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Discovery of the Anisian Fauna from Shikoku, Southwest Japan and its Geological Meaning

By

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Abstract

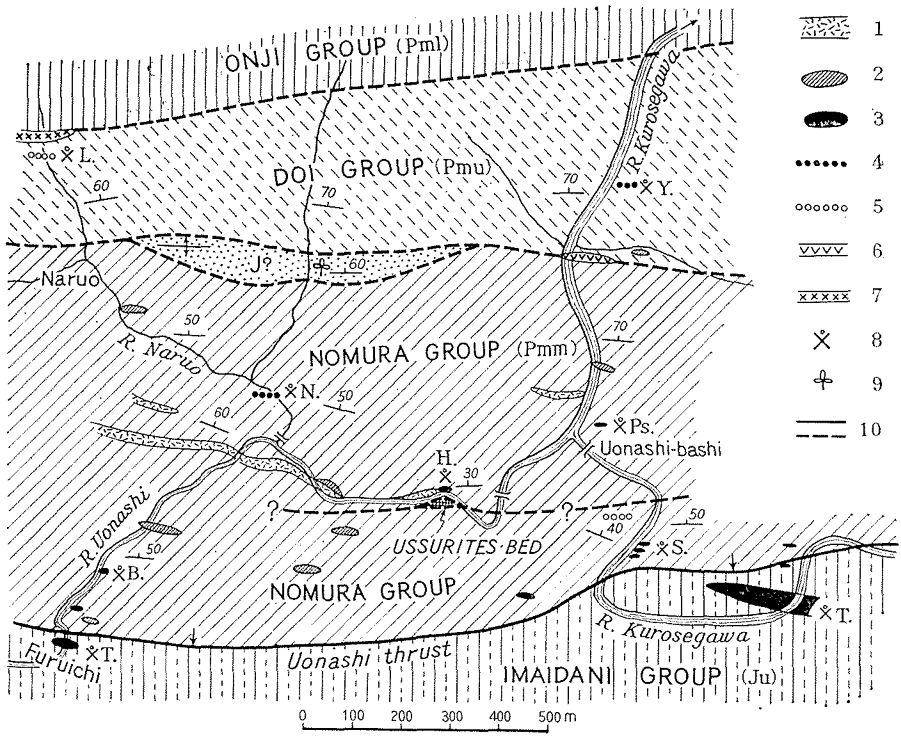
The Anisian fauna consisting of *Ussurites yabei*, *Balatonites* sp., *Hollandites* sp., *Pleuronectites* aff. *laevigatus*, *Entolium* cf. *microtis*, *Anodontophora trigona* n. sp. etc. was first discovered from the outer side of Southwest Japan. The fossil-bearing bed is found as a tectonic *Schuppe* of less than 10 m in thickness in the Permian strata at Uonashi in Ehime Prefecture, Shikoku. Some considerations on the Permo-Triassic orogeny are given based on this new datum in addition to the description of fossils.

In 1961 I took a short trip to investigate the Lower Triassic strata in Kyushu and Shikoku, Southwest Japan. At that time I was fortunate enough to find the Anisian fossils which had not been known at all in the outer side of Southwest Japan. The fossil-locality is at the right side of a small dam across the River Uonashi about 400 m upstream from the junction with River Kurosegawa at Uonashi in Ehime Prefecture, Shikoku. I had no chance of survey until I carried out the geological survey around the fossil-locality for two weeks in the autumn of 1962. This is a short paper dealing with the geological result and its meaning with a brief description of fossils.

Geology around the fossil locality (Text-figure 1)

ICHIKAWA and others (1956) divided the Chichibu Terrain in Shikoku into three geological units, the North, the Middle and the South Zones, which are separated from each other by the Kurosegawa tectonic zone and the Uonashi tectonic line, respectively.

The main part of the surveyed area occupies a part of the Middle Zone to the south of the Kurosegawa tectonic zone, and has been investigated in detail by IKEBE (1936), and NAKAGAWA and others (1959). According to them, the Middle Zone in this area is composed of the Lower Permian Onji group, the Middle Permian Nomura, the Upper



Textfigure 1. Simplified geological map of basement rocks around Uonashi-bashi, exclusive of terrace- and alluvial deposits.
1 basic tuff, 2 chert, 3 limestone, 4 limy conglomerate, 5 granule conglomerate, 6 dike rock, 7 leucocratic sheared granite, 8 animal fossil locality (Ps. *Pseudofusulina*, N. *Neoschwagerina*, Y. *Yabeina*, T. "Torinosu limestone", H. *Huangia*?, S. Stromatoporoid, B. Bryozoa, L. *Lepidolina*?), 9 plant fossil locality, 10 fault (actual and estimated)

