38. *Tertiary Structures of the Northwestern End of the Kitakami Mountainland, Iwate Prefecture, Japan.*

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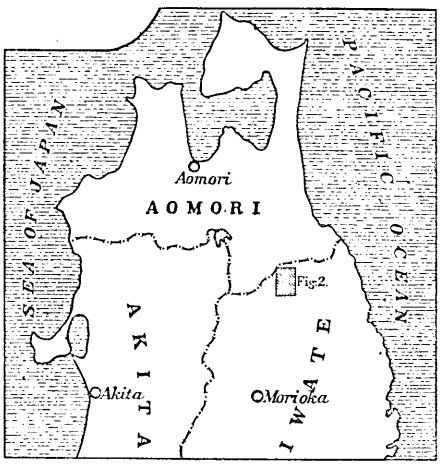
Contents.

Introduction.

Cainozoic formations are exposed along the Mabeti[1] valley near the town of Itinohe[2] and Hukuoka,[3] Ninohe-gôri, Iwate prefecture, and the

1) 馬淵川. 2) 一戸町. 3) 岩手縣二戸郡福岡町.

town of Sannohe,[4] Sannohe-gôri, Aomori prefecture. These regions are regarded as the most interesting in Northeast Japan from the geological point of view. Since 1911, when Prof. Shintaro Nakamura first published his well surveyed geologic map, "Ninohe" sheet, on a scale of 1/200,000[5], and reported many fossil localities in this region, our stratigraphic knowledges of this region have been increased by only one paper, an important one, in which the stratigraphy of this districts was treated by Prof. H. Yabe and S. Shimizu.[6]



Index Map.

According to Prof. S. Nakamura, the Cainozoic formations in this district consist of beds belonging to all Cainozoic ages from Pleistocene to Miocene. The lower part contains many fossil plants, and the upper many fossil mollusca, molluscoidea, shark's teeth (*Oxyrhina hastalis* Agassiz, *Carcharodon megalodon* (Charlesworth)) and *Echinarachnius*. He also reported the following fossil plants from the Hiranuka[7] basin, 16 km. south of the town of Itinohe; *Liquidambar formosana* Hance, *Sequoia langsdorfii* (Brongniart), etc. all of which are common in the Japanese Miocene.

S. Shimizu, in studying the stratigraphy of this district found many important fossils, such as *Vicarya vernuilli* d'Archiac, *Desmostylus japonicus* Yoshiwara et Iwasaki from his Yuda[8] group in this district, after which the stratigraphic importance of the district increased considerably. But to the writer's regret, S. Shimizu's manuscript was never published, and the writer came to know of his opinions only through Prof. H. Yabe's paper in the Proceedings of the Second Pan-Pacific Science Congress, in which Dr. S. Shimizu's views were given in detail.

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4) 青森縣三戸郡三戸町.

5) S. NAKAMURA, *Expl. Text. Geol. Map, Japan*, "Ninohe" sheet, 1:200,000, (1911).

6) H. YABE, "Recent Stratigraphical and Palaeontological Studies of the Japanese Tertiary," *Spec. Publ. Bernice P. Bishop Museum*, **7** (1921), 780–781.

7) 平糠. 8) 湯田.

The writer[9] has made clear the existence of three major cycles of sedimentation in the Neogene of Northeast Japan. Although S. Shimizu's views of the stratigraphic succession of Tertiary in this district conflict with the evidences of these three cycles in Northeast Japan, does the succession of strata conflict with these three cycles? The first task of the writer in this study is a re-survey of this discordant stratigraphic succession.

Dr. H. Matsumoto,[10] who studied the *Desmostylus japonicus* Yoshiwara et Iwasaki, the Miocene fossil mammal found in Japan, reported two localities for it in this Ninohe region, Yuda and Sikonai.[11] The latter locality is in the Kadonosawa[12] group of Shimizu, which is the upper group of the Yuda. Accordingly H. Matsumoto believed in the existence of two horizons of *Desmostylus japonicus* Yoshiwara et Iwasaki in this district. But this *Desmostylus* species were generally collected from one and the same horizon.

Are there horizones of *Desmostylus japonicus* Yoshiwara et Iwasaki in this district? To answer this question is the second task of this paper.

Studies of the structure of the Neogene beds in the western half of Northeast Japan have greatly progressed, thanks to the development of oil there, while our stratigraphic knowledge of the Neogene in the eastern half is still inadequate, although the geologic structure is more or less simple. But to compare the geologic structures and to correlate them are the first requisites. The third part of this paper deals with the correlation of strata in this district.

It was long unknown what structural characteristics are exposed in the Japanese Tertiary strata. The writer wishes to compare the structural characteristics of the Japanese Neogene. The first difficulty met with by the writer in comparing the geologic structures was our insufficient knowledge of the correlation of the Tertiary strata, which meant that he should study the Neogene stratigraphy of Japan. He[13] began by studying the Neogene of Southwest Japan, and compared the structural geologic characteristics of the Neogene in Southwest Japan with

9) Y. OTUKA, "Cycle of Sedimentation in the Japanese Neogene," *Geogr. Rev., Japan*, 8 (1932), 905-932, (in Japanese).

10) H. MATSUMOTO, "Mammalian Horizons of the Japanese Tertiary", revised, *Proc. 2nd Pan-Pacific Science Congress*, Australia, (1923).

11) 尻子内. 12) 門ノ澤.

13) Y. OTUKA, "Early Pliocene Crustal Movement in the Outer Zone of Southwest Japan and in Naumann's Fossa Magna," *Bull. Earthq. Res. Inst.*, 9 (1931), 340-352.

that of the Fossa Magna. His conclusion is that in the Outer Zone of Southwest Japan, the lower Pliocene or Pliocene strata are usually monoclinal with low angles either to the southwest or to the south, with the exception of a few small displacements, while contemporaneous deposits in the Fossa Magna form a complex anticlinorium, each pericline with a trend parallel to that of the Fossa Magna. What kind of structure characterizes the Neogene in the western half of Northeast Japan and the eastern? The tectonic discussion of this district forms the fourth task of this paper.

The writer wishes to express here his grateful thanks to Prof. M. Ishimoto, the Director of the Earthquake Research Institute, for his kind permission to engage in these studies, and to Prof. H. Yabe, the Director of the Institute of Geology and Palaeontology, Tôhoku Imperial University, for his invaluable suggestions and for kind permission to make use of unpublished geologic maps in the Institute, and to Mr. Kotora Hatai for his kind assistance in both field and indoor work, and to Mr. T. Kuroda for his courtesies, suggestions and criticisms upon the writer's determination of fossil mollusca.

Stratigraphic succession as schemed by Dr. S. Shimizu.

In 1921, Prof. H. Yabe[14] mentioned the following stratigraphic succession of the Tertiary strata as worked out by S. Shimizu under the title "Recent Stratigraphical and Palaeontological Studies of the Japanese Tertiary."

6. The Takamori[15] group.
5. The Suenomatsuyama[16] (or Suenomatuyama) group.
4. The Kadonosawa group.
3. The Yuda group.
2. The Nisatai[17] group.
1. The Yotsuyaku[18] (or Yotuyaku) group.

1. The Yotuyaku group, 224 meters thick and covering the bedrock series (Palaeozoic rocks) in clino-unconformity; it comprises in ascending order.

a. Basal conglomerate and tuffaceous sandstone, in which are intercalated thin coal seams.

b. Black soft shale, with some marine shells (*Ostrea* etc.).

c. Lower agglomerate.

d. Tuffaceous sandstone, shale, and conglomerate in alternation, containing

14) H. Yabe, *op. cit.*, (1921).

15) 高森. 16) 末ノ松山. 17) 仁佐平. 18) 四ツ役.

abundant impressions of leaves. Endo found such plant fossils as *Liquidambar formosana* Hance, *Fagus ferruginea* Ait. and *Oreodaphne* cfr. *osalinensis* Berry.

e. Middle agglomerate.

f. Tuffaceous sandstone and shale in alternation.

2. The Nisatai group, 10m. thick, which consists of

a. Conglomerate (*Ostrea* bed), grading in places to coarse sandstone, in association with shell limestone.

b. Sandstone.

Many marine shells are found in this group, of which a gigantic species of *Ostrea* is most attractive. This group is believed by Shimizu to rest upon the former with slight unconformity.

3. The Yuda group, 110m. thick.

a. Brownish gray sandy shale, in which are intercalated thin zones of rather incoherent sandstone.

b. Light gray to yellowish shale with thin bands of rather incoherent sandstone, and numerous marl nodules; very fossiliferous. *Vicarya* cfr. *callosa* Jenkins (=*Vicarya vernuilii* d'Archaic[19]) *Desmostylus* sp. being two prominent fossils from it.

c. Tuffaceous sandstone with intercalated thin shale layers.

Shimizu states that the Yuda group overlies the Nisatai and the Yotuyaku unconformably. The two fossils named above, indicate the contemporaneity of this group with *Desmostylus* beds of Hokkaido and Mino and the *Vicarya* beds of Hokkaidô, Hitachi, and Mino.

4. The Kadonosawa group, 280m. thick.

a. Tuffaceous sandy shale.

b. Tuffaceous sandstone with intervenning layers of shale; *Tellina* bed.

Shimizu believes that this gronp is para-unconformable with the older divisions.

A rather conspicuous unconformity.

5. The Suenomatsuyama group, 175m. thick.

a. Conglomerate, grading in places to beach sand; very rich in fossils, especially several species of *Pecten* which are abundant.

6. The Takamori group, 130m. thick.

a. Conglomerate;

b Sandstone (*Echinarachnius* Bed). Besides *Echinarachnius*, many molluscan shells and shark's teeth are found. Mr. Y. Ishiwara[20] distinguished three species of shark's teeth, namely, *Oxyrhina hastalis* Ag., *Carcharodon megalodon* (Charlesworth), and *Carcharinus commersoni* Blainville.

The Suenomatsuyama and Takamori groups are probably contemporaneous

19) Recently Prof. J. Makiyama* noted the occurrence of *Vicarya vernuilii* d'Archiac, but T. Takeyama** does not mention this locality in his paper on Japanese *Vicarya*. *J. MAKIYAMA, "Neogene" *Iwanami Kôza* (1933), (in Japanese). *T. TAKEYAMA, "Notes on the genus *Vicarya*, with Description of Two Japanese Forms," *Jap. Jour. Geol., Geogr.*, **10** (1933), 129-144.

20) Y. ISHIWARA, "On Some Fossil Shark-Teeth from the Neogene of Japan" *Sci. Rep., Tôhoku Imp. Univ.*, [ii], **5** (1921), 61-74.

with a part of the Tokiwa series of the Provinces of Iwaki[21] and Hitachi (or Hitati).

Prior to the publication of the foregoing Dr. H. Matsumoto[22] reported the occurrence of *Desmostylus* from the Kadonosawa group and pointed out the existence of two horizons of *Desmostylus japonicus* Yoshiwara et Iwasaki in this district[23]. There are however no particular descriptions of these two fossil localities.

The writer regrets that, owing to pressure of survey work, he was not able to collect these important fossils from these localities.

Geomorphology.

The district now to be described is situated in the north corner of Iwate prefecture, along the Mabeti river bordering the northwest margin of the Kitakami[24] mountainland, which estuary discharges into the Pacific at the city of Hatinohe[25], Aomori prefecture.

The height of the Kitakami mountainland gradually lessens towards the west of the Mabeti with "Piedmont-treppe" like topography (Fig. 3). The western region of the Mabeti is a low flat-topped mountainland about 500～300 m. above sea-level. The Neogene Tertiary, which forms these flat-topped surfaces, is exposed in a small area east of the Mabeti but more widely on the west, where it rests unconformably on complicated structures of Palaeozoic formation that compose the north part of the Kitakami mountainland.

The Mabeti, the Appi,[26] and other tributaries drain and dissect the western region, which was once a relatively low relief surface and was partly covered with Quaternary volcanic detritus. Along these dissected valleys, two kind of terraces, upper and lower, are seen, with a narrow Alluvial flood plain developed between them. In general, the rivers are still deepening their floors between these two kinds of terraces, while an Alluvial flood plain is being developed in the valley bottom.

a. The Hukuoka pumice beds.

The upper one of these two terraces consists of thick pumiceous beds below which thin gravel beds sometimes lie on the bed rocks. The writer wishes to call these pumice beds the Hukuoka pumice beds, for

21) 磐城・常陸.

22) H. MATSUMOTO, "A Contribution to the Morphology, Palaeobiology and Systematic of *Desmostylus*," *Sci. Rep., Tôhoku Imp. Univ.*, [ii], 3 (1918).

23) H. MATSUMOTO, *op. cit.* (1923).

24) 北上. 25) 八戸. 26) 安比.

good exposures of them are seen on the terrace at the back of Hukuoka town. The pumice is basic andesite or augite andesite pumice. The size of the pumice is generally large, about 10 cm. or more in diameter.

These pumice beds are exposed along the Mabeti, the Appi, and the Zyûmonzi[27] valleys, but no traces of them are seen in the eastern tributaries of the Mabeti. The writer observed the Hukuoka pumice beds at Zyonbuzi[28] village, 16 km. west of the town of Itinohe.

Judging from the distribution of these Hukuoka pumice beds, the writer believes that this pumice was ejected from the volcano, that is situated in the western region, and which filled those valleys that were dissected by the ancesters of these rivers.

Since then these pumice-filled valleys were re-excavated by the streams and river floors were formed at the level of the lower terraces.

Even now, the rivers are still deepening their floor to fair depths, leaving the lower terraces above the present river floors in the form of patches along the river Mabeti.

Distribution of the Hukuoka pumice beds.

Along the Mabeti: Hukuoka pumice beds are seen on the terraces west of the village of Kintaiti,[29] 25 m. above the lower terrace, on which the main street of the village is situated. These western terraces consist of Hukuoka pumice beds resting with unconformity on Tertiary bed rock. The pumice beds are well exposed at the mouth of the Numakubo[30] valley along the stream which has cut the terrace surface.

On the cut wall between Kamayasiki[31] and Mainosawa[32] in the south spur of the mouth of Zyûmonzi valley, the pumice beds are exposed in cross bedded stratification.

The terraces 120 m. above sea-level and west of Kamimainosawa[33] village, are also composed of pumice beds. Two stepped terraces behind the town of Hukuoka consist of Hukuoka pumice beds (Fig. 4). The upper of these two is 150 m. above sea-level, while the lower is about 130 m. Judging from its height the latter terrace may be contemporaneous with the terraces at Mainosawa and Kintaiti.

In Itukamati[34] and Muramatu,[35] south of Hukuoka town, pumice beds are also well exposed. The walls of Hukuoka castle, now in ruins, at Itukamati, are of the same material as these pumice beds. The height of the terrace surface is about 130m. It may be contemporaneous with the lower pumice terrace near Hukuoka town.

27) 十文字. 28) 浄法寺. 29) 金田一. 30) 沼久保. 31) 釜屋敷.
32) 米ノ澤. 33) 上米ノ澤. 34) 五日町. 35) 村松.

Similar pumice beds and terraces exist at Uesato, Isikiridokoromura[36]. Near Torigo,[37] Nakano,[38] and Noduki,[39] similar pumice beds occupy wide areas, the terraces being about 180 m, above sea-level.

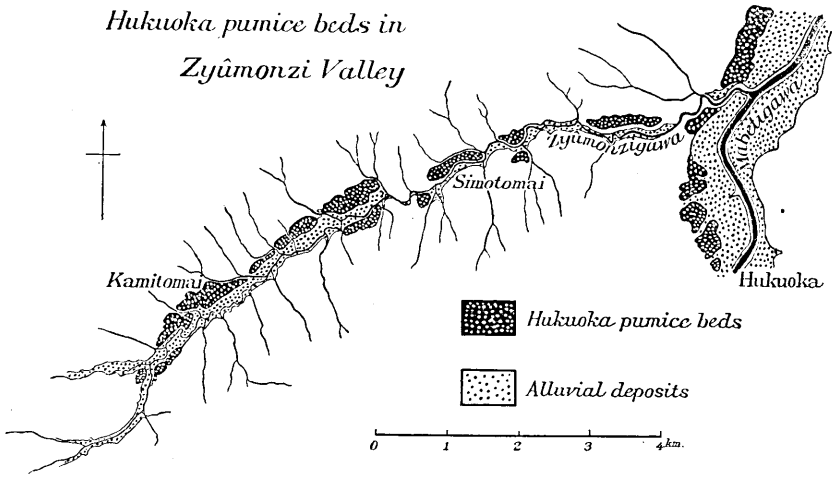

Fig. 1.

From Yagisawa,[40] west of Mabeti, to Hinokuti,[41] pumice beds are found near the termination of the mountain spur, both sides of which are deeply dissected by streams.

The small hill, southwest of Itinohe railway station, consists of Hukuoka pumice beds. Near Koida,[42] north of the town of Itinohe, crossbedded Hukuoka pumice beds, resting on the bed rocks, crop out on the walls of cuts along the new road from Itinohe to Narayama village.

The gently sloping terrace at the back of Nidatori[44] village along the Appi consists of these Hukuoka pumice beds.

A terrace consisting of these pumice beds is developed, 250～230 m. above sea-level, northwest of Zyonbuzi village, which is 20 km. west of the town of Itinohe, along the upper course of the Appi. This occurrence of Hukuoka pumice beds along the upper course of the Appi suggests that the pumice was wafted down from the upper course of the Appi.

On the valley floor of the Zyûmonzi, the pumice beds and the terraces they have formed are well preserved. The terraces, 180～200m. above sea-level at Kamitome.[45] Kodaira,[46] Tanaka,[47] Kadomatu,[48] Simo-

36) 石切所村上里. 37) 鳥越. 38) 中野. 39) 野月. 40) 八木澤. 41) 樋ノ口.
42) 小井田. 43) 檜山. 44) 似鳥. 45) 上斗米. 46) 小平. 47) 田中.
48) 門松.

tomai[49] consist of Hukuoka pumice. Though the writer did not survey the upper course of the Zyûmonzi valley, it seems certain that the pumice was wafted down from the upper course of the Zyûmonzi valley as in the case of the Appi. Fig. 1. shows the distribution of the pumice beds along the Zyûmonzi valley.

b. Gravels on the ridge of the mountain west of Hukuoka.

The ridge of the mountain (about 400 m. above sea-level) west of the Kitahukuoka railways station is a low relief surface covered with thin volcanic ashy soils resting on Tertiary bed-rock. This low relief surface continues southward to a height of about 400 m. above sea-level, while to the north it gradually becomes lower. Along the road from Okuyama,[50] Isikiridokoro-village, to Nidatori through Ôkubo,[51] thin beds of rounded pebbles are exposed on this low relief surface. Since of the rounded pebbles are Palaeozoic rocks. e.g. quartzite, graywacke sandstone, etc., the writer believes that these low reliefs of the ridge of the mountains may be remnants of the old erosion surface which was continuous with one another to the Paleozoic region to the east of this district. The western part of these low relief surfaces is covered with Quaternary volcanic material. These low relief surfaces then may antedate the formation of the Quaternary volcano of the western region. It is scarcely necessary to say that the formation of the low relief surface antedates the Hukuoka pumice beds. Judging from character of the gravels, the rivers that flowed over these low relief surfaces would have drained the Palaeozoic region (which probably was the Kitakami mountainland). The writer calls this low relief surface, the Ninohe surface.

c. Oritume-dake.[52]

As will be described later, Oritume-dake is a flat-topped mountain about 852m. above sea-level, and consists of Palaeozoic formation. It stands isolated and is about 400 m. above the Ninohe surface. The flat-topped surface is bounded on the north by the steep slope of Takaba,[53] Tukinokidaira,[54] and Ezonomori,[55] east of Nisatai[56] village (Fig. 6), on the south by the saddle of Kotôge (pass)[57], on the east by a steep fault-scarp like meridional slope, and on the west by the stepped slopes, and on the west by the stepped slopes rising from the Ninohe surface.

On account of the flatness of this mountain top and its steep boundaries, the writer first took the Oritume-dake to be a horst, or monad-

49) 下斗米. 50) 奥山. 51) 大久保. 52) 折爪岳. 53) 高場. 54) 槻木平. 55) 蝦夷ノ森. 56) 爾薩體. 57) 小峠.

nock, but after his geologic survey, he is convinced that it may be a sort of monadnock that resisted erosion through the hardness of its rocks.

The writer shares R. Tayama's[58] opinion that the steep eastern wall of Oritume-dake originated from a fault, but no evidence of any one-cycled fault scarp was found.

General stratigraphic succession.

The general stratigraphic successsion, according to the writer, of the district under discussion is as follows (Table I):

Table I.

Alluvial deposits. Lower terrace deposits. Hukuoka pumice deposits. Gravel beds on the Ninohe surface.			
Suenomatuyama series.		Mainosawa sands. (Nagamine[59] tuff sands.) Kamimainosawa[60] scoriaceous sands. Itukamati muddy sands. Anausi[61] sands.	*Pecten* beds. *Volsella* bed.
Kadonosawa series.	Upper Kadonosawa peries.	Kadonosawa beds. Sikonai alternation beds.	*Patinopecten* beds *Macoma* bed
	Lower Kadonosawa peries.	Tate scaly crushed black muds. Tate[62] *Ostrea* beds.	*Ostrea gravitesta* beds.
Yotuyaku series.		Upper plant beds. Upper agglomerate. Tuffaceous sandstone beds. Lower agglomerate. Koiwai[63] shell beds. Lower plant beds.	*Liquidamber* beds. *Crepidula jimboana* Yok. beds. *Sequoia* beds.
Nisatai liparite.			
Torigoe gabbro (and Sigetani[64] granite.)			
Palaeozoic formation.			

I. The Suenomatuyama series.

The Suenomatuyama series in this paper contain S. Shimizu's Suenomatuyama group and the Takamori group.

This series consist mainly of coarse grained sands (sometimes crossbedded), muddy sand, and scoriaceous sand. Its colour varies from bluish grey to dark brown. The type locality of this series is the *Patinopecten* bearing crossbedded sand that is exposed on the Namiuti

58) R. Tayama, (1930). 59) 長嶺. 60) 上米ノ澤. 61) 穴牛. 62) 館.
63) 小視. 64) 茂谷.

pass (or the Suenomatuyama pass) (Fig. 5). But besides this type locality, the Suenomatuyama series are well exposed along the river wall of the Mabeti and Siratori from the northern part of Hukuoka town to Anausi village in the Siratori[65] valley.

The stratigraphic succession of the Suenomatuyama series listed above is based on exposures in the latter locality.

Detailed descriptions of the Suenomatuyama series.

Between Mainosawa and Anausi.

(*a*) Mainosawa sands: The dark greyish sand beds exposed near the mouth of the Zyûmonzi valley dip about 5°–10° southwestward. But following this exposure to the south along the Mabeti valley, the angles of dip of the sand beds gradually decrease, while the direction of the dip changes to the north, forming a syclinal structure.

On account of the northward dip, the lower beds from here gradually begin to appear toward the upper course. Below the Mainosawa sand beds, which the writer calls the dark greyish sand beds as mentioned above, the brachiopoda bearing coarse-grained sands are exposed under the bridge between Kamimainosawa and Nagamine village. These coarse-grained sands beds consist of scoriaceous breccia, tuffaceous fragments, and coarse grained sand derived from other material.

The fossil mollusca collected from these coarse-grained sand beds are (Loc. 34 in Fig. 2).

Chlamys hastatus aff. *ingeniosa* Yokoyama.
Chlamys kotorana Otuka.
Chlamys sp.
Pallium swiftii etchegoini (Anderson).
Patinopecten tokyoensis kimurai (Yokoyama).
Venericardia ferruginosa (Adams et Reeve).
Spisula sp.
Panope japonica A. Adams.
Hemithyris posittaceae woodwardi Adams.
Terebratalia sp. 1.
Copotothyris grayi aomoriensis Hayasaka.
Magellania lenticularis innaiensis Hayasaka.
Magellania sp.
Laqueus rubellus Sowerby.

65) 白鳥澤.

Balanus sp.

Similar coarse-grained sand beds are exposed at the western foot of mount Takamori, east of Nagamine village. Here is the type locality of S. Shimizu's Takamori group.

The writer calls these fossiliferous sand beds the "Nagamine Sands"

Fossils from Nagamine Sands were collected from the north wall of a small valley to the east behind Nagamine village and from the east wall on the road from Nagamine to Takamori. The following fossils were collected from Loc. 38. in Fig. 2.

Pallium swiftii etchegoini (Anderson).
Patinopecten tokyoensis kimurai (Yokoyama).
Epitonium (*Boreoscala*) *nagaminensis* Otuka.
Coptothyris grayi aomoriensis Hayasaka.
Magellania lenticularis innaiensis Hayasaka.

Near the town of Hukuoka, the Nagamine Sands are underlain by black andestic breccia bearing tuffaceous sand beds, called by the writer the Kamimainosawa beds.

(*b*) The Kamimainosawa beds are bare of fossils. These beds are exposed along tne Mabeti from the mouth of a small stream at Kamimainosawa to the junction of the Siratori valley and the Mabeti at the town of Hukuoka. The lower part of these beds intercalate with scoria-rich subconsolidated tuff breccia beds. Back of Okuyama, at Isikiridokoromura the materials forming these breccia beds gradually increase in size, and change into agglomerates.

(*c*) The Itukamati Muddy Sand: The Kamimanoisawa beds are underlain the muddy sands as exposed under the bridge between Hukuoka town and Itukamati, at the mouth of Siratori valley. The writer calls these underlying beds Itukamati Muddy Sands. These beds consist of unstratified greyish muddy sand, the upper part of which is barren of fossils but contains sand pipe nodules.

The middle part of these muddy sand beds is rich in *Volsella barbata* (Linné). The lower part of the Itukamati Muddy Sands is underlain by fossiliferous Anausi Sands.

(*d*) The Anausi Sands exposed at the junction of the Siratori valley and the Anausi valley bear many fossil mollusca. Following exposures of these sand beds along the Siratori valley, the underlying Kadonosawa series appear on the valley floor with almost parallel unconformity.

This unconformity between the basal part of the Suenomatuyama series and Kadonosawa series is well exposed on the southern wall of the Siratori valley, near Kadonosawa.

The fossils collected from the Anausi sands, beside a whale rib collected from the valley floor near Anausi (Loc. 36 in Fig. 2), are

Volsella barbata (Linné).
Patinopecten tokyoensis kimurai (Yokoyama).
Patinopecten healey yamasakii (Yokoyama).
Pallium swiftii etchegoini (Anderson).
Panope japonica A. Adams.
Clementia ? sp.
Dosinia ? sp.
Chrysodomus modestus Kuroda.
Hemithyris psittaceae woodwardi Adams.
Linthia sp. 1.

As already mentioned, the stratigraphic succession of the Suenomatuyama series is very variable in its rock facies. The lateral changes of the rock facies are also variable. Consequently, the stratigraphic succession established along the Mabeti river and the Siratori valley as listed above is not directly applicable to the other localities of the Suenomatuyama series. But the stratigraphic succsssion of the Suenomatuyama series listed above is based on exposures more complete than in any other locality.

Near Isikiridokoro.

Following the exposures of the Suenomatuyama series along the Mabeti river from the mouth of the Siratori valley southward, a succession of strata is exposed similar to that seen in the Siratori valley; (loc. 16 in Fig. 2) so is the *Volsella barbata* (Linné) bed of the Itukamati Muddy Sands, as already noted. But these muddy sands are directly underlain by Kadonosawa series without any Anausi sand.

Distribution of the Mainosawa Sand beds in other localities.

Gentle synclinal Mainosawa sand beds near Mainosawa are exposed in the Zyûmonzi valley, and are cut by the Zyûmonzi-Yuda fault line, which will be described later. Very loose sands exposed near a mill at the mouth of the Zyûmonzi valley, containing *Patinopecten tokyoensis kimurai* (Yokoyama) and other mollusca, are the same beds as the Mainosawa Sands.

Distribution of the Nagamine sand beds.

These beds, which contain many fossil *Brachiopoda* and *Pectininae*,

and which crop out under the bridge between Mainosawa and Nagamine, are also exposed at Kamayasiki in the Zyûmonzi valley and in the Numakubo valley.

