ostrea gigas* Thunb., *Arca* (*Scapharca*) *subcrenata* Lke. and *Pecunculus formosanus* n. sp., of which the first three are still living. From these four it is not possible to draw any conclusion respecting the age of the beds in which they occur. It may be *Tertiary* (*Pliocene*) as the geologists of the Geological Survey think, or *Quaternary* (*Pleistocene*). The decision must be postponed for the future.

II. Upper Byoritz Beds.

The total number of the species obtained from the *Upper Byoritz Beds* amounts to eighty-five of which, however, eight are not accurately determined. The remaining seventy-seven consist of the following elements:

1. Species hitherto found only Recent. 17
2. Species hitherto found Recent as well as Youngest Pleistocene. 2
3. Species hitherto found between Recent and Upper Musashino (Pliocene or Pleistocene). 9
4. Species hitherto found between Recent and Lower Musashino (Upper Pliocene). 3
5. Species hitherto found between Recent and Pliocene older than Lower Musashino. 18
6. Species hitherto found between Recent and Miocene. . . 4
7. Species hitherto found only in Upper Musashino. 1
8. Species hitherto found between Upper Musashino and Pliocene. 1

9. Species hitherto found only in Pliocene. 1
10. Species hitherto found in Pliocene as well as in Miocene. 3
11. Species entirely new. 18
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From this we see that the species hitherto not known to be living are twenty-four in number, making up about 30% of the whole fauna. And of the living species, those which go up to the Pliocene are twenty-five, far outnumbering those which are older (Miocene four) or younger (Pleistocene and Upper Musashino eleven). From these considerations I believe that the beds in question can safely be placed in the *Pliocene*.

What is quite noteworthy about the whole fauna as considered from the climatolagical point of view is its much stronger affinity to that of temperate Japan than to that of the tropical regions. As every one knows, the island of Taiwan lies under the Northern Tropic. Consequently we are naturally led to expect that its younger Tertiary fauna would be quite tropical in character.

But this is far from being the case. Among the fifty-three living species, only the following seven (about 13%) may be said to be purely tropical:

1. Conus sinensis Sow.
2. Mitra sphaerulata Martyn.
3. Nassa canaliculata Lam.
4. Distortio cancellinus (Bois.)
5. Cypraea carneola L.
6. Arca (Argina) auriculata Lam.
7. Arca (Parallelopipedum) tortuosa L.

The remaining forty-six species consist of those which live either only in temperate seas, or in temperate as well as in tropical seas. And the former or purely temperate forms amount to twenty (about 38%), a number which is more than twice as many as the tropical ones. They are the following:

1. Terebra naumanni Yok.
2. Hemifusus ternatanus Gm.
3. Rapana bezoar L. var. thomasiana Gr.
4. Cassis japonica Rve.
5. Polinices sagamiensis Pils.
6. Sigaretus undulatus Lke.
7. Umbonium costatum (Val.)
8. Corbula erythrodon Lam.
9. Dosinia gruneri Phil.
10. Meretrix (Macrocallista) ezoensis Yok.
11. Sunetta excavata Haul.
12. Chione casinaeformis Yok.
13. Tapes undulatus Born.
14. Venericardia cipangoana Yok.
15. Astarte sulcata Dac.
16. Crassatellites heteroglyptus Pils.
17. Anomia lischkei Fisch. et Dautz.
18. Plicatula cuneata Dkr.
19. Pecten (Chlamys) laetus Gld.
20. Pecten (Vola) laqueatus Sow.

These forms are found only in Japan Proper (Western, Central and Northern Japan) except one, *Astarte sulcata*, which has not yet been found living in our seas, though fossil in the

Upper Musashino of Sado, an island in Japan Sea. The find of this species is very interesting, as it is now known as a boreal form. And so is also *Meretrix* (*Macrocallista*) *ezoensis* which at present lives only in Northern Japan.

Looking into the exclusively fossil (extinct) forms which amount to twenty-four, those which have already been found in tropical regions are again few. They are only the following four:

1. Pleurotoma carinata Gray var. woodwardi Mart.
2. Nassa verbeeki Mart.
3. Rostellaria spinifera Mart.
4. Pecten javanus Mart.

These have been described from the Pliocene of Java. The remaining twenty species consist of eighteen new and two Japanese.

