A BRIEF SUMMARY OF THE STUDIES OF ROCK-FORMING CALCAREOUS ALGAE IN JAPAN

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ABSTRACT

The rôle of calcareous algae is great in the construction of limestone formations. This note gives a retrospect of the studies pursued in Japan on the fossil algal floras taking part in the constitution of various limestones in different ages of the Japanese Islands and the islands of the Japanese possession in the pre-war time. In short, the algae of the corallinaceae and *Halimeda* are dominant in the Cenozoic limestones, *Petrophyton* in the Lower Cretaceous *Orbitolina* calc-psammite, algae of the Dasycladaceae and of the Porostromata, besides *Solenopora*, in the Upper Jurassic Torinosu limestone, algae of the Dasycladaceae, especially *Mizzia*, in the Permian fusulinid limestones and *Solenopora* in a Gotlandian limestone. Some remarks are added regarding *Collenia* and *Girvanella* limestones, and also two interesting finds of *Margaritina* and *Triploporella* in some Permian limestones of China.

THE first attempt to study rock-forming calcareous algae in Japan was undertaken about half a century ago by K. Nishiwada in the Geological Institute of the University of Tokyo under Prof. M. Yokoyama. The material he then dealt with is the nullipore limestone of the Sagara district, Sizuoka Prefecture, where there are two solitary hills entirely built of nullipores which he identified with *Lithothamnium ramossissimum* Reuss from the Leithakalk of the Vienna basin, Austria (NISHIWADA, 1894, p. 236, PL. 29, FIGS. 1-4). For a long time since, the studies of algal remains have been neglected, although similar or allied objects are common in the Tertiary and later limestones of Honsyû (the main Island of Japan) as well as of the Bonin Islands, Ryûkyû Islands, Borodino Islands and Formosa (Taiwan), all in Japanese possession in the pre-war time. In the meantime, there appeared three papers with the descriptions of fossil algae in some of these limestones: one by R. B. Newton and R. Holland who illustrated *Lithothamnium ramossissimum* from Formosa and Iriomote-zima, Ryûkyû Islands, in association of *Nephrolepidina* (NEWTON & HOLLAND, 1902, p. 17, PL. 1, FIG. 8); one by F. Heydlich who described *Lithohamniscum nahaense* nov., from a limestone of Naha, Okinawa-zima, Ryûkyû Islands (HEYDLICH, 1900, p. 1, PL. 7, FIGS. 1, 2), and the other by A. Karpinsky who described *Mizzia* of the Permian fusulinid limestone of Akasaka, Huha-gun, Gihu Prefecture (KARPINSKY, 1910, pp. 257-272, PL. 3). Yabe also cited many localities of fossil Corallinaceae in his note on the geological and geographical distribution of higher foraminifera in the Japanese Tertiary (YABE, 1920, p. 1 *et seq.*).

Since the foundation of the Institute of Geology and Palaeontology in the Tôhoku University, Sendai, this line of researches was pursued rather subsidiarily by some of the staff-members and students, until in late years one of the graduates, K. Ishizima, commenced his special studies. He already issued many papers in this connection in which the following forms were described (ISHIJIMA, 1923-1943).

LIST OF THE FOSSIL CALCAREOUS ALGAE DESCRIBED BY ISHIJIMA

Early Holocene: Raised coral reef

Amphiroa howei Ishijima	Isigaki-zima

Plio-Pleistocene: Ryûkyû limestone

Corallina ? sp.	Taikôzan
Amphiroa complexa Ishijima	Syôkôzan
A. cylindrica Ishijima	Syôkôzan, Kôtôsyo, Sirakawa
A. elegans Ishijima	Taikôzan
A cf. *ephedraea* (Lamx.) Aresch.	Wanai
A. foliacea Ishijima	Kawahira
A. formosana Ishijima	Taikôzan
A. fragilissima Ishijima	Syôkôzan, Kawahira
A hayasakai Ishijima	Zyunkôsi
A. howei Ishijima	Kôtôsyo
A. kotobukiana Ishijima	Kotobukiyama
A. kotobukiana wanaiensis Ishijima	Wanai
A longissima Ishijima	Sirakawa
A. rigida Lamouroux	Kôtôsyo
A. shirakawaensis	Sirakawa
A. taiwanica Ishijima	Kôtôsyo
A. tenuis Ishijima	Sirakawa, Kôtôsyo
A. verrucosa Kutzing	Kôtôsyo

