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Molluscan Fauna of the Lower Part of the Kakegawa Series in the Province of Tôtômi, Japan.

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With Plates I—VI.

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INTRODUCTION

Since 1919 a detailed study of the stratigraphical and faunal relations of the Tertiary rocks of East Tôtômi (Sizuoka-ken) on the Tôkaidô, Japan, was undertaken at the suggestion of Prof. S. NAKAMURA. The present paper is a result of that study and is restricted to the fauna and an outline of the stratigraphy of the lowest part of the type Kakegawa series which is found between the town of Kakegawa and Mori. The occurrence of a fauna in the Dainiti sands which is the basal bed of the Kakegawa series had been first brought to the attention of Imperial Geological Survey many years ago by the late Dr. K. NAKAJIMA and the Pliocene age of it had been recognized. Recently Prof. YOKOYAMA in his paper entitled "Tertiary Mollusca from Dainichi"¹ described forty-two species of which ten were quite new to science, and deemed the age of the Dainiti fauna to be the Lower Pliocene.

My conclusion is that the Dainiti sands as well as the overlying Tenaô sands belongs to the Lower Pliocene in age. The fauna of these beds while not a large one is evidently a typical strand-line facies, and the assemblage

¹ Jan. Coll. Sci. Univ. Tokyo, vol. 45, art. 2, 1923.

STRATIGRAPHIC POSITION AND GENERAL
CHARACTER OF
THE KAKEGAWA SERIES IN TÔTÔMI

In east Tôtômi, the Mesozoic and Cainozoic formations commencing from the bottom are Mikura (Cretaceous or Palaeogene), Ooigawa (Lower Miocene or older), Sagara (Upper Miocene), Horinouti (Transition), Kakegawa (Lower Pliocene), Soga (Upper Pliocene), Ogasa Conglomerate (Upper Pliocene), and the gravelly deposits of the Pleistocene age.

The Kakegawa formation as discussed in this paper occurs between Hutamata and Minamiyama. The type locality is the district between Mori and Kakegawa, where the formation is about 60 m. thick, the lithological characters of the strata represent a perfect cycle of sedimentation, commencing from the littoral facies of the basal part, gradually changing upwards into the thick muddy deposition of a deep sea and the again the shallow water condition following. A distinct unconformity with the underlying Ooigawa is observed in the type locality, but to the east of Kakegawa the base passes insensibly into the Horinouti formation.

There is found a marked unconformity between the top of the Kakegawa and the Soga, which is of the littoral facies and exhibits the final condition of the emergence of late Kakegawa times. The erosion had removed more materials from the top of the Kakegawa to the west of the type locality than to the east, before the Soga times.

The strata have dips of 10° — 15° S on an average and a strike of about N 50° W. There are observed many small, dip and strike faults and very slight foldings. Hereafter, all local groups corresponding to the typical Kakegawa formation will be called "the Kakegawa series." The age represented by the fauna of the Lower Kakegawa series will be named "Dainitian."

LITHOLOGY

The Kakegawa series between Mori and Kakegawa is a northwest-southeast strip about 10 km. in length. The unconformable relation to the underlying Ooigawa is marked by an eroded undulating rock-surface penetrated by boring shells, the basal conglomerate containing the rounded pebbles derived from the stones of the Ooigawa materials and the difference of the dips and strikes.

The Kakegawa is subdivided into three members. The sequence* of the strata along the NNE-SSW cross-section examined through Kakegawa is, in descending order, as follows:

unconformity.

- | | | | |
|----------------------------------|----|------------------------------------------------------------------------------------|-----------|
| D. Upper (Ketienzi Mudstone),** | 8. | Blue-gray muddy superfine sand, very massive. | 224 m. |
| C. Middle (Nangô Beds),*** | { | 7. Alternating sands and mud. | 146 m. |
| | | 6. Brown medium-grained thin-bedded sand. | 133 m. |
| | | 5. White fine tuff and tuffaceous superfine gray sandstone.
(Hosoya Beds) | 32 m. |
| | | 4. Alternating sands and mud. | 30 m.? |
| B. Transition (Iesiro Beds),**** | 4. | Alternating sands and mud. | 30 m.? |
| A. Lower (Dainiti Beds),***** | { | 3. Blue fine-grained sand (Tennô sands)..... | 40 m. |
| | | 2. Brown medium-grained massive sand (Dainiti sands)... | 27 m. |
| | | 1. Basal conglomerate..... | variable. |

unconformity.