The strong Japanese affinity shown by the fauna of the Upper Byoritz can only be explained by assuming that the seas around Taiwan during the deposition of the said beds had been more temperate than at present. And this is quite in accordance with the conclusion arrived at by me by studying the Pliocene Mollusca of Japan. Repeatedly I said in my papers previously published that the Pliocene molluscan fauna of our country represents that of a somewhat *cooler sea* than that of the present. And this *cooler character*, I may say, is more deeply, and therefore more clearly, impressed on the Taiwan fossils than on those of Japan Proper.

III. Lower Byoritz Beds.

These beds have yielded eightly species, of which the accurately determined are sixty-five, consisting of the following elements:

1. Species hitherto found only Recent. 14
2. Species hitherto found Recent as well as in Upper Musashino. 6
3. Species hitherto found between Recent and Lower Musashino. 2
4. Species hitherto found between Recent and Pliocene older than Lower Musashino. 14
5. Species hitherto found between Recent and Miocene. . . 3
6. Species hitherto found only in Upper Musashino. 2
7. Species hitherto found only in Pliocene. 3
8. Species hitherto found only in Miocene. 2
9. Species entirely new. 19

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From this we see that the species which at present are not known to be living are twenty-six, or 40% of the whole, a percentage somewhat greater than that of the Upper Byoritz, as is naturally to be expected. Of these twenty-six, if we leave out nineteen which are new, there remain seven whose names are as follows:

1. Conus kikaiensis Pils.
2. Mitra gembacana Mart.
3. Cadulus gordonis Yok.
4. Corbula substriata Yok.
5. Pecten (Vola) javanus Mart.
6. Pecten (Amusium) praesignis Yok.
7. Cucullaea pamotanensis Mart.

Cadulus gordonis and Corbula substriata occur in the Japanese *Upper Musashino*, Conus kikaiensis and Pecten praesignis in the Japanese *Pliocene*, Pecten javanus in the Javan *Pliocene* and

Mitra gembacana and Cucullaea pamotanensis in the Javan *Miocene*.

Of the thirty-nine living species, those which have already been found fossil are twenty-five, of which six go up to the *Upper Musashino*, two to the *Lower Musashino*, thirteen to the *Pliocene* and three to the *Miocene*.

From these considerations the Lower Byoritz Beds seem also to be *Pliocene*, inasmuch as the general faunistic character, climatologically viewed, is similar to that of the overlying beds. That character is as follows:

Of the thirty-nine living species, those which are to be looked upon as purely tropical are only four (10%), while those which are purely temperate or Japanese are fourteen (36%). The purely tropical forms are the following:

1. Turritella terebra L.
2. Dentalium subrectum Jeffr.
3. Hemicardium hemicardium (L.).
4. Arca (Parallelopipedum) tortuosa L.

The purely temperate or Japanese forms are the following:

1. Terebra lischkeana Dkr.
2. Cassis japonica Rve.
3. Polinices sagamiensis Pils.
4. Umbonium costatum Val.
5. Corbula erythrodon Lam.
6. Dosinia troscheli Lke.
7. Meretrix (Macrocallista) ezoensis Yok.
8. Sunetta excavata Hanl.
9. Diplodonta japonica Pils.

10. Venericardia cipangoana Yok.
11. Corbicula sandaiformis Yok.
12. Unio nipponensis v. Mart.
13. Anomia lischkei Fisch. et Dautz.
14. Pecten (Chlamys) lactus Gld.

Thus the great preponderance of temperate forms over tropical ones is quite as evident as in the fauna of the Upper Byoritz. From this we may assume that the strata composing the Lower Byoritz had been deposited in a sea in which climatically the same or similar condition prevailed as in the Upper Byoritz time. This of course does not compell us to assume the age of the Lower Byoritz to be Pliocene, for it is not at all unnatural to suppose that a climatically similar condition had also prevailed in the preceding Miocene. Besides, there is a reason of the danger of laying too much weight on the percentage of the living species, especially in the fossil fauna found in tropical regions. R. E. Dickerson in his "Fauna of the Vigo Group, Philippine Islands" states that the European percentage system usually employed in determining the age of the Tertiary beds of the temperate regions does not apply to those of the tropics, and he considers the Vigo Group, whose molluscan fauna contains seventy-five percent of the living species and should therefore be Pliocene according to the European scale, to be *Miocene* in age. And this he bases on the presence of a large foraminifer called *Lepidocyclina* which is said to serve as an index fossil in Indo-China and Java. Of course I am not certain whether what Dickerson says applies also to the island of Taiwan. But its position is not far from the Philippines and lies also in

the tropics. Accordingly, although we are not yet informed of the occurrence of the above said foraminifer in the beds of the Lower Byoritz, I should prefer to put off the exact determination of their age for the future.