A. wanaiensis Ishijima	Wanai
A. spp.	Sirakawa, Wanai, Tintôzan, Zyunkôsi
Archaeolithothamnium hanzawai Ishijima	Tôsato
Lithothamnium bandanum Foslie	Taikôzan
Lithophyllum moluccana Foslie	Kotobukiyama
L. sp.	Itoman
Arthrocardia weberi Ishijima	Kotobukiyama
Lithoporella australis Ishijima	Itoman, Kita-Daitô-zima
L. crassa Ishijima	Near Ota-ana
L. formosana Ishijima	Kotobukiyama
L. hayasakai Ishijima	North of Odake
L. parvus Ishijima	Kasari
L. ryûkyûensis Ishijima	North of Odake, Tôsato

Miocene —*Nephrolepidina* and related limestones

Corallina elliptica Ishijima	Ogamiyama, Megamiyama
Jania lemoini Ishijima	Kuboi
Archaeolithothamnium kuboiensis Ishijima	Kuboi
A. megamiensis Ishijima	Megamiyama
A. taiwanensis Ishijima	Payapaya
A. sp.	Nankô-Taikô
Lithoporella quadritica Ishijima	Megamiyama
Mesophyllum yabei Ishijima	Kayanuma

Upper Oligocene (Aquitanian) — *Spiroclypeus* limestone

Archaelithothamnium pseudo-nummuliticum Ishijima	Kôtôsyo

Upper Eocene — *Pellatispira* limestone

Archaeolithothamnium kobamazimaensis Ishijima	Sakota

LOCALITIES

Honsyû (main island), Japan
- Ogamiyama near Sagara, Haibara-gun, Sizuoka Prefecture
- Megamiyama near Sagara, Haibara-gun, Sizuoka Prefecture
- Kuboi, Ôisi-mura, Minami-Turu-gun, Yamanasi Prefecture
- Kayanuma near Matuda, Asigara-kami-gun, Kanagawa Prefecture

Kyûsyû
- Kasari, Kasari-mura, Amami-Osima

Ryûkyû Islands
- Tôsato, Isigaki-zima
- Kawahira, Isigaki-zima
- Sirakawa, south-west of Nisihara, Simaziri-gun, Okinawa-zima
- Near Ota-ana, Sinto-mura, Simaziri-gun, Okinawa-zima
- Itoman, Simaziri-gun, Okinawa-zima
- North of Odake, Kobama-zima
- Sakota, Kobama-zima
- Wanai, Okinoerabu-zima

Kita-Daitô-zima (North Borodino Island)

Taiwan (Formosa)
- Kôtôsyo (Botel Tobago)
- Taikôzan, Okayama-gun, Takao Prefecture
- Sôykôzan, Okayama-gun, Takao Prefecture
- Kotobukiyama, Takao
- Zyunkôsi, Kôsyun-gun, Takao Prefecture
- Nankô-Taikô, Taitô district
- Payapaya, Taitô district
- Tintôzan, Kansirei, Sirakawa-syô, Sinei-gun, Tainan Prefecture

Ishijima re-examined "*Lithothamnium ramossissimum*" of Nishiwada from Megami- and Ogamiyama; it is not a *Lithothamnium* s.s., but a *Lithophyllum* and now named by him *Lithophyllum nishiwadai* (ISHIJIMA, 1943 a, 71-73, TEXT-FIG. 7). The true generic position of "*Lithothamniscum nahaense* Heydlich" is still uncertain.

A good amount of calcareous algae, mostly Corallinaceae, takes part in the constitution of the Middle Eocene nummulitic tuff, Upper Eocene *Orthophragmina* limestone and Aquitanian *Eulepidina* limestone of Ogasawara-zima (Bonin Islands); these are not yet studied.

The fossils of the Corallinaceae, so common in the Cenozoic deposits, are rare in the Mesozoic of Japan, just as in the other parts of the world; yet they are occasionally found in thin sections of the Lower Cretaceous *Orbitolina* calc-psammite of the Miyako district in the Kitakami mountainland, and of the Upper Jurassic Torinosu limestone of the Sakawa basin in Sikoku and the Sôma district in the Abukuma mountainland; these remains are conventionally assigned to *Lithothamnium* by Yabe and Toyama (YABE & TOYAMA, 1928, pp. 150, 151, PL. 19, FIGS. 5, 6; PL. 23, FIG. 1).