It is evident that the transgression of the Kakegawa sea had taken place from the west to the east, being shown in that the time-lines including the faunal zones and the pyroclastic beds overstep to the east. At 2 km. southwest of Mori, the following sequence of rocks is observed.

* Mr. CHITANI mentions the stratigraphy of the Tertiary depositions in Southern Tôhoku. (Jour. Geogr., vol. 38, pp. 84—89. in Japanese). The following is a reformed correlation of his local subdivisions with mines:

Hizikata Beds	Ketienzi mudstone, (8).	
Satuka Beds	Nangô Beds, (7-6).	
Jozumi tuffite	Hosoya Beds, (5).	
Utida Beds	Iesiro** Beds, (4) and Dainiti Beds, (3-1).	
Hotta tuffite	Siraiwa tuff, (the tuff of no. 2 at 2 km. southwest of Mori).	
** 結縁寺泥岩	*** 南郷層	
**** 家代層	***** 大目層	

unconformity.

- | | | |
|------------|---|---------------------------------------------------------------------------------------------------|
| C. Middle. | { | 6. Alternating sands and mud. (lithologically equal to B.) |
| | | 5. Tuffaceous fine sandstone. (lithologically Tennô sands with admixture of pumiceous materials.) |
| | | 4. White fine tuff. |
| A. Lower. | { | 3. Buff medium-grained massive sand (Dainiti sands). |
| | | 2. White fine compact tuff, 0.5 m. |
| | | 1. Buff medium-grained massive sand. (Dainiti sands). |

In this section, the white tuff of No. 4 corresponds to that of No. 5 in the section through Kakegawa. Lithologically, the massive sand lower than this horizon is the same as the Dainiti sands in the first section. The lower pyroclastic horizon of No. 2 is of older origin than the basal bed at Dainiti. The probable same horizon reappears to the east of Kakegawa between the Kakegawa formation and the Horinouti formation. The local name of this tuff in the latter district is "Siraiwa tuff."

The rocks of the Lower Kakegawa are more sandy to the west than to the east. To the east, on the contrary, fine micaceous sands are predominant. The Dainiti sands near Kakegawa is 27 m. in thickness, but it is 45 m. at Dainiti and more to the west. The thickness of the Tennô sands is 40 m. at Kakegawa and 30 m. at Iesiro about 3 km. northwest of Kakegawa. In alternating beds, the sandy seams become thicker and thicker in approaching Mori.

FAUNA OF DAINITI

Abundant shell remains are found in the basal conglomerate and successive massive sand. The shells are generally snowy white, and shine out brilliantly against the surrounding matter; they are, however, generally not well preserved, and mostly weathered, particularly the pelecypodan shells. Hence, large and fragile bivalves were only safely obtained from hardened calcareous nodules. The fauna found in the very basal portion does not differ much from that of the following horizon.

The most characteristic forms are *Turritella perterebra* YOKOYAMA, *Suchium suchiense* YOKOYAMA, *Suchium mysticum* YOKOYAMA, *Latrunculus elatus* (YOKOYAMA), *Hinia kurodai* n. sp., *Asthenotoma yokoyamai* n. sp.,

Terebra abdita n. sp. and *Macoma totomiensis* n. sp.

Cancellaria nodulifera SOWERBY, *Ancilla albocallosa* LISCHKE and *Terebra bifrons* HINDS are the most common species which have survived to the recent. Among very common forms *Siphonalia cassidariaeformis declivis* YOKOYAMA and *Scapharca satoei castellata* YOKOYAMA are very closely related to the living species. Besides these, some forms grouped under the living species exhibit more or less certain ancestral variations.