IV. Upper Arisan Beds

The number of the species yielded by these beds amounts to twenty-three, of which the specifically determined ones are only eight. They are the following:

1. Dolium olearium Rrug.
2. Cypraea cinctoides n. sp.
3. Meretrix meretrix L.
4. Circe scripta L.
5. Loripes goliath n. sp.
6. Venericardia cipangoana Yok.
7. Pecten (Chlamys) satoi n. sp.
8. Pecten (Amusium) praesignis Yok.

Dolium olearium is hitherto only *Recent*. Meretrix meretrix is *Recent* as well as *Upper Musashino* and *Pliocene*. Circe scripta is *Recent* and also occurs in the *Upper Byoritz*. Venericardia cipangoana ranges between *Recent* and *Miocene*. Pecten praesignis is hitherto only *Pliocene* in Japan. The remaining three are new.

From these few it is hardly possible to judge the age of the beds in which they were found. But fortunately Newton and Holland have found a *Lepidocyclina* which they called *Lepidocyclina verbeeki* in a limestone intercalated between the beds at Shinkōkai, south of the city of Taihok. They also found a

elevated, narrow though rounded, separated by broad and shallow valleys. There are also two spiral cords, one on the shoulder and one immediately below it. On the older whorls several faint spiral striae are present below the second cord, with the points of intersection with the cords tubercular. The periphery is rounded, while the base is abruptly narrowed below, the surface being decorated with about four distant spiral cords. The caudal end shows a spiral ridge. Diameter 5 millim.

Fossil occurrence.—*Upper Byoritz Beds:* Taihanrok, Takao (高雄州恒春郡大板麓).

Family Conidae

8. Conus sinensis, Sowerby, var.

Pl. I. Fig. 8

Conus sinensis var. Martin, Foss. v. Java, p. 13, pl. I, figs. 13-15.

An almost perfect specimen, 28.5 millim. in height and 14 millim. in diameter, lacking the apex only. The whorls which are provided with several flat spiral cords are somewhat concave with the peripheral angle slightly projecting above the suture. The only difference from the Javan fossil lies in the absence of crenulations on the peripheral angle. The flat cords of the body-whorl are many and separated by intervals of about equal breadth. The incremental lines are prominent and striae-like.

Tryon (Man. Conch., VI, p. 76) unites *Conus sinensis* Sow. with *Conus sowerbyi* Rve. which he believes to be identical with *Conus undatus* Kien.

Fossil occurrence.—*Upper Byoritz Beds:* Enri, Shinchik (新竹州苗栗郡苑裡). Pliocene of Java.

Living.—China. Philippines. South Sea.

9. Conus kikaiensis, Pilsbry

Pl. I. Fig. 7

Conus kikaiensis. Pilsbry, New Jap. Mar. Moll., Gastr., Proc. Acad. Nat. Sci. Philad., Jan., 1904, p. 6, pl. 1, fig. 8.

A specimen of a small slender *Conus* with the apex and front-end broken. The whorls intact are five with the peripheral angle slightly projecting above the suture. Those forming the spire which is somewhat concave in lateral outlines are ornamented with a few spiral cords. The body-whorl is nearly straight in lateral outlines and possesses many spiral grooves (about eighteen) crossed and striated by lines of growth. Height, if perfect, about 18 millim. Diameter 6 millim.

Fossil occurrence.—*Lower Byoritz Beds:* West end of Fukki, Shinchik (新竹州苗栗郡福基). Pliocene of Japan (Ōsumi).

10. Conus comatosaeformis, n. sp.

Pl. I. Fig. 10

Shell narrow and elongated, the height being almost three times the diameter. Spire elevated, conical somewhat concave in lateral outlines and occupying more than one-fourth of the shell-height. The apex is lacking, and the whorls intact are seven. They are slightly concave with the peripheral angle somewhat projecting above the suture and furnished with a few (usually three) incised spiral lines, equally distributed on the surface. The body-whorl is almost straight in lateral outlines, showing a slight curvature only near the shoulder, smooth in the upper one-third and spirally grooved in the lower two-thirds.

The grooves gradually grow in breadth as they go downward and are cross-striated by lines of growth.

Only one example with the height (without apex) 30 millim. and the diameter 14 millim.

This species closely resembles *Conus comatosa* Pilsbry (*Conus dormitor* Pils.) described in a paper entited "New Japanese Marine Mollusca" already cited (p. 6 pl. I, fig. 9) and found fossil in Osumi together with the preceding species. But the latter has the spiral grooves on the whole surface.