Permian Doi and the Jurassic Kagio. In the eastern extension from this area the Upper Triassic Kochigatani and the Upper Carboniferous Itadorigawa group are intercalated lenticularly between the Doi and the Nomura, while in the western extension there are found the Lower Triassic Tao limestone and the Upper Triassic *Proarcestes* limestone as narrow strips along the Uonashi tectonic line, that is, the southern boundary of the Middle Zone. NAKAGAWA and others (op. cit.) reported the occurrence of *Neoschizodus*? sp., *Pernopecten* sp. and stems of crinoid from the coarse-grained, calcareous sandstone of the Nomura group. The author was able to find the undoubted Anisian fossils from the same rock, as will be discussed in the next section. The Nomura group in the northern side of the fossiliferous sandstone is composed mainly of slates and sandstones with intercalated cherts and basic tuffs. Relatively thick basic tuff accompanied by basaltic lava crops out at the lowest horizon attaining at most 50 m in thickness, and contains a brecciated limestone lens of about 7 m thick at the counter riverside of the fossil bed, where the basic tuff is thinning out. The limestone contains *Huangia*? sp., *Chaetetes* and bryozoans, which suggest the Permian age (probably Lower Permian). *Huangia*? sp. is most similar to *H. misakensis* reported by YOKOYAMA (1960, p. 243, pl. 27, figs. 5a-d) from the *Stylidophyllum eguchii* zone in the Taishaku district, which is correlated to the *Pseudoschwagerina* zone.* About 150 m above this limestone a conglomeratic limestone is intercalated within alternation of sandstone and slate at the river-bed of Naruo about 250 m upward from the junction with the River Uonashi. It contains fusulinid fossil *Neoschwagerina craticulifera* and is considered to be Meso-Permian in age. Therefore the age of the main Nomura group in the northern area is Middle Perman as considered by the former investigators, but the lower limit may go down to the Lower Permain. The group to the south of the Anisian strata is very similar in lithofacies to that of the northern part, but basic tuffs are less developed and conglomerates are often found. Fossil remains are rarely found in its limestone lenses. They are stromatoporoids from the river-bed of River Kurosegawa near Uonashi and bryozoans from the river-bed of the River Uonashi near Furuichi. Although exact dating of the rocks cannot be done from these fossils, it is most probably same as that of the northern group, because the lithofacies is very similar to each other and a limestone at Uonashi Primary School lying at about 1km west of this area has *Noeschwagerina craticulifera* and others.

The Anisian sandstone of about 5 m in thickness overlies conformably a dark grey, oolitic limestone of less than 2m in thickness which is barren of fossil. The limestone is underlain conformably by black slate of more than 3m in thickness. The lower limit of the slate cannot be ascertained. The upper limit of the sandstone is bordered by the River Uonashi, and the relation between the Anisian and the coralline Permian limestone at the counter river-side is not known. So the definite Anisian is only 10m or so in thickness, and could not be found in any other locality. There is no evidence which suggests an unconformity, and the Anisian is considered to be shut in the Permian Nomura group by faults as a small lens, although field evidences could not be obtained.

Fossil-contents and the geological meaning (Textfigure 2)

The Anisian fossils so far determined are listed below.

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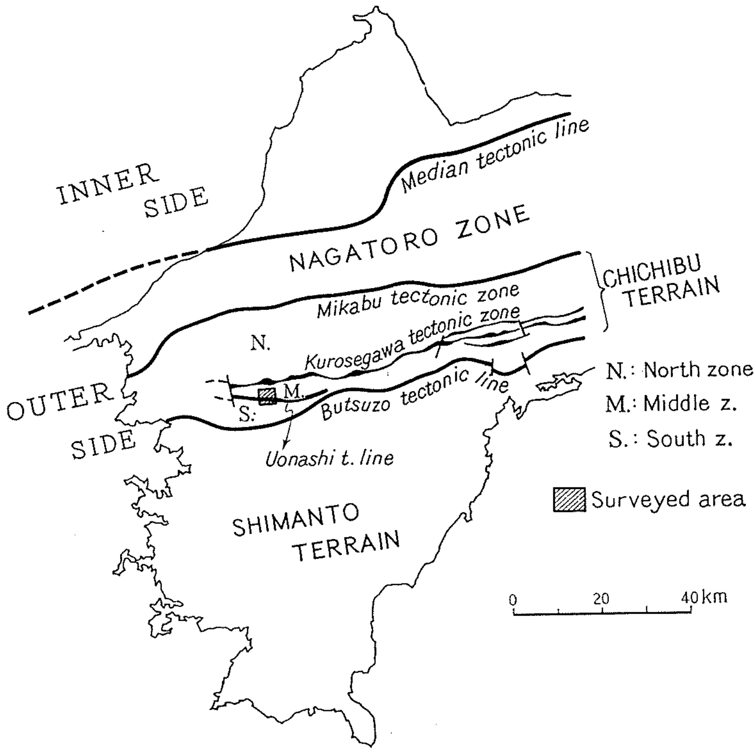
* Personal communication for which I am indebted to Dr. Yamagiwa of Osaka Gakugei University.

