On some Organic Remains from the Tertiary Limestone near Sagara, Tōtōmi.

By

Kyugaku Nishiwada.

With Plate XXIX.

[In the spring of this year I took advantage of a two days' stay in Sagara, Prov. Tōtōmi, to examine the Tertiary limestone developed near the town and to collect some of the organic remains abounding in it. In this way I came across some nullipore limestone, the occurrence of which in Japan has not yet been recorded. Since then I have made another short visit to this locality and have studied the collected materials, under the supervision of Professor M. Yokoyama, in the laboratory of the Geological Institute, College of Science, Imperial University. Prof. Yokoyama has placed me under great obligations to him for his kind suggestions and for the loan of Gümbel's paper on the fossil *Lithothamnion*.—Hongō, Tōkyō; November, 1894].

So far as I am aware, there are few limestones in the Japanese Tertiary that can give us more geognostic interest than that under consideration.

Upwards of 3 km. north-west of the town of Sagara, there are two limestone hills, lying one on either side of the Hagimagawa, a river which, after rising in the environs of Nakanishi, farther north-west of the present site, takes its sinuous course in a south-easterly direction between these hills and empties itself into the sea close to the town. That on the right of the stream is locally known as Mekamiyama and the other on the left of it as Okamiyama or

Okamidai, in allusion to the names of the villages Mekami and Okami. According to the Topographical Survey of the Army Department of the Empire, the former attains an elevation of 111.3 m. above the sea, while the latter is less high, or about 60 m.

The limestone occurring in the form of such isolated hills is of a quite unique character. A glance at the rock brings before us a congeries of the calcareous forms of some organic remains. The colour is cream-white or greyish-white, sometimes grey. It is pretty hard through the crystallisation of some of its organic inclusions. Chemically considered it is almost free from impurities,—ferric oxide, magnesia, etc., being present in only very small quantities.

As regards structure, its stratification is for the most part indistinct. The Okamiyama limestone is simply massive, there being no structure suggestive of bedding, except fissure-planes of which it is full and through which much solution has been effected. Much of the Mekamiyama stone, hidden as it is by its covering of soil, may be in the same state; but on the east flank of the hill, where extensive quarries afford an opportunity of studying its structure, it is certainly stratified and strikes N. 20°–30° E. with a very high inclination towards SEE. Mr. Nakashima[1] of the Imperial Geological Survey believes that the limestone of these hills suffers from an anticlinal folding, extending to the overlying strata, and that what is seen on the eastern flank of the Mekamiyama shows that the beds dip away from a central axis very steeply to the south.

During my second visit to the locality, an attempt was made to determine the relation of the limestone to the other sedimentary rocks. The evidence then obtained bearing upon this is, however, not quite decisive, although the rocks may in places be observed in association.

1. Shizuoka Zufuku Chishitsu Setsumeisho. p. 12.

Along a brook, on the north-western side of the Mekamiyama, there is exposed a Tertiary formation of sandstones and shales, to which reference will be made later on, which strikes nearly N-S. and dips to the east at an angle of 35°. On the north-eastern side of the hill is also seen an alternation of shale and sandstone quite similar to the others, the strike of which is nearly NE. and the south-easterly dip very high. Moreover, to the west of the hill, beyond a very narrow rice-field is laid bare along a brook another similar alternation with north-westerly inclination. At the Okamiyama, on the other hand, any such exposures as the above are concealed by the talus of limestone blocks on all sides of it. There is, moreover, but little outcrop of rocks in the neighbourhood, with the exception of a very limited patch laid bare at Oiwa, about 150 m. east of the hill, where sandstone and shale are found in a fragmentary state in association with the limestone. So far as my observation goes, it seems most probable that a series of sandstones and shales rests directly upon the limestone, and that the latter appears sporadically from underneath that series and still younger strata, as in the hills here under consideration.

The accompanying figures will perhaps render the mode of occurrence of the limestone clearer than any description.

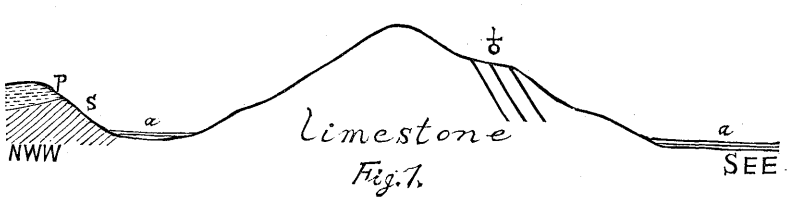


Fig. 1. Ideal section of the Mekamiyama from SEE. to NWW. Scale 1 : 7,000.