Fossil localities of this beds are locs. 31, 32, 33 & 42 in Fig. 2.

The fossils collected from the localities are listed in Table II.

In the Numakubo valley, near Kintaiti, fossiliferous coarse grained sand beds overlie the muddy beds of the Kadonosawa series with slight unconformity. These beds are exposed in the valley for some distances. But the sand grains of these beds increase in size. The calcareous beds consisting of *Balanus* shells overlie these sand beds almost with conformity.

These beds strikes N. 10° E., and dip westward 10°.

Calcareous beds similar to the foregoing are observed southeast of Nisatai village, in a valley floor situated east of a point 424 m. north of Oritume-dake, and also in the valley wall of Toyama[66] of the first named locality in Numakubo valley. Of these *Balanus* limestones, those of Numakubo and Toyama are supposed to be contemporaneous, while the other two localities are older than the two just mentioned.

The *Balanus* limestone in the valley of Toyama is exposed back of the mill in the eastern part of Toyama village. No southern continuation of this limestone bed is found in the Zyûmonzi valley.

The *Brachiopoda* and *Pectininae* bearing sand beds mentioned contain the following fossils:

Pallium swiftii etchegoini (Anderson).
Pallium swiftii nutteri (Arnold).
Patinopecten tokyoensis kimurai (Yokoyama).
Patinopecten healey yamasakii (Yokoyama).
Hemithyris psittaceae woodwardi Adams.
Coptothyris grayi aomoriensis Hayasaka.

Judging from these species, these sand beds may be contemporaneous with the Anausi beds or the Nagamine sands of the Suenomatuyama series. But a stratigraphic difference between these beds and the Sand beds is observable. If these beds are contemporaneous with the Anausi, the sands should then be overlain by the muddy sand that tops the Anausi sand, but such muddy sands are absent above these sand beds, and if the beds are of Nagamine sand, the underlying Kamimainosawa sand is absent. But these stratigraphic differences may be explained

66) 外山.

by overlaps of the beds, or by the activity of the primary Zyûmonzi fault. The writer believes that these beds may be the Nagamine Sands. A similar stratigraphic relation is observed near the mouth of Zyûmonzi valley. Following the Zyûmonzi valley upstream, in the next eastern of Kamiyama,[67] *Pecten*-rich sand are exposed on top of the Kadonosawa series. Above this sand ride the Mainosawa Sand beds. Then Mainosawa Sands in Zyûmonzi valley are overlain by other loose sands in which are found *Patinopecten tokyoensis murayamai* (Yokoyama) and *Panomya simotomensis* Otuka.

These *Patinopecten* bearing Sand beds are overlain by scoriaceous sandstone beds, exposed along the Zyûmonzi valley, west of Zyûmonzi, from which *Charcharodon megarodon* Charlesworth was collected. These shark's teeth beds may be contemporaneous with these of Nagakubo[68] that were reported by Prof. S. Nakamura and S. Shimizu.

Patinopecten tokyoensis murayamai (Yokoyama), which was first described from the Sandy Shale beds of the Akita oil-field, was collected from these Sand beds with other species of *Patinopecten*. The writer failed to obtain this species from any of the other horizons below these beds.

Distribution of the Kamimainosawa beds.

The Kamimainosawa beds have characteristics in its rock facies but their distribution are unknown. It is interesting to find that the Aikawa[69] agglomerate beds intercalate with these beds.

The Aikawa agglomerate beds are those agglomerate beds and two-pyroxene-andesite mass that are exposed along the Mabeti and Appi near Aikawa, southwest of Hukuoka town. On the northern slope of Nidatori, Gohentimura, these agglomerate beds, which contain fossil marine mollusca of the Suenomatuyama series, alternate with tuffaceous sandstone beds. On the western ridge of the Suenomatuyama pass (Namiuti[70] pass), similar agglomerate beds are exposed (Fig. 7).

On the west valley wall on the northern slope of the pass, the Suenomatuyama series rest unconformably on the next older Kadonosawa series (Fig. 8).

The Itukamati beds are exposed on the top of the pass between Hukuoka and Ezonomori, east of Hukuoka town. Similar beds form the mountain top (448 m. high northeast of the town of Itinohe and

67) 神山. 68) 長久保. 69) 合川; Green-hornblende-porphyrite associates with this volcanic mass near Okuyama. 70) 浪打峠.

north of Narayama). *Volsella barbata* (Linné) and *Patinopecten tokyoensis kimurai* (Yokoyama) are the common species in his Suenomatuyama series.

The beds which rest unconformably upon the Kadonosawa series and are exposed on the west wall of Siratori valley, near Sikonai and Kadonosawa, may be the Itukamati beds. The Anausi sands are not found here. They are limited to near Anausi, and are not elsewhere in this region.

Tne Suenomatuyama series east of Itinohe town.

The ridge running northeast from a point 356 m. east of the town of Itinohe, consists of sand beds of the Suenomatuyama series capping

Table II. (Fauna of the Suenomatuyama series).

Chlamys hastatus aff. *ingeniosa* Yokoyama.	30	—	-	—	34	—	—	—	—	—	—	—	—
Chlamys kotorana Otuka.	—	—	—	—	34	—	—	—	—	—	—	—	—
Chlamys sp.	—	—	—	—	34	—	—	—	—	—	—	—	—
Pallium swiftii etchegoini (Anderson).	30	31	32	33	34	—	36	—	38	—	40	—	42
Pallium swiftii nutteri (Arnold).	—	31	—	33	—	—	—	37	38	—	—	—	42
Patinopecten tokyoensis kimurai (Yokoyama).	30	31	32	33	34	35	36	37	38	39	40	41	42
Patinopecten tokyoensis murayamai (Yokoyama).	—	—	—	—	—	—	—	—	—	39	—	—	—
Patinopecten healey yamasakii (Yokoyama).	—	—	32	33	—	—	36	—	—	—	—	—	—
Volsella barbata (Linné).	—	—	—	—	—	35	36	—	—	—	—	—	—
Venericardia ferruginosa (Adams et Reeve).	—	—	—	—	—	—	—	—	—	39	—	—	—
Dosinia sp.	—	—	—	—	—	—	36	—	—	—	—	—	—
Spisula ? sp.	—	-	—	—	34	—	—	—	—	39	—	—	—
Panope japonica A. Adams.	—	—	—	—	34	—	36	—	—	—	—	—	—
Panomya simotomensis Otuka	—	—	—	—	—	—	—	—	—	39	—	—	—
Acmaea sp. 1.	—	—	—	—	—	—	—	37	—	—	—	—	—
Turritella fortilirata kadonosawaensis Otuka.	—	—	—	—	—	—	—	—	—	?	—	—	—
Epitonium (*Boreoscala*) *nagaminensis* Otuka.	—	—	—	—	—	—	—	—	38	—	—	—	—
Chrysodomus modestus Kuroda.	—	—	—	—	—	—	36	37	—	—	—	—	—
Fulgoraria (*Fulgoria*) *rupestris* (Gmelin).	—	—	—	—	—	—	—	—	—	39	—	—	—
Hemithyris psittaceae woodwardi Adams.	30	31	—	—	34	—	—	—	—	—	—	—	—
Terebratalia ? sp. 1.	—	—	—	—	34	—	—	—	—	—	—	—	—
Coptothyris grayi aomoriensis Hayasaka.	—	31	—	—	34	—	36	—	38	—	40	—	—
Magellania lenticularis innaiensis Hayasaka.	—	—	—	—	34	—	—	—	—	—	—	—	—
Laqueus rubellus Sowerby.	—	—	—	—	34	—	—	—	—	—	—	—	—
Linthia sp.	—	—	—	—	—	—	36	—	—	—	—	—	—
Echinarachnius sp.	—	—	—	—	—	—	—	—	38	—	—	—	—
Whale's rib.	—	—	—	—	—	—	36	—	—	—	—	—	—

(Numerals show the number of locality in Fig. 2.)

the Kadonosawa series. Many fossil remains were collected from loc. 30 in Eig. 2.

From fragments of *Balanus*, *Patinopecten tokyoensis kimurai* (Yokoyama), *Pallium swiftii etchegoini* (Anderson), *Chlamys ingeniosa* Yokoyama, *Hemithyris psittaceae woodwardi* Adams, the writer concludes that these sand beds may be contemporaneous with the Suenomatuyama series.

The Suenomatuyama series near Nidatori.

The Suenomatuyama series are exposed near Nidatori, but no fossils were collected there.

The stratigraphy considered from the fossils collected from the Suenomatuyama series.

The fossils collected from the Suenomatuyama series are as follows (Table II):

Comparing the fossils collected from the Suenomatuyama series as in the foregoing table, with those from other localities in Japan, it is found that nearly all the species have been reported from the lower Pliocene beds of Japan. The writer therefore believes that the Suenomatuyama series may be contemporaneous with the basal part of so-called Sandy Shale beds or the Alternation of Sand and Shale in the oil-field of Northeast Japan, namely, Chitani's[71] Yuri series. The Sandy Shale beds and the Alternation of Sand and Shale are supposed by Japanese geologists to be lower Pliocene and, sometimes, upper Miocene. The Ogawa beds of Middle Sinano[72] may also be contemporaneous with the Suenomatuyama series. They are correlated with the Etchegoin and San Pablo formations of California.[73] Some fossil shells from the lower part of the Zyôban coal-bearing beds[74] are also identical with the Suenomatuyama series. The age of the Suenomatuyama series may

71) Y. CHITANI, "On Geology of Oilfield in North Akita, *Jour. Geol. Soc., Tokyo*, **37** (1930), 732-739, (in Japanese).

M. YOKOYAMA, "Fossil Mollusca from the Oil-Fields of Akita," *Jour. Fac. Sci., Imp. Univ., Tokyo*, **1**, (1926), 377.

72) F. HOMMA, "Geology of Middle Part of Sinano," (1931), (in Japanese).

M. YOKOYAMA, "Tertiary Mollusca from Shinano and Echigo," *Jour. Fac. Sci., Imp. Univ., Tokyo*, **1** (1925), 1-23.

T. KURODA, "Geology of Middle Part of Sinano," of Homma, (1931), (in Japanese).

73) J. MAKIYAMA, *Tikyû*, **8** (1927), 181-188, (in Japanese).

74) M. YOKOYAMA, *Jour. Coll. Sci., Tokyo Imp. Univ.*, **45** (1925).

then be lower Pliocene or upper Miocene.

II. The Kadonosawa series.

The Kadonosawa series is a widely exposed formation overlain by the Suenomatuyama series with unconformity. The name comes from Kadonosawa, 2 km. east of Hukuoka town. Tuffaceous muddy sandstone or sandy mud formation, exposed of the floor of Siratori valley, near Kadonosawa, is the type. The Kadonosawa series consist of fossiliferous tuffaceous sandy mud and dark mud, which are tinged a bluish grey or bluish white, and are sometimes conglomerate at its base. The succession of strata forming the Kadonosawa series is well exposed along the wall of the Siratori valley between Anausi and Sakamoto.[75]

(*a*) The Kadonosawa beds: The upper part of this series is the massive fine-grained muddy sand directly overlain by the Suenomatuyama series. These the writer calls the Kadonosawa beds.

(*b*) The Sikonai beds: The next underlying beds are alternation of sand and mud, called the Sikonai sand beds.

(*c*) The Tate beds: The Sikonai sand beds are underlain by the Tate crushed scaly black mud beds, below which lie the Tate *Ostrea* beds.

The writer divides this series into two, the upper and the lower. The upper part of this series consists of the Kadonosawa beds and the Sikonai alternation, while the lower consists of the Tate crushed scaly mud beds and the Tate *Ostrea* beds, in which *Ostrea gravitesta* Yokoyama is common. These *Ostrea* beds are the base of the Kadonosawa series. The Yotuyaku series (continental deposits) develop below these beds. This stratigraphic relation holds in every exposure of these *Ostrea* beds of the Kadonosawa series. The writer therefore concludes that the Tate *Ostrea* beds near Sakamoto in the Siratori valley are types of the basal facies of the Kadonosawa series.

Detailed description of the Kadonosawa series.

(*a*) The Kadonosawa beds.

These beds are exposed below the Suenomatuyama series in the Siratori valley, near Sikonai and Kadonosawa. The upper part of these beds consist of muddy sand, and are rich in *Patinopecten tokyoensis*

75) 坂本.

kimurai (Yokoyama). The beds strike in a N–S direction, with a slightly westward dip. Loc. 22 in Fig. 2 is the fossil locality of these sand beds, from which the fossil mollusca collected were

Nuculana nidatoriensis Otuka.
Yoldia thraciaeformis Storer.
Yoldia intermedia kadonosawaensis Otuka.
Arca amicula Yokoyama.
Ostrea gigas Thunberg.
Patinopecten tokyoensis kimurai (Yokoyama).
Cardium sp.
Macoma optiva (Yokoyama).
Cultellus izumoensis Yokoyama.
Mactra sp.
Calyptrea sp. 1.
Cylichna sp.

The lower part of these beds intercalate with thin pumice bearing beds alternation with sandy mud beds. The following fossils were collected from these beds at locality 21 in Fig. 2. *Macoma tokyoensis* Makiyama and *Macoma optiva* (Yokoyama) are common species in these beds, which may be the *Tellina* beds of S. Shimizu.

Yoldia thraciaeformis Storer.
Yoldia intermedia kadonosawaensis Otuka.
Yoldia sagittaria Yokoyama.
Arca amicula Yokoyama.
Patinopecten tokyoensis kimurai (Yokoyama).
Venericardia ferruginea (Adams).
Clementia subdiaphana Carpenter.
Macoma optiva (Yokoyama).
Macoma tokyoensis Makiyama.
Cultellus izumoensis Yokoyama.
Turritella fortilirata kadonosawaensis Otuka.
Crepidula sp.
Polinices fissurata (Kuroda).
Sinum yabei Otuka.

It will be seen from the foregoing that the pelagic species, e. g., *Yoldia* are numerous in these beds. This alternation is exposed in the Tunagi valley northeast of Kadonosawa.

Owing to the direction of the Siratori valley between Sikonai and Kagitori being parallel to the strike of the Kadonosawa series, the

stratification of this series exposed on this valley wall seems to be almost horizontal. The unconformity between the Suenomatuyama series and the Kadonosawa series is exposed on the same valley wall.

(*b*) Sikonai alternation beds.

These beds are alternations of tuffaceous mud and sand beds, developed near the junction of the Numanotai[76] and the Siratori valley. The upper part of this alternation contains *Yoldia*, *Patinopecten*, *Macoma*, and *Venericardia*, while its lower part has rarely any fossils. These beds are exposed also in the Tunagi valley, and in the Oosimizu valley, northeast of Yuda village.

(*c*) The Tate crushed scaly black mud overlain by the Sikonai alternation are dark greyish, very fine crushed scaly mud, and rarely contain fossils. These beds which are always found associated with the next underlying Tate *Ostrea* beds, are exposed above the Tate *Ostrea* beds at Yuda, Tunagi valley, Narayama valley, etc. The thicknesses of the beds vary.

The Tate *Ostrea* beds which are represented by *Ostrea gravitesta* Yokoyama consist of conglomerate and sands, and are generally consolidated with calcareous matter. Below then generally lie irregularly stratified sand of the Yotuyaku series. The Tate *Ostrea* beds are exposed on the floors of the Siratori and Numanotai valleys near Tate.

The Tate *Ostrea* beds contain many fossils. The upper Kadonosawa series contain many open sea shells as already mentioned, while those of the Tate *Ostrea* beds are estuary, e. g., *Ostrea*, *Batillaria*, etc.

The Tate crushed scaly muds and the Tate *Ostrea* beds consist of the lower part of the Kadonosawa series as already stated. S. Shimizu's Yuda group and the Nisatai group are contemporaneous deposists with the lower part of the Kadonosawa series. The writer is convinced that these two groups and the lower part of the Kadonosawa series should not be superposed one above the other with unconformity as done by S. Shimizu, but should be arranged in one formation. The horizon of *Desmostylus japonicus* Yoshiwara and Iwasaki can then be also placed on a horizon in this region.

Distribution of the Kadonosawa series.

Siratori valley.

The strata succession of the Kadonosawa series in the Siratori

76) 沼ノ平.

valley has been described in a previous paragraph.

South of Tate, the Kadonosawa series are exposed on the west wall of Siratori valley, and the Tate *Ostrea* beds are exposed on the floor of every western tributary of the Siratori valley. At the back of the temple, west of Siratori village, Tate *Ostrea* beds are exposed. From the latter locality (loc. 7 in Fig. 2) the following fossils were collected,

Nuculana confusa kongiensis Otuka.
Yoldia sp. 3.
Arca amicula Yokoyama.
Arca ninohensis Otuka.
Ostrea gigas Thunberg.
Ostrea gravitesta Yokoyama.
Ostrea rosacea? Deshayes.
Chlamys islandicus nisataiensis Otuka.
Lucina (*Myrtea*) *yokoyamai* Otuka.
Taras ferruginata (Makiyama).
Cardium shinjiense Yokoyama.
Cardium sp.
Paphia siratoriensis Otuka.
Macrocallista pacifica (Dillwyn).
Dosinia japonica nomurai Otuka.
Macoma optiva? Yokoyama.
Solen sp.
Aloidis erythrodon nisataiensis Otuka.
Panope japonica A. Adams.
Zirphaea subconstricta (Yokoyama) *kotorai* Otuka.
Batillaria yamanarii Makiyama.
Batillaria tateiwai Makiyama.
Calyptrea yokoyamai tubura Otuka.
Polinices fissurata (Kuroda).
Polinices (*Euspira*) *meisensis* Makiyama.
Sinum yabei Otuka.
Surculites sp.
Suavodrillia makiyamai Otuka.
"*Cantharus*" *nakamurai* Otuka.
Nassarius simizui Otuka.
Nassarius kometubus Otuka.
Cancellaria spengleriana Deshayes.

Ringicula ninohensis Otuka.
Linthia sp.

The Kadonosawa series are exposed in the Narayama valley, which runs eastwardly from Koida, north of the town of Itinohe.

The Tate *Ostrea* beds are exposed on the terrace scarp, on the river side, behind Narayama village (loc. 8 in Fig. 2). The following species were collected from this locality. The Tate *Ostrea* beds here consist of conglomerate and sand, and large blocks of it are scattered on the valley floor near Hirahune.

Arca ninohensis Otuka.
Ostrea gravitesta Yokoyama.
Taras ferruginata (Makiyama).
Cardiun shinjiense Yokoyama.
Clementia subdiaphana yazawaensis Otuka.
Macoma optiva (Yokoyama).
Tellina nitidula Dunker.
Panope japonica A. Adams.
Cerithium atukoae Otuka.
Polinices meisensis Makiyama.

A small vertical fault runs through the Narayama valley, the north side of the fault being upheaved relatively to the opposite side, but the amount of displacement is only a few meters.

In the upper course of the Narayama valley, conglomerates of the Yotuyaku series are exposed, but without any Tate *Ostrea* beds.

The Kadonosawa series are exposed along the pass from Narayama to Takada,[77] and Sukohata.[78] This series here is almost horizontal, with strike N. 20° W., and a westwardly dip of 3°–5°.

On the valley floor, at the west of Hirahune, cracked platy Palaezoic quartzite is exposed, overlain directly by yellowish tuffaceous sand of the Kadonosawa series without any basal conglomerate. The southern slope of the Suenomatuyama pass is the locality for exposure of the Kadonosawa series, the basal gravel beds of the Kadonosawa series being exposed at the mouth of the western valley of this slope.

The town of Itinohe.

Itinohe valley.

The lower part of the hill back of the town of Itinohe consists of the Yotuyaku series, but the upper part of it consists mainly of the

77) 高田. 78) 双畑.

Kadonosawa series. The thickness of the Kadonosawa series here varies from about 120m. in the west part of this hill to about 50m. in the southeast. The series is overlain by the Suenomatuyama series forming a cap structure.

Fossils are rare in the Kadonosawa series here, where the writer collected some specimens of *Patinopecien tokyoensis kimurai* (Yokoyama) and *Cultellus izumocnsis* (Yokoyama).

Ostrea beds are exposed along both walls of the valley that runs from the back of Zizôdô,[79] north of the town of Itinohe southwestward. The fossils from here are ill preserved but a few specimens were collected from loc. 10, Fig. 2.

In the Kiredi[80] valley, southeast of the town of Itinohe large blocks containing *Ostrea gravitesta* Yokoyama were found.

Along the new road through Tyokai[81] village, in Saihôzi[82], west of Itinohe railway station, Tate *Ostrea* beds are exposed, underlain by the Nisatai liparite mass.

On account of its weathered condition, the geologic structures of the *Ostrea* beds here could not be worked out.

The Kadonosawa series near Sodenokota,[83] west of Saihôzi, rest unconformably upon Palaeozoic rocks, gabbro, and liparite. The writer collected *Arca amicula* Yokoyama from this locality.

Surveying the 438·5m. ridge south of Sarugasawa[84], along the road from the town of Itinohe eastward the Suenomatuyama series gradually thins out southwest of Sarugasawa, while the next underlying Kadonosawa series thins out at the saddle east of this 438·5 meter point.

Isikiridokoro village.

Near the Kitahukuoka railway station, the Kadonosawa series, which intercalates with the agglomerate beds, rest para-unconformably on the Kadonosawa series.

The other exposures of the Kadonosawa series near Isikiridokoro village are west of the southern end of the railway bridge over Mabeti river and the river cliffs along the Mabeti from the vicinity of the railway bridge to the wooden bridge over the Mabeti in Isikiridokoro village. Some fossil specimens were collected from the former exposure. The Kadonosawa series here are flexed upward by intrusion of the Aikawa andesite mass.

Nisatai and Yuda

79) 地藏堂. 80) 切地. 81) 烏海. 82) 西法寺. 83) 袖ノ子田. 84) 猿ケ澤.

As will be described later, Nisatai and Yuda are intersections of many fault lines, besides which, as already noted by another author,* are many landslides. On account of these tectonic characteristics, the geologic structure here is very complicated, as may be seen by the exposures on the cliffs of the river Mabeti near these villages. It is therefore difficult to study the succession of strata without any clues, but fortunately the writer found no difficulty in tracing the geologic structure from the Tate *Ostrea* beds which are occasionally exposed here.

For convenience, this part will be divided into five subparts for description in detail.

1. The Tunagi valley[85] is a fault valley. East of the fault is the down-thrown side. But its displacement is very small, only about ten odd meters. The black sand and the muddy sand of the upper Kadonosawa series is exposed at the mouth of the western valley of Nisatai village. These beds are then underlain by aggolomeratic *Ostrea* limestone that may be contemporaneous with the Tate Ostrea beds. These limestone beds consist of large subangular andesite blocks and contain *Ostrea gravitesta* Yokoyama, foraminifera, and corals. They are cut by the Tunagi fault in a north-south direction, while on the east of this fault, the muddy sand beds of the upper Kadonosawa series reappear with flexed structure. Exposures of this fault are seen on the floor of the valley west of Nisatai village, and south of Natumaki.[86] The upper Kadonosawa series are exposed in the upper course of this valley, also a little north of the road from the town of Hukuoka to Ezonomori in this valley. The crushed scaly mud of the lower Kadonosawa series are exposed 600m. east from Tunagi village, but without any Tate *Ostrea* beds. The fossil mollusca from the Tunagi valley are *Patinopecten tokyoensis kimurai* (Yokoyama), *Turritella fortilirata kadonosawaensis* Otuka.

2. Nisatai valley is a valley that branches from the river Mabeti at Yazawa, cutting through the middle of Nisatai village. The Tate *Ostrea* beds are exposed under a small bridge on the Karume[87] highway and continue to the southern end of Nisatai village.

The following species were collected from the northern part of Nisatai village in this valley:

Ostrea gravitesta Yokoyama.

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85) 繋. 86) 夏間木. 87) 軽米.

* *Jour. Geol. Soc., Tokyo*, 8 (1901), 92.

Lucina (Myrtea) yokoyamai Otuka.
Pillucina pisidium nisataiensis Otuka.
Pillucina contraria (Dunker).
Taras ferruginata (Makiyama).
Dosinia japonica nomurai Otuka.
Dosinia nagaii Otuka.
Sanguinolaria (Soletellina) minoensis Yokoyama.
Panope japonica (A. Adams).
Proclava ishiianum (Yokoyama).
Bedeva nakamurai Otuka.
Conus tokunagai Otuka.

The following were collected from coarse grained sand in the Nisatai village in this valley:

Arca ninohensis Otuka.
Ostrea gravitesta Yokoyama.
Ostrea rosacea Deshayes.
Patinopecten tokyoensis kimurai (Yokoyama).
Chlamys islandicus nisataiensis Otuka.
Lucina (Myrtea) k-hataii Otuka.
Pillucina pisidium nisataiensis Otuka.
Taras ferruginata Makiyama.
Cardium shinjiense Yokoyama.
"*Paphia*" *siratoriensis* Otuka.
Cyclina sinensis Gmelin.
Aloidis erythrodon nisataiensis Otuka.
"*Minolia*"*? sasai* Otuka.
Polinices fissurata Kuroda.
Polinices didyma (Bolten).
Tritonaria sp.
Nassarius kometubus Otuka.
Olivella consobrina (Lischke).
Cancellaria spengleriana Deshayes.
Balanus sp.
Echinodermata gen. sp.

The southern end of the Tate *Osrtea* beds here, which are underlain by the Nisatai liparite with unconformity, contain *Ostrea gravitesta* Yokoyama, *Pitar yabei* Otuka and *Astryclypeus* sp. etc.

Nisatai liparite is exposed in the Nisatai valley for a distance of about 2km. The fossils from this Nisatai valley are listed in Table IV.

As the direction of the Nisatai valley near Nisatai village is parallel to the strike of the basal part of the lower Kadonosawa series, the Tate *Ostrea* beds are exposed for long distances in the Nisatai valley.

On the road from Nisatai village to Ohagino[88] in the southern end of Nisatai village, *Balanus* limestone is exposed, associated with *Ostrea* beds. This is the lower *Balanus* limestone already referred to.

3. In Yuda, the Tate *Osrtea* beds and the Yotuyaku series are exposed as a complicated structure In loc. 5, Fig. 2., at Yazawa along the east shore of the Mabeti, Tate *Ostrea* beds appear in the north, dipping at about 20~30 degrees, and whence many specimens of *Macoma optiva* (Yokoyama) were collected. The following species were collected from here. These *Ostrea* beds are exposed also on the opposite side (loc. 1 in Fig. 2) of the Mabeti river.

Arca trlincata Conrad.
Arca ninohensis Otuka.
Ostrea gravitesta Yokoyama.
Patinopecten tokyoensis kimurai (Yokoyama).
"*Paphia*" *siratoriensis* Otuka.
Clementia subdiaphana yazawaensis Otuka.
Cyclina sinensis Gmelin.
Dosinia japonica nomurai Otuka.
Macoma optiva (Yokoyama).
Panope japonica A. Adams.
Cerithium atukoae Otuka.
Polinices meisensis Makiyama.
Polinices fissurata Kuroda.
Surculites sp.
Fusinus sp.

On the eastern cliff on the northwestward curve of the Mabeti, many fossils were collected from exposed loose soft muds containing large marly nodules and steeply inclined. *Ostrea gravitesta* Yokoyama, *Polinices fissurata* Kuroda, and *Cerithium atukoae* Otuka are the common species in these beds. The underlying greyish white or greyish black soft mud here are bare of fossils.

Tate *Ostrea* beds are exposed also on the west side of the Mabeti (loc. 2, Fig. 2).

The fossils from here resemble those from Yazawa. On the river

88) 大荻野.

cliff at Kobayasi, Tate *Ostrea* beds and crushed scaly mud beds are exposed in flexed structures. These *Ostrea* beds are underlain with para-unconformity by the Yotuyaku series, containing *Unio kobayasiensis* Otuka.

The mud beds of the Tate *Ostrea* beds, which are exposed in the valley of Osimizu,[89] are ovarlain by the upper part of the Kadonosawa series.