The Upper Jurassic Torinosu limestone contains many problematical fossils; one of them, *Nipponophycus ramosus* Yabe & Toyama, has slender branching cylindrical thallus, with a thick calcified wall, traversed radially by numerous fine canals, around the axial hollow; it somewhat recalls *Furcellaria* of the Rhodophyceae; but its true nature is unknown. It occurs also in the Lower Cretaceous *Orbitolina* limestone of the Soratigawa, Hokkaidô, and *Orbitolina* calc-psammite of the Miyako district (YABE & TOYAMA, 1928, pp. 142, 143, PL. 18, FIGS. 1-6; PL. 19, FIGS. 1-4; PL. 23, FIGS. 2, 3).

The Solenoporaceae, another group of the Floridae, is represented by the two genera *Solenopora* and *Petrophyton* in the Mesozoic rocks. The former has one species, *Solenopora* (*Metasolenopora*) *rothpletzi* Yabe in the Torinosu limestone of Sikoku (YABE, 1912, pp. 2-6, PL. 1, FIGS. 2-5), and the latter two species, one, *P. miyakoense* Yabe, in the

Lower Cretaceous calc-psammite of the Miyako district (YABE, 1912, pp. 6-8, PL. 2, FIGS. 1-8; TEXT-FIG. 4), and the other, *P. tenue* Yabe & Toyama, in the Lower Cretaceous limestone of Sakamoto, Yatusiro-gun, Kyûsyû (YABE & TOYAMA, 1928, p. 142, PL. 20, FIGS. 1, 2).

Solenopora is also reported by T. Sugiyama from the Gotlandian of the Kitakami mountainland, where its remains form *Solenopora* limestone which occupies a definite horizon in the uppermost part of his Kawauti series; the genus has a wide geological range from the Ordovician to the Jurassic in Europe.

Lime-secreting species of *Chara* is not living in Japan; likewise there is no fossil of calcareous Charophyta hitherto known. Calcareous deposits of fresh-water origin are rare.

Calcareous algae of the Chlorophyceae are geologically important. *Halimeda* of the Codiaceae is a great contributor to the Plio-Pleistocene Ryûkyû limestone, and there are limestones almost solely built of its segments. Its remains are also found not seldom in *Lepidocyclina* (s.l.) and *Miogypsina* limestones from various places.

Gymnocodium bellerophontis Rothpletz of the Codiaceae is an important leading fossil in the Permian *Bellerophon* limestone of south-eastern Europe; a similar form occurs very rarely in the Permian *Yabeina* limestone of the Kuma-gawa, Kyûsyû.

The Dasycladaceae is well represented by several interesting forms in the Torinosu limestone of the Sakawa basin, namely:

Clypeina hanabataensis Yabe & Toyama
Neogyroporella elegans Yabe & Toyama N. sp.
Thyrsoporella (?) *hanabataensis* Yabe & Toyama
Makroporella tosaensis Yabe & Toyama

Clypeina ranges from the Jurassic to the Tertiary; *Neogyroporella* is a new type allied to *Gyroporella* Gümbel emend Benecke from the Triassic. *Thyrsoporella* seems to have an equally wide geological range as *Clypeina*, though its fossils are previously known only from the Tertiary; *Makroporella tosaensis* is an ally of *M. pygmaea* Gümbel from the Upper Jurassic of Europe, and provisionally assigned to the genus, as Pia has done for *pygmaea* (YABE & TOYAMA, 1949 a, b).

Permian limestones are sometimes rich in Dasycladaceous algae; particularly *Mizzia* is the commonest fossil, almost pure accumulation of its tests forming *Mizzia* limestone at several places in Honsyû. At first A. Karpinsky described *Mizzia*, cf. *velebitana* Schubert, *M. japonica*, nov., and *Stolleyella yabei*, nov., from *Neoschwagerina* limestone of Akasaka; the two forms of *Mizzia* are now usually regarded to be specifically indistinguishable from each other and identical with *M. velebitana*, and the last one is also transferred by Pia to the same genus (KARPINSKY, 1910, pp. 257-272, PL. 3, FIGS. 1-13; PIA, 1920, pp. 23, 24, PL. 1, FIGS. 4-6). Y. Ozawa once stated the separate occurrence of *M. velebitana* and *M. japonica* in different horizons of the fusulinid limestones of Akasaka (OZAWA, 1927, p. 134); but it needs further confirmation.

R. Endo early reported on Dasycladaceous fossils of several types found in some Carboniferous limestones of the Kitakami mountainland, and referred them provisionally to the genera *Makroporella*, *Diplopora*, *Anthracoporella* and *Gyroporella*; these deserve further detailed examination and some of the above-mentioned generic references probably need revision (ENDO, 1924, p. 244).

