On some Cretaceous Fossils from Shikoku.

By

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With Plate XL.

The Cretaceous Formation in Shikoku occurs in several places. These occurrences, however, are restricted to two zones, lying one on each side of, and parallel to, the central zone of crystalline schists, which traverses the island from ENE to WSW along its longitudinal axis. The Cretaceous strata in the northern zone directly overlie these schists, and form a long narrow belt along the whole northern coast of the island, interrupted only here and there by alluvial flats. Beyond Shikoku, they continue on the east over the southern portion of the island of Awaji to the Katsuragi Mountains in Kii, while on the west, vanishing partly under the sea and partly under the volcanic rocks of Kyūshū, they seem to reappear on the islands of Amakusa. In the southern zone, they are not so continuous. They rather fill up trough-like depressions in the Palæozoic rocks, together with some other members of the Mesozoic Group. These depressions are known as the *Katsuragawa Basin*, the *Monobegawa Basin*, the *Ryōseki Basin*, and the *Sakawa Basin*. But here also the zonal distribution of the Cretaceous rocks is quite evident, as these basins all lie in one straight line parallel to the longitudinal axis of the island.

The northern zone is essentially composed of alternating layers of sandstone and shale, for which complex Dr. Harada[1] proposed the

1) T. Harada. *Die Japanischen Inseln.—Eine topographisch-geologische Uebersicht. I Lief. Published by the Imperial Geological Survey of Japan, 1890.*

name of *Izumi-Sandstone*, from the predominance of a certain greenish-grey hard sandstone, locally known under the name of *Izumi-stone*.

Fossils from this sandstone are very few. Besides a large so-called *Fucoid* which occurs at several places in Sanuki, we know only a *Helicoceras* described below, and some fragments of a large *Hamites-like* Ammonite found by Mr. Suzuki at Ōkuzure in Awaji. Harada,[1] however, mentions also some Foraminifera, bivalves, and conifers as occurring in this sandstone.

The Mesozoic *Basin of the Katsuragawa* occupies the upper part of the river of the same name in Awa. It was geologically investigated in 1883 by Mr. Y. Kikuchi, to whom we owe the first discovery of the Cretaceous formation in Shikoku. Here it consists of sandstones and conglomerates, superposing the Jurassic plant-bearing series. The sandstone is hard, fine-grained, and when fresh greenish-grey in colour, and has nearly the same appearance as the Izumi-stone, while on weathering it assumes a yellowish tint. It contains shells in great profusion, which however belong to a very few species, and are mostly found as casts. They are—

Trigonia pocilliformis,
Trigonia Kikuchiana,
Trigonia rotundata.

Mr. Kikuchi also found a fragment of an evolute as well as of a spirally rolled Ammonite.

The *Monobegawa Basin* is in Tosa. Its geological nature is not well known. We possess only a block of sandstone like that of the Katsuragawa, quite filled with casts of *Trigonia pocilliformis*.

The *Ryōseki Basin* is not far from the above, and occupies the southern portion of Nagaoka-gori, Tosa. Here the Cretaceous forma-

1) Loc. cit., p. 107.

tion seems to consist solely of sandstone which is as usual grey to greyish-green, fine-grained and hard. It contains *Trigonia pocilliformis* and *Tr. Kikuchiana* in tolerable abundance. Besides, it yields remains of many other Lamellibranchs, some Gasteropods and Echinoids, whose preservation, however, is very imperfect. The rock at Okuminodani directly overlies the Upper Jurassic Cidaris-Limestone.

Lastly, the *Sakawa Basin* is situated in Takaoka-gori of the same province, about 40 Km to the west of Ryōseki. What is known of it we owe to the investigations of Messrs Naumann[1] and Nasa,[2] the latter of whom planned the geological map[3] of the district.

The Cretaceous Formation of Sakawa is wholly composed of sandstone, which is quite similar to that of Ryōseki. On the south of the town of Sakawa, it lies partly on the Cidaris-Limestone, and partly on a series of shales and sandstone, which at Yoshida-Yashiki yields some plants.[4] Near Ochi, however, it seems to overlie directly the Triassic sandstone of the district.