Species	number of specimens (including fragmental ones)
Ussurites yabei DIENER	4
Balatonites sp.	2
Hollandites sp.	2
Nautiloid? gen. et sp. indet.	1
Pleuronectites aff. *laevigatus* (SCHLOTH.)	2
Entolium cf. *microtis* (BITTNER)	abundant
Variamussium? n. sp.	3
Pteria sp.	1
Lima? sp.	1
Anodontophora trigona n. sp.	common
A. sp. A	1
A. sp. B	1
Ostreid? gen. et sp. indet.	3
Pinnid? gen. et sp. indet.	2
Coelostylina sp.	2
Rhynchonellid	1
Stem of crinoid	abundant

Schizodus? sp. and *Crenipecten* sp. by NAKAGAWA and others are referred to *Anodontophora trigona* and *Entolium* cf. *microtis* in this paper, respectively. *Ussurites yabei* has been reported from the Lower Anisian in the Kitakami mountainland, Northeast Japan and in the Kolyma basin, Siberia. *Balatonites* sp. is most similar to *B. zitteli* MOJSISOVICS, *B. constrictus* ARTHABER and *B. gracilis* ARTHABER from the Upper Anisian in the Mediterranian province. *Hollandites* sp. reminds one of the Anisian *H. japonicus crassicostatus* SHIMIZU in the Kitakami. *Pleuronectites laevigatus* is confined to the German Muschelkalk, and *Entolium microtis* is limited to the Early Triassic in age. These fossils listed above evidently indicate the Anisian age, and probably the lower horizon, although materials are insufficient.

The Anisian strata so far known in Japan are limited only in the southern Kitakami massif and the Maizuru zone, where they succeed the Lower Triassic formation without interruption, and are covered unconformably by the Norian in the Kitakami and are in contact with the Karnian by fault in the Maizuru. The Lower Triassic in these regions is underlain clino-unconformably by the Upper Permain Toyama and Maizuru groups. These unconformities show the so-called Akiyoshi orogeny (KOBAYASHI, 1941) or Honshu orogeny (YAMASHITA, 1957) which reached the proximus during the Latest Permian to the Meso-Triassic. The same phenomenon has also been confirmed in the outer zone of Southwest Japan by the discovery of the "Sakashu unconformity" be-



Textfigure 2. Geological divisions of western half of Shikoku Island.

tween the Upper Triassic and the Lower Permian formations (ICHIKAWA and others, 1953). But the details of the crustal movement cannot be analyzed because of the poor development of the Lower Triassic strata and the absence of the Anisian. In this respect the discovery of the Anisian is important for considering the Akiyoshi or Honshu orogeny in the outer side of Japan.

In contrast with the thick development of the terrigenous sediments of the Lower Triassic in the inner side, the development of those of the outer side or Chichibu Terrain is represented mainly by thin limestones, most of which are limited to the middle Eo-Triassic (Flemingitan-Owenitan) in age (BANDO, 1961) and shut into the surrounding rocks by fault. Recently SAITO and others (1958) and KAMBE (1958) reported the conformable relation between the middle Eo-Triassic Kamura limestone and the late Meso-Permian limestone containing *Yabeina* cf. *katoi*, *Neoschwagerina margaritae* and *N. megasphaerica* in the Middle Zone of the Chichibu Terrain in Southern Kyushu. Although it cannot be concluded whether the apparent conformbale phenomenon indicates a true conformity or not untill the Latest Permian and the Earliest Triassic indexes are found between the two fossil-horizons, the crustal movement between the two ages must not be so remarkable as in the inner side of West Japan. Furthermore, very recently FURUKAWA and KANMERA (1962) reported the distribution of the thick sediments called the Konose group ranging from the Upper Permian *Yabeina globosa* zone to the Upper Triassic coral limestone without interruption in the southernmost part of the South Zone of the Chichibu Terrain in southern Kyushu.