Fossil occurrence.—*Lower Byoritz Beds:* South of Kwan-in San, Taikei Gai, Shinchik (新竹州大湓郡大湓街觀音山).

11. Conus oinouyei, n. sp.

Pl. I. Fig. 16

Shell rather small, oboonical, with spire low and concave in lateral outlines. Whorls about nine, either flat or slightly excavated, with peripheral angle projecting above the suture more on the younger whorls than on the older; spirally striate, with striae several in number and close together. Periphery angular. Body-whorl almost straight when laterally viewed, the curvature being very slight, apparently smooth on the upper two-thirds and spirally grooved on the lower one-third. Aperture narrow, parallel-sided.

A single example which we possess is about 35 millim. in height and 12 millim. in diameter.

The species which shows the closest affinity to the present is *Conus sieboldi* Rve. (Yokoyama, Foss. Miura Penin., p. 34, pl.

I, fig. 14), especially when it is young, which, however, has the peripheral angle more projecting and the whorls more concave.

Fossil occurrence.—*Lower Byoritz Beds:* South of Kwan-in San, Taikei Gai, Shinchik (新竹州大溪郡大溪街觀音山).

A fragment of a *Conus* resembling this species was picked up from the *Upper Arisan Beds* at Kōtei, Sansōshō, Shinchik (新竹州大溪郡三層庄坑底).

Family Pleurotomidae

12. Pleurotoma oxytropis, Sowerby

Pl. I. Fig. 11

Pleurotoma oxytropis. Yokoyama, Moll. Up. Musash. Tokyo, p. 409, pl. XLVI, fig. 7. Tryon, Man. Conch., VI, p. 168, pl. IV, figs. 37-39.

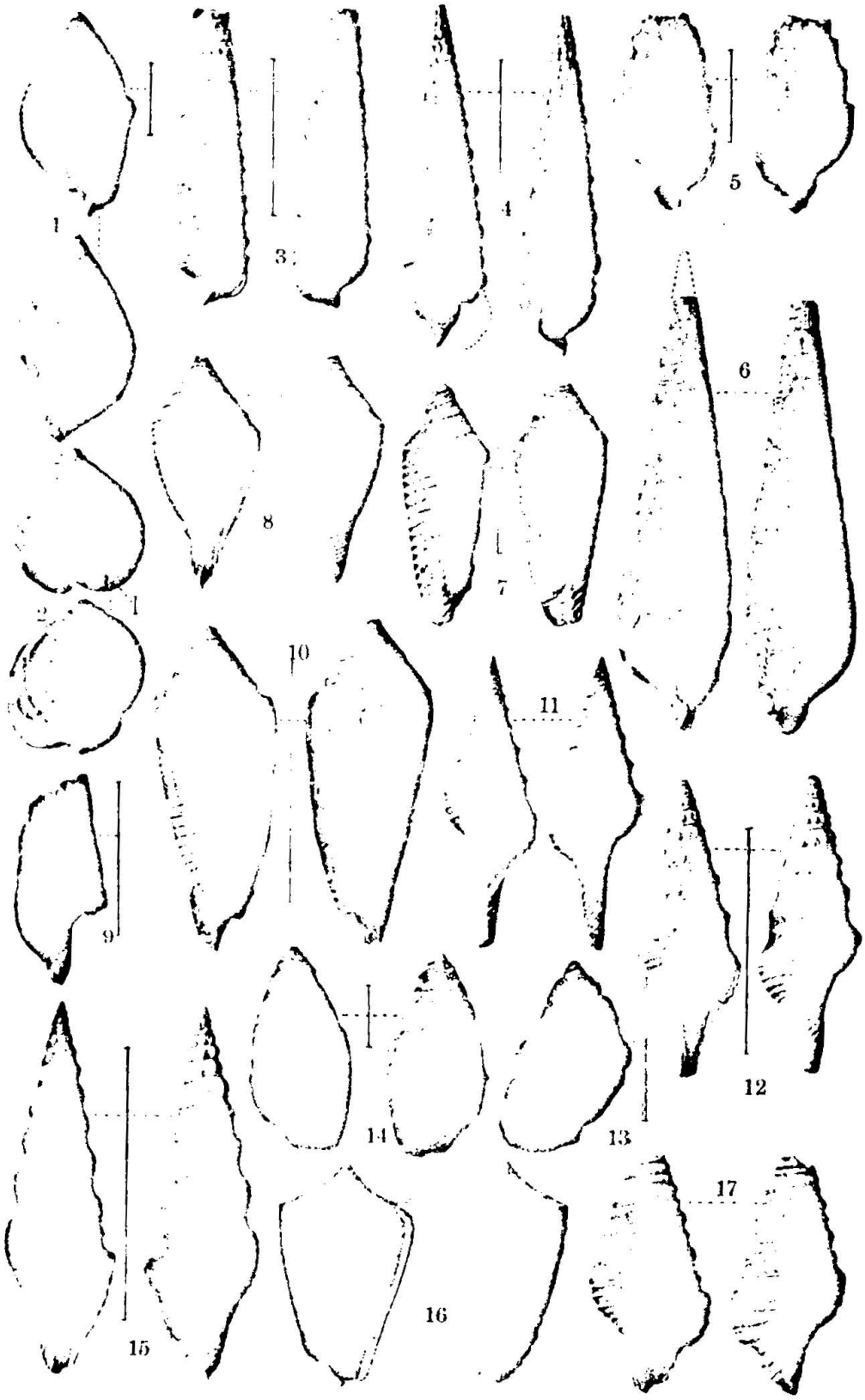
The spiral striae found on the surface of the whorls are very distinct, though such is not the case in the Musashino fossil of Japan hitherto found.