Besides Alectryonia, Lucina, Nucula, Solen, Rhynchonella and a Scaphites-like Ammonite, *Trigonia pocilliformis Tr. Kikuchiana*, and *Tr. rotundata* were also obtained from the above sandstone.

From what has been said above, it will be seen that the number of fossil species in the Shikoku Cretaceous is rather small; and these, moreover, are so imperfectly preserved that the majority of them are indeterminable. On this account, I can describe only four species in this paper. These four, however, are very important, as some of them not only show the undoubted Cretaceous age of the strata containing them, but at the same time, they give us the probability that

1) Naumann u. Neumayr. *Zur Geologie u. Paläontologie von Japon. Denks. d. math.-natürw. Classe d. K. Akad. d. Wissens., Wien, Bd. LVII, 1890.*

2) T. Nasa. *Report. of Geol. Surv. of Sakawamura, Tosa. 1885* (MS).

3) Given in Harada's *Japanischen Inseln*, l. c.

4) Nathorst considers these plants as Upper Jurassic. Vide *Beitr. z. Mesoz. Flora Japans. Denks. d. Math.-Nat. Cl. d. K. Akad. d. Wissens. Wien, Bd. LVII, 1890.*

at least the *Trigonia-Sandstone* is to be considered as contemporaneous with the Gaulto–Cenomanian Formation of Hokkaido (Ezo). Already in my paper entitled "Versteinerungen aus der japanischen Kreide,"[1] I have mentioned the occurrence of a scabrous Trigonia, allied to *Tr. aliformis Park.*, in the Cretaceous of Kagahara which I considered as probably belonging to the same epoch as that of Hokkaido. It is this same Trigonia, *Tr. pocilliformis* as I call it, which is so profusely found in the southern zone of Shikoku, playing so to say the rôle of the leading fossil of the Shikoku Cretaceous. The above view is moreover justified by the fact that Mr. Jimbo has recently discovered the same form of Trigonia occurring together with Ammonites in the Cretaceous of Hokkaido. Whether the *Izumi-Sandstone* is also to be referred to the same age is at present unsettled, as it has not yet given any characteristic fossils.

The two species of glabrous Trigoniæ also described below are palæontologically very interesting. They are forms which, like some Liassic species, exhibit a great external resemblance to the Triassic genus *Myophoria*. *Trigonia Kikuchiana*, whose only ally among the Trigoniæ is *Tr. Lingonensis Dum.* of the Lias of England and France, reminds one strongly of some forms of Myophoria glabræ, e.g. *M. lævigata* Alb. The other species, *Tr. rotundata*, has no kindred form among the Trigoniæ hitherto described; on the other hand, it has several corresponding ones among the glabrous Myophoriæ, such as *M. plebeja Gieb.*, *M. orbicularis Goldf.*, *M. rotunda Alb.* In fact, this recurrence of Myophoria-like Trigoniæ in the Japanese Cretaceous seems to confirm the view generally entertained by palæontologists, that there is a close relationship between these two genera.

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1). Palæontographica, Bd. XXXVI, 1890.

Description of the Species.

Trigonia pocilliformis *n. sp.*

Pl. XL, Fig. 1a, 1b, 2, 3.

Trigonia sp. Yokoyama, Versteinerungen aus der Japanischen Kreide, p. 199.

Shell subcrescentic, very inequilateral, inflated anteriorly, attenuated, narrowed, and flattened posteriorly. Beaks antero-mesial, touching, pointed, much incurved and also recurved. The anterior side of the valve is somewhat produced, and its margin is strongly convex, gradually passing into the convex ventral margin which is raised up posteriorly without any marked excavation. The dorsal margin commences at the small ligamental aperture behind the beak, and descends posteriorly with a slight concavity to meet the truncated siphonal margin nearly at a right angle. The escutcheon is lengthened, ovato-lanceolate when the valves are closed, broadest at about $^1/_3$ the distance from the beak, and concave for about $^2/_3$ the length from the same point, beyond which it flattens. It is transversely or somewhat obliquely costellated; the costellæ are simple and smooth, being coarser, more elevated and distant in the posterior than in the anterior portion of the escutcheon. They are also slightly curved out towards the posterior side, and somewhat oblique, with the marginal ends directed anteriorly. The number of these costellæ is probably 15–18, but those situated near the beak are so faint that they are hardly visible. The area begins near the beak as a slight ridge which gradually widens posteriorly and becomes broadest at the siphonal end, where it attains about $^1/_3$ the total height of the shell, and forms at the same time its posterior border. It is for the greater part of its length rendered bipartite by a groove which runs a little above its median

