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CITATION:

Nakazawa, Keiji. On the Monotis typica Zone in Japan. Memoirs of the College of Science, University of Kyoto. Series B 1964, 30(4): 21-39

ISSUE DATE:

1964-03-16

URL:

http://hdl.handle.net/2433/258270

MEMOIRS OF THE COLLEGE OF SCIENCE, UNIVERSITY OF KYOTO, SERIES B,
Vol. XXX, No. 4 Geology and Mineralogy, Article 3, 1964

# On the *Monotis typica* Zone in Japan

By

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(Received December 2, 1963)

**Abstract**

*Monotis typica* zone, that is, the lowest zone of *Monotis* in Japan is correlated to the uppermost part of the "Upper Karnian" in Siberia judging from the faunal assemblage. From the stratigraphic position and the fossil contents *typica* zone is considered to be earliest Norian in age, and the late Neo-Triassic Saragian age characterized by predominance of *Monotis* ranges most probably from latest Karnian to late Norian. Four faunizones of *Monotis*, such as, *typica*, *densistriata*, *ochotica* and *zabaikalica* are distinguished in the *Monotis* beds in Japan. Besides these, molluscan fossils from *typica* and *densistriata* zones of the Saragai group near Saragai-zaka in the Kitakami massif are described.

## Age of *Monotis typica* zone

The Neo-Triassic epoch in Japan is divided into two ages, the Sakawan and the Saragian (ICHIKAWA, 1956). The latter age is characterized by various kinds of *Monotis* (*Entomonotis*), and is generally considered to be Norian of the international division. It is further subdivided into two subages represented by the following animal fossils respectively.

Early Saragian subage: *M. scutiformis*, *M. typica*, *M. typica kolymica*, *Tosapecten suzukii*, *Dictyoconites nipponicus*, *Placites* aff. *oxyphyllus*, *Arcestes* aff. *oligosarcus*.

Late Saragian subage: *M. ochotica*, *M. ochotica densistriata*, *M. o. eurachis*, *M. pachypleura*, *M. ambigua*, *M. zabaikalica*, *M. z. semiradiata*, *Tosapecten* cf. *nabaensis*, *Oxytoma* aff. *subzitteli*, *Arcestes* sp., *Germanonautilus kyotanii*.

ICHIKAWA (1951) discriminated seven faunizones ($S_1$-$S_7$) in the type Saragai group distributed in the southern Kitakami massif, Northeast Japan. Recently ONUKI and BANDO (1958) settled four faunizones ($C_1$-$C_4$) in the same group and correlated the lowest zone $C_1$ to the zones $S_1$-$S_3$ by ICHIKAWA as shown in the annex table (Table 1). They considered zone $C_2$ represented by *M. typica* and its allies to be Karnian in age. The discrepancy concerning the age of *M. typica* zone is partly due to the different opinions about the horizon of *Arcestes* aff. *oligosarcus* and *Placites* aff. *oxyphyllus* reported

Table 1. Correlation of zones in the Saragai group by various authors

| | NAKAZAWA | | ONUKI & BANDO, 1958 | | | ICHIKAWA, 1954 | | |
|---|---|---|---|---|---|---|---|---|
| Norian | *Monotis zabaikalica* zone | | Chonomori formation | $C_4$ | *zabaikalica, semiradiata* | Upper formation | $S_7$ | *zabaikalica* |
| | *Monotis ochotica* zone | *pachypleura suzbone* | | $C_3$ | *ambigua, pachypleura, eurhachis, ochotica* | | $S_6$ | *eurhachis, pachypleura* |
| | | *ochotica* subzone | | | | | $S_5$ | *eurhachis, ochotica, ambigua, densist.* |
| | *Monotis ochotica densistriata* zone | | | $C_2$ | *densistriata, multistriata* | | $S_4$ | *densistriata* |
| | *Monotis typica* zone | aff. *iwaiensis* subzone | | $C_1$ | *scutiformis, typica, kolymica* | Middle f. | $S_3$ | *typica, densistriata* |
| | | *typica* subzone | | | | | | |
| Late Karnian | *Dictyoconites* zone | | | | | | $S_2$ | *Dictyoconites* |
| | *Tosapecten* zone | | | | | | $S_1$ | *Tosapecten, Oxytoma* |
| | | | Shindate f. | | | Lower I. | | |

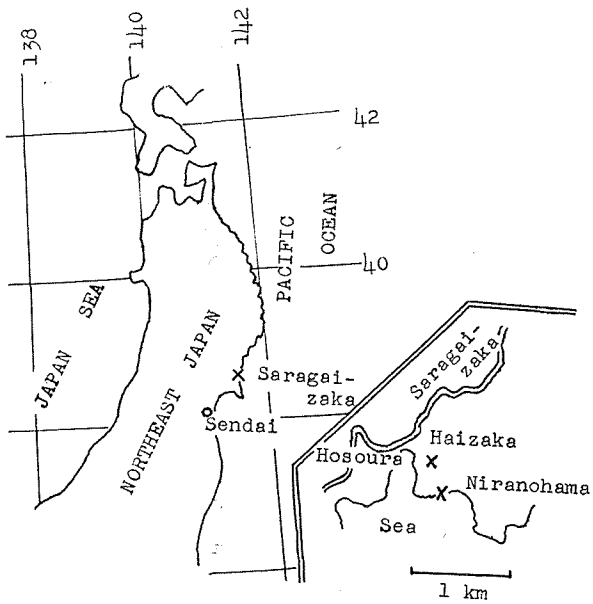
by SHIMIZU and MABUCHI (1932), which suggest the Norian time. ICHIKAWA considered the horizon of these ammonoids to be his lowest fossil zone ($S_1$), while ONUKI and BANDO referred it to their zone $C_2$ characterized by *M. o. densistriata.*

After a careful survey on the Saragai group at Niranohama and Hosoura in Miyagi Prefecture, where the cephalopod fossils in question were collected, the writer was able to establish the following sequence of fossil beds in the lower fossiliferous part of the Saragai group, and, moreover, obtain cephalopod fossils such as *Arcestes* sp. and *Rhacophyllites* sp.. The details will be reported in another paper now in preparation.* (See Textfigs. 1, 2 and Table 2)

Zone E ($S_5$)..*M. ochotica* (C), *M. o. densistriata* (C), *M. pachypleura* (C)

Zone D ($S_4$)..*M. o. densistriata* (A), *M.* aff. *scutiformis* (R), *M. yakutica* (R), *M.* aff. *iwaiensis*? (VR), *Oxytoma* cf. *subzitteli* (VR), *Leptochondria*? sp. (VR), *Palaeoneilo*? sp. (VR), *Schafhäutlia* sp. (VR), brachiopods (VR) and stems of crinoid (C)

* This will be printed in *Jour. Geol. Soc. Japan.* under the title of "On the Upper Triassic *Monotis* beds in Japan, especially on the *M. typica* zone."