⏚ limestone quarries.	s. sandstone and shale.
a. rice-field.	p. much younger Tertiary.

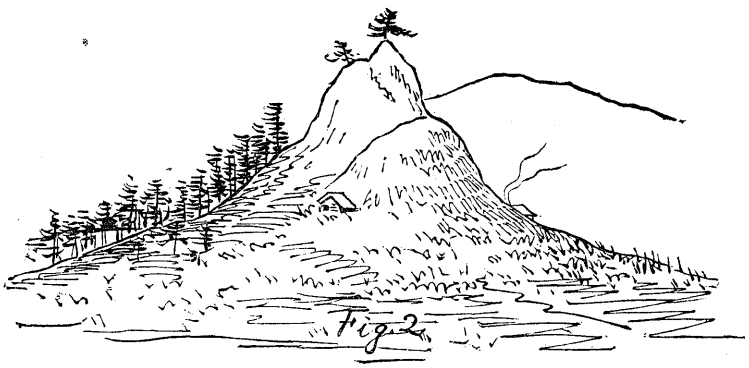


Fig. 2. A southern view of the Okamiyama or Okamidai, wholly made up of limestone. Sketched by the writer, Nov. 5th, 1894.

The organic remains occurring plentifully in the limestone are but few in genera. The following are some of the species which I have been able to recognise:

Lithothamnion.
Corals.
Millepora.
Foraminifera.
Turbo.
Pecten.

The abundance of the remains referable to each of these is generally in the order stated.

Description of the Fossils.

Lithothamnium ramosissimum Reuss.

Pl. XXIX. Fig. 1, 2, 3, and 4.

Nullipora ramosissima—Reuss, Naturw. Abh. v. Haidinger., Bd. II., 1848, p. 29; T. III., Figs. 10 and 11.

Nullipora ramosissima—F. Unger, Denks. d. k. Aka. d. W. in Wien, Bd. XIV, 1858. p. 23. T. V. Figs. 18–22.

Lithothamnium ramosissimum—C. W. Gümbel, Abh. der k. bayer. Akad. der W., II. Cl. XI, Bd. I, Abth. München, 1871. p. 24. T. I.

Lithothamnium ramosissimum—A. Rothpletz, Zeits. der deut. Geol. Ges., Bd. 43. 1891. p. 320.

Systematic knowledge of *Lithothamnion* is not as yet in a satisfactory condition. This fossil was formerly relegated to a coral under the various names of *Cellepora*, *Spondites*, *Nullipora*, *Melobesia*, and *Millepora* by Linné, Lamarck, Lamauroux, Cuvier, Ellis, Solannder, Reuss, etc., among whom the last author gave the name of *Nullipora ramosissima* to the irregularly ramified, coral-like calcareous form, occurring in the limestone of Leitha near Vienna. Kützing proposed the name of *Spondites stalactica* for the tiny stalactic form of it. Haidinger[1] offered the explanation that *N. ramosissima* is a sedimentary body. In 1858, Franz Unger proved for the first time that *N. ramosissima* is neither an animal nor a stalactic body, but a plant. In 1872, C. W. Gümbel wrote an excellent paper, entitled *Die so-genannten Nulliporen*, etc., in the above-quoted *Abhandlungen*, in which he embodies systematic descriptions of the fossil species and announces that they are to be distinguished from one another only by the relative dimensions of the tissue-cells. Solms-Laubach, on the contrary, said as follows: "It is extremely difficult to distinguish the species in the living representatives of this group, and it may be readily conceived that the difficulty of dealing with the fossil forms is still greater. We shall do well to follow Unger in this matter, and to put them all together as *Lithothamnium ramosissimum*."[2] Still more recently, A. Rothpletz, in München, accepted Gümbel's

1. *Berichte über die Mittheilungen von Freunden d. Naturw.*, Bd. IV., 1848, p. 442—cited in Unger's paper.

2. *Fossil Botany* (English translation of *Einleitung in die Palaeophytologie*). Oxford, 1891, p. 45. I am greatly indebted to Mr. Kenjiro Fujii, *Rigakushi*, of the Botanical Institute of the College of Science, for the loan of this work.

opinion as to identification of the fossil species, in conformity with which he described 14 species. In the determination of the present species I also am inclined to follow Gümbel.