line and parallel to it; each of the two somewhat unequal halves thus formed is moderately convex, and marked by fine transverse plications, some of which can become very coarse. The remaining portion of the valve is ornamented with coarse, elevated, slightly flexuous, crenated ribs whose number exactly corresponds to that of the costellæ of the escutcheon, being, so to speak, the continuations of the same, although interrupted in their course by the intervention of the area between. They arise at the border of the area as narrow crenulated ridges, and diverge in every direction, getting higher and broader as they approach the pallial border, into which they pass over without any marked curvature. The interspaces are smooth. The pallial border is rendered dentate by these ribs.

The internal characters of the shell are not well known.

The younger specimens of this shell are a little shorter, and the ribs more straight and less in number (Fig. 2).

I have already compared this species, in the work above cited, with *Trigonia aliformis Park.* It is nearer to the variety called *attenuata* by Lycett (A Monograph of the British Fossil Trigonia,[1] No. 3, p. 117, pl. XXV, Fig. 6) than to its typical form. Still there are marked differences between the two. The most striking lies in the ribs which, in the English form, are not only more numerous, but also describe concentric curves in the anterior portion of the shell, whereas in the Japanese, although somewhat flexuous in themselves, they all pass over straight to the pallial border without making any distinct curvature. Besides, in the former, the marginal ends of the costellæ of the escutcheon are directed posteriorly instead of anteriorly.

A species called *Trigonia Forbesii Lycett* (l. c. p. 122) from Verdachellum in India seems to show similarity in the course

1) *Palæontographical Society, Vol. XXIX, issued for 1875.*

of the ribs to the Japanese. But it differs in having a shorter shell and a broad costellated area.

Trigonia pocilliformis occurs sometimes in great abundance, filling the whole rock. It is, however, mostly preserved as casts, and even when the shell itself is fouud, this is so firmly attached to the stone that it is impossible to isolate it without breaking it to pieces. Furthermore, these casts are often so deformed that it is difficult to get specimens on which we could found a good diagnosis. The above figures [1] were taken from gypsum pressings of an external cast of a young as well as of a full grown specimen, which was considered as nearly perfect in shape.

This species is one of the characteristic fossils of the Japanese Cretaceous, being met with almost whereever the Cretaceous fossils are found. In Shikoku it is to be found at the following places:

Tanno in the Katsuragawa Basin; Sōyama and Okuminodani in the Ryōseki Basin; Hagino in the Monobegawa Basin (Kamigori, Tosa); Sendachino and Hirano near Ochi, and Yamanokami (Nagano) near Sakawa, both in the Sakawa Basin; Obama, Yokohata-mura, Agawagori, Tosa.

Outside of Shikoku, it occurs in the Sanchū Basin, and in Hokkaidō.

Trigonia Kikuchiana *n. sp.*

Pl. XL, Fig. 4, 5, 6.

Shell ovately trigonal, oblique, very convex. Beaks antero-mesial, prominent, incurved, and very slightly recurved. Anterior margin convex, gradually passing into a less convex ventral margin

1) The teeth which would be more or less visible in the dorsal as well as in the posterior view of this and of the following species are not shown in our figures, as these figures were all drawn after gypsum pressings of external casts.

which posteriorly meets with the nearly straight, obliquely ascending, siphonal margin almost at a right angle, the corner being rounded. Hinge-margin obliquely sloping on the posterior side, and going over to the siphonal margin without forming any marked angle at the point of junction. Area and escutcheon not distinctly separated, forming one, more or less flat, surface which is slightly depressed along its median line. The other portion of the shell, which makes an angle of about 90° with the areal surface, is marked off from the latter by a rounded edge, running from the beak to the postero-ventral corner and slopes to the anterior and ventral margins with a slight convexity. The entire surface of the shell is smooth, except near the beak where a few coarse shallow concentric sulci are mostly found.