In the Komaki[90] valley, the Kadonosawa series partly resembles the Black Shale formation in the oil-fields of northeast Japan. The series here rarely contain fossils. The writer collected *Patinopecten tokyoensis kimurai* (Yokoyama) from the west valley of Osimidu and the Komaki.

Yuda seems to be a weak tectonic part of this district. Mineral water issues and metamorphoses the rocks into loose greyish muds, very susceptible to landslides.

4. Near Ohagino, in the upper part of Nisatai village, Palaeozoic formation is exposed in a small area, its eastern part being covered by the Kadonosawa series with unconformity. The basal part of this Kadonosawa series, the Tate *Ostrea* beds, are exposed with many molluscan remains (loc. 9 in Fig. 2).

5. Kintaiti. The Kadonosawa series on the lower course of the Mabeti are exposed between Kintaiti and the railway bridge of the Mabeti, north of Kintaiti, and are overlain by the Syobuzawa[91] agglomerate (two pyroxene andesite) beds of the Suenomatuyama series. The fossils were collected from the black sand beds exposed along the west shore of the Mabeti.

The Kadonosawa series are exposed on the steep west cliff at the back of the Kintaiti railway station, but its southern extention is cut by the Zyûmonzi fault, by which this series is in direct contact with the Suenomatuyama series.

In view of these observations of all the outcrops of the Kadonosawa series and the collected fossils, the writer is convinced that the Tate *Ostrea* beds form the basal part of this series. They contain *Ostrea gravitesta* Yokoyama, and rest upon freshwater deposits or upon other older rocks. S. Shimizu's lower part of the Kadonosawa, the Nisatai, and the Yuda groups are contemporaneous with the Tate *Ostrea* beds.

Near Nidatori.

In the Nidatori region are isolated exposures of the Kadonosawa

89) 大清水. 90) 駒木. 91) 菖蒲澤.

series from the previous region due to extrusion of the Aikawa agglomerate. But as this series exposed here contain Molluscan remains which resemble those of the upper Kadonosawa series mentioned above, and are overlain by the Aikawa agglomerate beds of the Suenomatuyama series, the writer believes that this series may be contemporaneous with the Kadonosawa series.

The following are the fossils from the Kadonosawa series in Nidatori village (loc. 17 in Fig. 2.)

Yoldia cooperi ochotensis Khomenko.
Nuculana nidatoriensis Otuka.
Arca amicula Yokoyama.
Patinopecten tokyoensis kimurai (Yokoyama).
Lucina acutilineata Conrad.
Macoma tokyoensis Makiyama.
Macoma optiva (Yokoyama).
Cultellus izumoensis Yokoyama.
Venericardia ferruginea (Adams).
Cryptomya bussoensis Yokoyama.
Panope japonica A. Adams.
Panomya simotomensis Otuka.
Dentalium (*Fissidentalium*) sp.
Turritella fortilirata kadonosawaensis Otuka.
Crepidula nidatoriensis Otuka.
Chrysodomus modestus Otuka.

A molluscan fauna similar to that of Nidatori occurs at Hatimae, south of Nidatori (loc. 28 in Fig. 2.)

Geologic age of the Upper Kadonosawa series.

The fossils from the Upper Kadonosawa series are as follows (Table III):

The collected species number only 37. Of these, *Yoldia thraciaeformis* Storer was described from the Middle Neogene of Hokkaido and *Yoldia sagittaria* Yokoyama from the lower Tertiary Zyôban coal field. *Arca amicula* Yokoyama is a common species from the middle Neogene of Nagano prefecture.

Patinopecten tokyoensis kimurai (Yokoyama) has already been referred to. *Cultellus izumoensis* Yokoyama is the Pliocene and Miocene species in Japan. Large forms of *Venericardia ferruginea* (A. Adams) are common in the Middle part of the Zyôban coal bearing beds. *Sinum*

Table III. (Fauna of the Upper Kadonosawa series).

Acila divaricata? (*Hinds*).	—	—	—	—	—	25	—	—	—
Nuculana nidatoriensis Otuka.	17	—	22	—	—	—	—	—	—
Yoldia thraciaeformis Storer.	—	21	22	—	—	—	—	—	—
Yoldia cooperi ochotensis Khomenko.	17	—	—	—	—	—	—	28	—
Yoldia intermedia kadonosawaensis Otuka.	—	21	22	—	—	—	—	—	—
Yoldia sagittaria Yokoyama.	—	21	—	—	—	—	—	—	—
Yoldia sp. 3.	—	—	—	23	—	—	—	—	—
Arca amicula Yokoyama	17	21	22	—	—	25	—	—	—
Ostrea gigas Thunberg.	—	—	22	—	—	—	—	—	—
Chlamys sp. 1.	—	—	—	—	—	—	—	28	—
Chlamys sp. 2.	—	—	—	—	—	—	—	28	—
Patinopecten tokyoensis kimurai (Yokoyama).	17	21	22	23	24	25	26	28	29
Brachydontes senhausii (Reeve).	—	—	—	—	—	—	—	28	—
Venericardia ferruginea (A. Adams).	17	21	22	—	—	—	—	28	—
Lucina acutilineata Conrad.	17	—	—	23	—	—	—	28	—
Macoma optiva (Yokoyama).	17	21	—	—	—	—	—	28	—
Macoma tokyoensis Makiyama.	17	21	—	—	—	—	—	—	—
Cultellus izumoensis Yokoyama.	17	21	22	—	—	—	—	28	—
Mactra sp.	—	—	22	—	—	—	—	—	—
Cryptomya bussoensis Yokoyama.	17	—	—	—	—	—	—	—	—
Panope japonica A. Adams.	17	—	—	—	—	—	—	—	—
Panomya simotomensis Otuka.	17	—	—	—	—	—	—	—	—
Dentalium (*Antalis sp.*)	17	—	—	—	—	—	—	28	29
Turritella fortilirata kadonosawaensis Otuka.	17	21	—	—	—	—	—	—	—
Calyptrea sp. 1.	—	—	22	—	—	—	—	—	—
Crepidula nidatoriensis Otuka.	17	—	—	—	—	—	—	—	—
Polinices fissurata (Kuroda).	—	21	—	—	—	—	—	—	—
Sinum yabei? Otuka.	—	21	—	—	—	—	—	—	—
Cylichna sp.	—	—	22	—	—	—	—	—	—

yabei sp. nov. resembles the Miocene species of Kii.

Judging from these fossils, the age of the Upper Kadonosawa series is limited to the Miocene and Lower Pliocene, as in the Suenomatuyama series, while these series are overlain by the Suenomatuyama series, which are supposed to be the Lower Pliocene or the Upper Miocene beds of Japan.

The writer is inclined to the belief that this series is the Japanese

Upper Miocene or Middle Miocene.

From the fossils just mentioned another conclusion is arrived at, which is that the Upper Kadonosawa series were deposited in relatively deeper sea than there by the Suenomatuyama series and the Lower Kadonosawa series.

It is interesting to note that only a few species occurring in the next underlying bed remain in the lower part of this Upper Kadonosawa series.

Geologic age of the Lower Kadonosawa series.

The fossils of this series consist mostly of those from the Tate *Ostrea* beds. *Ostrea gravitesta* Yokoyama, whose specific position is discussed now by many authors is, at any rate, a very large uncommonly thick shelled Oyster. This species was first described by Prof. M. Yokoyama,[92] from specimens collected from the Lower Miocene beds of the Akita oil field. Recently T. Takeyama[93] reported this species from the middle or lower Miocene of Tuyama basin in Tyugoku and Kissyû-Meisen in Tyôsen (=Korea), with *Vicarya vernuilli* d'Archiac.

The fossils collected from this horizon are as follows: —

Table IV. (Fauna of the Lower Kadonosawa series).

Solemya tokunagai Yokoyama.	—	—	—	4	—	—	—	—	—	—	—
Nuculana confusa kongiensis Otuka	—	—	—	—	—	6	7	—	9	—	—
Yoldia sp. 4.	—	—	—	—	—	—	7	—	—	—	—
Arca amicula Yokoyama.	—	—	—	—	—	—	7	—	—	—	—
Arca trilineata Conard	1	—	—	—	5	6	—	—	—	—	—
Arca ninohensis Otuka	—	—	3	4	5	6	7	—	—	—	—
Ostrea gigas Thunberg	—	—	—	—	—	—	7	—	—	—	—
Ostrea gravitesta Yokoyama	1	2	3	4	5	6	7	8	9	10	11
Ostrea rosacea Deshayes	—	—	3	—	—	—	7	—	—	—	—
Chlamys islandicus nisataiensis Otuka	—	—	3	—	—	6	7	—	9	—	—
Lucina (Myrtea) k-hataii Otuka	—	—	3	4	—	6	—	—	—	—	—
Pillucina pisidium nisataiensis Otuka	—	—	3	—	—	—	—	—	—	—	—
Pillucina contraria (Dunker)	—	—	3	—	—	—	—	—	—	—	—
Taras ferruginata (Makiyama)	—	—	3	—	—	6	7	8	—	—	—
Cardium shinjiense Yokoyama	—	—	3	4	—	6	7	8	9	—	—

(to be continued.)

92) M. Yokoyama, *op. cit.*, (1926).

93) T. Takeyama, *op. cit.*, (1933).

Table IV. (*continued.*)

Cardium sp. 1.	—	—	—	—	—	6	7	—	—	—	—
Paphia siratoriensis Otuka	—	—	3	—	5	6	7	—	9	—	—
Clementia subdiaphana yazawaensis Otuka	—	—	—	4	5	6	—	8	—	10	—
Macrocallista pacifica (Dillwyn)	—	—	—	—	—	—	7	—	—	—	—
Pitar yabei Otuka	—	—	3	—	—	—	—	—	—	—	—
Cyclina sinensis Gmelin	—	—	3	—	—	6	—	—	—	—	—
Dosinia japonica nomurai Otuka	—	—	3	4	5	6	7	—	9	10	—
Dosinia nagaii Otuka	—	—	3	—	—	—	—	—	9	—	—
Macoma optiva (Yokoyama)	1	—	—	4	5	—	—	8	—	—	—
Sanguinolaria (*Soletellina*) *minoensis* (Yokoyama)	—	—	3	—	—	—	—	—	10	—	
Solen sp.	—	—	3	4	—	—	7	—	—	—	—
Cardilia yudaensis Otuka	—	—	—	4	—	—	—	—	—	—	—
Aloidis erythrodon nisataiensis Otuka	—	—	3	—	—	—	7	—	—	—	—
Panope japonica A. Adams	—	—	—	—	5	6	7	8	—	10	—
Zirphaea subconstricta (Yokoyama) *kotrai* Otuka	—	—	—	—	—	—	7	—	—	—	—
Minolia sasai Otuka	—	—	3	—	—	—	—	—	—	—	—
Cerithium atukoae Otuka	—	—	3	4	—	—	—	8	—	—	—
Batillaria yamanarii Makiyama.	—	—	—	—	—	—	7	—	—	—	—
Batillaria aff. *tateiwai* Makiyama	—	—	—	—	—	—	7	—	—	—	—
Proclava ishiianum (Yokoyama)	—	—	3	—	—	—	—	—	—	—	—
Calyptrea yokoyamai tubura Otuka.	—	—	—	—	—	—	7	—	—	—	—
Polinices fissurata (Kuroda)	—	—	—	4	5	6	7	—	—	—	—
Polinices meisensis Makiyama	—	—	—	—	5	6	7	8	—	—	—
Polinices didyma (Bolten)	—	—	3	—	—	—	—	—	—	—	—
Sinum yabei Otuka	—	—	—	—	—	6	7	—	—	—	—
Surculites yokoyamai Otuka	—	—	—	—	—	—	—	—	—	—	11
Surculites kurodai Otuka	—	—	—	—	5	—	7	—	—	—	—
Suavodrillia makiyamai Otuka	—	—	—	—	—	—	7	—	—	—	—
Bedeva nakamurai Otuka	—	—	3	4	—	—	—	—	—	—	—
Truncaria nakamurai Otuka	—	—	—	—	—	—	7	—	—	—	—
Tritonaria sp. 1.	—	—	3	—	—	—	—	—	—	—	—
Ancistrolepis yudaensis Otuka	1	—	—	4	5	—	—	—	—	—	—
Nassarius (Hinia) *simizui* Otuka	—	—	—	—	—	—	7	—	—	—	—
Nassarius (*Zeuxis*) *kometubus* Otuka	—	—	3	—	—	—	7	—	—	—	—
Fusinus sp. 1.	—	—	—	—	5	—	—	—	—	—	—
Olivella consobrina (Lischke)	—	—	3	—	—	—	—	—	—	—	—

(to be continued.)

Table IV. (*continued.*)

Cancellaria spengleriana Deshayes	—	—	3	--	—	—	7	—	—	—	—
Conus tokunagai Otuka	—	—	3	—	—	—	—	—	—	—	—
Ringicula ninohensis Otuka	—	—	—	—	—	—	7	—	—	—	—
Balanus sp.	—	—	3	—	—	—	—	—	—	—	—
Linthia sp.	—	—	—	—	—	—	7	—	—	—	—
Echinodermata gen. sp.	—	—	3	—	—	—	—	—	—	—	—
Astryclypeus sp.	—	—	3	—	—	—	—	—	—	—	—

Most of the species mentioned above suggest warm current fauna, but some of them seem to suggest that they were derived from the northern Pacific. *Batillaria yamanarii* Makiyama, *Batillaria* off *tateiwai* Makiyama, *Polinices meisensis* Makiyama, *Taras ferruginata* (Makiyama), and *Ostrea gravitesta* Yokoyama are closely related to the fauna from the lower Miocene of Kissyu-Meisen, in northeast Tyôsen.[94] *Sanguinolaria* (*Soletellina*) *minoensis* (Yok.), *Solemya tokunagai* Yokoyama, and *Surculites yokoyamai* Otuka, and *Proclava ishiianum* (Yok.) are reported from the Miocene of Japan.[95] *Astryclypeus* is the common species of Miocene *Miogypsina-Operculina* horizon in Northeast Japan. The stratigraphic successions of the Oil Tertiary of Northeast Japan and others are correlated as follows (Table V).

The formations above the "ml," the writer's "mm," contain cold water fauna, while "ml" is represented by the Miocene *Miogypsina-*

94) J. Makiyama, "Tertiary Fossils from North Kankyô-dô, Korea," *Mem. Coll. Sci, Kyoto Imp. Univ.* [B], **2** (1926); T. Takeyama, *op. cit.*, (1933).

95) M. Yokoyama, *Jour. Fac. Sci., Imp. Univ. Tokyo*, [ii], **1** (1926), 213-227; J. Makiyama, *Tikyû*, **16** (1931), 333.

96) Y. Otuka, *Jour. Geol. Soc., Tokyo.* **41** (1934), 333.

97) K. Watanabe, *Spec. Geol. Map. & Expl. Text, Joban Coal Field*, 1 : 15,000 (1928), (in Japanese).

98) Y. Chitani, *Jour. Geol. Soc., Tokyo*, **37** (1930), 732-739, (in Japanese).

99) Y. Iizuka, *Jour. Geol. Soc., Tokyo*, **37** (1930), 770-774, (in Japanese).

100) I. Omura, *Jour. Geol. Soc., Tokyo*, **37** (1930), 775-792, (in Japanese).

101) F. Homma, "Geology of Middle Part of Sinano," (1931), (in Japanese).

102) S. Imamura, *Jour. Geol. Soc., Tokyo*, **39** (1932), 310-312, (in Japanese).

103) H. Yabe, (1921) *op. cit.* pp. 789-790; K. Ishii and N. Kiyono, 1 : 75000, *Geol. Map. & Exp. Text*, "Tajimi" sheet.

104) T. Takeyama, *op. cit.*, (1933).

105) F. Yamanari and I. Tateiwa, *Geol. Map. of Tyôsen*, **3** and **4** (1925); J. Makiyama, *op. cit.*, (1926).

Operculina fauna. These faunal characteristics are convenient keys for distinguishing the "ml-mm" and "mm-mu" beds of Northeast Japan. The Miocene *Miogypsina-Operculina* horizon is generally associated with the *Miogypsina ozawai* Hanzawa, *Operculina complanata* Defrance, *Vicarya callosa* Jenkins, or *Vicarya yokoyamai* Takeyama and *Astryclypeus* sp., and is closely related to the *Desmostylus japonicus* Iwasaki et Yoshiwara horizon.

During early Miocene, Northern Japan was therefore influenced by warm water, which declined at the end of early Miocene when the region was suddenly subjected to the influence of cold water.

The lower half of the Kadonosawa series is the Middle or Lower Miocene, and may be contemporaneous with the Miocene *Miogypsina-Operculina* horizon of Northeast Japan, though the writer could not obtain any *Desmostylus japonicus* I. et Y., *Vicarya vernuilli* D'Archiac. The conformably overlying Upper Kadonosawa series may be contemporaneous with the

Table V (Correlation table of some Japanese Neogene) (Y. Otuka, 1934).

		Tôkyô[96]	Zyôban coal-field[97]	Ninohe Iwate	Oil-field of Northeast Japan: Akita[98]	Oil-field of Northeast Japan: Yamagata[99]	Oil-field of Northeast Japan: Niigata (Etigo)[100]	Oil-field of Northeast Japan: North Nagano[101]	Yatuo Toyama[102]	Tukiyosi Gihu (Mino)[103]	Tuyama Okayama[104]	Kissyû–Meisen NE. Tyôsen[105]	Western Hokkaidô[106]	Central Hokkaidô[107]
Pliocene	(nd) pd	Naganuma series			Takanosu series	Sinzyô series	Uonuma series						Setana series	
Pliocene	pm pl	Kosiba series		Suenoma-tuyama series	Yuri series	Kuraoka series	Tyûetu (=chûetsu) series	Sigarami and Ogawa beds	Omma series				Kuromatu-nai formation	
Miocene	mu mm ml	Dusi series	Yunagaya series	Kadonosawa series: Upper / Lower	Ogasima ser.: Huna-gawa / Onagawa / Daisima	Mogamigawa series	Kubiki series	Aoki and Bessyo beds?	Yatuo series	Tukiyosi formation	Uetuki (=Uëtsuki) series	Heirokudo formation	Yakumo formation	Kawabata series
Miocene	o	Hayama series	Siramidu series	Yotuyaku series	Sugoroku series		Lower tuff			Nakamura series			Kunnui formation	Poronai series

106) T. NAGAO and Y. SASA, *Jour. Geol. Soc., Tokyo*, 40 (1933), 555 and 750; 41 (1934), 47 and 97.; 41 (1933-34).
107) S. MURATA, *Jour. Geol. Soc., Tokyo*, 30 (1923).

black shale horizon, judging from its rock facies and faunal charcteristics.

From the foregoing, the Kadonosawa series may be Miocene, its upper half being upper or middle Miocene, and its lower half the middle or lower Miocene. If so, then since early Miocene, this region was transgressed by the sea, which temporarily regressed during late Miocene, as the result of which the unconformity between the Suenomatuyama series and the upper Kadonosawa series was formed. These transgression and regression in this district may correspond to the mu-ml (formerly mu-mm), and mu-pm cycle of sedimentation in Northeast Japan as believed by the writer. And the former transgression is a most predominant feature of early Neogene on Japanese Islands and Tyôsen (=Korea).

III. The Yotuyaku series.

The Yotuyaku series consists of volcanic materials, sandstone, shale, tuffite, agglomerate, and conglomerate. The beds vary in its rock facies in vertical and horizontal extention and gently tilt northwestward, occupying the southeastern area of the town of Hukuoka.

Detailed description of exposures of the Yotuyaku series.

In Numanotai valley, a distributary of Siratori valley, a thin bedded alternation of coarse grained sandstone and muddy sandstone are exposed below the Tate *Ostrea* beds. Following fossil plants were collected from loc. 45. Fig. 2:—*Phragmites* sp, *Smilax* sp, *Pterocarya* sp, *Magnolia* aff. *angustifolia* Newb., *Liquidambar* aff. *formosana* Hance, *Styrax* aff. *obassia* S. et Z. *Acer* sp.

Fossil bearing muddy sandstones are underlain by yellow tuffaceous muddy sand, dipping 30° westward. At the base of this formation, underlie a Nisatai liparite flow. Similar alternation beds are exposed in the Siratori valley, where some fossil plants were collected near Sakamoto.

In the Tengatuka[108] valley, charcoal-wood bearing alternation of sandstone and loose muddy sand are exposed at the mouth of the valley, and below this alternation lie the upper agglomerate beds. These upper agglomerate beds are underlain by yellowish tuffaceous sandstone which overlie the lower agglomerate (two pyroxene andesite) beds.

The Koiwai *Crepidula jimboana* Yokoyama bearing beds occupy the area between these formations and the Palaeozoic rocks. The basal

108) 天ケ塚.

part of these beds contain a few thin coal seams. From this coal bearing muddy sand, many fossil plants, e. g. *Sequoia* aff. *chinensis* Endô, *Dryopteris?* sp., *Pterocarya* sp., *Carpinus ?* sp., *Liquidambar* aff. *formosana* Hance, *Acer* sp, (*miyabei*-type), *Styrax* aff. *obassia* S. et Z., *Fraxinus* sp. (*puvinervis*-type) were collected.

The Nisatai liparite seems to underlie these beds, but the writer could not observe exposures of any close contact between these two rocks.

This stratigraphic succession of the Yotuyaku series is seen between Siratori village and Kotôge. Where the Siratori valley makes a curve in Siratori village, plant bearing muddy sand overlie the upper agglomerate beds. Near Takada village, yellow tuffaceous sand overlay the lower agglomerate beds in Siratori Tunagi valley. These lower agglomerates beds are underlain by tuffaceous muddy sand, the eastern limit of which is in contact with the Koiwai beds with a fault.

The Koiwai beds contain *Crepidula jimboana* Yokoyama as in the Tengatuka valley. To the east of this exposure, plant bearing muddy sand lie with almost horizontal bedding. *Sequoia* aff. *chinensis* Endô were collected from here.

These plant bearing beds are exposed near the exposures of Palaeozoic phyllitic quartzite, but the writer could not observe any exposures of the unconformity.

The Yotuyaku series exposed in Narayama valley is overlain by Tate *Ostrea* beds. The series is an alternation of yellow or dark greenish muddy sand and coarse grained sand. Some fossil plants are found in it near Sukohata. The Koiwai *Crepidula* beds are not found in this valley. The conglomerate of the Yotuyaku series, which is well developed in the southeast part of the valley, contain fragments of silicified wood exposed in the conglomerate of the valley floor. Going southeastward, this conglomeratic facies changes into agglomeratic. The agglomerate of the Yotuyaku series is well exposed on the ridge of point 501m.

In the Zizôdô valley, south of Narayama valley, alternation of agglomerate and the conglomerate of the Yotuyaku series is also developed. At the branching point between 501m. and the Keisei pass[109] a stem of large silicified wood is seen in this agglomerate. This series rests unconformably upon Palaeozoic rocks at the mouth of the Zizôdô valley along the Mabeti. Many fossil plants were collected from the tuffaceous sandstone exposed along the Mabeti at the town of Itinohe which stands on the Yotuyaku series.

109) 傾城峠.

The following are the species from this locality (Loc. 43).

Pterocarya n. sp., *Betula* sp., *Carpinus?* sp, *Magnolia* aff. *angustifolia* Newb., *Acer* sp? (*trifidum*-type).

From the plant bearing beds in the Hiranuka basin, described by Prof. S. Nakamura in the explanatory text of the Ninohe sheet, have been reported the some species. On comparing these species with those from the Yotuyaku series, the plant beds of Hiranuka may be contemporaneous with the Yotuyaku series. The Hiranuka plant bearing beds are almost horizontal and are separated from the other localities for Tertiary by Palaeozoic rocks. The plant beds are protected from denudation by the depressed structure, which was formed by block movement during Middle Tertiary. The writer observed that the strata of these plant-bearing beds are flexed upward at the southeast corner of this basin, but no evidences of faults were observable. (According to Prof. S. Nakamura, however, Tertiary beds contact with Palaeozoic rocks by fault lines on the other side of this basin.)

Geologic age of the Yotuyaku series.

Though the geologic age of the Yotuyaku series is difficult to determine owing to the small number of its fossil plants, it is clear that this series is older than that of the overlying Lower Kadonosawa series. The flora of the Kitaaiki Tertiary of H. Fujimoto[110] may be older than that of Yotuyaku. The Oguni plant beds, described by Morita,[111] may be contemporaneous with the Yotuyaku. But from the Yotuyaku series, ever green trees as *Quercus* etc., the common Japanese Miocene species *Comptoniphyllum japonicum* Nathorst were not collected. According to H. Fujimoto and S. Endô, the Kitaaiki Tertiary in Sinano is Older Tertiary, while, according to Morita, the Oguni plant beds are correlated with the Green Tuff formation in the oil-field of Northeast Japan, which age is Lower Miocene or Upper Oligocene. According to S. Endô *Sequoia chinensis* Endô is a common Palaecogene species. The Yotuyaku series may therefore be contemporaneous with the lower Miocene or upper Oligocene.

From this view point, the fauna of Koiwai is worth studying as the Middle Tertiary fauna of Japan. *Crepidula jimboana* Yokoyama,[112] a common species of this fauna is reported from the Lower Miocene or

110) H. Fujimoto, *Jour. Geol. Soc., Tokyo*, **37** (1930).

111) H. Morita, *Jap. Jour. Geol. Geogr.*, **1** (1931).

112) M. Yokoyama, *Jour. Sci. Imp. Univ. Tokyo*, [II], **3** (1931), 194.

upper Oligocene of Makumbets, Tokati(=Upper part of Poronai series?)

From the foregoing, the following conclusions are reached regarding the Yotuyaku series.

1. The Yotuyaku series is generally of land origin.

2. The age of the series may be lower Miocene or upper Oligocene. This series may be contemporaneous with the upper part of the Poronai series in Hokkaido.

3. The Koiwai shell beds are marine beds which may have been laid in the lower part of the Yotuyaku series.

4. During the Yotuyaku age, there were, at least, two epochs of volcanic activity in this district, as a result of which the agglomerate beds were intercalated in this series.

IV. The Nisatai liparite mass.

The Nisatai liparite is an igneous mass exposed at the north and south end of Nisatai village. It is exposed also near Motosinden,[113] east of Nisatai and in the Tengatuka valley.. This liparite mass is overlain by the Yotuyaku and Kadonosawa series. Fragments of Palaeozoic rocks are found in this liparite. The trend of the elongated exposure of the Nisatai liparite is parallel to the general trend of the structure lines of the Palaeozoic formation. Accordingly, this liparite mass extruded through the crack parallel to the general trend of the structural lines.

A similar igneous mass is exposed west of Itinohe station, below the Yotuyaku and Kadonosawa series. As in Nisatai liparite, this igneous mass contains fragments of Palaeozoic and gabbroic rocks. The writer believes that this igneous mass may be contemporaneous with the Nisatai liparite.

These igneous masses are older than the Yotuyaku series and never than the Palaeozoic as well as (probably) the next underlying Torigoe gabbro.

V. The Torigoe gabbro.

As to the Torigoe gabbro, which is exposed along the Mabeti under the railway bridge of the Mabeti, north of Itinohe station, according to Kondô[114] who studied it in detail, Torigoe gabbro intruded the Palaeozoic rocks at Kotaki.

113) 元新田.

114) N. KONDÔ, *Jour. Geol. Soc., Tokyo*, **37** (1930), 433-458 and 467-490.

VI. The Palaeozoic Formation.

The Palaeozoic rocks developed in this district are exposed near Kotaki (Tyôkai-mura), Mount Oritume, east of Nisatai village. The rocks of this formation, which are very crushed and compressed, consist of phylitic slate, platy quartzite, and crystalline limestone. The general trend of the strike is N. 10°W., but the dips vary considerably.

No evidences for determing the geologic age of this formation could be found. The writer, however, believes this formation to be Palaeozoic, owing to the similarity of its rock facies with those of the Titibu Palaeozoic system of the Japanese Permo-Carboniferous-Devon? formation.