Pleurotoma gendinganensis Martin (Foss. v. Java, p. 32, pl. V, figs. 79–84) which the author says is quite like *Pleurotoma laurotropis* Ad. et Rve. (Voyage Samarang, p. 40, pl. X, fig. 7) is probably identical with the present species.

Specimens rare.

Fossil occurrence.—*Upper Byoritz Beds:* (1) Jōnanseikō, Shiko Shō, Shinchik (新竹州苗栗郡四湖庄上南勢坑); (2) Kyushōkō, Enri Shō, Shinchik (同州同郡苑裡庄乌瓜坑); (3) Sankō, Injurin, Shinchik (同州大溪郡[]樹林三坑). Upper Musashino of Japan.

Living.—Central and Western Japan. China. Gulf of California. Panama.



Mollusca from the Oil-Field of Taiwan

Plate I

Fig. 1. Ringicula foveolata n. sp. Enlarged. Upper Byoritz: Shikō, Kōshun, Takao. P. 23

Fig. 2. Ringicula globulifera n. sp. Enlarged. Upper Byoritz: Wankyō, Tainan. 24

Fig. 3. Terebra naumanni Yok. Enlarged. Upper Byoritz: Shikō, Kōshun, Takao. P. 25

Fig. 4. Terebra subvariegata n. sp. Enlarged. Upper Byoritz: Hōtosak, Rinkō Shō, Taihok. P. 25

Fig. 5. Terebra sp. Enlarged. Upper Byoritz: Taihanrok, Takao. p. 27

Fig. 6. Terebra formosana n. sp. Upper Byoritz: Shikō, Kōshun, Takao. P. 26

Fig. 7. Conus kikaiensis Pils. Enlarged. Lower Byoritz: West end of Fukki, Shinchik. P. 29

Fig. 8. Conus sinensis Sow. Upper Byoritz: Enri, Shinchik P. 28

Fig. 9. Terebra lischkeana Dkr. Enlarged. Lower Byoritz: Injurin, Shinchik. P. 24

Fig. 10. Conus comatosaeformis n. sp. Enlarged. Lower Byoritz: South of Kwan-in San, Taikei Gai, Shinchik. P. 29

Fig. 11. Pleurotoma oxytropis Sow. Upper Byoritz: Jōnanseikō, Shiko Shō, Shinchik. P. 31

Fig. 12. Surcula javana (L.) Enlarged: Upper Byoritz: Shikō, Kōshun, Takao, P. 33

Fig. 13. Ocinebra sp. Upper Arisan: Shokōkō, Tainan. P. 42

Fig. 14. Olivella spretoides Yok. Enlarged. Upper Byoritz: Hōtosak, Rinkō Shō, Taihok. P. 35

Fig. 15. Drillia pseudoprincipalis Yok. Enlarged. Upper Byoritz: Kizan, Byoritz Gai, Shinchik. P. 32

Fig. 16. Conus ōinouyei n. sp. Lower Byoritz: South of Kwan-in San, Taikei Gai, Shinchik. P. 30

Fig. 17. Pleurotoma carinata Gray, var. woodwardi Mart. Upper Byoritz: Shikō, Kōshun, Takao. P. 32