The black slate of the *Ussurites* bed can hardly be distinguished from that of the Paleozoic formation, the sandstone is very similar to that of the Permian Nomura group by naked eyes as well as under the microscope excepting calcareous matrices, and quartz grains of the sandstone show wavy extinction in crossed nicols as in those of the surrounding Nomura group. As a whole the Anisian bed is rather similar to the Permian in lithofacies than to the Upper Triassic rocks, but the thickness is far smaller. When we consider the "Sakashu unconformity", the Honshu or Akiyoshi orogeny may have been most remarkable between the Anisian and the Karnian or Late Ladinian, although it was advanced step by step.

Judging from the above-mentioned data this orogenic movement was strongest in the Inner Side and also in the northern half of the Outer Side, that is, the Nagatoro Zone and the North Zone of the Chichibu Terrain, but weaker in the Middle and South Zones, and there is no interruption from the Permian to the Upper Triassic strata in the southernmost part of that Terrain.

Description of Species

Ussurites yabei DIENER

Plate 1, Figures 1-3; Textfigure 3.

1915. *Monophyllites (Ussurites) yabei* DIENER. p. 22, pl. 5, figs. 1-2.
1930. *Monophyllites (Ussurites) yabei*, SHIMIZU. p. 74.
1961. *Ussurites yabei*, POPOV. p. 110, pl. 16, fig. 5.

There is no complete specimen at hand, but the identification of this species with *Ussurites yabei* DIENER is beyond question by the characteristic ornaments composed of radial striae and broad radial ribs, the exactly identical suture lines with the type specimen and other specific characters. The radial ribs become broader and indistinct in the full-grown stage. The Siberian materials seem to have stronger radials than those of Japan.

Textfigure 3. Suture-line of *Ussurites yabei.*

Balatonites sp. indet.

Plate 1, Figures 6 a, b.

One incomplete specimen and a fragmental one have been obtained. Shell is rather evolute, compressed with rectangular cross section, both flanks of which are subparallel and slightly converging ventrally. Surface is covered by relatively weak, tuberculated, prosiradiate ribs with one or two intercalated secondaries. The stronger ribs are provided with three tubercles—umbulical, lateral and marginal—of nearly equal strength; the umbilical one is elongated in spiral direction and the lateral one is lying a little below the midheight of lateral side. Secondary ribs do not reach umbilical margin and have only marginal tubercles besides rare, rudimentary lateral ones. Venter is roof-shaped in the inner whorl, but subrounded in the outer, where the radials are swollen to nodes rather than tubercles.

Height of the last whorl	20 mm
Breadth of the last whorl	8.5 mm

This species is very similar to *Balatonites zitteli* MOJSISJOVICS (1882, p. 80, pl. 5, fig. 2; pl. 19, fig. 3) from Zone of *Paraceratites trinodosus* of the Alps, *B. gracilis* ARTHABER (1896, p. 68, pl. 6, fig. 9) and *B. constrictus* ARTHABER (ibid., p. 65, pl. 6, fig. 7, including *lineatus* ARTHABER, ibid., p. 69, p. 6, fig. 10) from Reifling limestone in the Alps. But the first species is more developed in tuberculation, that is, in addition to three tubercles on the primary ribs a weak tubercle is often seen between lateral and marginal ones. Moreover, the secondaries have sometimes lateral tubercles. The present species differs from *constrictus* in more evolute coiling, and from *gracilis* in the inner position of lateral tubercles. It is further distinguished from these three allied species in the more obscure ventral carination.

Hollandites sp. indet.

Plate 1, Figures 4, 5.

Two fragmental specimens are at hand, a larger external mould and a smaller internal one. The larger one is provided with strong, nearly straight radial ribs, which are rather loosely arranged. The smaller one has four, rounded radial ribs which are more closely set than the larger one. Both are considered to represent adult and younger growth stages, respectively. In such a state of preservation the determination is very difficult even generically, but the ornaments strongly remind one those of *Hollandites japonicus* and, especially, its subspecies *crassicostatus* reported by SHIMIZU (1930, p. 65, pl. 24, figs. 1, 2) from the *Hollandites* beds (=Isatomae formation of Inai group) in Miyagi Prefecture, Northeast Japan, and the present species is provisionally referred to that genus.

Pleuronectites sp. aff. *laevigatus* (SCHLOTHEIM)

Plate 2, Figures 6, 7.

Two incomplete, right valves are at hand. One is 33 mm high and 32 mm long, and the other is about 27 mm long. Shell is a little convex, subcircular in outline and nearly equilateral except in the auricular portion. Posterior ear is very small and not sharply defined from the flank; anterior ear is only partly preserved, but shows a distinct byssal sinus (pl. 2, fig. 7b). Surface is covered only by slightly lamellose, concentic sculptures in addition to weak growth-lines. There can be seen feeble, thread-like radial structure on the outer surface of inner shell layer.