Tectonic considerations.

a. Epeirogenetical crustal movement and volcanic activities.

The Palaeozoic formation and the Torigoe gabbro.

As described already, the succession of strata of the Tertiary developed near Itinohe and the town of Hukuoka is established as shown in Table I and these Tertiary beds range in age from lower Pliocene or upper Miocene to upper Oligocene or lower Miocene. The structural characteristics of these Tertiary beds are quite different from that of the underlying Palaeozoic rocks, the Tertiary beds overlying almost horizontally with unconformity the complicated Palaeozoic rocks. The structure of the Palaeozoic formations was deformed into a complicated structure before the laying down of the Tertiary deposits. The general trend of these complicated structural lines is about N. 20°–10°W. During or after this deformation, Torigoe gabbro intruded into these Palaeozoic rocks. Since then, these old rocks seem to have suffered from subaerial denudation just before the Tertiary deposition.

The conglomerate in the Yotuyaku series suggests that the relief of this district during the Yotuyaku age had a relatively large height.

Extrusion of the Nisatai liparite mass.

The Nisatai liparite mass extruded after the exposition of the Paraeozoic rocks, the structure of which was very complicated. The basal part of the Yotuyaku is closely related to the Nisatal liparite mass. As already mentioned, this igneous mass is distributed parallel to the general trend of the Palaeozoic structures and seems to extrude through fissures parallel to the structural lines of the Palaeozoic rocks.

The Yotuyaku series.

The thickness of the Yotuyaku series varies.

Near Yuda, Tukinokidaira, and Ezonomori the lower part of the Kadonosawa series rests directly on Palaezoic and other older rocks, while in the Siratori valley, Narayama valley, and Zizôdô valley, the Yotuyaku series are thickly developed below the Kadonosawa series.

West of the town of Itinohe, the thickness of the Yotuyaku series decreases and the Kadonosawa series is directly in contact with the older rocks. The writer considers that this variable thickness was caused by differential crustal movements of the blocks during the Yotuyaku stage, as in the case of the Hiranuka basin already referred to. The region of old rocks of Oritumedake, Kotaki, and others are upheaved blocks by which the Yotuyaku series was flexed upwardly, while the subsiding blocks were overlain by the thick Yotuyaku series. No evidences of the structural boundary of these subsiding and upheaving blocks, however, were found on the land surface. As shown by the geologic section in the map, two fault lines near Tunagi and Kotôge cut the eastern margin of the Yotuyaku series paralell to the western margin of Oritumedake.

Kadonosawa series

Since the occurrence of the block movements mentioned above, and after the Yotuyaku series had thickly deposited on the subsiding blocks, the marine transgression of the Kadonosawa age begun. The Tate *Ostrea* beds, which are evidences of the transgression, lie directly upon the Yotuyaku series, the Palaeozoic rocks, the Nisatai liparite, and other old rocks. From the geologic structures, and the rocks of the Kadonosawa series, the writer considers that after this transgression, the epeirogenetical crustal movement was the chief movement in this district. It is

Table VI.

	Period	Epeirogenetical crustal movement			Volcanic activities
pl	Suenomatuyama	Regression (pm.)	gentle northwestward tilting	Upheaval of land.	Extrusion of Aikawa and Syôbuzawa andesite.
mu		Transgression		Subsidence of land.	
	Upper Kadonosawa	Regression		Upheaval of land.	
mm					Eruption of tuff.
	Lower Kadonosawa	Transgression		Subsidence of land.	Two volcanic activities.
ml			Block movement.		
O	Yotuyaku	(Partial transgression and regression		Temporary subsidence of land.	Extrusion of Nisatai liparite.

noteworthy that the thickness of this series may be explained as follows: During the time of regression before the deposition of the Suenomatuyama series, the southeastern region was much more denuded than the northwestern seeing that the crust of this area gently tilts northwestward. The basal part of the Suenomatuyama series is associated with the eruption of Aikawa and the Syôbuzawa volcanic mass.

From the above considerations, the tectonic and volcanic movement since the Yotuyaku stage in this region occurred in the following order (Table VI).

From the foregoing table, the volcanic activities in this region are closely related to the epeirogenetical crustal movement, and the volcanic activities seem to have been the forerunners of the subsidence of land and the marine transgression.

b. Faulting

As already stated, since the geologic structuras are so simple that there is comparatively little faulting in this district, no fracture of importance has been detected.

Near Yuda, however, a great number of faults accompany the minor faulting and minor folding, though the faults are difficult to trace in detail owing to lack of exposures.

The Zyûmonzi fault is exposed at the third meandering point of the Zyûmonzi valley from the mouth. The exposure of the fault here shows that the rocks on either side are crushed and mixed in a width of about 75m. Fig. 9 is the exposure of this crushed zone on the wall of the Zyûmonzi valley. The strike of this fault zone is about N. 45°E., but its dip is unknown. The southeast side of this fault was upheaved relatively to the opposite by this fault, the Kadonosawa series being exposed and in contact with the Suenomatuyama series.

The Kobayasi fault is exposed on the river cliff of Kobayasi village, with strike about N–S, and dip about vertical.

The Nisatai fault is a little fault exposed in the west valley of Nisatai village. The east side of this fault is a down throw. It strike is about N. 10°W., and the dip vertical.

The Narayama fault runs in an east-west direction in the valley of Narayama, the south side of this fault was thrown down a few meters.

All the faults dip steeply; the south or east sides of these faults having been thrown down in opposite direction to that of the general dip of the Neogene in this district. These characteristics of the faults

remind the writer of H. Cloos's[115] "Antethetische Bewegung" of fault. The age of formation of these fault is not definitely known, but it is probable that these faults were formed during or after the Suenomatuyama epoch, and antedates the deposition of the Hukuoka pumice beds.

Conclusion

The region near the town of Hukuoka and Itinohe in the northern corner of Iwate prefecture presents several stratigraphic evidences by means of which Japanese stratigraphic problems may be settled.

The following is the geological history of the region.

Palaeozoic: The deposition of the Titibu (or Chichibu) Palaeozoic system (Permo-Devon?; marine).

Mesozoic?: The Titibu Palaeozoic system was disturbed and was changed into complicated structures.

Intrusion of the Torigoe gabbro (and the Sigetani granite).

Denudation.

Formation of the Kitakami mountainland, which is one of the main geotectonic units of the Japanese Islands.

Cainozoic: Oligocene and Miocene.

Deposition of the Yotuyaku series and block movement.

Intercalation of the Koiwai shell beds.

Volcanic activities during the Yotuyaku age.

Marine transgression of the Kadonosawa series.

Deposition of the Tate *Ostrea* beds.

Deposition of the upper part of the Kadonosawa series.

Regression of the sea.

Upper Miocene and Pliocene.

Marine transgression of the Suenomatuyama series.

Eruption of the Aikawa and the Syôbuzawa andesite mass.

Gentle northwestwardly tilting, and "antithetische Bewegung" of minor faults.

Regression of the sea.

Denudation and dissection.

Formation of the Ninohe surface.

Quaternary.

The Hukuoka pumice beds filled in the western tributaries of the Mabeti (Formation of the upper terrace).

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115) H. CLOOS, *Geol. Rundschau*, **19** (1928), 246-251.

Formation of the lower terrace.

Recent.

From the above, the succession of strata schemed by S. Shimizu should be revised as shown in Table I. His Nisatai, Yuda, and the lower part of the Kadonosawa group are contemporaneous with the Lower Kadonosawa series of the present writer.

The cycles of sedimentation in these regions agree well with that of the oil bearing Tertiary of Northeast Japan and others. It seems that the *Vicarya vernuilli* d'Archiac and the *Desmostylus japonicus* Yoshiwara et Iwasaki were collected from the lower part of the Kadonosawa series, so that the two specimens of the latter species reported from this district probably occurred on one formation.

The Tate *Ostrea* beds may be a transgressive sedimentary facies during eary Miocene.

The Neogene Tertiary beds exposed locally along the western margin of the Kitakami mountainland, as seen in Y. Saito's[116] studies, were not effected by the Tertiary folding of the western half of Northeast Japan. They are monoclinally tilted and are rarely cut by minor faults.

These are interesting structural characteristics of the Neogene of Northeast Japan. The Neogene Tertiary between Hukuoka and the town of Itinohe has similar structural characteristics as in those on the western margin of the Kitakami mountainland. But the faunal characteristics in the former differ from those of the latter.

The volcanic activities in this region are closely related to the epeirogenetical crustal movements of the land and the marine transgression.

From palaeontological studies, we find that during early Miocene, the warm water affected the fauna in this district, and through this faunal characteristic, the lower and middle Miocene of Northeast Japan are easily distinguished from the overlying beds whose fauna were affected by the cold water.

Descriptson of Species.

Class PELECYPODA

Solemya tokunagai Yokoyama

Pl. XLVII, Fig. 10.

1925 *Solemya tokunagai* Yokoyama, Jour. Coll. Sci. Tokyo Imp. Univ., 45, 31, Pl. VI, Figs. 1, 2, 3.

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116) Y. Saito, *Jour. Geogr., Japan*, 39, 40, 41, (1927-1928).

Geol. Range:—Miocene-Lower Pliocene[117]

Occurrence:—LOWER KADONOSAWA SERIES. Yuda (locality 4 in Fig. 2; rg. no. 1288.)

***Acila divaricata*?** (Hinds)

(1843 *Nucula divaricata* Hinds, Proc. Zool. Soc. London, p. 97.)

(1850 *Nucula mirabilis* Adams et Reeve, Samarang, Moll., p. 75, Pl. XXI, Fig. 8.)

(1920 *Nucula mirabilis*, Yokoyama, Jour. Coll. Sci. Tokyo Imp. Univ., **39**, 180, Pl. XIX, Fig. 9a, b.

Geol. Range:—Miocene[118]-Recent.

Occut.:—UPPER KADONOSAWA SERIES. Nisatai (loc. 25; rg. no. 1289.)

Nuculana nidatoriensis Otuka n. sp.

Pl. XLVII, Fig. 11.

Shell oblong, pyriform, tumid; beaks at anterior 2/5, slightly elevated, obtuse, inclined inward; anterior dorsal margin sloping so as to bring the somewhat acutely rounded point about midway to the base; posterior dorsal margin with about the same slope as the front, directly and slightly upturned. Posterior margin small and obliquely truncated; vertical margin full and well rounded; dorsal face very broad, with a wide, flattened, or somewhat depressed space; destitute of riblets, in front of the beak; and a long lanceolate one defined by a ridge behind. Length 14 mm., height 7·5 mm., thickness 3·5 mm? On the inner margin of the posterior end, the ridge which is characteristic of *Nuculana* (*Nuculana*) is obsolete.

Nuculana minuta (Fabricius)[119] from the North Pacific is closely allied to this species.

Nuculana confusa kongiensis Otuka is an other allied species. But this species has a ridge from beak to postero-dorsal margin.

Nuculana sp. 1 found in Nippon-kai (Japan sea) (Pl. XLVII, Figs. 12, 13) has finer concentric sculpture.

Occurrence:—UPPER KADONOSAWA SERIS. Kadonosawa (loc. 22; rg, no. 1292), Nidatori (loc. 17; rg. no. 1293, 1307.)

Nuculana confusa kongiensis Otuka n. sub sp.

Pl. XLVII Fig. 14

1929 *Leda confusa*, Yokoyama, Jour. Fac. Sci. Imp. Univ. Tokyo, [II], **2**, 394, Pl. LXXVI, Fig. 5.

This species is rarely found in the Kadonosawa series. The specimens from the Kadonosawa series are slightly shorter and higher than the recent specimens of *Nuculana confusa* Hanley[120] (Pl. XLVII, Fig. 15), which the writer collected from the Pacific coast of Tiba[121] prefecture. The figure of the specimen from the lower Kongi beds of North Karafto shown by M. Yokoyama coincides very well with the specimens from the upper Kadonosawa series in configuration. Length 13·5 mm., height 7·7 mm., thickness 2·6 mm. (with one valve.)

Geol. Ran:—Middle Neogene (Lower Kongi series.)

Ccur.:—LOWER KADONOSAWA SERIES. Siratori (loc. 7; rg. no. 1290, type sp.,)

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117) Kosiba series, Upper Part of Yunagaya series?

118) Yunagaya series.

119) *Fauna Grönl.* (1776); HANLEY, *Mon. Nuculidae*, (1863), Pl. III, Figs. 61 and 62.

120) HANLEY, *Mon. Nuculidae in Sowerby's Thes. Conch.*, (1866), 119, Pl. CCXXVIII, Fig. 85

121) 千葉

Sakamoto (loc. 6; rg. no. 1291), Takaba (loc. 9; rg. no. 1431).

Yoldia thraciaeformis Storer

Pl. XLVII, Fig. 16.

1838 *Yoldia thraciaeformis* Storer, Boston Jour. N. H., 2, 122.

1926 *Yoldia scapha* Yokoyama, Jour. Fac. Sci. Imp. Univ. Tokyo, [II], 1, 247, Pl. XXXI, Figs. 7-11.

Geol. Ran.:—Miocene-Lower Pliocene (Beds B and C in Embets).

Occur.:—UPPER KADONOSAWA SERIES. Siratori valley (loc. 22, 21; rg. no. 1294)

Yoldia cooperi ochotensis Khomenko

Pl. XLVII, Figs. 17, 18.

1930 *Yoldia cooperi ochotensis* Khomenko, Transaction of the Fareastern Branch of the Geological and Prospecting Trust, p. 59, Pl. III, Figs. 3 and 4.

Geol. Ran.:—Middle Neogene.

Occur.:—UPPER KADONOSAWA SERIES. Nidatori (loc. 17; rg. no. 1296, 1306, 1307), Hatimae (loc. 28; rg. no. 1297).

Yoldia intermedia kadonosawaensis Otuka

Pl. XLVII, Fig. 19.

This subspecies has a more elongate shell and a more rounded ventral margin than *Yoldia intermedia* Sars (1865, Sars, Fos. Dyre. Quatern. Period, p. 38, Figs. 92, 96; or Tab. IV, Figs. 9, 9 a.)

Occur.:—UP. KAD. SER. Siratori valley (loc. 21, 22; rg. no. 1303 type sp., 1304.)

Yoldia sagittaria Yokoyama

1925 *Yoldia sagittaria* Yokoyama, Jour. Coll. Sci. Tokyo Imp. Univ., 45, 10 and 20, Pl. II, Figs. 10, 11.

Geol. Ran.:—Miocene (Middle part of Zyôban coal field.)

Occur:—UP. KADONOSAWA SERIES. Siratori valley (loc, 21; rg. no. 1305.)

Yoldia sp. 3

Occur.:—UP. KAD. SER. Kintaiti (loc. 23).

Yoldia sp. 4

Occur.:—LOW. KAD. SFR. Siratori (loc. 7; rg. no. 1316).

Arca amicula Yokoyama

Pl. XLVII, Fig. 20

1925 *Arca amicula* Yokoyama, Jour. Fac. Sci. Imp. Univ. Tokyo, [II], 1, 19, Pl. VII, Figs. 2-4.

Geol. Ran.: Miocene-Lower Pliocene.

Occur.:—UP. Kad. SER. Siratori valley (loc. 21, 22; rg. no. 1308, 1309, 1310), Nisatai (loc. 25; rg. no. 1312), Kotaki (rg. no. 1602), Nidatori (loc. 17; rg. no. 1311).

LOW. KAD. SER. Siratori (loc. 7; rg. no. 1290).

Arca aff. ***trilineata*** Conrad

1856 *Arca trilineata* Conrad, Proc. Acad. Nat. Sci. Philadelphia, 8, 314.

Geol. Ran.:—Miocene-Pliocene.

Occur.: LOWER KADONOSAWA SERIES. Yazawa (loc. 1, 5; rg. no. 1314, 1313), Sakamoto (loc. 6; rg. no. 1315).

Arca ninohensis Otuka n. sp.

Pl. XLVII, Figs. 21, 22

Shell medium in size, oblong, thick, inequilateral, slightly inequivalve. Beak at the anterior third of the hinge margin, prominent, much incurved. Anterior end rounded, shortly and obliquely truncate above, regularly arcuate below passing gradually into the

Measurements:

	Length	Height	Thickness	Length of hinge margin	Notes
1	14·7 mm	11·1 mm	5·0 mm	10·6 mm	left valve
2(Paratype)	16·8	12·7	5·9	15·3	right valve
3	22·15	17·0	7·0	——	left valve
4	29·25	24·0	11·4	19·7	„
5	——	29·7	——	——	right valve
6	40·25	35·45	18·25	30·75	left valve
7(Holotype)	47·1	38·35	19·6	36·4	„

broadly rounded ventral margin which is straightened behind; posterior end produced, twice as long as the anterior, narrowly rounded: posterior slope nearly straight, about twice as long as the anterior.

Antero dorsal angle about 120°, postero dorsal 140°. Sculpture consisting of 28 to 30 subequal squarish ribs; granulate on the left valve, but more or less smooth on the right. Ribs of the anterior part of the left valve and medial part of the right divided with a shallow, sometimes obsolete, median groove, Cardinal area medium sized; hinge straight with numerous fine teeth. Inner margin strongly crenulated.

This species from Ninohe, Iwate prefecture differs from *Arca abdita* Makiyama,[122] in having a broader area of obsolete dichotomous ribs on the left anterior and right medial portions. According to Prof J. Makiyama, *Arca abdita* Makiyama, has a narrow area, and each rib with a shallow median groove.

Occurrence:—LOWER KADONOSAWA SERIES. Siratori (loc. 7; rg. no. 1317, cotype; 1318), Nisatai (loc. 3, rg. no. 1323), Yuda (loc. 4; rg. no. 1324), Yazawa (loc. 5, rg. no. 1320), Tate (loc. 6, rg. no. 1321, 1322).

Okuda collected a subspecies of *Arca ninohensis* Otuka from S. Imamura's Nisitoyama beds[123] in Toyama prefecture. In this subspecies the dichotomous character is completely obsolete. According to Imamura and Okuda, the Nisitoyama beds may be younger than the Middle or Lower Miocene strata.

Ostrea gigas Thunberg

(1793 *Ostrea gigas* Thunberg, K. Vet. Ac. Nya Handl., **14**, 140.)

1920 *Ostrea gigas*, Yokoyama, Jour. Coll. Sci. Tokyo Imp. Univ., **39**, 162, Pl. XV, Figs. 1-4, Pl. XVII, Fig. 2 (only).

Geol. Ran.:—Miocene-Recent.

Occur.:—UPPER KADONOSAWA SERIES. Siratori valley (loc. 22.)
LOWER KADONOSAWA SERIES. Siratori (loc. 7; rg. no. 1328).

Ostrea gravitesta Yokoyama

1926 *Ostrea gravitesta* Yokoyama, Jour. Fac. Sci. Imp. Univ. Tokyo, [II], **1**, 388, Pl.

122) J. MAKIYAMA, *Mem. Coll. Sci., Kyôto Imp. Univ., op. cit.* (1926), 152-153, Pl. XII, Fig. 11.

123) S. IMAMURA, *op. cit.* (1933).

XLV, Figs. 1 a, b, c, 2 a, b, c.

Geol. Ran.:—Middle Miocene-Lower Miocene (Green tuffite in Akita prefecture, Tuyama basin).[124]

Occurrence:—LOWER KADONOSAWA SERIES. All localities of the Low. Kadonosawa series. (Rg. No. 1326).

Ostrea rosacea? Deshayes

1836 *Ostrea rosacea* Deshayes, Anim. s. vert. 2nd ed., **7**, 236.

Geol. Ran.:—Pliocene[125]-Recent.

Occur.:—LOW. KAD. SER. Nisatai (loc. 3), Siratori (loc. 7; rg. no. 1329, 1330).

Unio kobayasiensis Otuka n. sp.

Pl. XLVII, Fig. 24

Shell oblong ovate, rounded in front, somewhat pointed at the ventral angle behind, umbonal region eroded, but prominent; beak at the antero one fourth of the shell length. Surface sculptured with fine concentric wrinkles and striae. Side of the shell slightly compressed at the ventral middle.

Measurements: Length Height Thickness

Monotype. 59mm. 39mm. 23mm.

This species resembles *Unio douglasiae nipponensis* v. Martens in its outline, but the former has a shorter shell. The anterior margin and umbonal area slightly weathered.

Occurrence:—YOTUYAKU SERIES. Kobayasi (loc. 11; rg. no. 1593).

Chlamys hastatus aff. ***ingeniosa*** Yokoyama

1929 *Chlamys hastatus ingeniosa* Yokoyama, Imp. Geol. Surv. Japan, Rep., **104**, 5, Pl. VI, Fig. 2.

Geol. Ran.:—Middle Neogene (Nanao in Noto).

Occur.:—SUENOMATUYAMA SERIES. Mainosawa (loc. 34; rg. no. 1332), Sarugasawa (loc. 30).

Chlamys kotorana Otuka n. sp.

Pl. XLVII, Fig. 25.

Shell medium sized, of medium thickness, more or less elliptical or elongated subcircular, in-equilateral, posterior margin more or less produced; somewhat flattopped narrow ribs, finely imbricated when fresh, smooth when worn, very variable in number, multiplying with growth by intercalation, in this specimen 36-38 primary and intercalated ribs. Hinge line about half the length of the shell, variable with 8 or 9 (or 10?) radiating riblets of the anterior left ear.

Measurement: Height 56·5mm., length 61mm., length of hinge line 27·0mm., thickness (with left valve only) 0·9mm.

Occur.:—SUENOMATUYAMA SERIES. Kamimainosawa (loc. 34; rg. no. 1333, monotype).

This species is characterized by its elongated form. *Chlamya akitana* Yokoyama[127] is an allied form. But *Ch. akitana* Yok. has bifurcated ribs and higher altitude than this new species.

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124) T. Takeyama, *op. cit.* (1933).

125) M. Yokoyama, *Jour. Coll. Sci., Tokyo Imp. Univ.*, **39** (1920), 163, Pl. XVII, Figs. 1 and 3.

126) Martens, *Sitz. Ber. Nat. Freunde*, (1877), 119.

127) M. Yokoyama, *J. F. Sci. Imp. Univ. Tokyo*, [II], **1** (1926), 388, Pl. XLIV, Figs. 15, 16, 17.

Chlamys sp.[128] described from Noto by M. Yokoyama is another allied form, but this species has more finer ribs on its surface.

The Pliocene fossil form of *Chlamys vesiculosa* Dunker[129] resembles this species in its in-equilateral form, but in size and ribs it is essentially different from the latter species.

Chlamys islandicus nisataiensis Otuka

Pl. XLVII, Fig. 26

Shell moderate in size, the height almost equal to the length, subequivalve and subequilateral except for the ears, rather thin, compressed, radially costate. Beaks small, sharply pointed, approximate. Ears unequal, the anterior large, triangular, that of the right valve with a deep byssal notch; the posterior triangular, truncated behind at right angles or obtuse. Discs right angled above with the dorsal margins descending slightly concave meeting with the regularly rounded ventral margin at broad angles. Left valve more or less inflated than the right which margin is crenate. Sculpture: anterior ear of left valve with about 6-12 unequal scaly radial riblets (12 in the paratype of the left valve), that of the right valve divided into the upper area with flexuose, lamellated, horizontal, incremental lines; posterior ears with 6 to 12 low scarbrous riblets, which interspaces with a feeble riblet; the riblet obsolete near the upper margin; discs with 30 to 33 subequal, equidistant, flattopped, roundly edged ribs which are dichotomous at its ventral part (they show the dichotomous character after reaching a height of about 30mm.); interspaces as wide as or a little narrower than the ribs, usually with an intercalating riblet; except for the posterior and anterior part. The posterior and anterior part densely ribbed, and the intercalating riblet obsolete. Incremental lines very fine, not much imbricated. Interior side obscurely radially grooved. Ventral margin strongly crenated.

Measurements:

Height	Length	Number of ribs	
33·5 mm.	33·0 mm	30	(holotype; right valve).
——	55·0 mm.	36?	(paratype; left valve).
15·5 mm.	15·5 mm.	31	(paratype; right valve).
10·1 mm.	10·1 mm.	30	(paratype; right valve.)

Occurrence: –LOW. KAD. SER. Nisatai (loc. 3; rg. no. 1334, paratype and cotypes), Tate (loc. 6; rg. no. 1291), Siratori (loc. 7, rg. no. 1335), Takaba (loc. 9, rg. no. 1336).

The number of ribs are more or less variable in this species. Recently Prof. M. Yokoyama described Chlamys akitana (Yokoyama) from the lower horizon of the Akita oil bearing Tertiary, which is most allied to this new species. But the former has a broader interspace between the ribs, fewer ribs, and a straighter antero- and postero-dorsal margin, and more acute angles between the postero-dorsal and the antero-dorsal margin. The young form of *Chlamys akitana* (Yokoyama) is hardly distinguishable from that of this species.

Chlamys meisensis Makiyama[130] is another allied species. But the former has broader interspaces between the ribs, fewer ribs, and a straighter antero- and postero-dorsal margin.

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128) M. YOKOYAMA, *Imp. Geol. Surv. Rep.*, **104** (1929), 6, Pl. V, Figs. 3, 4.

129) DUNKER, *Index. Moll.*, (1882), 241, Pl. XI, Fig. 1.

130) J. MAKIYAMA, *op. cit.* (1926), 156-157, Pl. XIII, Fig. 4.

From the type species,[131] this new subspecies is distinguished by its blunt dorsal angle and shallow byssal notch.

Chlamys sp. 1.

An indeterminable specimen was collected from the Upper Kadonosawa series.

Occurrence:—UPPER KADONOSAWA SERIES. Hatimae (Loc. 28; rg. no. 1337).

Chlamys sp. 2.

An indeterminable specimen was collected from the Upper Kadonosawa series.

Occurrence:—UPPER KADONOSAWA SERIES. Hatimae (loc. 28; rg. no. 1338).

Chlamys sp. 3.

An indeterminable specimen was collected from the Suenomatuyama series.

Occurrence:—SUENOMATUYAMA SERIES. Kamimainosawa (loc. 34; rg. no. 1339).

Pallium swiftii etchegoini (Anderson)

1905 *Pecten etechegoini* Anderson, Proc. Calif. Acad. Sci., [iii], **2**, 198, Pl. XVIII, Figs. 92, 93

1911 *Pecten cosibensis* Yokoyama, Jour. Geol. Soc. Tokyo, **18**, 4, Pl. I, Figs. 3, 4.

1926 *Pecten heteroglyptus* Yokoyama, Jour. Fac. Sci. Imp. Univ. Tokyo, [II], **1**, 304, Pl. LIII, Figs. 7, 8.

Geol. Ran.:—Miocene? (Yamasiro)[132]-Pliocene.

Occur.:—SUENOMATUYAMA SERIES. Sarugasawa (loc. 30, rg. no. 1340), Numakubo (loc. 31, 32, rg. no. 1343), Kamayasiki (loc. 33, 42), Kamimainosawa (loc. 34, rg. no. 1342), Anausi (loc. 36, rg. no. 1341), Nagamine (loc. 38, rg. no. 1344), Suenomatuyama (loc. 40, rg. no. 1345).

Pallium swiftii nutteri (Arnold)

1906 *Pecten* (*Chlamys*) *nutteri* Arnold, Prof. Paper, 47, U. S. Geol. Survey, p. 67, Pl. XI, Figs. 3, 4, 4a.

1926 *Pecten heteroglyptus* Yokoyama, Jour. Fac. Sci. Imp. Univ. Tokyo, **1**, 304, Pl. XXXIII, Figs. 1-6.

Geol. Ran.:—Miocene? (Yamasiro)[132]-Pliocene.

Occurrence:—SUENOMATUYAMA SERIES. Kamayasiki (loc. 33, 42), Kamimainosawa (loc. 37; rg. no. 1348), Numakubo (loc. 31; rg. no. 1346), Nagamine (loc. 38; rg. no. 1347).

Patinopecten tokyoensis kimurai (Yokoyama)

1925 *Pecten kimurai* Yokoyama, Jour. Coll. Sci., Tokyo Imp. Univ., **45**, 27, Pl. IV, Figs. 1-6; Pl. II, Fig. 4.