Textfigure 1. Index map of locality

Zone Cb ($S_4$)..*M.* aff. *iwaiensis* (A), *M.* sp. B (A), *M. typica* (C),

Zone Ca ($S_3$)..*M. typica* (A). *M.* sp. A (R), *M.* sp. B (VR), *M.* aff. *iwaiensis* (VR), *Oxytoma* cf. *subzitteli* (VR), *Pteria* sp. (VR), *Halobia* sp. A cf. *obruchevi* (VR), *H.* sp. B aff. *fallx* (VR), *Pleuromysidia*? sp. (C), *Arcestes* sp. (VR) *Rhachophyllites* sp. (VR), *Spiriferina* sp. (VR), gastropod (VR)

Zone B ($S_2$)..*Dictyoconites nipponicus* (C), fragments of drift wood

Zone A ($S_1$)..*Tosapecten* cf. *suzukii* (VR), gastropod (VR)

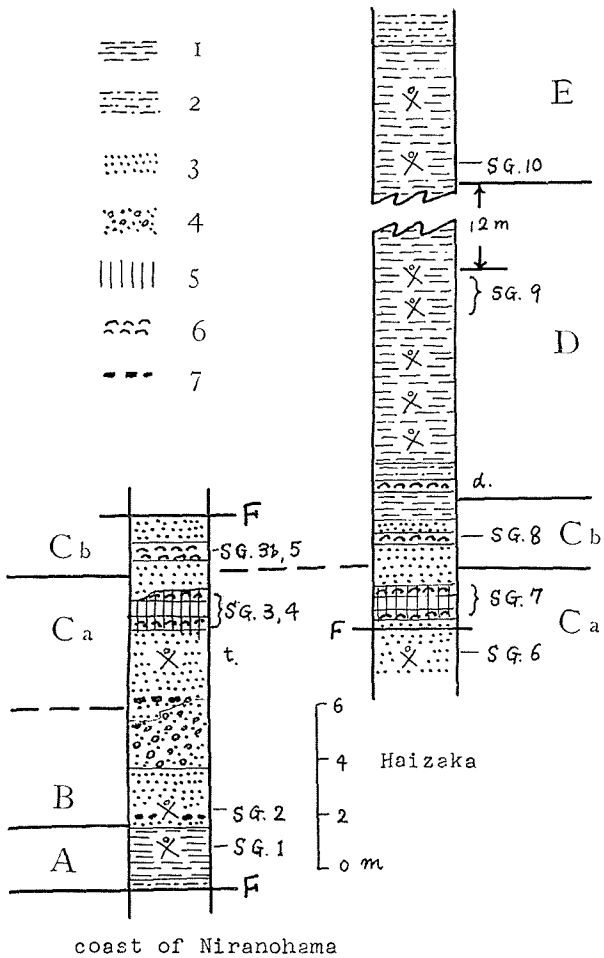
A: abundant, C: common, R: rare, VR: very rare.

$S_1$-$S_5$: zones by ICHIKAWA

ICHIKAWA (1951) reported the occurrence of *Monotis* sp. (*tenuissima* MS), *Lima* sp., *Pleuronectites* sp., *Pteria* sp. etc. from zone A, in addition to the above listed fossils.

It has been confirmed that the ammonoids in problem occurred from zone Ca, that is, ICHIKAWA's zone $S_3$ and ONUKI and BANDO's $C_1$. The above-mentioned authors, therefore, have made a mistake as to the horizon. Zone Ca can be assigned to the lower subzone of *M. typica* zone as will be discussed in the next section.

Next the writer will examine the age of *Monotis* beds, especially of *Monotis typica*. ONUKI and BANDO's zone $C_1$ was defined to be characterized by *M. typica*, *M. scutiformis*, *Dictyoconites nipponicus* etc., but in discussing the age it should be separated into three zones *Tosapecten*, *Dictyoconites* and *typica* as has been done by ICHIKAWA.




Textfigure 2. Columnar section of the Saragai group at Haizaka and the coast of Niranohama.

A-E: faunizones, 1: sandy shale, 2: fine-grained sandstone, 3: medium- to coarse-grained sandstone, 4: pebble-bearing, coarse-grained sandstone, 5: glauconite-bearing sandstone, 6: shell bank, 7: fragment of drift wood, t: *Monotis* cf. *typica*, d: shell bank of *M. ochotica densistriata*, F: fault, SG. 1-10: number of fossil locality. Zone D is fossiliferous throughout the strata.

Table 2. Table of fossil occurrences

| zone | A | B | $C_a$ | | | | $C_b$ | | D | E |
|---|---|---|---|---|---|---|---|---|---|---|
| locality no. (SG.) / species | 1 | 2 | 3 | 4 | 6 | 7 | 5 | 8 | 9 | 10 |
| *Tosapecten* sp. | × | | | | | | | | | |
| gastropod | × | × | | | | | | | | |
| *Dictyoconites nipponicus* | | ○ | | | | | | | | |
| *Pteria* sp. | | | | × | | | | | | |
| *Spiriferina* sp. | | | | × | | × | | | | |
| *Rhacophyllites* sp. | | | | | | × | | | | |
| *Arcestes* sp. | | | | △ | | × | | | | |
| *Halobia* cf. *obruchevi* | | | | × | | × | | | | |
| *Halobia* aff. *fallax.* | | | | △ | | △ | | | | |
| *Pleuromysidia*? sp. | | | | | △ | | | | | |
| *Oxytoma* cf. *subzitteli* | | | | | | △ | | | × | |
| *Monotis typica* | | | ◎ | ◎ | △ | ◎ | ○ | △ | | |
| *M.* sp. A | | | | △ | | △ | × | | | |
| *M.* sp. B | | | | | | × | ◎ | | | |
| *M.* aff. *iwaiensis* | | | | | | △ | △ | ◎ | | |
| *M. ochotica* | | | | | | | | | | ○ |
| *M. o. densistriata* | | | | | | | | | ◎ | ○ |
| *M. yakutica* | | | | | | | | | △ | |
| *M.* aff. *scutiformis* | | | | | | | | | △ | |
| *M. pachypleura* | | | | | | | | | | ○ |
| *Schafhäutlia* sp. | | | | | | | | | × | |
| *Palaeoneilo* ? sp. | | | | | | | | | × | |
| *Leptochondria* ? sp. | | | | | | | | | × | |
| stem of crinoid | | | | | | | | | ○ | |

◎ abundant, ○ common, △ rare, × very rare

*Dictyoconites nipponicus* was considered by SHIMIZU and MABUCHI (1932) to be most similar to *D. multisulcatus* BÜLOW from Timor (Bülow, 1915, p. 47, pl. 59, figs. 2-4; pl. 62, fig. 2) and *D.* aff. *haueri* MOJ. described by DIENER (1908, p. 56, pl. 2, fig. 2) from Himalaya. The former occurred from the strata containing mixed cephalopod fauna of Karnian and Norian, and the latter came from the Karnian. Therefore, *Dictyoconites* zone is probably Karnian in age. On the other hand occurrence of *Placites* aff. *oxyphyllus* and *Arcestes* aff. *oligosarcus* suggests the Norian age of *typica* zone. Unfortunately the specimens of these ammonoids have been neither described nor preserved, and the re-examination cannot be made. *Arcestes* sp. collected by the

writer is somewhat similar to Norian *Arcestes oligosarcus* MOJSISOVICS and Karnian-Norian *Arcestes trauthi* DIENER from Alps. It is not certain whether the species is the same as *A.* aff. *oligosarcus* by SHIMIZU and MABUCHI. *Rhachophyllites* sp. is most similar to *R.* sp. reported from the Karnian in Kyushu (ORITA, 1962, p. 4, not illustrated), and "*Discophyllites* cf. *ebneri*" described by TRECHMANN (1917, p. 184, pl. 17, fig. 7) from the Karnian in New Zealand. Therefore, if the specific comparison by SHIMIZU and MABUCHI is to be accepted, the *typica* zone is characterized by mixed ammonoid fauna of Karnian and Norian, although materials are insufficient.