The remains of our *Lithothamnion* play such an important *rôle* in the building up of the limestone, as to warrant the designation of *Lithothamnion-Limestone* (*Nulliporenkalk*). The fractured surfaces have a porcellanous aspect, and are cream-white in colour.

The thallus is much ramified into tiny stalactic forms or shrubs, which are rounded at the ends, variable in length and breadth, measuring from 1 to 3 mm. across, and having smooth surfaces. (Fig. 1, Pl. XXIX). Generally it resembles either that of *L. byssoides* (Lamarck) Phil., a living species in the Adriatic Sea, which was described and figured by Dr. Hauck in his *Meeresalgen Deutschlands und Oesterreichs*,[1] or the lower one of the two figures given in Prof. Zittel's *Handbuch der Palaeontologie*.[2]

Examined under the microscope, the cells composing the outer part of a branch of the thallus are 6–8 angled (not unfrequently 5–7 angled according to the imperfection of the slides), as may be seen in a transverse section. A vertical section, on the other hand, shows that the tissue-cells are mainly of rectangular shape and regularly arranged in layers lying one on another as concentric shells. In certain slides, sections of the cells show the walls as either round or sinuous; they can then hardly be distinguished from those seen in a tangential section of *Solenopora*.[3]

The cell-division is active. In the "hypothallium," so-

1. Leipzig, 1885, p. 275, Taf. II., Fig. 1.
2. II. Abth. *Palaeophytologie*, Leipzig. 1890, p. 38.
3. A. Nicholson and Etheridge, *Geol. Mag.*, Dec. III, Vol. II, p. 529.
   ————, *Geol. Mag.* Dec. III., Vol. V., p. 15.
   A. Brown, „ „ Dec. IV., Vol. I., p. 145 and 195.

called by Areschong, or "Markstrang" of Solms-Laubach, the cells are divided and multiplied principally by means of dichotomy, or "subdichotomy", according to Bornet, and sometimes trichotomy or "subtrichotomy"; while in the "perithallium," so-called by Rothpletz, the cell-increase takes place mostly by the process of transverse fission or "Quertheilung."

In the slides prepared, traces of the pores suggestive of what are known as "tetraspores" are sometimes seen in the perithallium; no remains of cystocarps have been recognised.

The approximate dimensions of the perithallic-cells are 12-29 μ in length and 12-19 μ in breadth, while the hypothallic-cells are of still larger size, being not unfrequently 25 μ broad and 37-50 μ long. The former dimensions approach much more closely to those of *L. ramosissimum* Reuss than to those of any described by other authors. Relying upon this fact only, and putting aside any point as to form, as Gümbel suggested, it will not be far from the truth to class our species with *L. ramosissimum*.

Stylophora sp.

Pl. XXIX. Fig. 6.

Coral remains are also abundant, but all of them found as casts and consequently indeterminable. One of them, however, may belong to the section of *Madreporaria*, and perhaps to the genus *Stylophora*, in so far as it shows traces of the fully developed six septa, etc.

Millepora sp.

Pl. XXIX. Fig. 7.

Besides the above coral remains, there occurs another coral-like form which may be regarded as belonging to *Millepora* of the

Hydrocorallinæ. A part of the branches of the cœnosteum entirely converted into crystalline calcite is shown in Pl. XXIX. Its tangential section exhibits traces of the gastropores and dactylopores. A vertical section shows that the cream-white calcified tubes are intersected by transverse partitions or "tabulæ," a structure suggestive of what are called zoöidal tubes, which traversed the calcareous skeleton of the animal, and contained the gastrozoöids and dactylozoöids.

No literature relating to fossil *Millepora* beyond the text-books of Professors Zittel and Nicholson, is accessible to me; and it is therefore impossible at partition to identify thes pecies or study the details of this doubtful form.

Foraminifera.

The microscope reveals the presence of many of the simpler forms of Foraminifera in the limestone, but few of them are well preserved. On this account no good sections for examination have been got but so far as they can be identified in sections, they appear to belong to *Globigerina*, *Nodosaria*, *Miliola*, *Rotalia* (?), and *Amphistegina*.

Pecten sp.

For this specimen I am indebted to Mrs. Miye Atsumi, of Okami, who was kind enough to submit it to me for examination. Its species proves to be indeterminable through imperfect preservation.

Loc., Okamiyama; rare.

Turbo mekamiensis m.

Pl. XXIX. Fig. 5 *a* and *b*.