Geol. Ran.:—Middle Neogene.

Occur.:—SUENOMATUYAMA SERIES. (Rg. no. 1349, 1350, 1351, 1352, 1353, 1354, 1355, 1356, 1357, 1358, 1359, 1360, 1361, 1362, 1363.)

UPPER KADONOSAWA SERIES. (Rg. no. 1364, 1365, 1366, 1367, 1368, 1369, 1370, 1371, 1372, 1373, 1374, 1375).

Patinopecten tokyoensis murayamai (Yokoyama)

1926 *Pecten murayamai* Yokoyama, Jour. Fac. Sci. Imp. Univ. Tokyo, [II], **2**, 887, Pl. XLIV, Figs. 18-20.

Geol. Ran.:—Middle or Lower Pliocene (Akita).

Occur.:—SUENOMATUYAMA SERIES. Kamayasiki (loc. 39; rg. no. 1376).

Patinopecten healey yamasakii (Yokoyama)

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131) MÜLLER, *Zool. Dan. Prodr.*, 2990 (1776), 248.

132) M. YOKOYAMA, *Jour. Fac. Sci., Imp. Univ. Tokyo*, [II], 2 (1930), 400 and 402.

1925 *Pecten yamasakii* Yokoyama, Jour. Fac. Sci. Imp. Univ. Tokyo, [II], 1, 17, Figs. 1, 2, 4, 5.

Geol. Ran.:—Upper Miocene-Lower Pliocene.

Occurrence:—SUENOMATUYAMA SERIES. Kintaiti (loc. 32, rg. no. 1381, 1382). Anausi (loc. 36; rg. no. 1379, 1380), Kamayasiki (loc. 33; rg. no. 1378), Sarugasawa (loc. 30; rg. no. 1377).

Volsella barbata (Linné)

1758 *Mytilus barbata* Linné, Syst. Nat. 10 ed., p. 705.

1922 *Modiolus barbata*, Yokoyama, Jour. Coll. Sci. Tokyo Imp. Univ., 44, 174, Pl. XIV, Fig. 19.

Geol. Ran.:—Miocene[133]-Recent.

Occur.:—SUENOMATUYAMA SERIES. Itukamati (loc. 35; rg. no. 1401, 1402), Anausi (loc. 35, 36), Isikiridokoro.

Brachidontes senhausii (Reeve)

1857 *Modiola senhausii* Reeve, Conch. Icon. sp. 20.

1927 *Modiola senhausii*, Yokoyama, Jour. Fac. Sci. Imp. Univ. Tokyo, [II], 1, 435, Pl. XLIX, Fig. 6.

Geol. Ran.:—?-Pleistocene-Recent.

Occur.:—UPPER KADONOSAWA SERIES. Hatimae (loc. 28.).

Venericardia ferruginosa (Adams et Reeve)

1850 *Cardita ferruginosa* Adams et Reeve, Zoology Voy. H. M. S. Samarang. sp. 78, Pl. XXI, Fig. 21.

1920 *Venericardia cipangoana* Yokoyama, Jour. Coll. Sci. Tokyo Imp. Univ., 44, 137, Pl. XI, Fig. 2.

Geol. Ran.:—Miocene (Zyôban)-Recent.

Occur.:—SUENOMATUYAMA SERIES. Mainosawa (loc. 34.).

Venericardia ferruginea (Adams)

Cardita ferruginea Adams, Syst. Conchylien Cabinet, Martini and Chemnitz., *Cardita*, p. 17, Pl. VI, Fig. 11.

1920 *Venericardia ferruginea*, Yokoyama, Jour. Coll. Sci. Tokyo Imp. Univ. 44, 139, Pl. XI, Figs. 3, 4.

Geol. Ran.:—Miocene-(Zyôban)-Recent.

Occur.:—SUENOMATUYAMA SERIES. (small type) Kamayasiki (loc. 39; rg. no. 1409).

UPPER KADONOSAWA SERIES. (large type) Kadonosawa (loc. 21; rg. no. 1407), Nidatori (loc. 17; rg. no. 1405, 1406, 1408), Hatimae (loc. 28; rg. no. 1297).

Lucina acutilineata Conrad.

1849 *Lucina acutilineata* T. A. Conrad, U. S. Exped., x, Geol., p. 725.

1850 *Lucina annulata* Reeve, Conch. Icon., vi, *Lucina*, sp. 17, Pl. IV, Fig. 17.

1920 *Lucina borealis*, Yokoyama, Jour. Coll. Sci. Tokyo Imp. Univ., 44, 133, Pl. X, Fig. 7.

Geol. Ran.:—Oligocene[134]-Recent.

Occur.:—UPPER KADONOSAWA SERIES. Kintaiti (loc. 23; rg. no. 1411), Hatimae (loc. 28.), Nidatori (loc. 17; rg. no. 1410).

Lucina k-hataii Otuka n. sp.

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133) M. YOKOYAMA, *Jour. Fac. Sci., Imp. Univ. Tokyo*, [II], 1 (1925), Pl. 224.

134) GRANT & GALE, *Mem. San Dieje Soc., Nat. Hist.*, 1 (1931), 287.

Pl. XLVII, Figs. 27, 28.

Shell rather small, more or less thin, with the surface more or less irregularly and concentrically lamellated; anterior end longer attenuated; posterior end more plump, obscurely vertically truncated; beak low pointed; lunule small, crescentric in form, deeply impressed, with fine, close, more or less irregularly crenated striae parallel to the hinge margin; postero-dorsal area more or less distinct, extending to the postero-ventral margin. Ligament impressed, broadly curved.

Measurements:	Length.	Height.	Thickness.
No. 1. (Cotype)	18 mm.	16 mm.	10 mm.
No. 2. (Cotype)	17 mm.	15.5 mm.	8 mm.
No. 3. (Cotype)	15·5 mm.	14·5 mm.	7 mm.
No. 4. (Cotype)	14 mm.	13·5 mm.	6 mm.

This species resembles *Lucina* (*Myrtea*) *acutilineata* Conrad, but the former is easily distinguished from the latter, in the smaller size and finer concentric striae, and a longer, inequilateral shell.

Occur.:—LOWER KADONOSAWA SERIES. Nisatai (loc. 3; rg. no. 1417, type), Yuda (loc. 4), Tate (loc. 6; rg. no. 1418).

Lucina yokoyamai Otuka n. sp.

Pl. XLVII, Figs. 29, 30, 31, 32.

Shell Dall's *Lucinisca* type,[135] small, lenticular ventricose; surface cancellated; with concentric thick lamellae and radiating riblets. Concentric lamellae rude prominent near the margin. Anterior dorsal area, small, marginal; extremity emarginate above. Lunule depressed small. Cardinal and lateral teeth distinct; inner margin minutely crenulated. Posterior dorsal area narrow, in which the radiating riblets are obsolete.

Measurement:	Height.	Length.	Thickness.	No. of ribs in the medial area.
No. 1 (Cotype)	11·5mm.	12·2mm.	10·0mm.	39
No. 2 (Cotype)	8·5mm.	9·0mm.	5·0mm.	38–39
No. 3 (Cotype)	8·0mm.	8·7mm.	4·2mm.	39
No. 4 (Cotype)	8·5mm.	9·2mm.	5·5mm.	37

This new species from Ninohe is closely allied to *Lucina* (*Myrtea*) *nuttallii* Conrad[136] from the American Neogene, but is readily recognized by the finer concentric sculpture and larger beak.

Occur.:—LOWER KADONOSAWA SERIES. Nisatai (loc. 3; rg. no. 1412), Yuda? (loc. 4), Tate (loc. 6; rg. no. 1414), Siratori (loc. 7; rg. no. 1413).

Pillucina pisidium nisataiensis Otuka n. subsp.

Pl. XLVII, Figs. 33, 34.

Shell small, rounded, moderately convex, oblique, inequilateral, the dorsal area hardly indicated or obsolete; beak small, low, but pointed, prosogyrate over a small moderately impressed rather narrow lunule; anterior dorsal margin slightly truncated; posterior dorsal margin convexly arched, as high as the beak; surface finely, concentrically, rather closely grooved, with a weak keel running from beak to anterior margin. Diverging ribs being of about the same strength and prominence as the concentric sculpture. Number of ribs about 30 or more. Inner margin crenate.

Measurement: height 10·1mm.; length 9·7mm.; thickness 6·1mm.

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135) DALL, *Proc. U. S. Nat. Mus.*, **23** (1901), 805.

136) CONRAD, *Jour. Acad. Nat. Sci., Phila.*, **1** (1837), 255, Pl. XX, Fig. 2.

This subspecies is nearly allied to *Pillucina pisidium* (Dunker)[137] from Japanese waters and Japanese Pleistocene. Our specimen has a higher and thicker shell, with more rude prominent diverging ribs and concentric sculpture.

Occurrence:—LOWER KADONOSAWA SERIES. Nisatai (loc. 3, rg. no. 1415, monotype).

Pillucina contraria (Dunker)

Pl. XLVIII, Figs. 37, 38.

1882 *Lucina contraria* Dunker, Index Moll. Maris Japon, p. 215, Pl. XIII, Figs. 12, 13, 14.

1920 *Lucina contraria*, Yokoyama, Jour. Coll. Sci., Tokyo Imp. Univ., **39**, 134, Pl. X, Fig. 8.

Two specimens which were collected from Nisatai valley are more or less higher shells than the Recent and Pleistocene specimens.

Geol. Ran.:— Pleistocene-Recent.

Occur.:—LOWER KADONOSAWA SERIES. Nisatai (loc. 3; rg. no. 1416).

Taras ferruginata (Makiyama)

Pl. XLVII, Fig. 35, Pl. XLVIII, Figs. 39, 40.

1926 *Diplodonta ferruginata* Makiyama, Mem. Coll. Sci. Kyoto Imp. Univ., [B], **2**, 157, Pl. XII, Figs. 12, 13.

Geol. Ran.:—Upper Oligocene?—Middle Miocene.

Occur.:—LOWER KADONOSAWA SERIES. Nisatai (loc. 3; rg. no. 1419), Tate (loc. 6; rg. no. 1291), Siratori (loc. 7; rg. no 1420, 1436), Narayama (loc. 8; rg. no. 1421).

Cardium (Cerastoderma) shinjiense Yokoyama

Pl. XLVII, Fig. 36.

1923 *Cardium shinjiense* Yokoyama, Jap. Jour. Geol. Geogr., **2**, 7, Pl. II, Fig. 6.

This species is distinguished from *C. ciliatum* Fabricius[138] from the California coast by its truncated posterior margin, more produced postero-ventral margin and higher beak.

Geol. Ran.:—Miocene-Pliocene.

Occur.:—LOWER KADONOSAWA SERIES. Nisatai (loc. 3; rg. no. 1424), Yuda (loc. 4, rg. no. 1430), Tate (loc. 6; rg. no. 1442), Siratori (loc. 7; rg. no. 1423, 1425, 1426, 1427, 1428), Narayama (loc. 8; rg. no. 1429), Takaba (loc. 9).

Cardium sp. 1.

Two specimens which look like *Cardium* (*Cerastoderma*) *shiobarense* Yokoyama (1926, Jour. Fac. Sci, Imp. Univ. Tokyo, [II], **1**, 134, Pl. XX, Figs. 2-5.) were collected.

Occur.:—LOWER KADONOSAWA SEIRES. Tate and Siratori (loc. 6, 7).

"Paphia" siratoriensis Otuka n. sp.

Pl. XLVIII, Figs. 98. 41a, b, Pl. L, Fig. 98.

Shell elongate, turgid, sculptured with fine concentrical and radial grooves. Concentrical striae prominent and radial sculpture obsolete on the posterior third of the shell surface. On the middle of the shell, the concentrical striae broken. Lunule well defined by a depressed line. Escutcheon obsolete, narrow. Inner margin smooth.

Measurement:	Height	Length	Thickness
No. 1 (Cotype)	10mm.	15mm.	2mm.
No. 2 (Cotype)	23mm.	33·5mm	9·5mm.
No. 3 (Cotype)	20·5mm.	30·5mm.	xmm.

137) DUNKER, *Moll. Jap.*, (1861), 28, Pl. III. Fig. 9.

138) FABRICIUS, *Fauna Grönl.*, (1780), 410.

Occur.:—LOWER KADONOSAWA SERIES. Siratori (loc. 7; rg. no. 1435, cotype), Nisatai (loc. 3; rg. no. 1437), Yazawa (loc. 5, 1; rg. no. 1441, 1439), Tate (loc. 6; rg. no. 1434, 1433), Takaba (loc. 9; rg. no. 1431).

The writer could not find the section of *Paphia* Bolten 1798 that has such characteristic of surface sculpture as described above. The writer considers that it may possibly be a new section of Paphia.

Protothaca jedoensis (Lischke)[139] is a shell closely allied to this species. But the former has very rudely sculptured and shorter shell than the latter.

Clementia* (*Compsomyax*)** aff. ***subdiaphana Carpenter

Pl. XLVIII, Fig. 42.

1864 *Clementia subdiaphana* Carpenter, Brit. Assn. Adv. Sci., Rep. for 1863, p. 602, 607, 640.

1924 *Marcia subdiaphana*, Oldroyed, Stanford Univ. Publ. Geol., 1, 155, Pl. XXXVIII, Fig. 1; Pl. XXXVIII, Fig. 3.

1931 *Clementia* (*Compsomyax*) *subdiaphana*, U. S. Grant, IV and H. R. Gale, Mem , San. Diego Soc. Nat. Hist., 1, 334, Pl. I, Figs. 10a, 10b, ? 15.

Geol. Ran.:—Miocene?-Lower Pliocene-Recent.

Occur :—UPPER KADONOSAWA SERIES. Sikonai (loc. 21; rg. no. 1443).

Clementia* (*Compsomyax*) *subdiaphana yazawaensis Otuka

Pl. XLIX, Figs. 64 a, b.

According to Grant and Gale, the description of *Clementia* (*Compsomyax*) *subdiaphana* Carpenter is as follow: "Shell moderate in thickness, sculptured only with fine growth lines, elongate-ovate varying considerably in outline and ventricosity, beaks anterior to the middle and pointing forward, anterior slope short and abruptly descending, posterior dorsal margin almost parallel for a short distance with the ventral margin, lunule broad and very faintly defined, escutcheon depressed but not defined; hinge like that of *Pitar*, but lacking the anterior left lateral; valve margins smooth, pallial sinus broad and strongly ascending." But this Japanese subspecies has a more or less lower shell. The type species has a more convex ventral margin.

Occur.:—LOWER KADONOSAWA SERIES. Yazawa (loc. 5 and 1; rg. no. 1446, 1447, 1448, 1450), Yuda (loc. 4; rg. no. 1452), Tate (loc. 6; 1451); rg. no. Narayama (loc. 8; rg. no. 1449, 1453), Itinohe (loc. 10; rg. no. 1454).

Saxidomus? sp.

Occur.:—SUENOMATUYAMA SERIES. Anausi (loc. 36).

Macrocallista pacifica (Dillwyn)

(1817 *Venus pacifica* Dillwyn, Cat. Rec. Shells, i, p. 175)

1920 *Meretrix* (*Callista*) *chinensis*, Yokoyama, Jour. Coll. Sci., Tokyo Imp. Univ., 39, 120, Pl. VIII, Figs. 9, 10.

Geol. Ran.:—Cret.-Recent.

Occur.:—LOWER KADONOSAWA. Siratori (loc. 7; rg. no. 1455)

Pitar yabei Otuka

Pl. XLVIII, Figs. 49, 50.

Shell moderate in size, solid, thick, trigonally ventricose, slightly polished, marked by minute concentric growth lines; beak large, subcentral or slightly posterior; anterior end prominent, rounded, posterior narrowly rounded; ventral margin broadly convex; lunule feebly defined by an impressed line.

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139) LISCHKE, *Jap. Meeresconch.*, 3 (1874), 84, Pl. VII, Figs. 1-9.

Interior margin smooth.

Measurements:	Length.	Height.	Thickness.
No. 1 (cotype)	26·5mm.	22·0mm.	8·2mm (with one valve)
No. 2 (cotype)	43·5+xmm.	37·0mm.	12.5mm („)
No. 3 (cotype)	?	26·1mm.	11·7mm („)
No. 4 (cotype)	30·0mm	?	9·0mm („)

Pitar limatula (Sowerby)[140] is an allied species. But the new species has blunter beak and a more elongate form. *Pitar itoi* Makiyama[141] from Lower Miocene of Tyosen has an elongate and mare inequilateral shell.

Occur:—LOWER KADONOSAWA SERIES. Nisatai (loc. 3; rg. no. 1456).

Cyclina sinensis Gmelin

1792 *Cyclina sinensis* Gmelin, Conchyl. Cab., **11**, Pl. II, Fig. 5.

1920 *Cyclina chinensis*, Yokoyama, Jour. Coll. Sci, Tokyo Imp. Univ., **39**, 119, Pl. VIII, Figs. 7, 8.

Geol. Ran.:—Miocene (Mino)-Recent.

Occur.:—LOWER. KADONOSAWA SERIES. Tate (loc. 6; rg. no. 1457), Nisatai? (loc. 3; rg. no. 1458).

Dosinia japonica nomurai Otuka n. subsp.

Pl. XLVIII, Fig. 54.

Specimens collected from Ninohe Miocene have more or less lower shells, and a longer postero-dorsal margin than those of the species. The antero-dorsal margin of these specimens is blunter than in *Dosinia japonica* (Reeve).[142]

Occur.:—LOWER KADONOSAWA SERIES. Nisatai (loc. 3; rg. no. 1465, 1463), Yuda (loc. 4; rg. no. 1466), Yazawa (loc. 5; rg. no. 1462), Tate (loc. 6; rg. no. 1467), Siratori (loc. 7; rg. no. 1464), Itinohe (loc. 10; rg. no. 1460, 1498), Takaba (loc. 9; rg. no. 1499).

Dosinia nagaii Otuka n. sp.

Pl. XLVIII, Fig. 55

Shell large, solid, moderately convex, obliquely elongate ovate, nearly as long as high, inequilateral. The postero-dorsal border usually more abruptly sloping than the antero-dorsal and the anterior border more broadly rounded than the posterior. Surface regularly concentrically furrowed. Beak small, pointed. Lunule narrowly elongate (length 8 mm. width 2·25mm. measured with one valve of type specimen).

Measurement:	Height.	Length.	Thickness.
Monotype	5·25mm.	5·25mm	1·13mm (with one valve)

Occur.:—LOWER KADONOSAWA SERIES. Nisatai (loc. 3; rg. no. 1461, monotype), Takaba (loc. 9; rg. no. 1472).

Dosinia kaneharai[143] Yokoyama is an allied species. But this new species is easily distinguished from *D. kaneharai* Yokoyama by its inequilateral, obliquely elongate form and less prominent anterior margin.

Dosinia japonica Reeve *nomurai* Otuka has a greatly sloping postero-dorsal margin and more acute angles between the anterior dorsal margin and the antero-ventral margin.

Dosinia angulosa Philippi[144] is an other allied species. But this new species has a

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140) SOWERBY, *Conch Cab.*, p. 59, Pl. XXII, Fig. 5.

141) J. MAKIYAMA, (1926), *op. cit.* p. 159, Pl. XIII, Fig. 7.

142) REEVE, *Conch. Icon.*, (1850), Pl. III, Fig. 17.

143) M. YOKOYAMA, *Jour. Fac. Sci., Imp. Univ. Tokyo*, [II], **1** (1926).

144) PHILIPPI, *Abbild. Beschr. Conch.*, **2** (1847), 229, Pl. VI, Fig. 1.

longer postero-dorsal margin, and a more inequilateral form.

Dosinia sp.

One incomplete specimens was collected from Suenomatuyama series.

Occur.:—SUENOMATUYAMA SERIES. Anausi (loc. 36; rg. no. 1468).

Tellina nitidula Dunker

Tellina nitidula Dunker, Malakoz. Bl., **6**, 229.

1861 *Tellina nitidula*, Dunker, Moll. Japonica, p. 27, Pl. III, Fig. 14.

1920 *Tellina nitidula*, Yokoyams, Jour. Coll. Sci., Tokyo Imp. Univ., **39**, 112-113, Pl. VII, Fig. 15.

Geol. Ran.:—Miocene-Recent.

Occur.:—LOWER KADONOSAWA SERIES. Narayama (loc. 8; rg. no. 1469).

Macoma optiva (Yokoyama)

Pl. XLVIII, Fig. 51.

1925 *Tellina optiva* Yokoyama, Jap. Jour. Geol. Geogr. **2**, 6, Pl. II, Figs. 3, 4.

Geol. Ran :—Miocene-Low. Pliocene.

Occur.:—UPPER KADONOSAWA SERIES. Kagitori (loc. 21; rg no. 1483), Nidatori (loc. 17; rg. no. 1484), Hatimae (loc. 28.)

LOWER KADONOSAWA. Yazawa (loc. 1, 5; rg. no. 1474, 1475, 1476, 1478, 1479, 1482), Narayama (loc. 8, rg. no. 1481), Yuda (loc. 4, rg. no. 1480).

The specimens collected from the Upper Kadonosawa series are generally small in size, but those from the Lower Kadososawa series are large. The figure of *Macoma dissimilis* (Marten) illustrated by Prof. M. Yokoyama from Northern Karafto[145] completely agrees with the specimens from the Upper Kadonosawa series.

Macoma tokyoensis Makiyama

1920 *Macoma dissimilis*, Yokoyama, Jour. Coll. Sci., Tokyo Imp. Univ., **39**, 116-117, Pl. VII, Figs. 19, 20.

1927 *Macoma tokyoensis* Makiyama, Mem. Coll. Sci., Kyoto Imp. Univ., [B], **1**, 50.

Geol. Ran.:—Miocene?-Lower Pliocene-Recent.

Occur.:—UPPER. KADONOSAWA SERIES. Siratori valley (loc. 21; rg. no. 1485, 1487), Nidatori (loc. 17; rg. no. 1486).

Sanguinolaria (***Soletellina***) ***minoensis*** (Yokoyama)

Pl. XLIX, Figs. 65 a, b.

1926 *Soletellina minoensis* Yokoyama, Jour. Coll. Sci., Imp. Univ. Tokyo, [II], **1**, 7, Pl, XXVIII, Figs. 13-16.

Geol. Ran.:—Miocene.

Occur.:—LOWER KADONOSAWA SERIES. Nisatai (loc. 3; rg. no. 1495, 1496, 1497), Itinohe (loc. 10; rg. no. 1521).

Solen sp.

One incomplete specimen was collected.

Occur.:—LOWER KADONOSAWA SERIES. Siratori, Yuda, Nisatai.

Cultellus izumoensis Yokoyama

1923 *Cultellus izumoensis* Yokoyama, Jap. Jour. Geol. Geogr., **2**, 5, Pl. II, Fig. 1.

Geol. Ran.:—Miocene-Pliocene (Tatibana group[146] in Musasi.)

Occur.:—UPPER KADONOSAWA SERIES. Kagitori (loc. 21; rg. no. 1492, 1494), Kadonosawa (loc. 22; rg. no. 1490), Nidatori (loc. 17; rg. no. 1493), Hatimae (loc. 28.),

145) M. YOKOYAMA, *Jour. Coll. Sci., Imp. Univ. Tokyo*, [II], **2** (1929), Pl. LXXIV, Fig. 2.

146) Y. OTUKA, *Jour. Geol. Soc., Tokyo*, **39** (1932), 644.

Koida (rg. no. 1491).

Mactra ? sp.

One incomplete specimen was collected from Kadonosawa series.

Occur.:—UPPER KADONOSAWA SERIES. Kadonosawa (loc. 22; rg. no. 1500).

Spisula ? sp.

A broken specimen. Fragment of beak resembles that of *Spisula sachlinensis* Schrenck.

Occur.:—SUE. SER. Kamimainosawa (loc. 34; rg. no. 1501), Kamayasiki (loc. 39).

"Cardilia" yudaensis Otuka n. sp.

Pl. XLVIII, Figs. 46, 47, 48.

Shell small in size, inequivalve, thin, strongly convex, longitudinally oval; left valve almost one and a half times higher than long, inequilateral. Right valve higher than the left, two times higher than long, subequilateral. Posterior half of the surface with about 12 radiating ribs generally somewhat broader than the interspaces, disappearing on the anterior half. Irregular concentric wrinkles are visible on the surface. Beak prominent, roundly incurved, and pointed.

Measurement:	Height.	Length.	Thickness.
Monotype	{15 mm. (right) / 12·5 mm. (left)}	9·7 mm.	10·9 mm.

I am unable to find the genus of this new shell. *Cardilia* is an allied genus, but this shell has an inequivalved shell.

Cardilia semisulcata Lamarck[147] is easily distinguished from this new species by its equivalved shell and more depressed beak.

Occur.:—LOWER KADONOSAWA SERIES. Yuda (loc. 4; rg. no. 1506).

Cryptomya bussoensis Yokoyama

Pl. XLVIII, Fig. 52.

1920 *Cryptomya bussoensis* Yokoyama, Jour. Coll. Sci. Tokyo Imp. Univ., 44, 126, Pl. VII, Figs. 1, 2.

Geol. Ran.:—Pleistocene-Recent

Occur.:—UPPER KADONOSAWA SERIES. Nidatori (loc. 17; rg. no. 1507, 1508).

Aloidis erythrodon nisataiensis Otuka n. subsp.

Pl. XLVIII, Figs. 43, 44, 45.

Shell oblong ovate, nearly equivalve; anterior margin rounded; posterior margin more produced and angularly carinated; surface with fine concentric grooves.

Measurements:	Height.	Length.	Thickness.
No. 1 (cotype)	8·5 mm.	14·0 mm.	4·0 mm. (one valve).
No. 2 (cotype)	9·0 mm.	15·5 mm.	4·4 mm. 〃
No. 3 (cotype)	8·3 mm.	14·5 mm.	3·6 mm. 〃
No. 4 (cotype)	9·0 mm.	14·3 mm.	3·6 mm. 〃
No. 5 (cotype)	10·0 mm.	17·1 mm.	4·3 mm. 〃

This new subspecies is easily distinguished from the type species[148] by its smaller valves and finer concentric grooves.

Occur.:—LOWER KADONOSAWA SERIES. Nisatai (loc. 3; rg. no. 1509), Siratori (loc. 7; rg. no. 1510).

Panope japonica A. Adams

147) LAMARCK, *Anim. sans vert.*, 2 *ed.* 6, 447.

148) LAMARCK, *Anim. sans vert.*, 6, 138.

1850 *Panopaea japonica* A. Adams, Proc. Zool. Soc., 18 (1849), 170, Pl. VI, Fig. 5.

1851 *Panopaea generosa* Gould, Proc. Bost. Soc., 3 (1850), 215.

1922 *Panope generosa*, Yokoyama, Jour. Coll. Sci., Tokyo Imp. Univ., 44, 121, Pl. VI, Figs. 14, 15.

Geol. Ran. :—Miocene-Recent.

Occur. :—SUENOMATUYAMA SERIES. Kamimainosawa (loc. 34), Anausi (loc. 36; rg. no. 1520).

UPPER KADONOSAWA SERIES. Nidatori (loc. 17; rg. no. 1518), Hatimae (loc 28; rg. no. 1511).

LOWER KADONOSAWA SERIES. Yazawe (loc. 5; rg. no. 1514, 1519, 1517), Tate (loc. 6; rg. no. 1515, 1516), Siratori (loc. 7; rg. no. 1522), Narayama (loc. 8; rg. no. 1513), Itinohe (loc. 10; rg. no. 1512).

"Panomya" simotomensis Otuka.

Pl. XLIX. Figs. 66 a, b.

Shell thin ovate-subquadrate, gaping very widely in the rear, medial portion of valves depressed and bounded by two radial folds; surface with concentric furrows.

Measurements:	Height.	Length.	Thickness.
Monotype	27 mm.	46 mm.	6·5 mm.

Angles of radial folds are about 45°.

This new species is distinguished from *Panomya arctica* (Lamarck)[149] in the shorter dorsal margin and more inequilateral shell. The beak of *Panomya simotomensis* Otuka is situated on the anterior third of the shell.