In this respect the occurrence of *Halobia* aff. *fallax* and *H.* cf. *obruchevi* from *typica* zone, though very rare, is noticeable. *H. fallax* is a Norian species of Northern Alps but occurs from the Karnian of Alaska (SMITH, 1927), and *H.* cf. *fallax* is associated with *M. typica* of the Upper Karnian of Siberia (KIPARISOVA, 1936, 1938, 1954). *H. obruchevi* is found in the Upper Karnian of Siberia with *M. typica* and *Sirenites*, (KIPARISOVA, 1936, 1938). From these faunal assemblages, *typica* zone in Japan, at least the lower subzone, is correlated to the Upper Karnian *M. typica* beds in Siberia or the Lower *Monotis* beds in Maritime Province of USSR. *Monotis* cf. *montini* MCLEARN described by CSERNA (1961, p. 27, pl. 5, figs. 1-3) from the Karnian of Mexico resembles *M. scutiformis multicostata* KIPARISOVA (1954, p. 38, pl. 30, figs. 1, 2) more than *montini*. *M. scutiformis*, *M. typica* and their allies are therefore considered to have appeared already in late Karnian in Asiatic province of USSR and Mexico, although most species of *Monotis* including *Monotis* s.s. and *Entomonotis* are the characteristics of the Norian time. Nevertheless, it is worthy of note that the characteristic Halobiids of the Karnian are usually found in the lower horizon of the shell-limestone of *typica* in Siberia (TUCHKOV, 1958), and in Maritime Province *typica* occurs from the upper member of the Lower *Monotis* beds*. It seems certain to the writer that *M. typica* and its relative appeared in late Karnian, flourished at the latest stage of the "Upper Karnian" in USSR and dissapeared before late Norian. ICHIKAWA (1958) stated the common occurrence of *M. o. densistriata* with *typica* in Japan, but the writer could not find this from his *typica* zone. The *typica* zone in Japan is more correctly correlated with the uppermost part of the "Upper Karnian" in USSR (NAKAZAWA, 1958). Whether the uppermost part of the Upper Karnian in USSR is really included in the type Karnian of Alps or not is a disputable problem, because no ammonoid is found in this part. Furthermore, in West Canada *M. subcircularis*, the species intimately related to *densistriata* is found in the late Norian *Halorites-Rhabdoceras* horizon, and *M. alaskana* which resembles *typica* rather than *salinaria* occurs from the late Early Norian *Himavites* zone (TOZER, 1961). Under existing circumstances *typica* zone in

* Personal communication of Dr. KIPARAISOVA, to whom the writer is much obliged.

Japan and the uppermost part of the "Upper Karnian" in USSR are tentatively referred to earliest Norian until more definite evidences will be obtained. Saragian age which is usually referred to as Norian is considered to range from latest Karnian to late Norian.

## Zonation of *Monotis* beds in Japan

As pointed by ICHIKAWA (1958) the evolutional trend of *Monotis*, which decreases in the number of radial costae, is clearly recognized in the specimens collected zone by zone from the Saragai group. The evolutional series is represented by *typica-ochotica densistriata—ochotica ochotica—*(*ochotica* forma *eurhachis* or *sparsicostata*)*—pachypleura—zabaikalica semiradiata—zabaikalica**, or less probably by *typica—iwaiensis—*"*multistriata*"*—pachypleura—zabaikalica semiradiata—zabaikalica*. The writer is now inclined to consider that *multistriata*, *pachypleura* and *ambigua* are united into a single species. Similar evolutional trend may be assumed from the sequence of *Monotis* beds (Warepan) in New Zealand studied by GRANT-MACKIE (1959). Taking into consideration the stratigraphic succession and the evolutional trend, the following faunizones of *Monotis* can be distinguished in the *Monotis* beds in Japan in descending order.

*M. zabaikalica* zone..*zabaikalica*, (*z. semiradiata*, *pachypleura*, *ochotica*)
*M. ochotica* zone
  *M. pachypleura* subzone....*pachypleura*, (*ochotica*, *zabaikalica*, *z. semiradiata*)
  *M. ochotica* subzone....*ochotica ochotica*, (*pachypleura*, *o. densistriata*)
*M. ochotica densistriata* zone....*o. densistriata*, (aff. *scutiformis*)
*M. typica* zone
  *M. iwaiensis* subzone....*iwaiensis*, aff. *iwaiensis*, *M.* sp. B, (*typica*, *scutiforims*)
  *M. typica* subzone....*typica*, (*typica kolymica*, *scutiformis*)
  (The species enclosed with brackets are accessory members.)

All these zones are well developed in the Kitakami massif, but in the other areas not so completely known. Most of the *Monotis* beds are represented by *densistriata* and *ochotica* zones. Excepting the Kitakami *M. typica* zone is known only in Yamaguchi Prefecture (*M. typica* bed) and Kumamoto Pref. (upper member of the Takagochi

* *Pseudomonotis* sp. nov. described by KIPARISOVA (1936, p. 81, pl. 1, Figs. 1-3) from the Karnian in Kolyma basin is apparently very similar to *zabaicalica* in the nearly smooth shell, but it has no direct relation with the latter, because the radial ornament appears in the later growth-stage contrary to the case of *zabaikalica* which rarely has obsolete radials on the umbonal portion. *M. muikahatensis* (Hase, 1961, p. 83, pl. 12, figs. 12-18) closely related to the former species is found also in the *M. typica* bed in Japan.

formation with *M.* cf. *typica*) in West Japan (HASE, 1959; ORITA, 1962). *Pseudomonotis subcycloidea* described by KOBAYASHI (1935, p. 29, pl. 7, fig. 1) from the Kamosho formation in Yamagushi Pref. is probably identical with *scutiformis*, and. *Ps. ochotica* var. *densistriata* (ibid., pl. 7, fig. 2) at the same locality is more similar to *typica* than to *densistriata*. So this part of the formation may be referable to *typica* zone.

The lowest fossil horizon represented exclusively by *M. iwaiensis* at Itsukaichi may indicate an upper subzone of *typica* zone.

*M. zabaikalica* zone is recognizable above *pachypleura* subzone in the Myogatani formation in Gifu Pref., Central Japan, as in the Saragai group (ICHIKAWA et al., 1961), but at the other localities of *zabaikalica*, such as Itsukaichi, Tsuyama and Shikoku (KOBAYASHI and ICHIKAWA, 1949c), the exact stratigraphic horizon is not confirmed.

The *Monotis* beds in the Circum-Pacific province are correlated by *Monotis* as shown in the Table 3.

Table 3. Correlation of *Monotis* beds in the Circum-Pacific region.

| | Japan | | Siberia | N. America | New Zealand |
|---|---|---|---|---|---|
| Norian | *zabaikalica* | | *ochotica* fauna (Upper Norian) | | *calvata* |
| | *ochot.* | *pachypl.* | | *ochotica* (Arctic region) *subcircularis* | *gigantea, routhieri* |
| | | *ochotica* | | | *pachypleura, routhieri* |
| | *densistriata* | | *densistriata, typica* fauna (Lower Norian) | *alaskana* | *densistriata, richmondiana, salinaria* |
| | *typica* | *iwaiensis* | | | |
| | | *typica* | *typica* fauna (Upper Karnian) | "cf. *montini*" (Mexico) | |
| Late Karnian | | | | | |

## Description of molluscan fossils from *typica* and *densistriata* zones in the Saragai Group

### CEPHALOPODA

*Rhacophyllites* sp. indet.