The species is closely allied to *Pleuronectites laevigatus* from the German Muschelkalk. The present species differs from *laevigatus* reported by BRONN (1856, p. 55, pl. 11, fig. 11), SALOMON (1900, p. 348, pl. 14, figs. 1,2), WALTHER (1906, p. 26, pl. 5, fig. 22), and ASSMANN (1915, p. 600, pl. 31, figs. 24, 25) in the smaller size, more equilateral and higher outline. PHILIPPI's specimen (1900, p. 78, textfig. 1) from the upper Muschelkalk in Weimar is almost identical with this species except in the larger size.

Entolium sp. cf. *microtis* (BITTNER)

Plate 1, Figures 7, 8.

1959. *Pernopecten* sp., NAKAGAWA and others, p. 41.

Shell is small, slightly convex, suborbicular in shape, equilateral, a little higher than long, and has an apical angle of about 105 degrees. Both ears are very small, obtusely triangular in shape, and hinge-margin is very short, being less than one-third of the shell-length. In the short hinge-length the species is undoubtedly closely allied to *Entolium microtis* described by BITTNER (1899, p. 2, pl. 1, figs. 12-15) and KIPARISOVA (1938, p. 250) from Ussuriland. Several specimens show an inner fibrous structure radiating from the beak, and sometimes feeble, obscure radial ornaments are impressed on the inner mould as in the case of *microtis* from Ussuri.

The species is probably identical with the latter one, but in such a simple shell a strict determination requires a comparison with actual materials from Ussuri.

Measurement (in mm)

Length	Height	Hinge-length
18.5	20.5	6.5
17	20.5	5.0
15	15	
18	17	
18.5	20	
10	?	3.0

Pteria sp. indet.

Plate 2, Figures 8a, b.

Only an incomplete, left valve is available. Shell is small, pteriform; posterior ear is relatively small with a hinge-margin shorter than the length of the shell, and the angle between the hinge-margin and the dorsal margin of the main body is very actue amounting to about 15 degrees; anterior ear is not preserved but presumably very small, and the beak is probably subterminal.

In general outline the species is similar to *Pteria sturi* (BITTNER) (1895, p. 69, pl. 8, figs. 1-4) from the Karnian of the Alps but differs in the shorter hinge-length. *Pteria boeckhi* (BITTNER) (1901, p. 25, pl. 4, figs. 14-17) and *P. pannonica* (BITTNER) (ibid., p. 25, pl. 4, fig. 13) from the Karnian of Bakony are other allied species, but the former is larger in size and has probably larger anterior ear, and the latter is less oblique in outline and has a larger posterior ear.

Variamussuim? new species indet.

Plate 1, Figures 9, 10.

Three incomplete right? valves have been procured. Shell is small, a little convex, suborbicular in shape, slightly longer than high. Ears are only partly preserved. Although the outer surface cannot be observed, it is considered to be smooth. Near the peripheral part of the interior there are weak radial ribs consisting of 17-18 primary ribs and 5-7 shorter ones intercalated between them. It is not certain whether these ribs exhibit really inner ribs like those of ammussiids or not, because the outer surface cannot be examined, and the ribs reach the peripheral margin without thickening. Therefore the identification to the genus *Variamussium* is provisional.

Length	Height	Number of "inner" ribs primary	secondary
15.5	14.3	17	5
12.5	13.0	18	7

Anodontophora trigona, new species

Plate 2, Figures 1-3.

1959. *Schizodus*? sp. NAKAGAWA and others, p. 41.

Description: Shell relatively small, trigonal in outline, longer than high, fairly convex; test thin. Lunule deeply excavated; escutcheon demarcated by a ridge from the posterior area; posterior area trigonal, provided with a very weak median ridge, on both sides of which obsolete striae are rarely seen; posterior carina being distinct and convex. Umbo prominent; beak prosogyrous, lying at the anterior one-fourth or one-fifth of shell-length. Surface covered by weak, close-set growth lines. Neither pallial line nor muscular impression observable; dentition could not be confirmed and, if present, very weak or obsolete judging from that of the allied species B described below.