Occur. :—SUENOMATUYAMA SERIES. Simotome (loc. 39; rg. no. 1524)

UPPER KADONOSAWA SERIES. Nidatori (loc. 17; rg. no. 1523)

Zirphaea subconstricta (Yokoyama) ***kotorai*** Otuka

Pl. XLVIII, Fig. 53

This shell is closely allied to *Zirphaea subconstricta*[150] (Yokoyama) but differs in its more rude concentric sculptures. Concentric sculptures of *Zirphaea subconstricta* (Yok.) are finer than the new subspecies.

According to Dall, Grant and Gale, Pacific *Zirphaea crispata* (Linné)[151] may probably be *Zirphaea gabbi* (Tryon)[152] or *Pholadidea ovoidea* (Gould).[153] The Japanese *Zirphaea crispata* may be a dintinct species.

Zirphaea subconstricta (Yokoyama) well agrees with the living Japanese *Zirphaea crispata*. *Zirphaea subconstricta* (Yokoyama) easily distinguished from *Zirpheaa gabbi* (Tryon) by its more steeply sloping dorsal margin, and more constricted anterior margin.

Occur. :—LOWER KADONOSAWA SERIES. Siratori (loc. 7; rg. no. 1525).

Class Scaphopoda

Dentalium (***Antalis***) sp.

This *Dentalium* is closely allied to *D. rhabdotum* Pilsbry,[154] but differs in its surface

149) LAMARCK, *Hist. Anim. san. Vert.*. 5 (1818), 458, (as *Glycymeris*).

150) M. YOKOYAMA, *Jour. Coll. Sci., Tokyo Imp. Univ.*, 45(1923), 38, Pl. II, Fig. 13.

151) LINNÉ, *Syst. Nat. Ed.*, 10 (1758), 670.

Zirphaea constricta Sowerby (Thes. Conch., 3, 489, and 489, Pl. CIV Fig. 27) may be Japanese *Zirphaea crispata* (Linné), but the former specific name is preoccupied by Philippi (Thes. Conch, 2 (1829)).,

152) TRYON, *Proc. Acad. Nat. Sci., Philadelphia*, 15 (1863), 144, Pl. I. Fig. 1.

153) GOULD, *Proc. Boston Soc. Nat. Hist.*, 4 (1851), 87.

154) PILSBRY, *Proc. Acad. Nat. Sci., Phila.*, 57 (1905), 116, Pl. V, Figs. 45-47.

ornamentation.

Occur.:—UPPER KADONOSAWA SERIES. Nidatori (loc. 17; rg. no. 1591), Hatimae (loc. 28; rg. no. 1597), Osimizu (loc. 29; rg. no. 1590).

Class GASTOROPODA

Acmaea sp. 1.

Shell thin, conical, elliptical in outline, obtusely pointed at the apex which is on the anterior third. Anterior as well as posterior straight. Surface smooth, with concentric growth lines. Length 20 mm., breadth 17 mm., height 7 mm.

Occur.:—SUENOMATUYAMA SERIES. Kamimainosawa (loc. 37; rg. no. 1526).

This shell resembles *Acmaea asmiiformis* Yokoyama[155] of the Upper horizon, Sawane Pliocene in Sado Island, but in this sp. the apex is situated more anterior of the shell than the latter sp.

Acmaea (*Tectus*) *sigaramiensis* Makiyama[156] is also closely allied to this species. But the former has radial ribs on the shell surface.

"Minolia" sasai Otuka n. sp.

Pl. XLIX, Figs. 82 a, c, Pl. LI, Fig. 82 b.

Shell small thin, with a low conical spire. Whorls about five, convex. Sculptured with low spiral ridges, which number about 6 on the penultimate whorl. Base sculpture with fine spiral striae which number about 13~14. Umbilicus widely open. Aperture subcircular. Height 5 mm., diameter 6·5 mm.

Minolia tasmanica Tenison-Wood[157] of Yokoyama closely resembles this species. But the former has a broad horizontal terrace.

Occur.: -LOWER KADONOSAWA SERIES. Nisatai (loc. 3, rg. no. 1527).

Turritella fortilirata kadonosawaensis Otuka

Pl. LI, Fig. 104

The upper half of the surface sculpture of a whorl in the specimens collected from the Kadonosawa series is flat and slopes steeply, with 3 (or 4) narrow spiral threads; the lower half is ventricosa, with 2 strong flat topped spirals the interspace of which are ornamented with fine spirals.

Occur.:—SUENOMATUYAMA SERIES. Kamayasiki.

UPPER KADONOSAWA SERIES. Kadonosawa (loc. 21, rg. no. 1533, 1534), Nidatori (loc. 17, rg. no. 1535).

Turritella fortilirata Sowerby (Pl. LI, Figs. 105, 102)[158] has four or five spiral threads and *Turritella fortilirata saishuensis* Yokoyama[159] (Pl. LI, Fig. 103) has three strong threads. In the interspaces of the spiral threads of *Turritella fortilirata saishuensis* Yokoyama, finer spiral lines are presented.

Turritella perterebra[160] Yokoyama (Pl. LI, Fig. 101) is a shell having from six to ten fine spiral threads with intercalaries of finer threads.

Turritella andenensis Otuka n. sp. (Pl. LI, Figs. 113, 100) from the Pliocene of Akita

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155) M. YOKOYAMA, *Jour. Fac. Sci., Imp. Univ. Tokyo*, [II], 1 (1926), 287, Pl. XXXIV, Fig. 15.

156) J. MAKIYAMA, *Tikyû*, 8 (1927), 187, Pl. III, Fig. 1.

157) M. YOKOYAMA, *Jour. Coll. Sci., Tokyo Imp. Univ.*, 44 (1922), 109-110, Pl. V, Fig. 19.

158) SOWERBY, *Ann. Mag. Nat. Hist.*, [viii], 14 (1914), Pl. II, Fig. 12.

159) M. YOKOYAMA, *Jour. Coll. Sci., Tokyo Imp. Univ.*, 44 (1923), 3-4, Pl. I, Fig. 2.

160) M. YOKOYAMA, *Jour. Coll. Sci, Tokyo Imp. Univ.*, 45 (1923), 11, Pl. II, Figs. 2-5.

closely resembles the preceeding species. *T. andenensis* Otuka has fine unequal spiral threads on the spra-sutural area, and the lower part of the outer margin of the aperture more produced than those of *T. perterebra* Yokoyama. The description of *Turritella andenensis* Otuka is as follows:

"Shell high turreted, consisting of many whorls (19 in the type specimens) which consist of two more or less flat surface making a spiral keel. The keel is always on the lower third of the whorls. Surface of the upper two thirds ornamented with fine unequal threads, coarse ones of which there are about 8 alternating with finer ones on the penultimate, and ultimate whorl. Spiral sculptures are broadened on the subsutural area and the keel. Finer spiral sculptures are superimposed on the broad sculptures. The lower third of the whole surface ornamented with two coarse spiral threads with secondary and tertiary finer spiral threads. Aperture sub-ovoidal, upper end of the aperture angulate. Lower part of the outer margin of the aperture produced foreward.

Measurement	Apical angle	Length	Diameter
Cotype (Fig. 99)	15°—16°	74 mm.	17·5 mm.
Cotype (Fig. 100)	15°—16°	62 mm. (apical part missed)	17 mm.

Occurrence:—Anden (A), Oga Peninsula, Akita."

Turritella kiiensis Yokoyama[161] is a shell closely allied to *T. andenensis* Otuka. But the former has a more depressed suture and coarse spiral threads.

Batillaria atukoae Otuka n. sp.

Pl. XLIX. Figs. 69 and 70.

Shell moderately small and turreted, the apical angle being about 26°-27°. The number of whorls can not be exactly given, as the specimens invariably lack the apical portion, but it seems to be over 8. They are shouldered and are as a whole flattish, with three spiral tuberculated bands. The band beneath the upper suture on the penultimate and ultimate whorl bearing spiny tubercles which number ten on the ultimate whorl, and about 16 on the penultimate whorl. The number of tubercles beneath the upper suture on the one preceeding is 20, so that on the upper whorls they look like a close row of small beads. The spiny tubercles are ornamented with fine spiral lines. Two bands beneath the spiny tubercled band are closely rowed on the last two whorls. A spiral thread is visible in the interspace of the two lower bands.

Aperture subpentagonal, and anteriorly extended. Inner side of outer lip horizontally furrowed. The suture of the ultimate whorls obliquely ascends near the aperture forming an angle with the spiral sculpture of the penultimate whorls. A thick callous covers the inner lip and extends above. The anterior canal is deep short, and bent.

Measurements.	Height.	Diameter.
Monotype	ca. 30 mm.	ca. 14-15 mm.

Occur.:—LOWER KADONOSAWA SERIES. Yuda (loc. 4; rg no. 1536, type), Narayama (loc. 8; rg. no. 1537), Nisatai (loc. 3; rg. no. 1540).

This new species resembles *Cerithium baculum* Yokoyama[162] from the Miocene of Kii in its spiny tuberculated and beaded band. But this n. sp. differs from the latter in that the three tuberculated bands have fewer spiny tubercles on the preceeding whorls.

Vicarya vernuilli yokoyamai[163] Takeyama is an allied species in its surface sculpture,

161) M. Yokoyama, *Jap. Jour. Geol. Geogr.*, 2, (1923), 52, 53, Pl. VI, Figs. 9, 10.

162) M. Yokoyama, *Jap. Jour Geol. Geogr.*, 2 (1923), 52, Pl. VI, Fig. 12.

163) T. Takeyama, *Jap. Jour. Geol. Geogr.*, 10 (1933), 134, Pl. XIII, Fig. 4.

but this n. sp. has a shorter form and no deep sinus.

Potamides ancisus Yokoyama[164] is also allied to this species but has more spiral threads.

Cerithium baculum Yokoyama[165] from the Zyôban coal field differs from this new species in its more acute apical angles and in the larger number of spiral cords.

Batillaria yamanarii Makiyama

Pl. XLIX. Figs. 80, 81.

1926 *Batillaria amanarii* Makiyama, Mem. Coll. Sci. Kyoto. Imp. Univ., [B], 2, 148-149, Pl. XII, Fig. 4.

1929 *Cerithium proavitum* Yokoyama, Jour. Fac. Sci. Imp. Univ. Tokyo, [II], 2, 366-367, Pl. LXX, Fig. 3.

Geologic range:—Lower Miocene (Heirokudo formation in Tyôsen; Uetuki series).

Occurrence:—LOWER KADONOSAWA SERIES. Siratori (loc. 7; rg. no. 1538).

Batillaria tateiwai Makiyama

Pl. XLIX. Fig. 71.

1926 *Batillaria tateiwai* Makiyama, Mem. Coll. Sci. Kyoto Imp. Univ., [B], 2, 147-148, Pl. XII, Figs. 5, 6.

1929 *Cerithium sakamotoi* Yokoyama, Jour. Fac. Sci. Imp. Univ., Tokyo, [II], 2, 367, Pl. LXX, Fig. 4.

Geologic range:—Lower Miocene (Heirokudo formation, Uetuki series).

Occurrence:—LOWER KADONOSAWA SERIES. Siratori (loc. 7; rg. no. 1539).

"*Proclava*" ffa. *ishiianum* (Yokoyama)

Pl. XLIX. Figs. 72, 73

1926 *Cerithium ishiianum* Yokoyama, Jour. Fac. Sci. Imp. Univ. Tokyo, [II], 1, 218, Pl. XXVIII, Figs. 11, 12.

Shell moderate in size, thick, solid, turreted, the apical angle being about 20° regularly increasing, with a ratio of diameter to height of about 9 to 32. Upper whorls ornamented with three nearly equidistant spiral cords which are finely beaded. The upper most cords, which are infra-sutural become stronger on the latter whorls. On the lower five whorls, the beads of the upper cord become spiny which numbering about 15-16. A few spiral cords run on the spiny tubercles. The number of the lower spiral beaded cords is about 13 (upper) -10 (lower) in 10mm. length. Periphery rounded. The beaded character on the spiral cords is obsolete near the apertute. Base ornamented with about 6 equidistant spiral cords. Lower part of the outer lip of the aperture extends anteriorly. Inner lip covered with callus deposits, with one weak fold. The columellar end is broken in this specimen.

Measurements. Height ca. 64mm; diameter ca. $\frac{17{\cdot}5+16{\cdot}5}{2}$mm.

(Apical portion and lower end partly missing).

Occurrence:—LOWER KADONOSAWA SERIES. Nisatai (loc. 3; rg. no. 1541, monotype).

Cerithium baculum Yokoyama[166] from the Zyôban coal field differs from this species

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164) M. YOKOYAMA, *Jour. Fac. Sci. Imp. Univ. Tokyo*, [II], 2 (1929), 367-368, Pl. LXX, Fig. 2.

165) M. YOKOYAMA, *Jour. Coll. Sci. Tokyo Imp. Univ.*, 45(1925), 12, Pl. II, Fig. 6.

166) M. YOKOYAMA, *Jour. Coll. Sci. Tokyo Imp. Univ.*, 45(1925), 12, Pl, II, Fig. 6.

in that the latter has 3 or 4 beaded spiral cords.

The original description of *Cerithium ishiianum* Yokoyama is founded on a single broken specimen and several casts. The specimens from Nisatai is somewhat different from the original figure in its beaded cords, but other characteristics almost agree with Yokoyama's description. The writer is convinced that this specimen from Nisatai may be no other than *Cerithium ishiianum* Yokoyama.

Epitonium* (*Boreoscala*) *naganinensis Otuka

Pl. LI, Figs. 111 a, b.

The description of the present species is based on a broken specimen.

Shell small, turreted, the apical angle being about 23°, with many whorls, of which the lower 4 are preserved. The whorls sculptured with longitudinal ribs, and varices. Longitudinal ribs are 12-13 on the ultimate whorl, 14 on the penultimate. Interspace of the ribs broader than the rib, ornamented with rounded spiral threads, which number about 8-7 on the later whorls. Basal disk distinct, defined by a prominent ridge. Aperture subrounded. Height 13 mm (upper part missing); diameter 7 mm.

Occurrence:—SUENOMATUYAMA SERIES. Nagamine (loc. 38; rg. no. 1546).

Epitonium turriculoides (Yokoyama) from the Pliocene of Miura peninsula resembles this species. But the former differs from the latter in that it is a small shell with less prominent ribs. The new species has more prominent spiral threads in the interspaces of the ribs.

Boreoscala eximia (Adams et Reeve)[168] living in the China Sea resembles this species but the number of longitudinal ribs of the former is larger than the latter.

Epitonium (*Arctoscala*) *condoni* Dall[169] and *E.* (A.) *saundersi* Tegland[170] from Middle Tertiary of California are also allied species. But this species has a small shell, and 8-7 equall spiral sculptures.

Calyptrea sp. 1.

Pl. XLVIII, Figs. 62a, b.

Shell conical, with a subcentral apex that is spiral; surface smooth, with concentric irregular growth lines.

Calyptrea mammillaris of Yokoyama[171] from the Zyôban coal field resembles this species.

Occurrence:—UPPER KADONOSAWA SERIES:—Kadonosawa (loc. 22; rg. no. 1547).

Calyptrea yokoyamai tubura Otuka n. subsp.

Pl. XLIX, Figs. 78 a, 79; Pl. L, Fig. 78b.

Shell small, flatly conical, spiral; shell nearly circular in outline. Apical part smooth, like *Calyptrea yokoyamai* Kuroda.[172] Surface covered by a fine irregular, obliquely radiating tuberculose sculpture which is the subspecific demarkation from the type species.

Measurements:	Height.	Diameter.
Monotype	4·2 mm. ton	8·7 mm.

167) M. Yokoyama, *Jour. Coll. Sci., Tokyo Imp. Univ.*, **39** (1920), 78, Pl. V, Fig. 12.
168) Adams et Reeve, *Zool. Voy. Samarang*, (1850).
169) Dall, *U. S. Geol. Surv. Proffessional Paper*, **59** (1900), 53, Pl. III-1, Figs. 1, 12.
170) Tegland, *Bull. Dep. Geol. Sciences*, **23** (1933), 133, Pl. XIII, Figs. 7, 8, 9.
171) M. Yokoyama, *Jour. Coll. Sci. Tokyo Imp., Univ.*, **45** (1924), 11, Pl. I, Fig. 17.
172) T. Kuroda, *Venus*, **1** (1929), 94.

Occurrence :—LOWER KADONOSAWA SERIES. Siratori (loc. 7 ; rg. no. 1592).

Crepidula jimboana Yokoyama.

Pl. LI, Fig. 112.

1931 *Crepidula jimboana* Yokoyoma, Jour. Fac. Sci. Imp. Univ. Tokyo, [II], 3, 194, Pl. XI, Fig. 1.

According to M. Yokoyama, the description of this species is as follows: "Shell large, thick, convex, elongate-oblong, with lateral margins subparallel. Apex almost marginal, curved. Surface rudely concentrically striated. Breadth and height on an average about one-half of length. The largest example measures about 75 mm. in length." Many specimens present.

Geol. Range :—Lower Miocene-Upper Oligocene (Makumbets, Tokati).

Occurrence :—YOTUYAKU SERIES. Siratori-tunagi (loc. 46; rg. no. 1700).

Crepidula nidatoriensis Otuka n. sp.

Pl. XLVIII, Figs. 63 a, b.

Shell thin, semiovoidal, moderate in size, smooth; whorls about one and a half. The apex curved backward and up, contact with body whorls; surface of the last marked by fine conspicuous incremental lines;

Measurements :	Height.	Length.	Width.
No. 1 (Type)	10 mm.	25 mm.	19 mm.
No. 2 (Cotype)	8 mm.	23 mm.	16·5 mm.

Occurrence :—UPPER KADONOSAWA. Nidatori (loc. 17 ; rg. no. 1548, 1549).

Crepidula auricula Yokoyama[173] is a more elongate and higher shell than this species. This species is exceedingly wider than the former.

Crepidula jimboana Yokoyoma is a large shell. This species is characteristic in having a plump last whorl.

Crepidula isimotoi Otuka n. sp.

Pl. XLVIII, Figs. 56, 57, 58, 59 a, b, 60, 61.

Shell small, thin, irregular, but generally ovate oblong in outline, strongly convex; beak very small, spirally coiled, depressed to the body whorl. Body whorl large. Surface smooth with concentric growth lines.

Measurement :	Height.	Length.	Width.	Diameter of aperture.
No. 1 (cotype) (Fig. 59a, b)	3·5 mm.	8·5 mm.	5·0 mm.	7·0 mm. largest diameter. 5·8 mm. smallest diameter.
No. 2 (cotype)	5·5 mm.	9·7 mm.	6·0 mm.	7·5 mm. largest diameter. 6·0 mm. smallest diameter.
No. 3 (cotype)	2·5 mm.	7·5 mm.	5·0 mm.	6·3 mm. largest diameter. 5·0 mm. smallest diameter.
No. 4 (cotype)	5·1 mm.	9·5 mm.	6·0 mm.	7·5 mm. largest diameter. 6·0 mm. smallest diameter.
No. 5 (cotype)	3·5 mm.	6·5 mm.	4·0 mm.	6·2 mm. largest diameter. 4·0 mm. smallest diameter.

Occurrence :—LOWER KADONOSAWA SERIES. Siratori (loc. 7, rg. no. 1550).

Crepidula auricula Yokoyama from the Upper Oligocene of the Zyôban coal field, mentioned above, is a shell closely resembling this species in outline. But the latter species has a very small spiral beak which is apressed to the body whorl.

Polinices fissurata (Kuroda).

1931 *Neritaeformis fissurata* Kuroda, Geology of the Middle Part of Sinano (1930), p.

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173) M. YOKOYAMA, *Jour. Coll. Sci., Tokyo Imp. Univ.*, 45, Pl. I, Fig. 5.

75, Pl. X, Figs. 74, 75 (in Japanese).

Geol. Ran.:—Miocene-Lower Pliocene (Sinano).

Occurrence:—UPPER KADONOSAWA SERIES. Sikonai (loc. 21; rg. no 1552); LOWER KADONOSAWA SERIES. Tate (loc. 6; rg. no. 1553), Yuda (loc. 4; rg. no. 1554), Yazawa (loc. 5; rg. no. 1555). Siratori (loc. 7; rg. no. 1556).

Polinices* (*Euspira*) *meisensis Makiyama.

Pl. XLIX, Figs. 76, 77.

1926 *Polinices* (*Euspira*) *meisensis* Makiyama, Mem. Coll. Sci. Kyoto Imp. Univ., [B], **2**, 150-151, Pl. XII, Fig. 7.

Geol. Range:—Lower Miocene (Heirokudo formation in Tyôsen).

Occurrence:—LOWER KADONOSAWA SERIES. Tate (loc. 6; rg. no. 1558), Siratori (loc. 7; rg no. 1557), Yuda (loc. 5; rg. no. 1559), Narayama (loc. 8; rg. no. 1560).

Polinices didyma (Bolten).

1798 *Albula didyma* Bolten, Mus. Bolten, **2**, 20.

1920 *Polinices ampla* Yokoyama, Jour. Coll. Sci., Tokyo Imp. Univ., **39**, 77-78, Pl. V, Figs. 5, 6.

Fossil specimens from Nisatai are smaller than the specimens of living and Pleistocene form. Measurements of the specimens from Nisatai is as follows:

	Height	Diameter.
No. 1.	14 mm.	8 mm.
No. 2.	13·5 mm	7 mm.
No. 3.	12 mm.	6 mm.
No. 4.	11 mm.	5·5 mm.

Occurrence:—LOWER KADONOSAWA SERIES. Nisatai (loc. 3; rg. no. 1583).

Sinum yabei Otuka n. sp.

Pl. XLIX, Figs. 74, 75.

Shell of more or less small size, Naticoid, of about three or two and a half rapidly enlarging whorls; body whorl large, aperture ample, elongate ovoidol, longest diameter at about an angle of 45°-40° from axis of spire; outer lip simple inner lip thin, lamellated, upper part of the inner side covered with thin callus deposits. Umbilicus slightly opened; sculpture consisting of spiral grooves separating a strap-like surface, the grooves gradually broadened near the end of the body whorl, and an intersticial fine ridge appears; growth lines on the body whorl crossing spiral sculpture; suture distinct, obliquely abutting, sometimes nearly tangential near the apex of the spire.

Measurements.	Height	Diameter.	Largest diameter of the aperture.	Smallest diameter of the aperture.
No. 1 (type)	18·0 mm.	18·5 mm.	17·0 mm.	11·0 mm.
No. 2 (paratype)	17·5 mm.	19·0 mm.	16·0 mm.	10.5 mm,

Sinum ineptus (Yokoyama)[174] from Lower Miocene of Kii is distinguished from this species by its small upper whorls and depressed form.

Sinum javanicum (Gray)[175] has a large depressed shell.

Sinum scopulosum (Conrad)[176] is closely related to this species. But the former is easily distinguished by its elongated aperture, and more convexed outer margin. This

174) M. Yokoyama, *Jap. Jour. Geol. Geogr.* **2** (1923), 52-54, Pl. VI, Fig. 16 (as *Sigaretus*).

175) Griffith and Pedgeon *in Cuvier's Mollusca and Radiata*, (1834), 596, Pl. XLI, Fig. 1.

176) Conrad, *U. S. Expl. Exped., Geol.*, (1849), 727., Pl. XIX, Figs. 6, 6a, (as *Sigaoetus*).

new species is closely related to *Sinum obliqua*[177] Gabb from the Tejon group of California, but it is distinguished by its outline, which is more ovate (transversely) than oblong. *Sinum obliqua* Gabb is a small elongate shell.

Occurrence:—UPPER KADONOSAWA SERIES. Kadonosawa? (loc. 21; rg. no. 1564); LOWER KADONOSAWA SERIES. Siratori (loc. 7; rg. no. 1561, type), Tate (loc. 6; rg. no. 1562).

Surculites yokoyamai Otuka n. sp.

Pl. L., Fig. 92.

1925 *Pleurotoma* sp. Yokoyama, Jour. Coll. Sci., Tokyo Imp. Univ., 45, 8, Pl. I, Fig. 9.

Shell large, spired, biconic, apex slightly depressed; whorls with a more or less sharp shoulder, the area above the shoulder being strongly concave, and the shoulder surmounted by small indistinct nodes on the preceeding whorls. The number of nodes is 17-18 in the whorl preceeding the penultimate whorl. The surface is sculptured with many spiral cords about 6 in 5 mm. length with an intercarary between each pair. The growth lines moderately strong, and form a mesh sculpture with the spiral cords. Columella smooth.

Geologic range:—Miocene? of Zyôban (Izura).

Occurrence:—LOWER KADONOSAWA SERIES. Yuda Kobayasi (loc. 11; rg. no 1551).

This species closely resembles *Surculites* (*Megasurcula*) *cooperi* (Arnold)[178] but the former has a more depressed apex and more prominent surmounted nodes on the shoulder margin, than the latter.

Surculites (*Surculites*) *wynotchensis* (Weaver)[179] from California Miocene is allied to this species. But the former is the shorter shell with a more prominent shoulder and with fewer surmounted nodes.

Pleurotoma sp. illustrated by Prof. M. Yokoyama from the Miocene of the Zyôban coal field agrees with this specimen.

Measurement:	Height	Diamter
Monotype (lower part missing)	38·5 mm.	21 mm.

Surculites kurodai Otuka.

Pl. L., Fig. 94.

Shell large and depressedly turreted, biconic; whorls with a blunt shoulder on which some distinct nodes are surmounted. Number of nodes about 14. Surface sculptured with fine subequal spiral cords, which number about 6 in 5 mm. length on the lower part of the body whorl, about 7-8 in 5 mm. length on the shoulder area of the body whorl. The Shoulder nodes are limited near the shoulder angles.

Measurements:	Height.	Diameter.
	47·0 mm.	28·0-20·0 mm.

Occurrence:—LOWER KADONOSAWA. Siratori (loc. 7; rg. no. 1565), Yazawa (loc. 5 type locality; rg. no. 1566).

This species resembles *Surculites* (*Pseudotoma*) *intorta*[180] (Brochi) from Oligocene to Pliocene of Belgium, but the former has a more depressed spire and a higher collared

177) DICKERSON, *Proc. Calif. Acad. Sci.*, [iv], 5 (1915), Pl. V, Figs. 5 a, 5 b.

178) ARNOLD, *Mem. Calif. Acad. Sci.*, 3 (1903), 203, Pl. VII.

179) WEAVER, *Wash. Geol. Survey Bull.*, 15 (1912), 70, Pl. XI, Figs. 78, 88, 89, 94; Pl. XIV, Fig. 121.

180) GRANT and GALE, *Mem. San-Diego Soc. Nat. Hist*, 1 (1931), 500, Pl. XXV, Fig. 2.

suture.

Suavodrillia makiyamai Otuka.

Pl. L, Fig. 91 a ; Pl. LI, Figs. 91 b, 114.

Shell small, fusiform with a high spire which is acute and slender, angularly turriculate, highter than the aperture; and a moderately long anterior canal; whorls 6·5 with a large raised keel at the middle, the surface above and below the keel concave; periphery of the body whorl convex, with 2 keels, the lower of which is narrower than the upper; interspaces of these three keels ornamented with fine spiral threads, numbering five between the subsutural band and the upper large keel, and two between the upper large keel and the 2 peripheral keels. Base sculptured with four oblique spiral cords. Protoconch of three whorls, smooth. Aperture elongate oval; angled at the upper end; columella subvertical, covered with a narrow callus deposits, and slightly excavated. Fasciole slightly defined by a depressed groove, and sculptured with indistinct oblique grooves. The canal is not long for the genus, slightly bent. The rounded sinus notch lies in the nearly smooth concave area between the shoulder and the suture.

Measurement:	Height.	Diameter.
Monotype	8 mm.	2·9 mm.

Occurrence:—LOWER KADONOSAWA SERIES. Siratori (loc. 7; rg. no. 1589).