Plate 3, Figures 1a-c: Textfigure 3

A single, fragmental specimen has been procured from *typica* subzone at Haizaka

in Hosoura. Only ventral part is preserved of about 60mm× 30mm × 25mm in size, which retains first lateral saddle and a part of external and first lateral lobes of suture-lines (Textfig. 3). These elements of the suture exhibit undoubtedly the

Textfigure 3. Suture-line of *Rhacophyllites* sp.

character of *Rhacophyllites*, and resemble especially those of the Karnian *Rhacophyllites* sp.* reported by ORITA (1962) from the Tanoura formation in Kumamoto Prefecture, Kyushu and of "*Discophyllites* cf. *ebneri*" described by TRECHMANN (1917, p. 184, pl. 17, fig. 7) from the Karnian of New Zealand rather than those of Norian species such as *debilis* and *neojurensis*, in the deep external lobe and simple first lateral lobe. The New Zealand species, which was correctly referred to *Rhacophyllites* by SPATH (1934, p. 323), is distinguished from the present one by more broadly rounded venter and slender first lateral saddle. *Rhacophyllites* sp. from Kyushu is so fragmental that the exact comparison can not be done, although the suture-lines are more similar to those of this species than those of New Zealand.

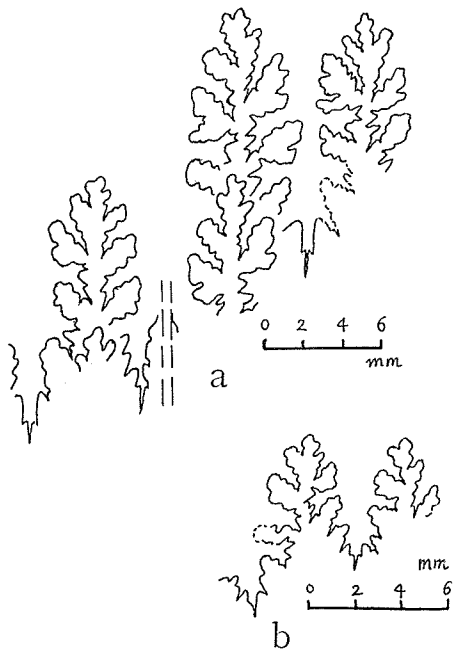
### *Arcestes* sp. indet.

Plate 3, Figures 2a-d and 3a-c: Textfigure 4

Three incomplete individuals of moderate and a small size have been found from *typica* zone at the coast near Niranohama and at Haizaka.

Shell is discoidal and compressed with rather acutely arched venter. Umbilical part is broken off, but presumably umbilicus is very small but not closed. Body chamber is not preserved, and the phragmocone is provided with sigmoidal constrictions which are distantly disposed. Surface is entirely smooth. Suture is of typical *Arcestes* type, consisting of six? lateral lobes between venter and umbilical seam; first and second lateral saddles are high and slender, deeply digitated; external lobe is shallower

* The species has not yet been described. The author could examine the original material now kept at Kyushu University through the courtesy of Dr. KANMERA at that university.




Textfigure 4. Sketch of suture-lines of *Arcestes* sp. a: outermost part, b: third and fourth lateral saddles of preceding one volution of about 38 mm in diameter. Sashed line is infered.

than the first lateral; siphonal saddle is relatively high and weakly denticulated.

All the specimens have been strongly deformed by later forces as shown in the cross section (pl. 3, fig. 3.), and the original shape can hardly be reconstructed accurately, although it is undoubtedly more globose than the present state. Therefore, the specific comparison is very difficult. In the disocidal shape, and high and slender saddles, present species is allied to *Arcestes* (*Stenarcestes*) sp. (NAKAZAWA, 1959, 132, pl. 9, figs. 2a-d; textfig. 3,4) from *ochotica* zone at Jito, West Japan, but the venter is less acute, widest position of the volution lies more ventrally, and the umbilicus may not be closed. Furthermore the last part of the preserved shell has a tendency to become more depressed suggesting a modification of body chamber. It is more similar to *A. oligosarcus* MOJSISOVICS (1875, S. 115, Taf. 44, Fig. 1-6; Taf. 53, Fig. 3) of the Norian Hallstatt limestone and *A. trauthi* DIENER (1919, S. 10, Taf. 1, Fig. 2,3) from the Karnian-Norian mixed fauna of Feuerkogel. It differs from *oligosarcus* in the narrower umbilicus, more slender lateral saddles, sharrower external lobe than the first lateral one, and from *trauthi* in probably more compressed whorls and broad

leaflets of the lateral saddles. Accurate comparison is impossible because the preservation is insufficient.

## LAMELLIBRANCHIATA

### *Monotis (Entomonotis) typica* (KIPARISOVA)

Plate 3, Figures 4-8; Plate 4, Figures 1,2.

1910. *Pseudomonotis scutiformis*, WITTENBURG. S. 68, Taf. 5, Fig. 9-11.
1932. *Pseudomonotis scutiformis*, KIPARISOVA. p. 21, pl. 1, figs. 14-18.
1936. *Pseudomonotis scutiformis* var. *typica* KIPARISOVA. p. 84, pl. 1, figs. 6,7,9,10.
1937. *Pseudomonotis scutiformis* var. *typica*, KIPARISOVA. p. 195, pl. 6, fig. 5.
1938. *Pseudomonotis scutiformis* var. *typica*, KIPARISOVA. p. 19, pl. 4, figs. 2-6.
1954. *Pseudomonotis (Entomonotis) scutiformis* var. *typica*, KIPARISOVA. p. 38, pl. 29, figs. 7-9.
1958. *Monotis (Entomonotis) typica*, ICHIKAWA. S. 180.
1961. *Monotis (Entomonotis) typica*, HASE. p. 80, pl. 12, figs. 1-12.

This species is fairly variable in shape and ornaments and in convexity as well. Having inequivalved shell it belongs to subgenus *Entomonotis*, but the left valve is not so inflated as usual *Entomonotis*. The right valve is a little convex, but sometimes inflated as much as the left (pl. 3, fig. 7; pl. 4, fig. 2), and sometimes nearly flat (pl. 3, fig. 6; pl. 4, fig. 1). Typical form is inequilateral, longer than high and elongated posteroventrally (pl. 3, fig. 8), but someone are regularly rounded (pl. 3, fig. 6). Posterior ear is very small, covered by radial costae as in the flank of the shell and hardly distinguishable from the rest of the body. Surface is sculptured by numerous, fine, radial costae of first and second orders, which are somewhat variable individually in strength and development, especially of secondaries. Total costae amount to 40 to 60 (mean 50) in number, among which are the primaries 33 to 50 (mean 38) and the secondaries 5 to 23 (mean 12).

Less convex left valve than usual *Entomonotis*, numerous and fine radial costae and striated, ill-defined posterior ear are the distinctive features of this species from *ochotica* and its relatives.

Japanese *typica* is quite identical with the type in Siberia in every specific characters mentioned above. The species was treated as variety (or subspecies in the present sense) of *scutiformis*, but it is here referred to as a distinct species, as the variability of the latter species is not enough known.