Being an exotic fresh-water form, the occurrence of *Thiara totomiensis* n. sp. is very interesting. The number of described species is 98.

FAUNA OF HÔNOHASI*

The preservation of the fossils in the bed of medium-grained brown sand with occasional pockets of pebbles of Hônohasi of which the outcrop at the tunnel between Hônohasi and Iwasibara is the best, is better than in most localities, and their abundance in a few localities makes the collections from this place particularly valuable. Most of the fossils are in two zones, one near the base and the other in the bed approximately 10 m. above it.

The upper zone comprises *Pecten praesignis* YOKOYAMA abundantly while that species is very rare in the lower zone. The most characteristic species of the basal bed are *Glycimeris totomiensis* n. sp., *Venus yokoyamai* n. sp., *Venericardia panda* (YOKOYAMA), *Siphonodentalium nipponicum* n. sp., *Suchium obsoletum* MAKIYAMA, *Billium kurodai* n. sp. and *Terebra coa* n. sp. *Venericardia panda* was very rare at Dainiti, but here it is found very abundantly.

The most abundant living species is *Dosinorbis bilunulata* GRAY. Species common to Dainiti and this locality are *Acila minuta* n. sp., *Scapharca satoei castellata* YOKOYAMA, *Litrunculus elatus* (YOKOYAMA), *Siphonalia cassidariaeformis declivis* YOKOYAMA, *Caesia demissa* YOKOYAMA, *Terebra bifrons agaliensis* n. subsp., and *Clavatula patruelis dainichiensis* (YOKOYAMA). *Turritella perterebra* YOKOYAMA is not so numerous as in the first locality. Some forms subspecifically differ from the species of

* 方ノ橋

Dainiti; *Terebra asukensis* YOKOYAMA (from *T. abdita*), *Cythereella totomiensis tachymorpha* n. subsp., and *Kurtziella ugali hobasiensis* n. subsp., are the examples.

As a whole, the fauna of Hônohasi and Iwasibara seems to be a little younger than that of the Dainiti. This consideration is also shown by the eastward overlap of the Dainiti sands upon the old erosion surface.

FAUNA OF THE BASAL BED TO THE WEST OF TENNÔYAMA

The conglomerate found near the bridge of Saigô contains abundant fossil shells. Compared with the above two faunas, the preservation of this fauna is not good. Most of the materials are hardly determined. Although the distance between this locality and the Hônohasi-tunnel is only about a kilometer, the fauna is evidently younger, roughly corresponding to the *Pecten praesignis* zone at Iwasibara.

The most characteristic forms are *Glycimeris totomiensis* n. sp., *Pecten praesignis* YOKOYAMA, and *Suchium obsoletum conglomeratum* MAKIYAMA.

The latter subspecies was very rare in the Hônohasi zone, but reaches its acme in this horizon. The conglomerate is not thicker than 2 m. and the immediately following calcareous sandstone also contains casts of a similar fauna.

FAUNA OF TENNÔYAMA

Just above the buff massive Dainiti sands at Saigô there is a richly fossiliferous fine sand stratum which is the type of the Tennô sands. The shell remains are mostly of autochthonic origin and indicate somewhat deeper conditions of deposition. The fauna may be subdivided into three horizons, though they are not separated by distinct boundaries but transitional without being interrupted by a barren portion. The lowest horizon is found at the west-side of Tennôyama (in front of the Tennô-shrine) and is represented by a mutation of *Suchium suchiense* YOKOYAMA which differs somewhat from the parent form of the Dainiti zone. The middle part of the bed cropping out at the east-side of the hill contains a large number of Gastropoda. Owing to the high weathering, the fossils are very fragile and a perfect

specimen was hard to obtain except for some cemented in nodules.