Suavodrilia declivis (Martens)[181] is closely allied to this species, but the former has a larger shell and no subsutural band or collar. This species has many fine spiral ornamentations.

This species resembles *Turris kurodai*[182] Makiyama in its outline, but has a shorter shell, and fewer peripheral keels. *T. kurodai* has three peripheral keels and a peripheral notch.

"Trophon" nakamurai Otuka n. sp.

Pl. V, Figs. 67, 68

Shell small, moderate in thickness; spire rather low; less than one half to the shell height, consisting of four half tabulate whorls. Whorls ornamented by strong rounded ribs which number about nine on the last whorl, and eleven on the penultimate. Spiral sculpture consists of rounded, more or less regular spiral cords about 5, and on the ultimate more than 13. These numerical values are not counted from the intercalary. Aperture subquadrangle; the outer lip slightly expanded, with more than 5 teeth on its inner side. Canal narrow, not short.

Measurements:	Height.	Height of penultimate.	Diameter.
Monotype No. 1.	22·5 mm.+x	11·2 mm.	15 mm.
„ No. 2.	17·1 mm.+x	8·5 mm.	11 mm.

Occurrence:—LOWER KADONOSAWA SERIES. Nisatai (loc. 3; rg. no. 1568), Yuda (loc. 4; rg. no. 1570).

Trophon (*Bedeva*) *birileffi* (Lischke)[183] (=*Trophon pathyrhaphe* (Smith) of Yok.)[184] resembles this species, but the former has less prominent ribs and a blunter shoulder. This species has sharper shoulder and the spire stiffer than *Trophon* (*Bedeva*) *birileffi*

181) Martens, *Conch. Mitthl.* 1, 39, Pl. XI, Fig. 2; M. Yokoyama, *Jour. Coll. Sci. Tokyo Imp. Univ.*, 44 (1922), Pl. I, Fig. 26 (as *Pleurotoma vertebrata* Smith).

182) J. Makiyama, *Mem. Coll. Sci. Kyoto Imp. Univ.*, [B], 3, 49, Pl. IV, Figs. 19, 20.

183) Lischke, *Malak. Bl.*, (1871), 39.

184) M. Yokoyama, *Jour. Coll. Sci. Tokyo Imp. Univ.*, 44 (1922), 63, Pl. III, Fig. 1.

(Lischke).

Owing to bad preservation of the specimens, the nature of the varices and siphonal fascioles can not observed.

Truncaria nakamurai Otuka n. sp.

Pl. LI, Figs. 106, 107, 108.

Shell with a small blunt apex, followed by about 4 sculptured rapidly enlarging, roundly shouldered later whorls; the apex is broken in this species. The last whorl is constricted at the base. Sculpture of ten irregular transverse rounded ribs, beginning at or near the suture and continuing over the periphery to the base ot the whorl. Varices prominent, about 4 on the ultimate whorl, then the apical view of the shell nearly pentagonal in form. The spiral sculpture consists of (on the last whorl of about ten), equal cords, with an obsolete intercalary. Aperture rather elongated, differentiated from the canal. Inner side of the outer lip toothed. Number of the teeth about 4. Outer lip finely crenated by the sculpture; columellar is simple with a thin callus; canal narrow, deep, somewhat recurved; siphonal fassciole strong, enclosing the reflected inner lip with a not very deep umbilical pit;

Measurement:	Height.	Diameter.
Monotype	23·8 mm.	16·0 mm.

Occurrence:—LOWER KADONOSAWA SERIES. Siratori (loc. 7; rg. no. 1567).

This species resembles *Truncaria filosa* (Adams et Reeve)[185] from the China Sea but the former is a small which has more depressed spire and no spinous ornamentations.

Tritonalia sp. 1.

Shell long; whorls more than five with spiral sculpture and varices; varices three-four; spiral sculpture consists of about 4 ribs and fine cords.

Occurrence:—LOWER KADONOSAWA SERIES. Nisatai (loc. 3; rg. no. 1569).

This shell resembles *Tritonalia* (*Ceratostoma*) *emarginata*[186] (Sowereby), but the former has a higher spire.

Chrysodomus modestus Kuroda.

1925 Chrysodomus phoeniceus, Yokoyama, Jour. Coll. Sci., Tokyo Imp. Univ., 14, 10, Pl. I, Fig. 1.

1925 Chrysodomus despectus, Yokoyama, Jour. Fac. Sci. Imp. Univ. Tokyo, [II], 1, 5, Pl. I, Fig. 3.

1931 Chrysodomus modestus Kuroda, Geol. of Middle Sinano, p. 78-79, Pl. XIII, Fig. 109; Pl. XI, Fig. 83.

Geol. Ran.:—Upper Miocene-Lower Pliocene?

Occurrence:—SUENOMATUYAMA SERIES. Anausi (loc. 36: rg. no. 1571), Kami-mainosawa (loc. 37; rg. no. 1572).

Ancistrolepis yudaensis Otuka n. sp.

Pl. L, Fig. 88.

Shell large, solid, with two nuclear and about five subsequent whorls rapidly enlarging; nucleus whorls smooth; the later whorl with a shoulder keel ornamented with spiral cords. On the surface between the shoulder keel and next suture line three prominent spiral cords are present. The lowest of them forming a keel which defines the base of the shell on the body whorl. The interspace of these cords has finer spiral lines intercalated in. The surface area between the shoulder keel and the suture

185) Adams et Reeve, (1850).

186) Sowerby, *Proc. Zool. Soc.*, (1840).

(preceeding) ornamented with fine spiral cords which number about 16.

Occurrence:—LOWER KADONOSAWA SERIES. Yuda (loc. 4; rg. no. 1574), Yazawa (loc. 1; rg. no. 1575), Yazawa (loc. 1; rg. no. 1573).

This species differs from *Ancistrolepis magnus*[187] Dall by its simple suture; the latter species has a channel or a second keel near the suture.

Ancistrolepis damon polygramma[188] Dall is closely related to this species, but the former has a higher spire and loose suture line.

Nassarius* (*Hinia*) *simizui Otuka n. sp.

Pl. L, Fig. 85, 86, 87.

Shell narrowly ovate, stout, cancellated. Spire subturreted, almost equal in height with the aperture, conic in outline with an angle of about 50° degrees. Nucleus whorl of 3·5 smooth, convex whorls, turreted, slowly increasing. Later whorls 5, slightly convex, sculptured with 7·5 spiral cords, separated by narrower sulcae, the subsutural one broadest and more or less granulose, and the upper second cords more or less finer than the others. Snboblique axial ribs, 18 in number on the penultimate whorl, their interspaces wider than themselves. Body whorl convex, contracted below, with 14-13 spiral cords. Lower ten of which are arranged with broader interspaces on the base than the upper cords. Subsutural area distinctly bouuded by the subsutural cord like shouldered shell. Fasciole defined with a shallow groove, with 5 oblique lines upon the surface. Aperture elongate ovate, oblique, slightly channeled above and with a short deep reflected canal below. Outer lip varicose, with internal lirations which number more than 11; inner lip with a sharply delimited callus deposit on which 2 upper unequal and 2 lower denticles are folded.

Measurement:	Height.	Diameter.
Monotype	10 mm.	5·5 mm.

Occurrence:—LOWER KADONOSAWA SERIES. Siratori (loc. 7; rg. no. 1576).

This species closely resembles *Nassarius* (*Hinia*) *kurodai* Makiyama[189] but the former has a small higher shell and fewer axial ribs.

Nassarius* (*Zeuxis*) *kometubus Otuka n. sp.

Pl. LI. Figs. 110 a, b, 109.

Shell globose, granulated. Spire conic, a half shell height with a blunt apex. Protoconch of 3 smooth, convex, whorls, turreted, gradually increasing. Later whorls about three, convex sculptured with 9 spiral cords separated by narrower interspaces, disposed in suboblique axial ribs, the ribs 26 in number on the penultimate whorl. Their interspaces wider than themselves; the subsutural cords with a wide excavated groove in front. Body whorl convex, contracted, below, with 19-18 spiral cords. Suture impressed but not canaliculated. Fasciole defined with a deep spiral groove, with four spiral sculptures. Aperture ovate; with a short broad reflected canal below. Outer lip convex, varicose, smooth within. Columella smooth short and concave, obliquely truncate below.

Measurement:	Height.	Diameter.
Monotype	4 mm.	2·5 mm.

Occurrence:—LOWER KADONOSAWA SERIES. Siratori (loc. 7; rg. no. 1588), Nisatai (loc. 3; rg. no. 1577).

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187) DALL, *Proc. U. S. Nat. Mus.*, **17** (1895), 709.

188) DALL, *Proc. U. S. Nat. Mus.*, **54** (1918), 230.

189) MAKIYAMA, *Mem. Coll. Sci., Kyoto Jmp. Univ.*, [B], **3** (1927)

This species resembles *Nassarius* (*Zeuxis*) *caelatus* (A. Adams), but the former is a smaller shell with fewer spiral cords than the latter species, and with rounded whorls.

Fusinus sp. 1.

Occurrence:—LOWER KADONOSAWA SERIES. Yazawa (loc. 5; rg. no. 1578).

Olivella consobrina (Lischke).

Pl. L, Figs. 89, 90.

1871 *Oliva consobrina* Lischke, Jap. Meeres Conch., **2**, 62, Pl. V, Figs. 10, 11.

1927 *Olivella consobrina*, Makiyama, Mem. Coll. Sci. Kyoto Imp. Univ. [B], **3**, 80.

The specimens from the Lower Kadonosawa series has a smaller shell with more acuminate spire, and has a more distinct columella area with two folds and an indistinctly defined one.

Geol. Ran.:—Miocene-Lower Pliocene-Recent.

Occurrence:—LOWER KADONOSAWA SERIES. Nisatai (loc. 3; rg. no. 1579).

Fulgoraria* (*Fulgoraria*) *rupestris (Gmelin).

Voluta rupestris Gmelin, Sys. Nat. p. 3464.

1908 *Voluta rupestris*, Hirase, Conch. Mag., pp. 215-216, Pl. XXXII, Figs. 2, 3.

Geol. Ran.:—Lower Pliocene?—Recent

Occurrence:—SUENOMATUYAMA SERIES. Kamayasiki (loc. 39; rg. no. 1580).

The number of axial ribs in fossil specimens agree with those of living species. But the angle of the upper rounded shoulder is more acute than the recent species.

Cancellaria spengleriana Deshayes.

Pl. L. Fig. 99.

1843 *Cancellaria spengleriana* Deshayes, Anim. s. Vert., **9**, 415.

1920 *Cancellaria spengleriana*, Yokoyama, Jour. Coll. Sci. Tokyo Imp. Univ., **39**, Pl. II, Figs. 2, 3.

1927 *Cancellaria spengleriana*, Makiyama, Mem. Coll. Sci. Kyoto Imp. Univ., [B], **3**, 84-85.

The specimens from the Lower Kadonosawa series are more or less small in size.

Geol. Ran.:—Miocene-Recent.

Occurrence:—LOWER KADONOSAWA SERIES. Nisatai (loc. 3; rg. no. 1582), Siratori (loc. 7; rg. no. 1581).

Conus tokunagai Otuka n. sp.

Pl. L. Figs. 83, 84.

Shell moderate in size, elongate conic; spire elevated, acute, slightly concave when seen sideways. Whorls 9-8 shouldered; shoulder smooth, subrounded, above which the surface is somewhat concave with oblique line of growth and fine spiral striae which number about 6-8 on the penultimate whorl. On the body whorl the oblique spiral cords only appearing near the lower end. Number of the oblique spiral cords about 13-11 near the inner margin of the aperture. Number of cords in 5 mm. length about 5-6. Aperture long and narrow.

Occurrence:—LOWER KADONOSAWA SERIES. Nisatai (loc. 3; rg. no. 1593).

This species is very closely allied to *Conus pauperculus* Sowerby, living in the temperate waters of Japan, but the former differs from the latter in that the shell has a high spire and prominent spiral cords with broad interspaces.

Ringicula ninohensis Otuka.

Pl. L, Figs. 95, 96.

1933 *Ringicula* (*Ringiculina*) *ninohensis* Otuka, Venus, **4**, 15-16, text fig. a-d.

Shell small, ovately globose, with acute apex. Whorls five-four and a half, convex,

very rapidly growing and spirally ornamented with fine, low, rounded ribs which number about 7-9 (8 in the type specimen) on the penultimate whorl, and 11-14 (12 in the type) on the ultimate. Base more or less rounded. Aperture elongated, higher than half of the height of the shell, and anteriorly somewhat widened and notched. Posterior canal present. Columellar folds two, strong and prominent. Callus of the inner lip broad, more than half of the apertural height, on which the callus is thickly deposited to make four longitudinal ridges, which are limited by an oblique furrow running from the base of the upper columellar fold to the columellar end. At about the upper third of the inner lip a broad triangular tooth projects into the aperture. Outer lip thickened and roundly swollen. Inner margin transversally crenulated; the number of crenula corresponds to that of the spiral ribs on the ultimate whorl.

Measurements:	Height.	Diameter.
No. 1 (type)	4·1 mm.	2·6 mm. (1586)
No. 2 (paratype)	3·5 mm.	2·7 mm.
No. 3 (paratype)	3·4 mm.	2·2 mm.
No. 4 (paratype)	3·2 mm.	2·4 mm.
No. 5 (paratype)	4·1 mm.	2·65 mm.

Occurrence:—LOWER KADONOSAWA SERIES. Siratori (loc. 7; rg. no. 1586).

The closest ally of this species is probably *Ringicula musashinoensis* Yokoyama which occurs in the Naganuma beds (upper Pliocene) near Yokoyama. But the former species is easily distinguished from the latter having a peculiar configuration of the callus area of the inner lip and a crenulated outer margin of the outer lip.

Cylichna sp.

Occurrence: — UPPER KADONOSAWA SERIES. Kadonosawa (loc. 22; rg. no. 1587).

Cylichna affabilis Yokoyama resembles to this species in its outline.

Class BRACHIOPODA

Hemithyris psittaceae woodwardi Adams.

1863 *Rhynchonella woodwardi* Adams, Ann. Mag. Nat. Hist., [iii], **11**, 100.

1887 *Rhynchonella psittaceae woodwards*, Davidson, Monogr. Rec. Brach, p. 168, Pl. XXIV, Figs. 12, 13.

1823 *Hemithyris psittaceae woodwardi*, Hayasaka, Jap. Jour, Geol. Geogr., **2**, 117-120.

Geol. Ran.:—Upper Miocene-Recent.

Occurrence:—SUENOMATUYAMA SERIES. Mainosawa (loc. 34; rg. no. 1601), Numakubo (loc. 31; rg. no. 1600), Sarugasawa (loc. 30; rg. no. 1599).

Terebratalia? sp. 1.

Occurrence:—SUENOMATUYAMA SERIES. Mainosawa (loc. 34; rg. no. 1605).

Coptothyris grayi aomoriensis Hayasaka.

1932 *Coptothyris grayi aomoriensis* Hayasaka, Sci. Rep. Tohoku Imp. Univ., [iv], **8**, 9, Pl. I, Figs. 5, 6.

1933 *Coptothyris grayi aomoriensis*, Hayasaka, Jap. Jour. Geogr. **10**, 125-128, Pl. XII, Figs. 1-5.

Geol. Ran.; -Uppen Miocene-Recent.

Occurrence:—SUENOMATUYAMA SERIES. Numakubo (loc. 31; rg. no. 1594). Mainosawa (loc. 34; rg. no. 1595), Anausi (loc. 36; rg. no. 1596), Nagamine (loc. 38; rg. no. 1597), Suenomatuyama-toge (loc. 40; rg. no. 1598).

Magellania lenticularis innaiensis Hayasaka.

1922 *Magellania lenticularis innaiensis* Hayasaka, Sci. Rep. Tohoku Imp. Uuiv., [ii],

6.

Geol. Ran.:—Middle Neogene.

Occurrence:—SUENOMATUYAMA SERIES. Mainosawa (loc. 34, 1603).

Magellania sp. 1.

Occurrence:—SUENOMATUYAMA SERIES, Mainosawa (loc. 34; rg. no. 1606).

Laqueus rubellus Sowerby.

1846 *Terebratula rubellus* Sowerby, Thes. Conch., 1, 350-351, Pl. I; 19, Fig. 40-42.

1931 *Laqueus rubellus*, Hayasaka, Venus, 3, 7.

Geol. Ran.:—?—lower Pliocene-Recent.

Occurrence:—SUENOMATUYAMA SERIES, Mainosawa (loc. 34; rg. no. 1605).

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38. 北上山地北西端の第三系地質構造

地震研究所　大塚彌之助

新第三紀以來の日本の地質構造發達史の研究の必要上，北上山地西北緣部の第三系の層序及び地質構造が述べてある．

北上山地西北緣即ち岩手縣二戸郡一戸町・福岡町附近の層序は次の如くで，中村新太郎教授(1911)，矢部教授，清水三郎博士 (1921) の研究報告がある．

冲積層：　氾濫原及び低位臺段丘礫を含む．

福岡輕石層：　大輕石塊（徑 30 cm. 內外）を含む洪積統輕石層が高度 150 m，內外の段丘を形成してゐる．福岡町背後の段丘を構成するのでかく呼んだ．

末ノ松山統：　清水博士の高森層群及び末ノ松山層群を含み，末ノ松山浪打峠を標式露出地とする．粗砂，礫層砂からなり，鳥越・合川附近に合川安山岩體があつて，その集塊岩は合川安山岩體の集塊岩を挾在し，この安山岩體は末ノ松山統堆積初期の噴出である．採集化石は Table II の如く下部鮮新統か又は上部中新統を示し，信濃の柵・小川層の動物群に類似し，寒流の影響を受けた淺海のものであることがわかる．

門ノ澤統；　清水博士の門ノ澤層群・仁佐平層群・湯田層群を含み，後二者は門ノ澤層群の下部と一致す．白鳥澤・門ノ澤附近に露出してゐるのを標式とし，上部は凝灰質泥質細砂又は半凝固淤泥層で．下部は *Ostrea gravitesta* Yokoyama を特徵とする黑色砂又は黑綠色砂礫層で，清水博士の報ぜられた *Vicarya, Desmostyles Japonicus* Yoshiwara et Iwasaki の産出層準である．採集化石は上部は Table III の如くで，末ノ松山統と同樣の地質時代を示すも，動物群は末ノ松山統より深き，泥砂帶のもので，末ノ松山統との間には不整合があつて，門ノ澤堆積後末ノ松山統堆積前に海退・海進の現象があつたやうに見える．故に末ノ松山統の時代の限界より判定して中上部中新統と考へることができる．

門ノ澤統の下部は採集化石は Table IV の如くで，美濃の月吉層群，吉州・明川の坪六洞層群，津山盆地の植月統に對比でき，中下部中新統は動かない（恐らく Vindobon 階？であらう．）そして門の澤統下部の一部は東北日本の所謂 *Miogypsina-Operculina* と同時代と考へられる．

四ツ役統：　之は清水博士の四ツ役層群である．上部には *Liquidambar formosana* Hance, *Acer* 等を出し，稍〻下位には *L. formosana?* Hance の他に *Sequoia sinensis Endô* その他 *Acrostichium* sp. らしきものを含む．尙 *Tellina, Ostrea* と共に *Crepidula jimboama* Yokoyama を含む地層ありて，之等の化石より見て，北海道の川端統・幌內統の中間位或は幌內統の上部の地質時代を示すものではあるまいかと考へられる．

上部植物化石帶下には安山岩質集塊岩介在し，基底下には石英粗面岩及びその凝灰岩存在し，古生層を貫き，その上に横はる．

これらの地層の他の地方の地層に對する關係は Table V の如くと考へられる．

上記の事實及び對比から，北上山地西緣と東北日本油田地域との間に新第三系の地質構造上著しい相違があり，前者は僅に傾動するにかかはらず (Fig. 2)，後者は著しい褶曲を示すことで，北上山地は１つの古き大地塊にして，その西緣にこの福岡町附近の新第三系が載つてゐるものと考へられる．

沈積輪廻は東北日本の他の地方とよく一致し，中新世前半に於ける海進は日本各地に觀察でき，一

部は朝鮮北部に達したと考へられる.

斷層は一般に走向に一定の傾向は見られぬが, 地層の「傾斜」の方向に反對の方向が比較的低まる傾向が見られ, 地層の傾斜から見ると北上山地が曲降してゐるやうに見えるのに, 斷層から見ると北上山地の方が落ちてゐるやうに見える.

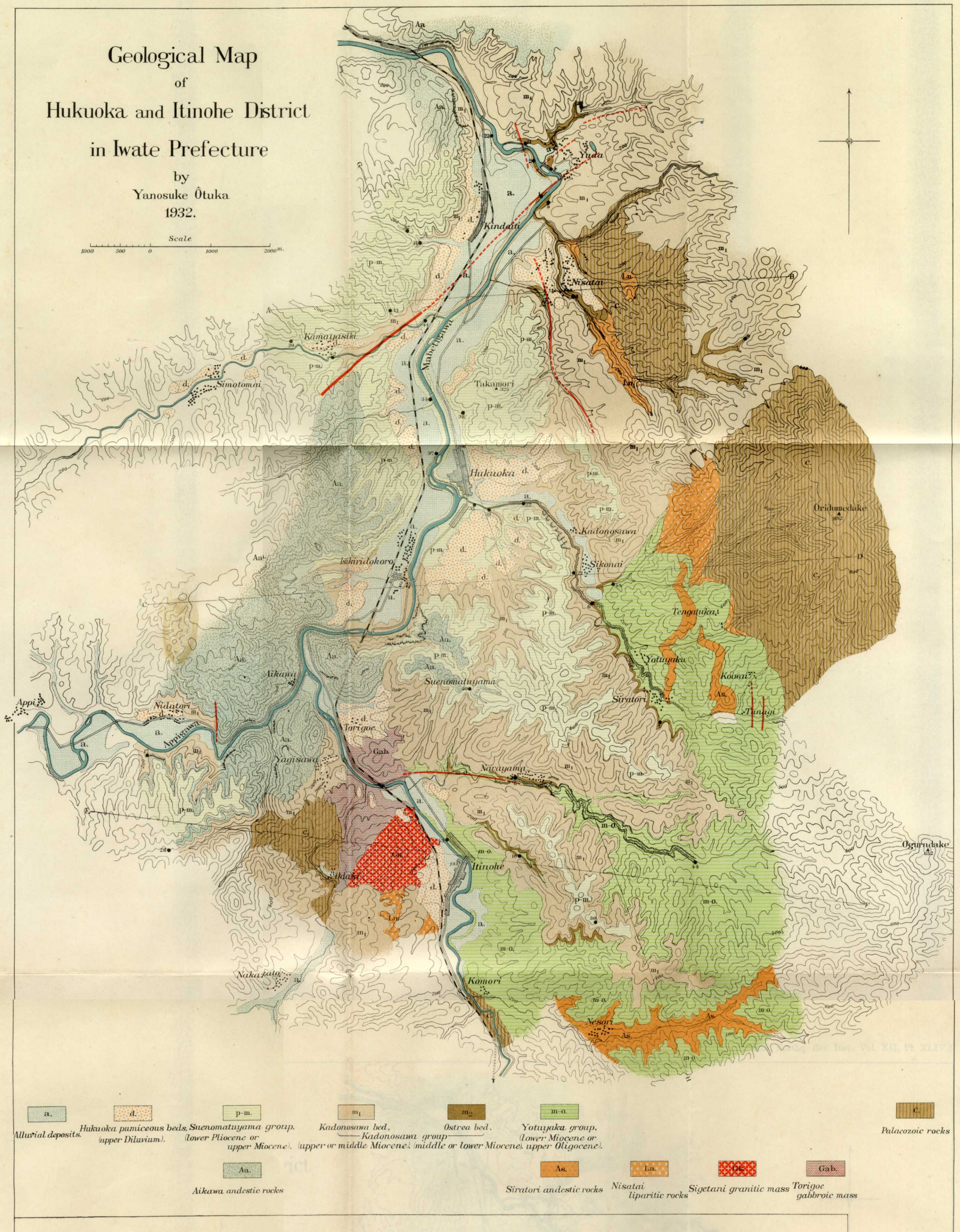
Vicarya, Desmostylus japonicus Yoshiwara et Iwasaki の産出層は今日用ひられてゐる formational unit が變はる程異る層準に擴がつて產したものと考へられず, 寧ろ殆ど一地質系統中から產したものと考へてもよいやうな結果となつた.

火山活動と造陸運動的地殼運動との間に密接な關係があるやうに見え, 海進を示す地層の基底に粗粒な火山物質が多いことがこの地方では觀察でき, 他地方でもこの點に留意する必要があると思つた.

Geological Map
of
Hukuoka and Itinohe District
in Iwate Prefecture

by
Yanosuke Ôtuka
1932.

Scale
1000 500 0 1000 2000 m.



a. Alluvial deposits.

d. Hukuoka pumiceous beds, (upper Diluvium).

p-m. Suenomatuyama group, (lower Pliocene or upper Miocene).

m_1 Kadonosawa bed, (upper or middle Miocene).

m_2 Ostrea bed, (middle or lower Miocene).

Kadonosawa group

m-o. Yotuyaku group, (lower Miocene or upper Oligocene).

C. Palaeozoic rocks

Aa. Aikawa andestic rocks

As. Siratori andestic rocks

Ln. Nisatai liparitic rocks

Gs. Sigetani granitic mass

Gab. Torigoe gabbroic mass

Fault

27 Fossil Localities

Fig. 2.

Fig. 3. Flat-topped ridges and accordance of summit-levels in the Kitakami mountainland. View looking southeast from Ogurayama.

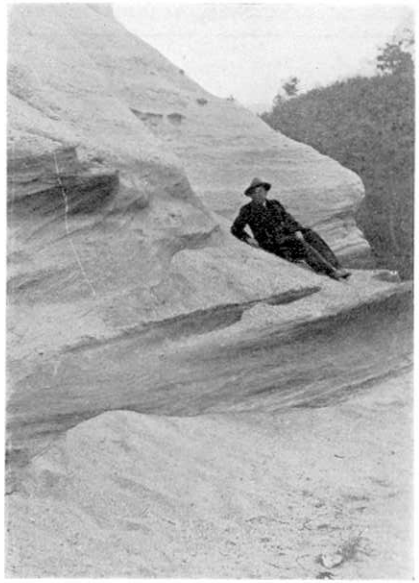


Fig. 5. Cross-bedded sandstone (Suenomatuyama series). Namiuti pass.

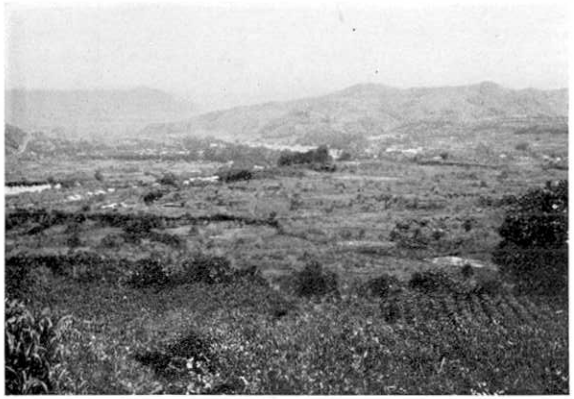


Fig. 4. Flat-topped ridges of Ninohe surface (background), and upper terrace on the Hukuoka pumice beds (foreground).

Fig. 6. Steep slope of Ezonomori (on the right). View looking east from the divide at the head of the Tunagi valley.

（震研彙報 第十二號 圖版 大塚）

Fig. 7. Unconformity between Aikawa agglomerate, the Suenomatuyama series and the Kadonosawa series. View looking south.

Fig. 8. Unconformity between the Suenomatuyama series and the Kadonosawa series. View looking west from the northern slope of Namiuti pass.