Crowded in fossil bank of *typica* subzone, common in the succeding aff. *iwaiensis* subzone.

*Monotis* (*Entomonotis*) sp. indet. A

Plate 4, Figs. 3, 4,

Several left valves are at hand in association with *M. typica*. These shells are similar to *typica* in numerous, fine, radial costae of more than fourty in number, but differ in the strongly inflated valve, and in the weaker, obsolete radials without secondaries. In the lack of secondary costae the species is somewhat similar to *iwaiensis* ICHIKAWA (1951, p. 43, textfigs. 1,2) from Itsukaichi near Tokyo, but the radials are much weaker and finer.

Measurement:

| | Height | Length |
|---|---|---|
| JM 11089 | ca 27 | 34 |
| JM 11094 | 26 | 32 |

*Monotis* (*Entomonotis*) sp. indet. B

Plate 4, Figures 7, 8, 9a.

This species is very similar to elongate form of *M. typica* in outline and in weakly convex left valve. The radial costae is composed almost of primaries amounting to 20 to 40 (mean 35) in number, and the secondaries are absent or very rare (usually less than 4, maximum 7). This species is distinguished from *typica* by less number of primaries and paucity of secondaries. In this point it resembles aff. *iwaiensis* described below, but differs in the more elongate outline transversally, weaker radials and less inflated left valve.

It occurrs abundantly in *M.* aff. *iwaiensis* subzone at the coast of Niranohama, and very rare at Haizaka.

*Monotis* (*Entomonotis*) sp. indet. C

Plate 4, Figures 5, 6.

The species is represented by a left and a right valve obtained from *typica* subzone at the coast of Niranohama. Shell is relatively large, obliquely ovate in outline elongated posteroventrally. Right valve is a little inflated, sculptured by strong, 27 primary costae, and 9 weak secondaries. Left one is a little more inflated than the right, having 29 strong primaries and 12 weak secondaries. The primary costae of both valves grow stronger and broader toward the periphery, where the secondaries are inserted. This species resembles very much *M. typica* and *M.* sp. B in the outline and weak convexity of the left valve. It differs from *typica* in the stronger primary costae of less number.

It is distinguished from *M.* sp. B in the larger size, stronger primaries and more numerous secondaries. But in comparing the equivalent growth-stage these two species are more similar with each other. The described species may be a mere varietal form of *typica* or sp. B.

### *Monotis* (*Entomonotis*) sp. aff. *iwaiensis* ICHIKAWA

Plate 4, Figures 9b, 10, 11

cf. 1951. *Monotis* (*Entomonotis*) *iwaiensis* ICHIKAWA. p. 43, Textfigs. 1,2.

This species has strongly inflated left and a little convex or flat right valve like in *ochotica.* Surface of the shell is covered by relatively strong, primary costae of 25-37 (mean 31) in number and a very few secondaries (0 to 7, mean 3); interstices of the primaries are relatively wide. In the general outline and strength of radial ornaments the described species is rather similar to *ochotica densistriata* than to *typica*, but easily distinguished from the former by more numerous primary costae and poor development of secondaries. It also differs from *multistriata* (KOBAYASHI and ICHIKAWA, 1949, p. 255, pl. 9, fig. 11 and 12) in the more numerous and much weaker radials, and from *tenuicostata* KOBAYASHI and ICHIKAWA (ibid., p. 255, pl. 9, fig. 14) by flat and broader intersticials and less prominent umbo. It is most intimate to *iwaiensis* from the lowest fossil horizon of *Monotis* beds at Itsukaichi, which is distinguished from the former only by the more number of primaries (about 40).

Rare in the lower subzone of *typica*, abundant in the upper subzone making aff. *iwaiensis* subzone.

### *Monotis* (*Entomonotis*) sp. aff. *scutiformis* (TELLERP)

Plate 5, Figures 1,2

cf. 1886. *Pseudomonotis scutiformis* TELLER. S. 125, Taf. 19, Fig. 3.

This species resembles very much *M. scutiformis* in the subcircular, nearly equilateral outline and regular alternation of primary and secondary costae, but the primaries are twenty or so, while the latter species has about thirty and the umbo of the former locates at a little more anterior position than in *scutiformis.* It is interesting that such a species having less number of radials is found at a higher horizon than *scutiformis*. Rare in *densistriata* zone at Haizaka and Saragaizaka.

*Monotis* (*Entomonotis*) *ochotica densistriata* (TELLER)

Plate 5, Figures 3-5.

1886. *Pseudomonotis ochotica* var. *densistriata* TELLER. S. 119, Taf. 17, Fig. 7,8,13,14; Taf. 18, figs. 9,10.
Other synonymic list is omitted.

*M. ochotica densistriata* from the Saragai group is somewhat different from the typical form in the smaller size, relatively numerous, radial, primary costae of more than 20 in number, rare tertiary costae, and development of radial sculpture on the posterior ear. In these respects this form seems to show a primitive aspect, but it does not indicate a difference of horizon from the other *densistriata* zone. It resembles *M. yakutica* in the above-mentioned features, but is distinguished by more inequilateral outline.

Abundant in *densistriata* zone, common in *ochotica* zone.

*Leptochondria*? sp. indet.

Plate 5, Figure 15

A single, internal cast of left valve is at hand. Shell is nearly equilateral, 16 mm long and equally high and a little inflated; hinge line is straight and 9 mm long. Both ears are obtusely triangular in outline, depressed, but not sharply defined from the disc; anterior ear is much larger than the posterior. Surface is sculptured by 16 fine, primary costae and alternating secondary striae, which appear about 7 mm apart from the apex; in addition to them, tertiaries are inserted near the periphery. Weak, close-set concentric ornaments are also observable making somewhat lattice appearance together with the radial culptures.

This species is similar to the Karnian *Chlamys mojsisovicsi* KOBAYASHI and ICHIKAWA (1949 c, p. 165, pl. 5, figs. 1-6) in the ornaments and the shape of both ears, but the general outline of the disc is more circular, and the radials are weaker and less in number. It seems to resemble more *Leptochondria*, such as *L. alberti* (GOLDFUSS) (1838, S. 138, Taf. 89, Fig. 1; Taf. 120, Fig. 6; etc.) in general outline and less sharply defined ears from the disc, although both ears are more unequal. Because the hinge is not known, the generic position cannot be decided.

*Pteria* sp. indet.

Plate 5, Figure 17

A right, internal mold has been procured from *typica* zone. Shell is 13 mm long

and 9 mm high, pteriform, and slightly inflated. Surface is entirely smooth. Hinge is not observable. This form resembles most the Karnian *Pteria hofmanni* (BITTNER) (1901, S. 27, Taf. 4, Fig. 6-9) from Bakony in Europe, but much smaller in size and the anterior ear is relatively larger.

### *Halobia* sp. A aff. *fallax* MOJSISOVICS

Plate 5, Figures 9a, b, 10

cf. 1874. *Halobia fallax* MOJISISOVICS. S. 29, Taf. 5, Fig. 6,5.
cf. 1927. *Halobia fallax*, SMITH. p. 115, pl. 98, figs. 10, 11.
cf. 1936. *Halobia* cf. *fallax*, KIPARISOVA. p. 95, pl. 3, fig. 5.
cf. 1954. *Halobia* cf. *fallax*, KIPARISOVA. p. 43, pl. 34, figs. 1.