The uppermost horizon is divided from the middle merely by the reason that it contains a greater number of *Pecten praesignis* YOKOYAMA and *Crassatellites oblongatus uchidanus* YOKOYAMA. Instead of *Suchium suchiense*, there are obtained many *Suchium obsoletum arenarium* MAKIYAMA and *Turricula subdeclivis* (YOKOYAMA) in these middle and upper horizons. *Scapharca satowi castellata* YOKOYAMA, *Venericardia panda* (YOKOYAMA), *Latrunculus clatus* (YOKOYAMA), *Ancilla albocallosa* (LISCHKE) are likewise very common. *Glycimeris totomiensis* n. sp. is now very rare, while *Glycimeris rotunda* (DUNKER) comes in abundance replacing the position. The new addition of *Microfusius magnificus* (LISCHKE) and *Xenophora exuta* (REEVE) is very noteworthy.

COMPLETE FAUNAL LIST

The following is a complete list of the species from the different localities: the species found are marked with ×.

Abbreviation of the local names:

- 大: Dainiti, Uguri-mura, Sati-gun. (周智郡宇刈村大日)
 方: Hônobasi, Saigô-mura near Kakegawa. (西郷村方橋)
 鱒: Iwasibara and Asuka, Taruki-mura near Kakegawa. From the upper horizon of the Dainiti sands. (垂木村鱒原, 同飛鳥)
 西: Saigô-bridge to the west of Tennôyama near Kakegawa.
 社: Westside of Tennôyama, in front of the Tennô-shrine; shortly designated as Tennô-shrine. (天王神社)
 天: Eastside of Tennôyama, shortly designated as Tennôyama. (天王山)
 垂: All localities in Kamiyasiki and Asuka, Taruki; belonging to the Tennô sands; shortly designated as Taruki. (垂木村上屋敷, 同飛鳥)
 仁: Including all outcrops which almost always contain fossil remains in Nitô, Kakegawa-mati. The Tennô sands. (掛川町仁藤)
 U: B, C and D divisions of the Kakegawa formation in the type locality.
 神: Kakegawa series of Tosa Province. (Kônomine* Beds).
 L: Living species of Central and Western Japan between the Bôshû Peninsula and Nagasaki Harbour. Those indicated by (×) are not found living in this region but in other places of the world.

* 神ノ峯

of the subgenus, by the following respects: the adult shell is much smaller; the axial plicae are not so flat and stout; the whorls are less in number and the suture is not undulating.

Terebra (Acuminia) sp.

Occurrence.—Dainiti.

A species of *Acuminia* is represented by a single small shell with a largely fractured aperture. It has a height of about 8mm. in seven whorls, and its last whorl has a diameter of over 2mm. in perfect condition. It resembles in some respects a new species of *Acuminia* from Amami-Ōsima, but it is more slender and smaller. The surface exhibits very obscure axials.

Conidae

Conus sieboldianus n. sp. (Plate IV, figs. 16, 17.)

Shell rather small, straight, elongate-biconic, very broadly and angularly shouldered, not very thick. Spire conoidal, scalar, about one-third the height of the aperture, outline straight. Whorls about 8, regularly increasing, concave; the angle of the shoulder close to the lower suture forming a supra-sutural ridge; the surface below the angle vertical, less than a sixth of the height of a whorl; the last large, attenuated below. Suture impressed, irregularly undulating, slightly appressed. Sculpture: the angle granulate on the early 3 post-embryonal whorls; the concave slope of the shoulder with numerous hair-like curved radial threads, nothing but enforced incremental lines, crossed by very obscure unequal spiral lines; the body-whorl with about 4 shallow grooves around the periphery just below the angle, and many spiral grooves on the anterior portion, increasing the widths anteriorly; curve of incremental lines concave above the angle and slightly arched forward below. Aperture straight and narrow, with parallel lips. Height, 28mm.; diameter, 14mm. Type: Cotype, no 401.

Occurrence.—Nitô.