The shell seems to have been moderately thick. The median depression of the posterior surface is more marked in the adult than in the younger specimens. The internal casts show two strong, transversely striated, diverging teeth.

Among the Cretaceous Trigoniæ there is none which can be compared to this species. But in the Lias there is one, *Trigonia Lingonensis Dum.* (Lycett, Monogr. of Brit. Foss. Trigonia, No. 3, p. 98, pl. XXII, Fig. 1-4), which shows a close affinity to it. The latter, however, has a little broader shell and the posterior side distinctly separated into area and escutcheon by a sharp ridge.

Trigonia Kikuchiana, like *Tr. Lingonensis*, is one of those forms of Trigonia which externally exhibit a great resemblance to the older genus *Myophoria*.

It occurs almost always as casts, and also often much distorted. The internal mould drawn on the plate has the back accidentally depressed. Fig. 4 is from the largest specimen we got. This was a broken one, but has been restored in our figure. Its shape somewhat differs from that of Fig. 5, especially in its anterior

margin. But this difference is probably due to the mode of preservation.

Very frequent at Tanno; also occurs at Sōyama near Ryōseki, and Yamanokami (Nagano) near Sakawa.

Trigonia rotundata *n. sp.*

Pl. XL, Fig. 7, 8, 9.

Shell suborbicular, slightly broader than high, somewhat inequilateral, convex. Beaks approximate, a little pushed anteriorly, prominent, pointed, and incurved. Both the anterior and posterior margins convex, gradually passing into a less convex ventral margin. Hinge-margin also arched. The escutcheon is not clearly separated from the area, there being only a trace of a broad and flat ridge between, running from the beak to the upper end of the posterior margin, which makes the area slightly depressed along its median line. The other portion of the shell is moderately convex, and separated from the area by an obtuse edge, and making with the latter an angle of about 120°. The entire surface of the shell is smooth, if we except a few coarse, shallow concentric sulci near the beak, and coarse, concentric rugæ which sometimes appear on the posterior side near the ventral margin.

In appearance of area and escutcheon this species is very similar to the preceding one.

Among the forms of Trigonia hitherto described, there is none which shows any relation to it. Among the Myophoriæ, however, there are several corresponding forms which have been mentioned before.

Like the two foregoing species, *Trigonia rotundata* occurs mostly

as casts, one of which is figured on the plate. It shows two strong, striated, diverging teeth.

Quite as numerous as *Trigonia Kikuchiana* at Tanno; occurs also near Sakawa at Ninomiya, Yamanokami, and Sendachino.

Helicoceras *sp.*

Pl. XL, Fig. 10, 10*a*.

A fragment of the body-whorl of a snail-like Ammonite, elliptical in section, somewhat higher than broad, and with the body-chamber occupying about one half of the entire volution. The external sculpture consists in fine, rounded, transverse ribs, slightly undulatory in their course, and weakest on the umbilical side of the whorl, where some of them even disappear. Their number is about 50 in one circuit. The sutures on the external side of the whorl are indistinct. But as far as they are seen in our specimen, they are deeply and much incised, with saddles and lobes bipartite; the siphuncle seems to lie on the outer side, so that our fragment is that of a Helicoceras which is, at least, closely akin to *Helicoceras indicum Stol.* (Cret. Cephalopoda of Southern India, p. 184, pl. 86, Fig. 1–2). But as the specimen is imperfect, its exact specific determination is not possible.

Helicoceras indicum occurs in the Arrialoor Group of India.

Our specimen was found in a very fine-grained shaly sandstone of Oumi, Ōuchigori, Prov. Sanuki.

PLATE XL.

Plate XL.

Fig. 1*a*, 1*b*. Trigonia pocilliformis. A full grown specimen.

„ 2. „ „ A young specimen.

„ 3. „ „ Cast, somewhat distorted.

„ 4. Trigonia Kikuchiana. A full grown specimen.

„ 5*ab*. „ „ A somewhat smaller specimen. 5*b*, seen from the posterior side, showing the indistinct separation of area and escutcheon.

„ 6. Trigonia Kikuchiana. Cast, accidentally depressed on the back.