Shell is small, slightly convex, roundly trapezoidal in outline, with a length of about one and a half of height. Umbo lies at about anterior one third of the length. Anterior ear is smooth marked by a deep furrow from the rest. The anterior half of the shell is sculptured by weak, but relatively wide radial costae, which are bi- or trifurcate and curve anteriorly with the convex side backward; they become finer posteriorly and diminish completely near posteroventral margin. These radials bend abruptly forward at 12 mm under the beak. Weak concentric folds are seen on the umbonal portion.

Described form is very similar to *H. fallx* from Alps and North America and cf. *fallx* from Maritime Province and Siberia in radial ornament and a position of the beak, but differs a little in the less developed concentric sculpture and broader outline.

Very rare in *typica* subzone at Niranohama, Haizaka and Saragaizaka.

### *Halobia* sp. B cf. *obruchevi* KIPARISOVA

Plate 5, Figures 11a, b and 12?

cf. 1936. *Halobia obruchevi* KIPARISOVA. p. 97, pl. 3, figs. 1,3,4.
cf. 1938. *Halobia obruchevi*, KIPARISOVA. pl. 6, p. 25, figs. 1-3.

Only a right valve nearly identical with *obruchevi* has been obtained from the *typica* bank at Haizaka in Hosoura. Shell is slightly inflated, much longer than high having a length of 28 mm and a height of 17 mm. Beak is located at the more anterior position than anterior one third of the length. Anterior ear is fairly large demarcated by a distinct radial furrow from the rest of the body. Surface is covered by very weak radial costae, which grow weaker and more closely set posteriorly and then completely disappear leaving smooth, trigonal posterior area bounded by obsolete furrow from the anterior main part. Radial costae are simple and straight, usually not furcate and

bend suddenly forward at 13 mm under the beak. In addition to the radials, concentric folds are developed on the whole surface.

From these characters mentioned above, this species is almost identical with *H. obruchevi* described from the Karnian in Siberia, but the radials seem to be less developed in the posterior part of the shell. Strict comparison cannot be made as the material is insufficient. Another specimen obtained from *typica* bank at the coast near Niranohama (pl. 5, fig. 12) is very similar to this species in outline and ornaments but the radials are usually bifurcate. Consequently, its identification to above described species is somewhat doubtful.

*Pleuromysidia* ? sp. indet.

Plate 5, Figures 13a, b, 14

Shell is obliquely ovate in outline, elongated posteroventrally, higher than long, and inequivalve. Left valve is strongly inflated with a small, depressed posterior ear; anterior ear is lacking. Surface is smooth except concentric folds of somewhat irregular strength. Right valve is moderately convex; concentric sculpture is obsolete and the surface is nearly smooth. Posterior ear is like that of the left, but the presence of the anterior one is not confirmed. Hinge-line of both valves is short and straight.

In the general shape and smooth shell excepting concentric folds this species is similar to *Monotis zabaikalica* (KIPARISOVA, 1932 ),but the right valve is more inflated, and the left one is more expanded posteroventrally. It seems more akin to *Pleuromysidia* in the shape and inflated right valve, but distinguished by lacking the radial sculpture. As the presence of right anterior ear is not confirmed and the hinge character is not known, the generic position is uncertain.

Common in *typica* subzone at Haizaka and west of Isadomae (in block).

*Oxytoma* sp. cf. *subzitteli* KOBAYASHI and ICHIKAWA

Plate 5, Figures 6-8

1949. *Oxytoma zitteli*, KOBAYASHI and ICHIKAWA. p. 220, pl. 2, figs. 3-6.
1959. *Oxytoma zitteli*, TOKUYAMA. p. 7, pl. 2, figs. 19a-c.
1963. *Oxytoma* cf. *subzitteli*, NAKAZAWA. p. 54, pl. 2, figs. 10-12.
cf. 1949. *Oxytoma subzitteli*, KOBAYASHI and ICHIKAWA. p. 221, pl. 2, figs. 7,8.

Three left valves and a right are in hand. In one of the left valve (pl. 5, fig. 6) the radial costae consist of 6 primaries, alternating secondaries of irregular strength and 2 or 3 intersticial striae of third or fourth order. In another left valve (pl. 5, fig. 7) 7 primaries are somewhat irregular in strength, among which the anterior three costae grow

strong at the rear extremity. In the right internal cast (pl. 5, fig. 8) a large, circular, posterior adductor scar is preserved at the center near the dorsal margin, and two very small pits referrable to pedal retractor scars are seen near the apex of umbonal cavity. Hinge area, which is partly observed in the internal cast, is relatively broad and grooved by 7 parallel striae, but ligament pit is not preserved.

This form is quite identical with *O.* cf. *subzitteli* described from *ochotica* beds at Jito (NAKAZAWA, 1963) and is also very similar to *O.* "*zitteli*" from the Upper Karnian of Shikoku (KOBAYASHI and ICHIKAWA, 1949), although differs slightly from "*zitteli*" in the obtusely triangular, left anterior ear which is less sharply defined from the disc. The opisthogyrous umbo of *O. subzitteli* from Shikoku (KOBAYASHI and ICHIKAWA, 1949) is most probably due to secondary deformation, and *zitteli* by KOBAYASHI and ICHIKAWA may be the same species as *subzitteli* as formerly stated (NAKAZAWA, 1963).

Very rarely found in *typica* and *densistriata* zones at Haizaka.

*Schafhäutlia* sp. indet.

Plate 5, Figures 16 a, b

Only a pair of valves has been obtained from *densistriata* zone at Haizaka. The specific comparison is impossible because of the severe secondary deformation of the specimen. The species is referred to belong to the genus *Schafhäutlia* in the strongly convex, circular shell and in having two, strong, cardinal teeth divergent from under the beak.

*Palaeoneilo*? sp. indet.

Plate 5, Figure 18

The species is represented by only a left external cast collected from *densistriata* zone at Haizaka. Shell is 13 mm long and 9.5 mm high with a depth of 3 mm. Umbo lies a little anterior to the middle of the shell. Shell is fairly inflated at the medial part, narrowing rather rapidly forward, and truncated posteroventrally. Surface is covered by distinct, close-set, concentric ribs. As the hinge is not preserved, it cannot be decided even generically, but it is noticeable that the species fairly resembles *Palaeoneilo lineata* GOLDFUSS (1838, S. 153, Taf. 124, Fig. 17; BITTNER, 1895, S. 133, Taf. 16, Fig. 1-16) from the Karnian St. Cassian beds in Apls. It differs from the latter in having no depression at the both sides of the inflated medial portion.

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## Postscript

During this paper was in print, the writer received the following importtant paper kindly sent to him by Dr. E. G. WESTERMANN: Succession and Variation of *Monotis* and the associated Fauna in the Norian Pine River Bridge Section, British Columbia, *Jour. Paleont., Vol. 36, No. 4, 1962.* The writer overlooked this caressly. According to WESTERMANN the following species succession of *Monotis* is found in descending order in the Upper Pardnet Formation of the Schooler Greek Group.

bed "h": *Monotis ochotica posteroplana* WEST.
beds "f"+"g": *M. subcircularis* GABB (+*M.* cf. *ochotica posteroplana in* "g")
bed "e": *M. callazonensis* WEST. +*M. jakutica* (TELLER)
bed "d": *M. ochotica densistriata* (TELLER)
bed "b"+"c": *M. scutiformis pinensis* WEST.
bed "a": *M.* n. sp.? aff. *scutiformis*

This succession coincides rather well with that of Japan. The beds "a", "b" and "c" characterized by *M. scutiformis* group may be correlated to *M. typica* zone in this paper. Below these beds the *Himavites* zone with *M.* cf. *scutiformis* is inferred, and they are referred to as middle Norian in age later than the age considered in this paper. The conclusive settlement about the age and correlation of *typica* zone in Japan and Siberia needs further paleontological data and, especially, strict biostratigraphical study in Siberia.