Remarks and comparison: In the trigonal, *Myophoria*-like outline the species looks very like *Schizodus* or *Neoschizodus*, and has once been referred to *Schizodus* with question, but it does not belong to these genera because of the obsolete dentition and the absence of muscular impression, and is most probably referred to *Anodontophora.* In general outline *A. myophorioides* MANSUY (1919, p. 13, pl. 2, fig. 13; pl. 3, figs. 2a-d) from the Karnian of Tonkin and *A. breviformis* SPATH (1935, p. 75, pl. 22, fig. 4) from the Skythian of Greenland are somewhat similar to the present species. According to PATTE (1926) the former is nothing but a secondarily deformed *trapezoidalis* MANSUY (ibid., p. 13, pl. 2, figs. 11a-d: pl. 3, figs. 1a-c: Patte, 1926, p. 66, pl. 10, figs. 38-43; pl. 2, figs. 1-4) which has a trapezoidal outline rather than trigonal. *A. breviformis* differs in the longer shape and the less anterior position of the beak. *A. convexa* MANSUY (1920, p. 39, pl. 5, fig. 8) from the Upper Triassic of Laos is another allied species in the convex shell, but more quadrangular in outline.

Measurements:

Length	Height	L/H	Postition of beak from anterior end
24	17	1.3	1/4
ca 21	17	1.3	1/4
ca 17	12	1.4	1/5
31	24	1.3	1/3.3

Anodontopora sp. indet. A

Plate 2, Figure 5.

Only a left valve is at hand. It is 14 mm long and 13.5 mm high, and looks like that of the preceding species in the *Myophoria*-like shape, but is distinguished by the much higher shell and the more posterior position of the beak which lies at about two-fifths of the length from the anterior end.

Anodontopora sp. indet. B.

Plate 2, Figure 4.

The species is represented by a relatively large left valve, which is 44 mm long and 30 mm high. It differs from *trigona* in the position of the beak and in the less convex posterior carina. In these points this is more similar to *Schizodus*, but can be readily distinguished from it in the obsolete dentition.

Coelostyilna sp. indet.

Plate 2, Figure 11.

Shell is small, high and slender, turreted rather than fusiform, consisting of six rounded whorls. The surface of the body whorl is nearly smooth by naked eye except for two spiral threads on the shoulder and obsolete spiral band on the middle of the lateral surface, but by magnifying glass there can be seen very faint spiral striae covering the posterior half of the whorl. Growth-lines are only weakly sinuated. Protoconch and apertural portion are not preserved.

Although the sample is incomplete, it may be said that it belongs to *Coelostylina* in the external shape. The species is very similar to some species of *Coelostylina*, such as *similis* (MUNSTER) from the Karnian of the Alps (BROILI, 1907, p. 119, pl. 10, figs. 61-66; pl. 11, figs. 1-6, especially to forma *typica*, pl. 10, figs. 62, 66) and from Timor (JAWORSKI, 1915, p. 125, pl. 45, figs. 6-8), *conica* (MÜNSTER) from the Alps, and the Anisian *abbreviata* KOKEN (1897, p. 89, pl. 17, figs. 2a, b). It differs from *similis* of the Alps in the angulated shoulder, and from that of both the Alps and Timor in the presence of spiral ornament. From *conica* and *abbreviata* it is distinguished by the higher shape and more numerous whorls.

Measurement:

Length	Width
25	11

Rhynchonella? sp. indet.

Plate 2, Figure 10.

Only an incomplete dorsal valve is at hand.

Shell is small in size, subtetragonal in shape, wider than long, and strongly inflated, provided with a broad, flat-topped median fold. Neither plication nor concentric ornament are present.

As the specimen is incomplete and the internal structure cannot be observed, the definite generic position cannot be discussed. The species is most similar to *Rhynchonella projectiformis* described by BITTNER (1890, p. 41, pl. 31, figs. 16, 17) from the Anisian in the Alps and *Coenothyris cuccensis* BITTNER (1902, p. 528, pl. 18, fig. 33) from the Anisian in the South Alps, in the external shape, but the extremity of the lateral lobe is situated at a higher position than in the two species, and shell is more convex than in *cuccensis*.

Measurement:

Length	Half of width
14	9.5

Ostreid? gen. et sp. indet.

Plate 2, Figure 13.

Shell is small, ovate in outline, a little convex, 11 mm wide and about 15 mm high. Umbonal half is smooth and the outer half sculptured by weak radial ribs more than 14 in number. Hinge and musculature are not known. The specimen is too incomplete for identification even generically. It has some alliance to plicated ostreid or anomiid.