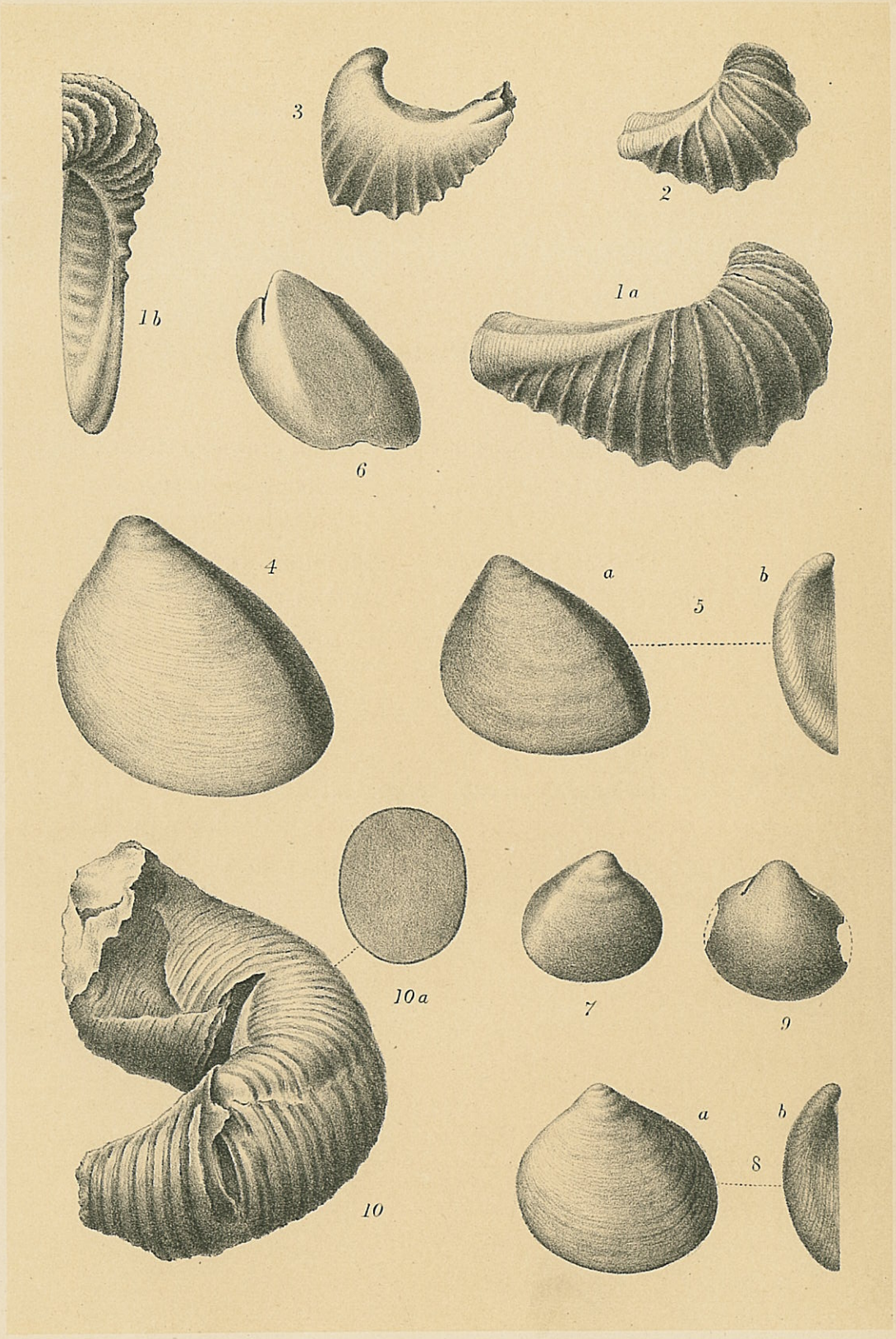
„ 7. Trigonia rotundata. Right valve.

„ 8*ab*. „ „ Left valve of a full grown specimen partly restored. *b*, seen from the posterior side.

„ 9. Trigonia rotundata. Cast.

„ 10. Helicoceras sp.

„ 10*a*. „ „ Transverse section.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