## Explanation of Plate 3

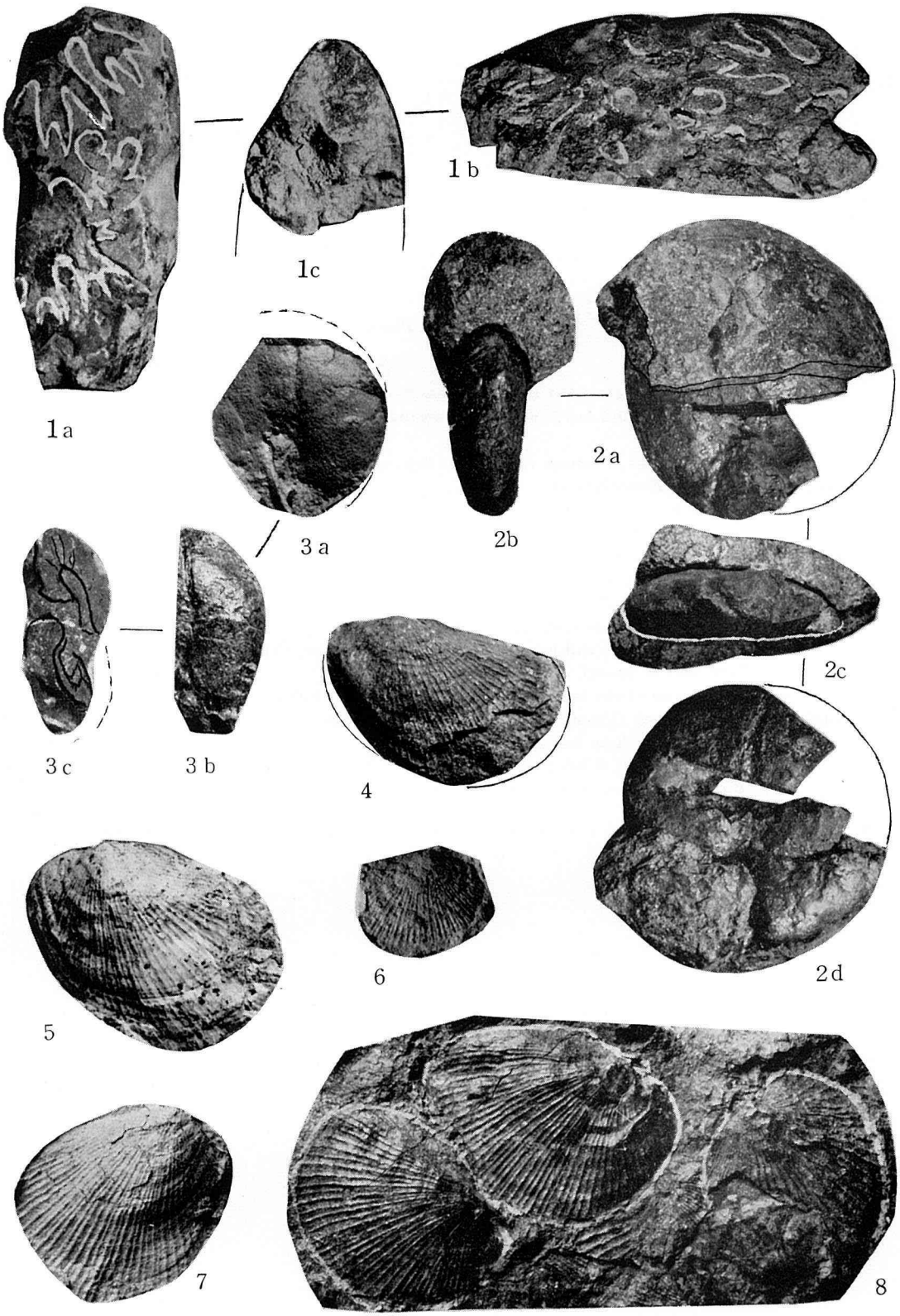
Figs. 1a-c. *Rhacophyllites* sp. indet. ..... p.
Two lateral views (a, b) and cross section (c) of the fragmental internal mould. Reg. no. JM 30006.

Figs. 2a-d and 3a-c. *Arcestes* sp. indet. ..... p.
Two lateral (2a, d) and two ventral views (2b, c) of the incomplete internal mould; a quarter of the outer volution being broken off. Reg. no. JM 30003. Lateral view of rubber compound cast (3a) and of internal mould (3b) of smaller specimen, and slightly excentric cross section (3c) showing strong deformation of the shell. Reg. no. JM 30004.

Figs. 4-8. *Monotis* (*Entomonotis*) *typica* (KIPARISOVA) ..... p.

4. Internal mould of left valve. Reg. no. JM 11088e
5. Rubber compound cast from external mould of left valve. Reg. no. JM 11086.
6. Rubber compound cast from external mould of right valve, showing flat and semicircular shell. Reg. no. JM 11088b
7. Rubber compound cast from external mould of right valve, showing convex, ovate shell. Reg. no. JM 11090.
8. Internal moulds of three right valve, showing normal form. Reg. no. JM 11037.

All figures are in natural size. All illustrated specimens are kept in Geological and Mineralogical Insititute, University of Kyoto.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## Explanation of Plate 4

Figs. 1, 2. *Monotis* (*Entomonotis*) *typica* (KIPARISOVA). ..... p.
1. Rubber compound cast from external mould of nearly flat right valve. Reg. no. JM 11092.
2. Internal mould of convex right valve. Reg. no. JM 11087.

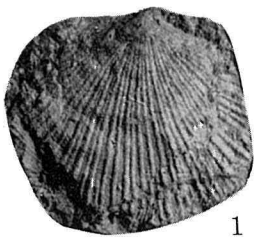
Figs. 3,4. *Monotis* (*Entomonotis*) sp. A. ..... p.
3. Internal left mould. JM 11089.
4. Rubber compound cast from left external mould. Reg. no. JM 11094.

Figs. 5,6. *Monotis* (*Entomonotis*) sp. C. ..... p.
5. Right internal mould. Reg. no. JM 11095.
6. Rubber compound cast from left external mould. Reg. no. JM 11091.

Figs. 7, 8, 9a. *Monotis* (*Entomonotis*) sp. B. ..... p.
7. Right external (a) and internal moulds (b, c). Reg. no. JM 11101.
8. Left internal mould. Reg. no. JM 11104.
9a. Gypsum cast from left external cast. Reg. no. JM 11102a.

Figs. 9b,10,11. *Monotis* (*Entomonotis*) sp. aff. *iwaiensis* IOHIKAWA ..... p.
9b. Gypsum cast from left external mould. Reg. no. JM 11102b.
10. Internal moulds of left (a, b) and right (c) valves. Reg. no. JM 11099.
11. Rubber compound casts of left (a, b) and right (c d) valves. Reg. no. JM 11100.