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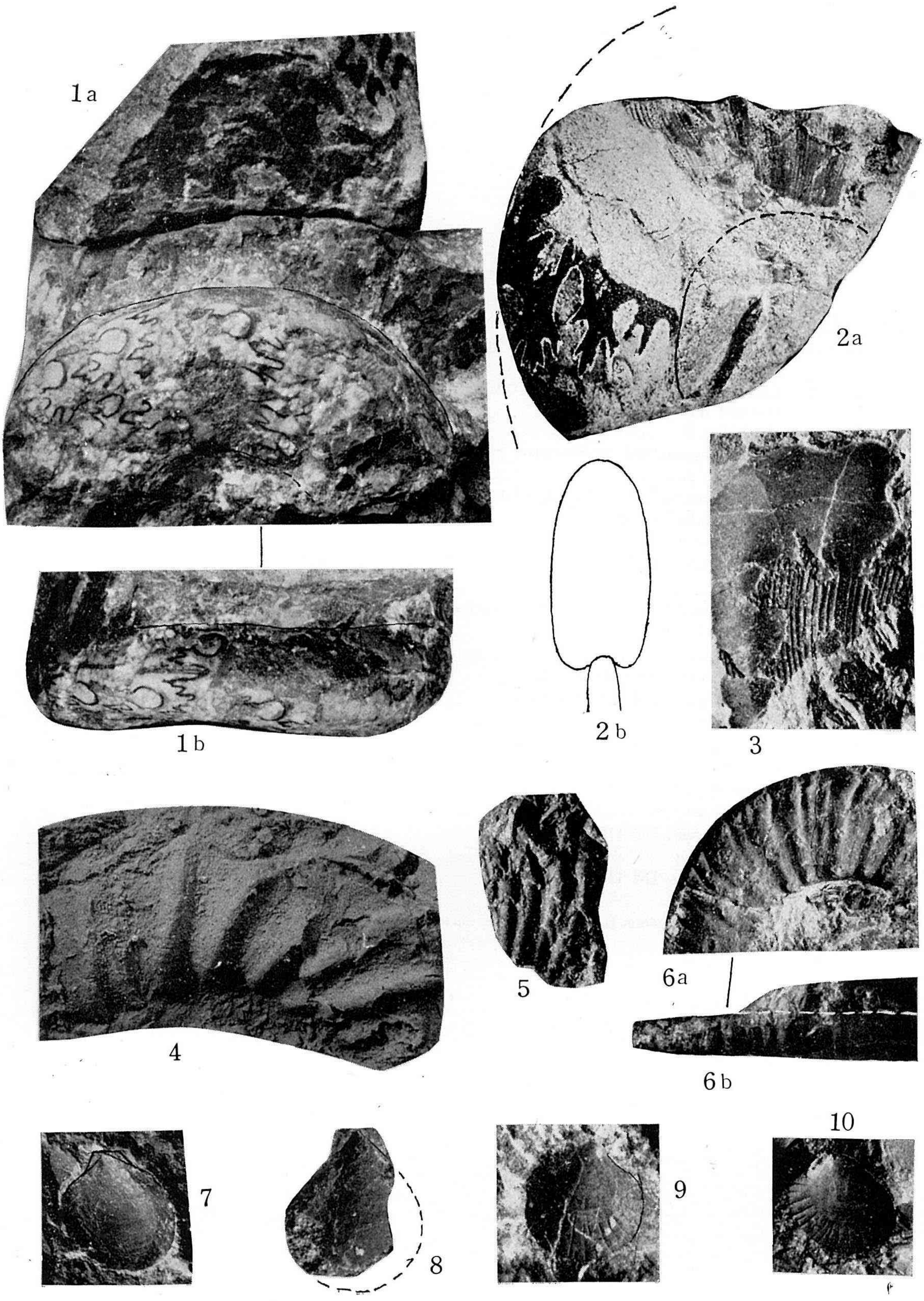
Explanation of Plate 1


1a
2a
1b
2b
3
4
5
6a
6b
10
7
8
9

Explanation of Plate 2

Anodontophora trigona n. sp. .... p.

Fig. 1. Internal mould and partly external cast (ventral and anterior portions), holotype, JM 11069.

Fig. 2. External cast, posterior view, JM 11069 B.

Fig. 3. Internal mould, JM 11070.

Anodontophora sp. indet. B .... p.

Fig. 4. Internal mould and anteroventral external cast, JM 11073.

Anodontophora sp. indet. A .... p.

Fig. 5. Internal mould, JM 11065 B, ×1.5.

Pleuronectites sp. aff. *laevigatus* (Schloth.) .... p.

Fig. 6. External cast of right valve, JM 11064.

Fig. 7. External (a) and internal mould (b) of right valve, JM 11065 A.

Pteria sp. indet. .... p.

Fig. 8. External cast (a), ×1.5, and reconstructed outline from the growth line (b), JM 11066 A.

Lima? sp. indet. .... p.

Fig. 9. External cast, JM 11074A, ×2.

Fig. 12. External mould, JM 11068, ×1.3.

Rhynchonella? sp. indet. .... p.