Shell turbinated or ovate-pointed; composed of 5 whorlsl convex and separated by subcanaliculated sutures, upper two whors,

nearly smooth, lower three spirally sculptured with liræ, which number 5 on the penultimate and 12 on the last whorl, and are generally wider than their interstitial furrows: among the liræ on the body whorl the subsutural is the largest. Aperture indistinct, but nearly ovate (?)

Height of the shell .....48mm.
Width .....43mm.
Spiral angle.....86°
Approximate ratio of body whorl to entire shell 70 : 100.

T. mekamiensis is allied to some of the living species. In the form of the shell, the number of whorls, and the liræ on the body whorl, it resembles *T. artensis* Montrouzier 1860 (Tryon, *Manual of Conchology*, vol. X, p. 196 Pl. 45, Figs. 96, 97), from which, however, it is distinguished in its sculpture, the living one having spiral ribs which are narrower than the interstices. In the last point it coincides with *T. argyrostomus* Linn. 1758 (The same book, p. 197. Pl. 40, Fig. 18 ; Pl. 46, Fig. 8) ; but not in the other characters of the shell of this species.

It is mostly found as casts, of which parts of the limestone bed, common on the eastern flank of the Mekamiyama, are full. The specimen figured was kindly given me by Mr. Sadahe Yagi, of Mekami·

The Tertiary formation, within which the limestone makes its appearance in a local manner, subdivides into an Upper and Lower series.[1]

---

1. Mr. Nakashima has given these divisions the names of Upper Oigawa Tertiary and Lower Oigawa Tertiary, and considers the former to be probably Pliocene and the latter Miocene.

a) The Upper series is of vast extent, covering most of the southern part of the province of Tōtōmi, and is overlaid discordantly by the not-less-widely distributed Quaternary formation. It consists of shale, sandstone, and conglomerate, all of tufaceous nature, and yields a number of fossil shells. Amongst them are species of *Nassa japonica* Adams, *Lampania zonalis* Lamarck, *Cerithium*, *Chemnitzia*, *Rissoa*, *Tellina nasuta* Conrad, *Petricola*, *Corbula*, *Arca granosa* Linné, *Ostea gigas* Thumberg etc.[1]

Judging from these shell remains, the Upper series may be considered as contemporaneous with the Pliocene Tertiary developed in the environs of Tōkyō, a detailed account of which is found in Dr. Brauns' *Geology of the Environs of Tōkyō*.

Overlaid by the Pliocene Tertiary just described, there lies b) the Lower series occupying a very limited area. It is mainly made up of dark-greyish shale and brownish or greyish sandstone—just that alternation which is found overlying the limestone, as already described. With the exception of the limestone, this series has yielded so far no harvest of any characteristic fossils for the determination of its geological age. According to the order of superposition, however, there can be no reasonable doubt that this division is older than the Upper one, so that it will be admitted that the limestone may belong to some older epoch than the Pliocene.

Now, putting out of account the other remains in the limestone, we know that *L. ramosissimum* Reuss has hitherto been found in the Miocene Tertiary and in no other formation. Hence, the recurrence of this species in the limestone, together with the fact that the rock is overlaid discordantly by the above-mentioned Pliocene strata,

1. Loc. cit. p. 16.

seems to suggest that it may be assigned to the Miocene, together with the associated sandstones and shales.

PLATE XXIX.

Plate XXIX.

Fig. 1.—A macroscopical view of *L. ramosissimum* in the polished surface of a block of the Limestone.

Fig. 2 and 3.—Vertical sections of its branches × 80.

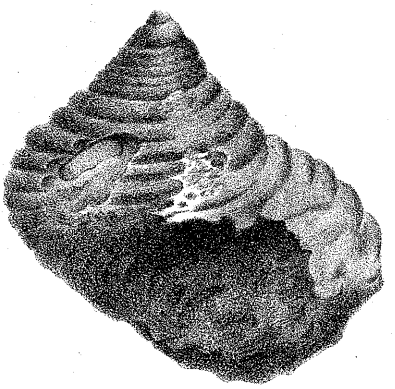
Fig. 4.—Transverse section of the same × 80.

Fig. 5 a and b.—*Turbo mekamiensis* Nishiwada; nat. size.

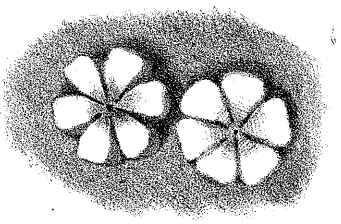
Fig. 6.— Casts of *Stylophora* sp., greatly enlarged.