All figures are in natural size. All illustrated specimens are kept in Geological and Mineralogical Institute, University of Kyoto.



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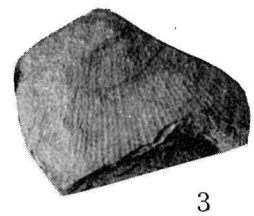

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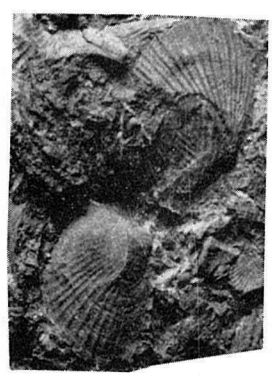

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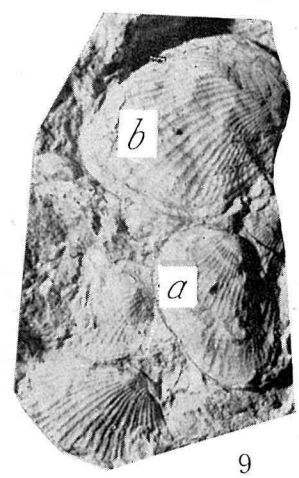


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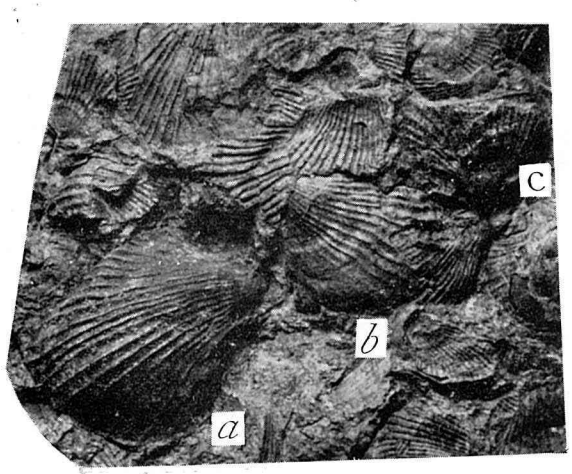


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## Explanation of Plate 5

Figs. 1,2. *Monotis* (*Entomonotis*) aff. *scutiformis* (TELLER). ..... p.

1. Rubber compound cast from right external mould. Coll. by S. Matsushita from Saragaizaka. Reg. no. JM 11033.
2. Gypsum cast from right external mould. Coll. by S. Matsushita from Saragaizaka. Reg. no. JM 11022.

Figs. 3-5. *Monotis* (*Entomonotis*) *ochotica densistriata* (TELLER). ..... p.

3. Gypsum cast from right external mould. Reg. no. JM 11041.
4. Right internal (a) and left external (b) moulds. Coll. by S. Matsushita from Haizaka. Reg. no. JM 11024.
5. Left internal mould. Haizaka. Reg. no. JM 11129.

Figs. 6-8. *Oxytoma* cf. *subzitteli* KOBAYASHI and ICHIKAWA. ..... p.

6. Rubber compound cast from left external mould. Coll. by I. Hayami from *densistriata* zone at Haizaka. × ca. 1.4. Reg. no. JM 11021.
7. Left external mould from *typica* zone at Haizaka. Reg. no. JM 11084.
8. Right internal mould from the same locality as the preceding, (m): posterior adductor scar and (p): pedal retractor scar. JM 11085.

Figs. 9a,b and 10. *Halobia* sp. A aff. *fallax* MOJSISOVICS. ..... p.

9. Right internal mould (a) and rubber compound cast from external mould of the same (b), ×1.5. Reg. no. JM 11088a.
10. Right internal mould. JM. 11095a.

Figs. 11a,b and 12?. *Halobia* sp. B cf. *obruchevi* KIPARISOVA. ..... p.

11. Rubber compound cast from right external mould, ×1.5(a) and ×1 (b). Reg. no. JM 11124.
12. Rubber compound cast from left external mould ×1.5. JM 11124b.

Figs. 13,14. *Pleuromysidia*? sp. indet. ..... p.

13. Left internal mould (a) and rubber compound cast from external mould of the same (b). Reg. no. JM 11127.
14. Right internal mould. Reg. no. JM 11125.

Figs. 15. *Leptochondria*? sp. indet. ..... p.

Left internal mould, ×1.5. Reg. no. JM 11044.

Rigs. 16a,b. *Schafhäutlia*? sp. indet. ..... p.

Internal mould (a) and rubber compound cast from external mould of the same (b). Reg. no. JM 11043.

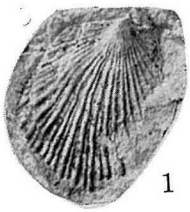
Figs. 17. *Pteria* sp. indet. ..... p.

Right internal mould. Reg. no. JM 11096.

Fig. 18. *Palaeoneilo*? sp. indet. ..... p.

Rubber compound cast from left external mould. Reg. no. JM 11128a.

All figures without indication are in natural size. All illustrated specimens are kept in Geological and Mineralogical Insititute, University of Kyoto.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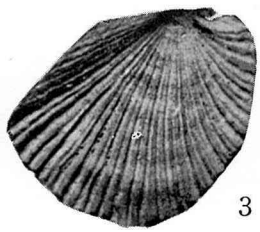
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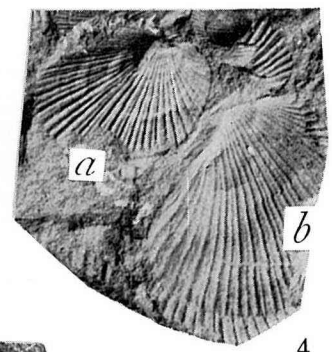

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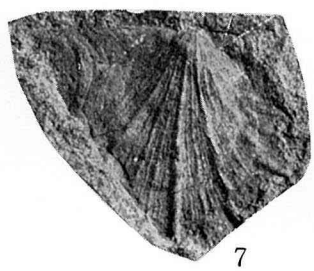
5


Ca× 1.4 6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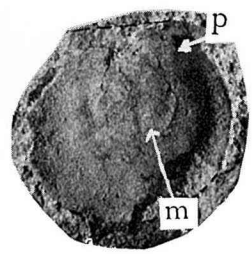
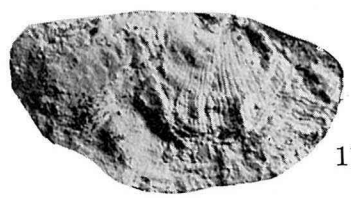


8


× 1.5 9 a

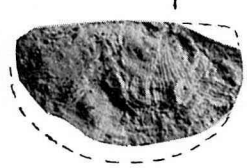

10


11 a

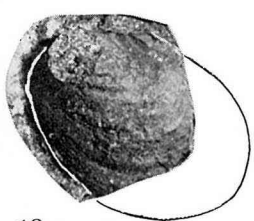
× 1.5


× 1.5 9 b


× 1.5 12

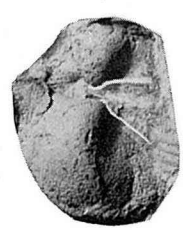

11 b


16 a


13 a

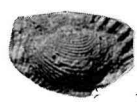

14


× 1.5 15


16 b


13 b


17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