The Torinosu limestone of Sikoku, Kyûsyû and the Abukuma mountainland has in common *Pycnoporidium lobatum* Yabe & Toyama and *Stenoporidium chaetetiformis* Yabe & Toyama. These are probably related to *Solenoporella* Rothpletz, *Ortonella* Garwood, *Mitscheldeania* Wethered, *Zonotrichites* Bornemann, *Dimorphostroma* Reis, and *Hedströmia* Rothpletz. With the exception of the first genus, all the others are included by Pia in the group Thamnidia of the Porostromata (Schizophyceae) (YABE & TOYAMA, 1928, pp. 146-150, PL. 20, FIG. 3; PL. 21, FIGS. 1-5; PL. 22, FIGS. 1-4).

Kitakamiania eguchii Ishijima is another resemblant of *Ortonella*, *Mitscheldeania* and *Pycnoporidium*; its filaments are much broader and separated from one another by broader intervals than in *Pycnoporidium lobatum* and often come into contact with adjacent ones or are supported by common transverse bars. Ishijima considers it to be most nearly related to the Codiaceae (ISHIJIMA, 1943, pp. 639-641, FIGS. 1, 2).

Pseudoolites, pisolites or crusts formed of the filaments of *Girvanella* in more or less concentric layers are not rare in limestones of different geological ages. *G. tosaensis* Yabe & Toyama of the Torinosu limestone is an encrusting form (YABE & TOYAMA, 1928,

p. 151, PL. 23, FIGS. 4-6), while *G. manchurica* Yabe & Ozaki of the Lower Cambrian of south Manchuria forms pisolites (YABE & OZAKI, 1930, p. 82, PL. 25, FIGS. 1-7), and *G. sinensis* Yabe of the Ordovician of Middle China pseudoolites (YABE, 1912, p. 1, PL. 1, FIG. 1). The latter two give rise to *Girvanella* limestones, which serve efficiently as horizon indicators at least locally, one in south Manchuria and northern Korea, and the other in the Gorge region of the Yangtzekiang. *G. grabaui* Paul is another pisolite-forming species from the Lower Permian Chuanshan limestone of Middle China (PAUL, 1938, pp. 211-214, TEXT-FIG. 1).

While *Girvanella* reveals minute filaments, no trace of any organic structures is visible in *Collenia* or *Cryptozoon* and their allies, common in certain Pre-Cambrian and older Palaeozoic limestones. If these objects are really organic in origin, they may be produced more probably by the agency of algae, especially Schizophyceae, than of any other organisms. These objects are not yet found in Japan, but are richly represented in north China, south Manchuria and northern Korea.

A. G. Grabau distinguished *Collenia sinensis*, *C. cylindrica* and *C. angulata*, all new, in the Sinian Nankou limestone of Nankou Range in north China (GRABAU, 1922, pp. 77-79), and R. Endo & C. E. Resser *C. grabaui*, *C. fouchouensis* and *C. tahoensis*, all new, besides *C. cylindrica*? in the Sinian limestone of south Manchuria (ENDO & RESSER, 1937, pp. 104-107, PLS. 15-18). Of these various forms, *C. tahoensis* assumes the growth-form typical of *Collenia*, both *C. cylindrica* and *C. grabaui* that of *Cryptozoon*, and C. *fouchouensis* that of *Gymnosolen*; *C. angulata* is nearly a miniature figure of angular folds of strata and its organic nature is most doubtful, since the writer has seen a splendid example of it on a grand scale in an exposure of a thin-bedded limestone in the Nankou Range, which is to be explained only as a structural feature of strata. Later, V. P. Maslov transferred *C. cylindrica* to his new genus *Conophyton* (MASLOV, 1938, p. 329, PL. 1, FIGS. 1, 5, 6).

Except these *Collenia*-like objects of doubtful algal origin, very little is known about the fossil calcareous algae in China, where marine limestone formations of different ages of the Palaeozoic era are extensively developed. Among a few material from China examined from time to time by the writer, there are two interesting forms, namely *Margaritina schwageri* (Zittel) and *Triploporella* (*Sinoporella*) *leei* Yabe.

The former species first described from the Productus limestone of the Salt Range, India, is found in a limestone float collected at Sintan Gorge of the Yangtzekiang. Its true nature and systematic position are uncertain; K. v. Zittel considered it to be a foraminifera, Schwager as a Pharetrones and J. J. Galloway as a calcareous alga; the last view the writer tends to accept (YABE, 1949 b). The latter is the earliest member of the Dasycladaceous genus *Triploporella*, for which a new subgenus is proposed on certain features diverging from the typical Jurassic and Cretaceous forms (YABE, 1949 a).

A rich harvest of fossil calcareous algae is expected in future from the Palaeozoic limestones of China.

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