Fig. 7.—*Millepora* sp. Vertical section of part of a branch of the cœnosteum.

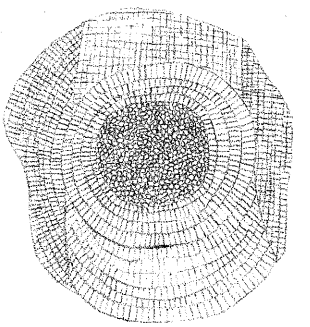
5a



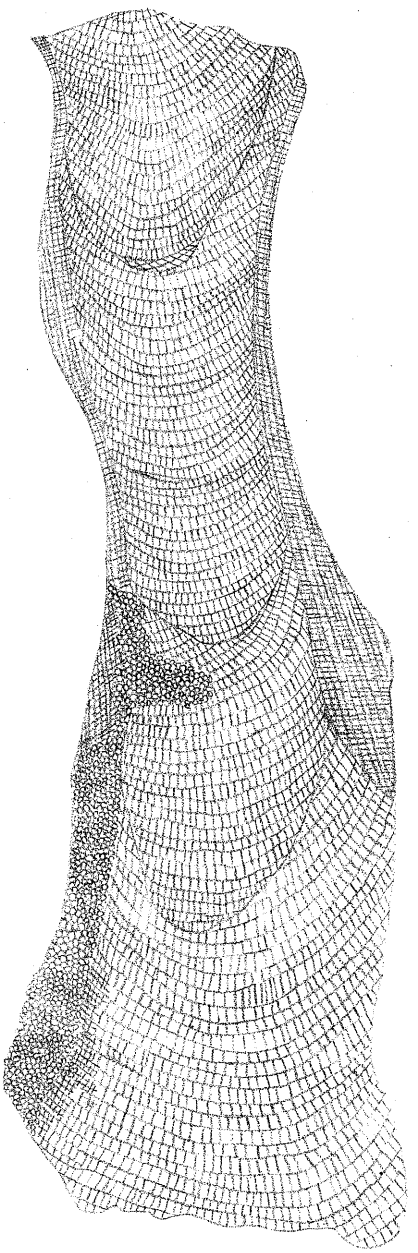
6



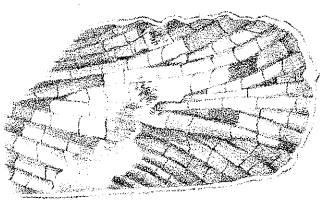
4



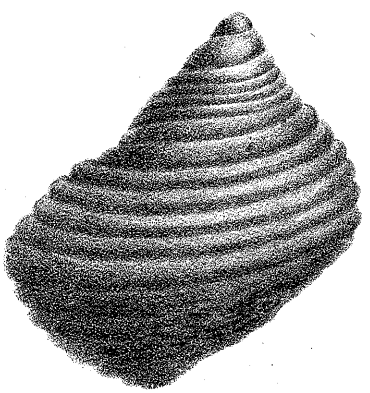
2



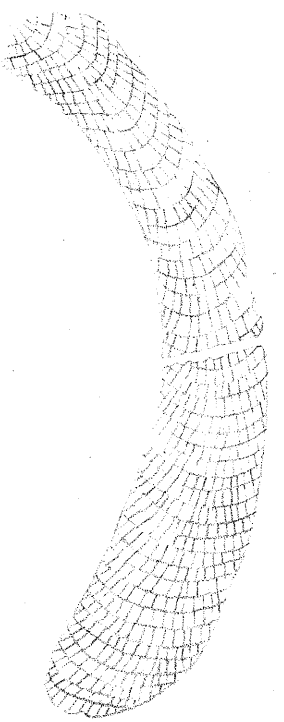
7



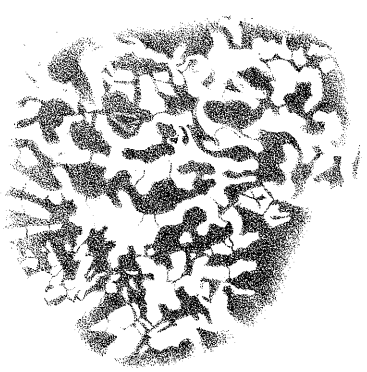
5b



3



1



Seikwadō. Tōkyō. Japan.