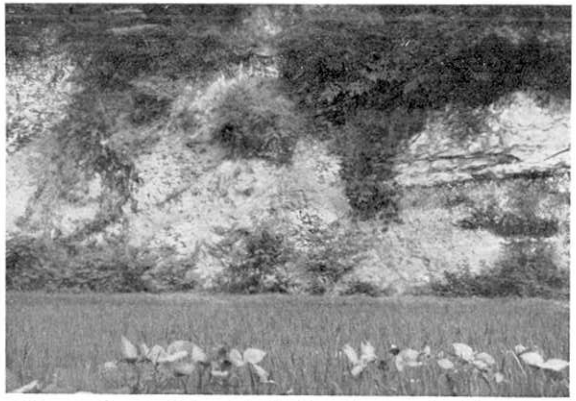


Fig. 9. Crushed (on the left) and uncrushed (on the right) stratification. Zyûmonzi fault. Kamayasiki.

Plate XLVII.

Plate XLVII.

Fig. 10. *Solemya tokunagai* Yokoyama.
Fig. 11. *Nuculana nidatoriensis* Otuka. Left valve. Cast.
Fig. 12. *Nuculana* sp. 1 Right valve. Inside.
Fig. 13. *Nuculana* sp. 1 Right valve. Outside.
Fig. 14. *Nuculana confusa kongiensis* Otuka. Left valve.
Fig. 15. *Nuculana confusa* (Hanley). Left valve.
Fig. 16 *Yoldia thraciaeformis* Storer. Left valve.
Fig. 17. *Yoldia cooperi ochotensis* Khomenko. Left valve.
Fig. 18. *Yoldia cooperi ochotensis* Khomenko. Left valve. Cast.
Fig. 19. *Yoldia intermedia kadonosawaensis* Otuka. Left valve.
Fig. 20. *Arca amicula* Yokoyama. Left valve.
Fig. 21. *Arca ninohensis* Otuka. Left valve.
Fig. 22. *Arca ninohensis* Otuka. Left valve. Apical view.
Fig. 24. *Unio kobayasiensis* Otuka.
Fig. 25. *Chlamys kotorana* Otuka.
Fig. 26. *Chlamys islandicus nisataiensis* Otuka.
Fig. 27. *Lucina k-hataii* Otuka.
Fig. 28. *Lucina k-hataii* Otuka.
Fig. 29. *Lucina yokoyamai* Otuka.
Fig. 30. *Lucina yokoyamai* Otuka.
Fig. 31. *Lucina yokoyamai* Otuka.
Fig. 32. *Lucina yokoyamai* Otuka
Fig. 33. *Pillucina pisidium nisataiensis* Otuka.
Fig. 34. *Pillucina pisidium nisataiensis* Otuka.
Fig. 35. *Taras ferruginata* (Makiyama).
Fig. 36. *Cardium* (*Cerastoderma*) *shinjiense* Yokoyama.

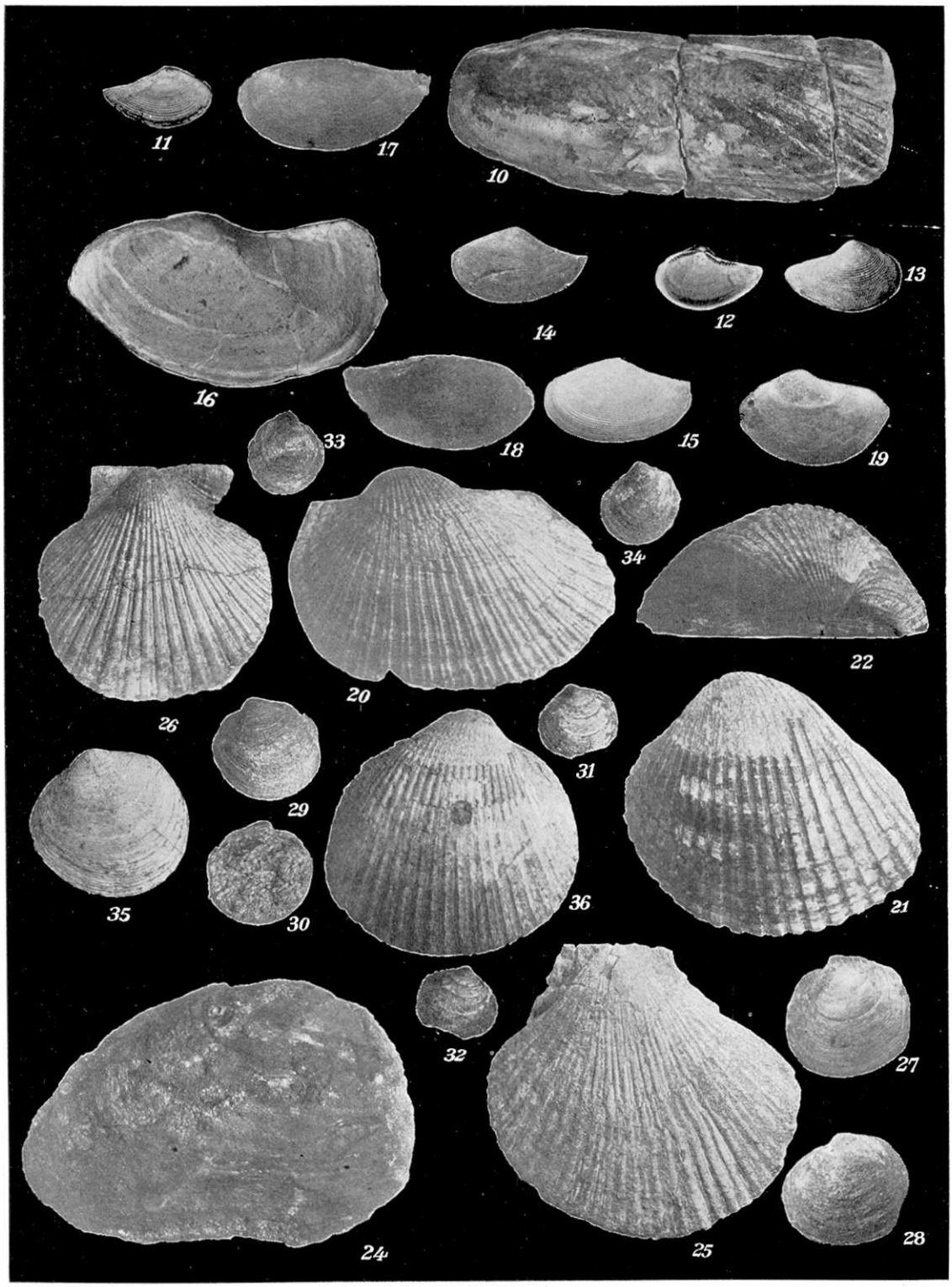

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Plate XLVIII.

Plate XLVIII.

Fig. 37. *Pillucina contraria* (Dunker).
Fig. 38. *Pillucina contraria* (Dunker).
Fig. 39. *Taras ferruginata* (Makiyama).
Fig. 40. *Taras ferruginata* (Makiyama).
Fig. 41. "*Paphia*" *siratoriensis* Otuka. b. Enlarged.
Fig. 42. *Clementia* (*Compsomyax*) aff. *subdiaphana* Carpenter.
Fig. 43. *Aloidis erythrodon nisataiensis* Otuka.
Fig. 44. *Aloidis erythrodon nisataiensis* Otuka.
Fig. 45. *Aloidis erythrodon nisataiensis* Otuka
Fig. 46. "*Cardillia*" *yudaensis* Otuka.
Fig. 47. "*Cardillia*" *yudaensis* Otuka.
Fig. 48. "*Cardillia*" *yudaensis* Otuka.
Fig. 49. *Pitar yabei* Otuka. Side view.
Fig. 50. *Pitar yabei* Otuka. Apical view.
Fig. 51. *Macoma* optiva (Yokoyama).
Fig. 52. *Cryptomya bussoensis* Yokoyama.
Fig. 53. *Zirphaea subconstricta* (Yokoyama).
Fig. 54. *Dosinia japonica nomurai* Otuka.
Fig. 55. *Dosinia nagaii* Otuka.
Fig. 56. *Crepidula isimotoi* Otuka.
Fig. 57. *Crepidula isimotoi* Otuka.
Fig. 58. *Crepidula isimotoi* Otuka.
Fig. 59. *Crepidula isimotoi* Otuka. b is shown on Plate LI
Fig. 60. *Crepidula isimotoi* Otuka.
Fig. 61. *Crepidula isimotoi* Otuka.
Fig. 62. *Calyptrea* sp. 1. a. Apical view. b. Side view.
Fig. 63. *Crepidula nidatoriensis* Otuka. a. Apical view. b. Side view.

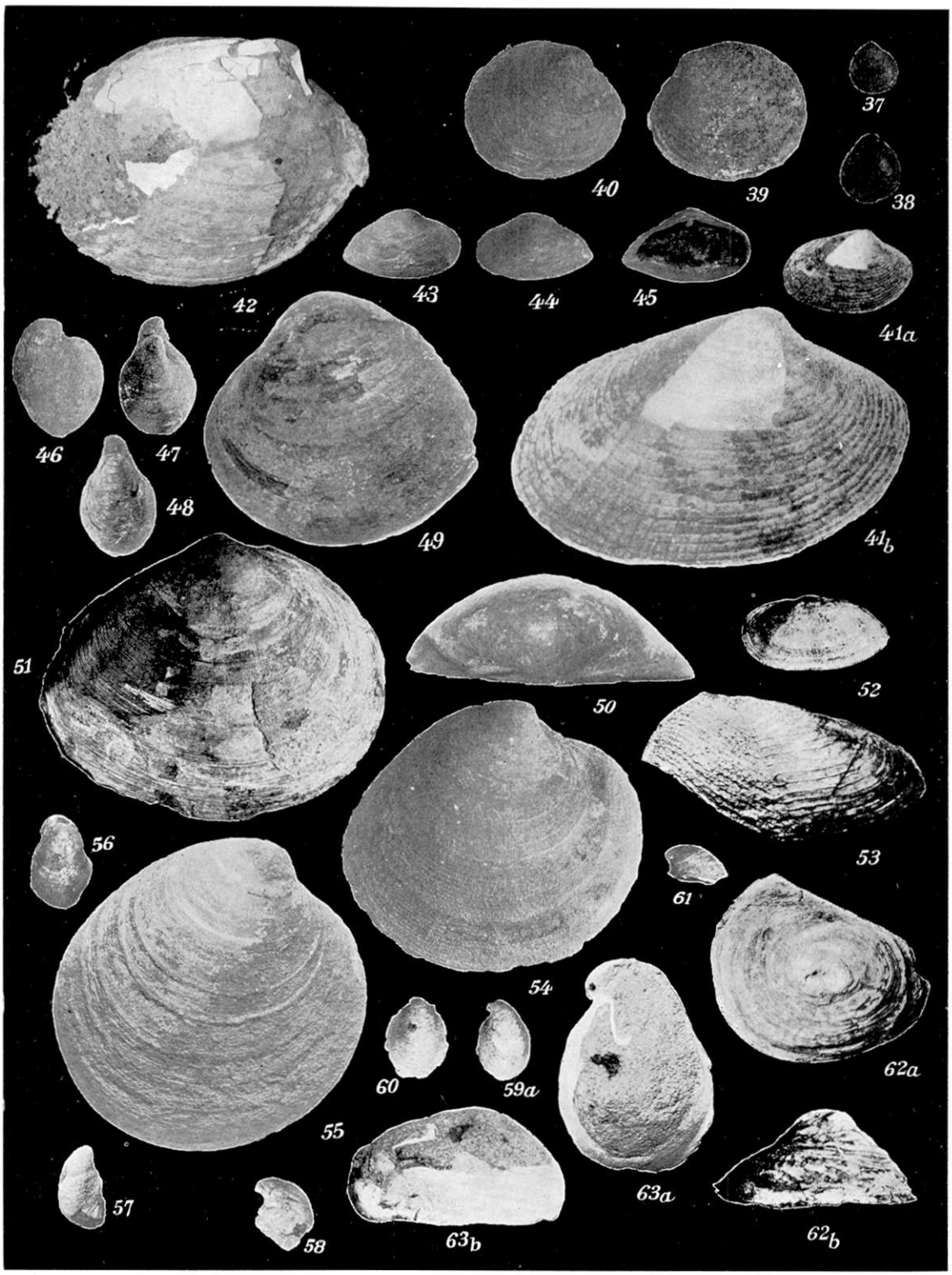
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Plate XLIX.

Plate XLIX.

Fig. 64. *Clementia* (*Compsomyax*) *subdiaphana yazawaensis* Otuka.
a. Apical view. b. Side view.

Fig. 65. *Sanguinolaria* (*Soletellina*) *minoensis* Yokoyama. a. Side view.
b. Apical view.

Fig. 66. "*Panomya*" *simotomensis* Otuka. a. Side view. b. Apical view.

Fig. 67. "*Trophon*" *nakamurai* Otuka.

Fig. 68. "*Trophon*" *nakamurai* Otuka.

Fig. 69. *Batillaria atukoae* Otuka (Specimen from Narayama).

Fig. 70. *Batillaria atukoae* Otuka (Specimen from Yuda). Type specimen.

Fig. 71. *Batillaria tateiwai* Makiyama.

Fig. 72. "*Proclava*" aff. *ishiianum* (Yokoyama).

Fig. 73. "*Proclava*" aff. *ishiianum* (Yokoyama). Slightly enlarged.

Fig. 74. *Sinum yabei* Otuka.

Fig. 75. *Sinum yabei* Otuka.

Fig. 76. *Polinices* (*Euspira*) *meisensis* Makiyama.

Fig. 77. *Polinices* (*Euspira*) *meisensis* Makiyama.

Fig. 78. *Calypterea yokoyamai tubura* Otuka. Apical view.

Fig. 79. *Calypterea yokoyamai tubura* Otuka. Side view.

Fig. 80. *Batillaria yamanarii* Makiyama.

Fig. 81. *Batillaria yamanarii* Makiyama.

Fig. 82. "*Minolia*" *sasai* Otuka a. Later whorls. c. Apical fragment.
Fig. 82 b is shown on Plate LI.

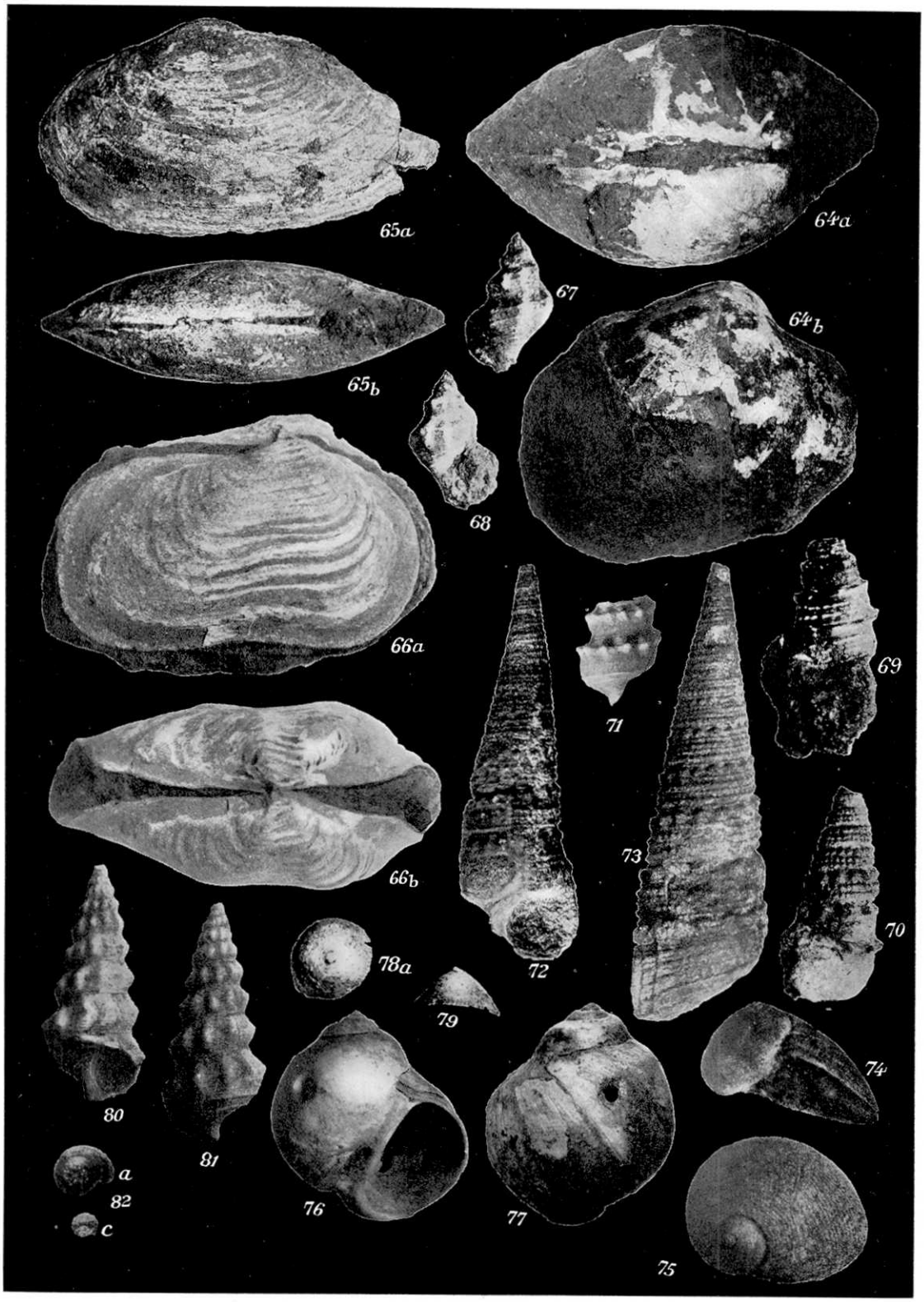
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Plate L.

Plate L.

Fig. 78b. *Calyptrea yokoyamai tubura* Otuka. Enlarged.
Fig. 83. *Conus tokunagai* Otuka.
Fig. 84. *Conus tokunagai* Otuka.
Fig. 85. *Nassarius* (*Hinia*) *simizui* Otuka.
Fig. 86. *Nassarius* (*Hinia*) *simizui* Otuka.
Fig. 87. *Nassarius* (*Hinia*) *simizui* Otuka.
Fig. 88. *Ancistrolepis yudaensis* Otuka.
Fig. 89. *Olivella consobrina* (Lischke).
Fig. 90. *Olivella consobrina* (Lischke).
Fig. 91. *Suavodrillia makiyamai* Otuka. b is shown on Plate LI.
Fig. 92. *Surculites yokoyamai* Otuka.
Fig. 93. *Surculites kurodai*? Otuka (Young specimen from Siratori).
Fig. 94. *Surculites kurodai* Otuka (Specimen from Yazawa).
Fig. 95. *Ringicula ninohensis* Otuka. Enlarged.
Fig. 96. *Ringicula ninohensis* Otuka. Enlarged.
Fig. 97. *Chlamys* sp. (Specimen from Siratori).
Fig. 98. "*Paphia*" *siratoriensis* Otuka. Cast.
Fig. 99. *Cancellaria spengleriana* Deshayes.

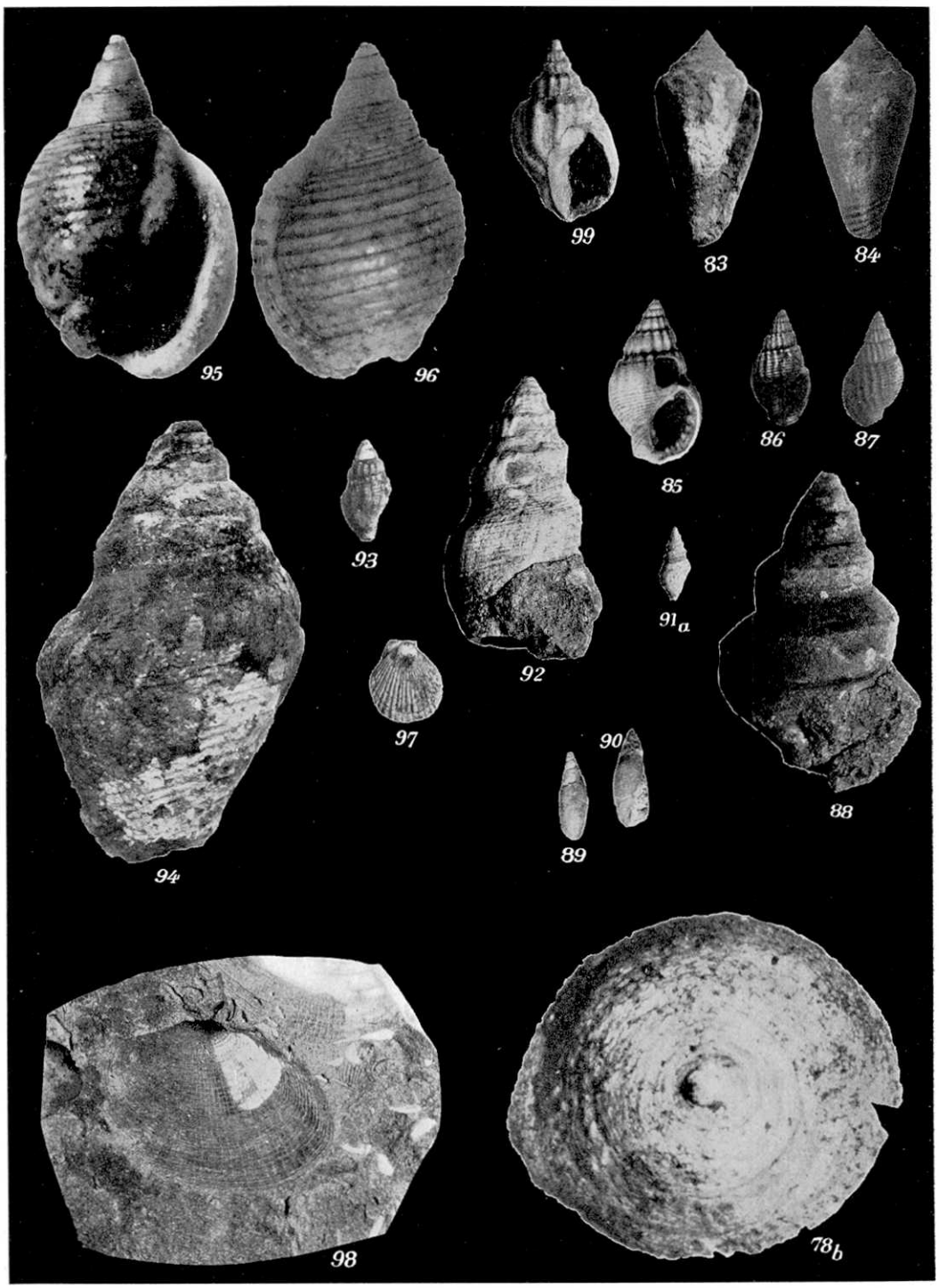
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Plate LI.

Plate LI.

Fig. 59b. *Crepidula isimotoi* Otuka. Enlarged.

Fig. 82b. "*Minolia*" *sasai* Otuka. Enlarged.

Fig. 91b. *Suavodrilia makiyamai* Otuka. Enlarged.

Fig. 100. *Turritella andenensis* Otuka (Specimen from Pliocene of Anden, Akita).

Fig. 101. *Turritella perterebra* Yokoyama (Specimen from Lower Kakegawa series, Dainiti).

Fig. 102. *Turritella fortilirata* Sowerby (Specimen from Lower Pleistocene of Tiba Prefecture).

Fig. 103. *Turritella fortilirata saishuensis* Yokoyama (Specimen from Pliocene of Omma).

Fis. 104. *Turritella fortilirata kadonosawaensis* Otuka.

Fig. 105. *Turritella fortilirata* Sowerby (Specimen from Nippon-kai).

Fig. 106. *Truncaria nakamurai* Otuka.

Fig. 107. *Truncaria nakamurai* Otuka.

Fig. 108. *Truncaria nakamurai* Otuka.

Fig. 109. *Nassarius* (*Zeuxis*) *kometubus* Otuka. Enlarged.

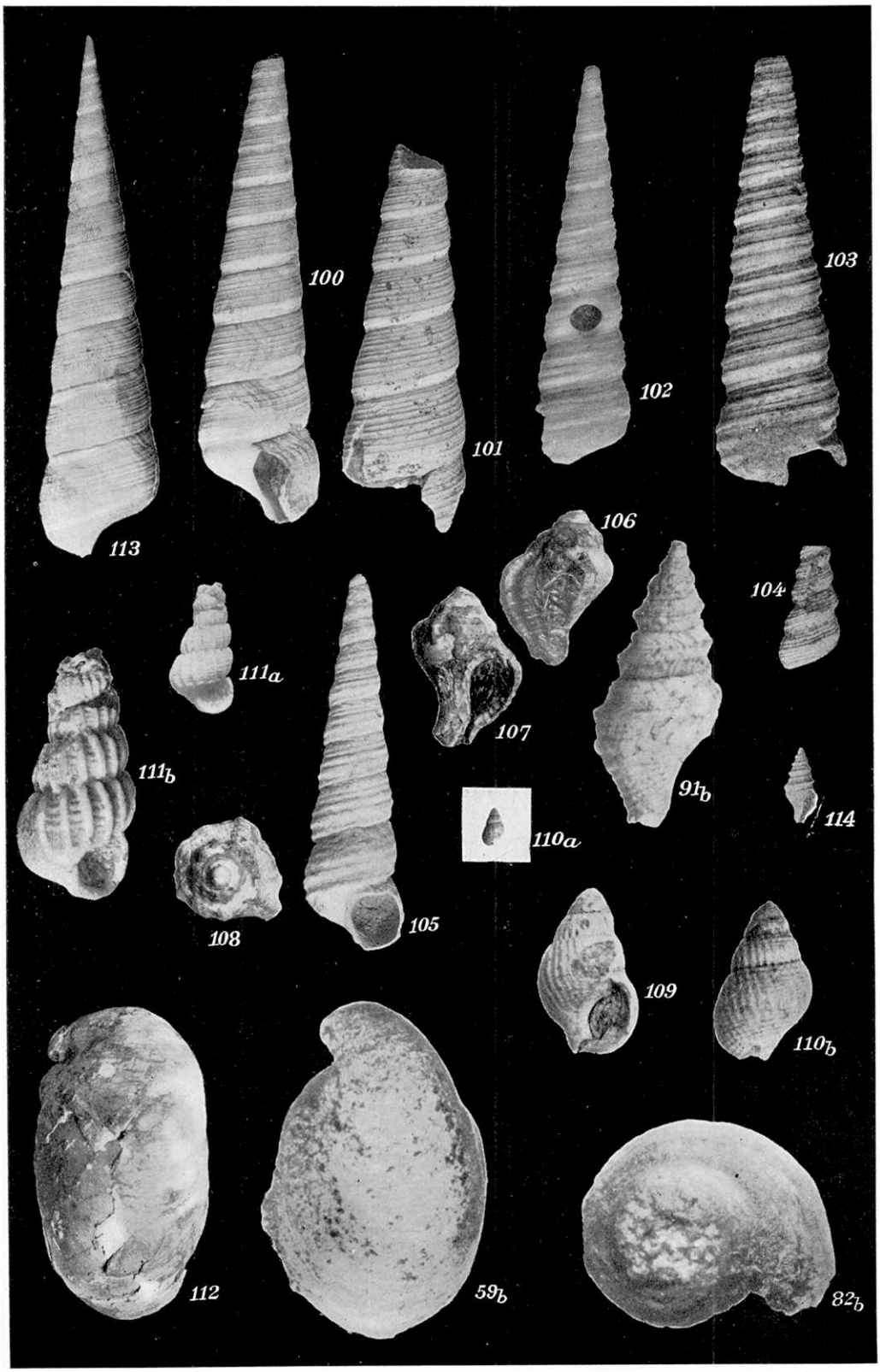
Fig. 110. *Nassarius* (*Zeuxis*) *kometubus* Otuka. b. Enlarged.

Fig. 111. *Epitonium* (*Boreoscala*) *nagaminensis* Otuka.

Fig. 112. *Crepidula jimboana* Yokoyama.

Fig. 113. *Turritella andenensis* Otuka (Specimen from Pliocene of Anden, Akita).

Fig. 114. *Suavodrilia makiyamai* Otuka.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