Fig. 10. External cast of dorsal valve, JM 11070 B.

Coelostylina sp. indet. .... p.

Fig. 11. External cast of body whorl and internal mould of spire, JM 11077, ×1.5.

Ostreid? gen. et sp. indet. .... p.

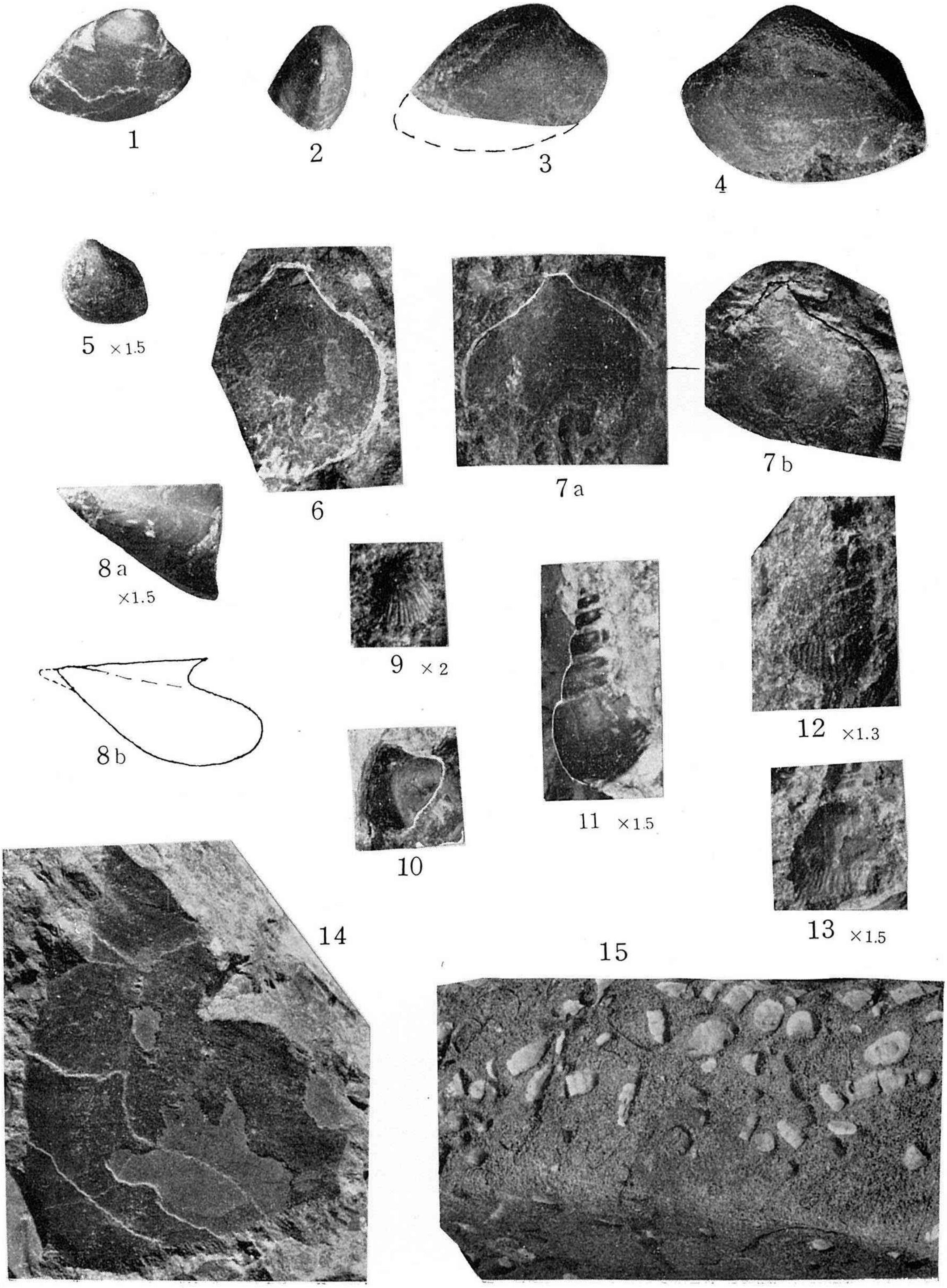
Fig. 13. External cast, JM 11066 B, ×1.5.

Nautiloid? gen. et sp. indet.

Fig. 14. External cast, JM 11057 A.

Stems of crinoid

Fig. 15. Showing numerous fragmental stems accumnlated on the bedding plane.


1
2
3
4
5 ×1.5
6
7 a
7 b
8 a ×1.5
8 b
9 ×2
10
11 ×1.5
12 ×1.3
13 ×1.5
14
15