This species is very closely allied to *C. sieboldii* REEVE (Conch. Icon., sp. 269.), a species living in the temperate waters of Japan, from which

it differs in that the shell is much smaller, the spire is straight and not so sharply acuminate, the supra-sutural ridges is not so elevated, the suture is appressed, and that there is shallow but distinct peripheral grooves on the body-whorl. Some of *C. sieboldii* are less elongate and approach the present species. But the spire of the living species is always acuminate and its outline is markedly concave. I have not examined the specimens of *C. rarimaculatus* SOWERBY, a living species of the China Sea, which is said to be the young of *C. sieboldii*. Judging from the figure (Proc. Zool. Soc., 1870, pl. 22, f. 4.), that species has no peripheral grooves of *C. sieboldianus*.

Conus tuberculatus YOKOYAMA.

1920. *Conus tuberculatus* YOKOYAMA, Foss. Miura Penin., p. 34, pl. 1, f. 15, 16.

Occurrence.—Dainiti.

Distribution.—Lower Musasino of Miura.

A small specimen with a height of 8mm. of this pretty species has come under examination. It has a mammillar protoconch consisting of two convex smooth volutions. The post-embryonal whorls are four; their angles are tuberculated; the slope of the shoulder is somewhat concave and has a few fine spiral lirae. The shape, the ornamentation and all the other characters show that the specimen is unquestionably identical with Prof. YOKOYAMA's species although it is somewhat smaller than the type.

Turritidae

Turris ugaliensis n. sp. (*Plate IV, fig. 18.*)

Occurrence.—Dainiti (very rare).

This is an extinct form which partakes of the characters of *T. unedo* VALENCIENNES, *T. leucotropis* ADAMS & REEVE and *T. gendinganensis* MARTIN.* There is only a fractured body-whorl with a diameter of 19mm. In sculpture, it approaches closely *T. unedo*, which, however, differs in having a double rib on the angle and more prominent threads generally.

* K. MARTIN, Fossilien von Java, p. 32.

15. <i>Venericardia panda</i> (YOKOYAMA)	40
16. Same specimen as fig. 15.	40
17. <i>Siphonodentalium nipponicum</i> n. sp. ×4	59
18. <i>Siphonodentalium nipponicum</i> n. sp. ×4	59
19. <i>Siphonodentalium nipponicum</i> n. sp. ×4	59

PLATE III.

Fig.	Page.
1. <i>Polinices sagamiensis</i> PILSBRY... ..	74
2. Same specimen as fig. 1.	74
3. <i>Monilea cingulata</i> n. sp. ×2	60
4. Same specimen as fig. 3	60
5. <i>Lacuna intermedia</i> n. sp. ×12... ..	64
6. <i>Cingula (Setia) subangulata</i> n. sp. ×10	65
7. <i>Thiara totomiensis</i> n. sp.	66
8. <i>Bittium kurodai</i> n. sp. ×4	66
9. <i>Turritella totomiensis</i> n. sp.	69
10. <i>Uromitra nakamurai</i> n. sp. ×2	78
11. <i>Bittium crosio</i> n. sp. ×10... ..	67
12. <i>Lyria michonica</i> n. sp.	76
13. Same specimen as fig. 12.	76
14. <i>Oliva mustelina</i> LAMARCK ×15	79
15. Same specimen as fig. 14	79
16. <i>Gyrineum (Biplex) perca prisca</i> n. subsp.	71
17. <i>Fulgoraria (Psephaea) totomiensis</i> n. sp.	77
18. Same specimen as fig. 17	77

PLATE IV.

Fig.	Page.
1. <i>Cypræolina solida</i> n. sp. ×4	83
2. <i>Marginella (Cystiscus) tokuensis</i> n. sp. ×4... ..	82
3. <i>Cancellaria pristina</i> (YOKOYAMA)	85
4. Same specimen as fig. 3	85
5. <i>Clavatula kakegawensis</i> n. sp. ×4	100
6. <i>Terebra bifrons ugaliensis</i> n. subsp. ×2... ..	91
7. Same specimen as fig. 6	91
8. <i>Trigonostoma kurodai</i> n. sp. ×2	85
9. <i>Terebra abdita</i> n. sp.	86
10. <i>Terebra yokoyamai</i> n. sp. ×10	87
11. <i>Terebra amabilis</i> n. sp. ×2	88

