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Triassic Conodonts from the Mikabu Greenrocks in Central Shikoku

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Introduction

The Mikabu greenrocks are a composite igneous formation composed mainly of ultrabasic to basic rocks, being associated with less amount of siliceous, pelitic and carbonate sediments. They, as a whole, have been assigned to metamorphics of high-pressure greenschist grade and not a few Japanese authors have inclined to define them as a reresentative of the so-called ophiolite suite of oceanic origin (*e.g.*, SUZUKI, 1977).

Together with the Sambagawa crystalline schists the Mikabu greenrocks constitute the Sambagawa Metamorphic Belt, one of the major geotectonic units in Southwest Japan (Fig. 1). The Mikabu rocks are distributed near along the south margin of the Sambagawa Belt, being in direct contact with the sediments of the south-adjacent Chichibu Belt in several places of Shikoku though the stratigraphic and tectonic relations between the sediments of Chichibu Belt and the Mikabu rocks have not been elucidated exactly. The Sambagawa metamorphics and the Mikabu greenrocks as well are almost barren in fossils except very rare occurrence of microfossils which are of no use in age determination (KANMERA, 1977). On the other hand, the northernmost part of the Chichibu Belt, namely the northern half of the North Subbelt of the Chichibu Belt, has long been believed to be composed mostly of Late Palaeozoic (Permian) sediments (*e.g.*, KATTO *et al.*, 1961; SUZUKI, 1965, 1967, 1977). These so-called Palaeozoic sequences have been named the Kamiyakawa or the Odamiyama Formations, but there has been known only a very rare occurrence of guide fossils.

On the basis of the study on the major rock bodies of the Mikabu greenrocks in Shikoku SUZUKI has recently remarked that the igneous stratigraphy of the Mikabu can be considered almost established in Southwest Japan. He considers that the metamorphosed sediments associated with the Mikabu greenrocks are assignable to the Early to Middle Permian (SUZUKI, 1977). But exactly saying the geochronology of the Mikabu rocks and the Sambagawa schists should not be considered established as yet because there have been virtually no direct evidences proving their geologic ages, and the geologic age of the original rocks of Sambagawa metamorphics inclusive of the Mikabu greenrocks has been estimated only on the basis of similarity of the

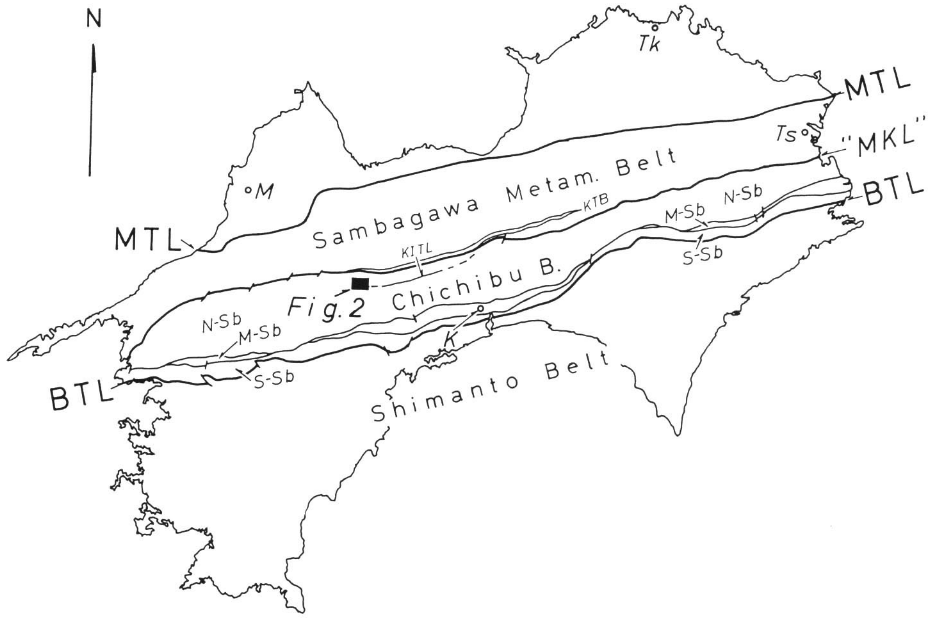

Fig. 1. Tectonic subdivision of Shikoku (modified from KATTO *et al.*, 1977) and location of the studied area (black square).

Boundaries between major tectonic units: *MTL* — Median Tectonic Line; "*MKL*" — the so-called Mikabu Tectonic Line; *BTL* — Butsuzo-Itokawa Tectonic Line. Minor tectonic lines: *KTB* — Kiyomizu Tectonic Belt; *KITL* — Kamiyakawa-Ikegawa Tectonic Line. Subdivisions of the Chichibu Belt: *N-Sb* — North Subbelt; *M-Sb* — Middle Subbelt; *S-Sb* — South Subbelt. Place names: *K* — Kochi; *M* — Matsuyama; *Tk* — Takamatsu; *Ts* — Tokushima.

The presence of the "Mikabu Tectonic Line" has been suspicted by many authors. The area between *KTB* and *KITL* is named the Sambagawa South Marginal Belt, which is the southernmost zone of the Sambagawa Metamorphic Belt in central Shikoku.

lithological succession as compared with those of the Chichibu Belt, or of structural conformity between the Sambagawa and the Chichibu Belts (*e.g.* SUZUKI, 1964 *etc.*).

To summarize, there have been almost no positive evidences proving the geologic age of the metamorphic sequences that compose the southern part of the Sambagawa Belt, inclusive of the so-called Mikabu Belt, and the northernmost part of the Chichibu Belt.

After several years search for conodonts in the terrane of the above-mentioned metamorphics in central and eastern Shikoku the author could ascertain the occurrence of conodonts from several localities. The finding of conodonts made possible for the first time a reasonable estimation on the age of the Mikabu greenrocks. As reported already in preliminary form (KUWANO & SUYARI, 1978, 1979), the geologic age of the Mikabu rocks can be assigned to the Carboniferous and the Triassic. But in the present paper the author instends to describe the Triassic conodonts and to discuss the geological meanings of conodont ocurrence from the Mikabu greenrocks.

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Outline of Geology

The conodonts that will be described below were discovered from schistose limestone layer exposed at two localities in Tsuboi, Ikegawa-cho, Agawa-gun, Kochi Prefecture (Fig. 2, Localities 1 and 2). Tsuboi is located near the south margin of the Sambagawa Metamorphic Belt, or more precisely saying situated almost on the boundary of the Sambagawa South Marginal Belt in the north and the North Subbelt of the Chichibu Belt in the south. There are developed green schist and phyllite together with well-bedded limestone near Tsuboi. These rocks constitute a succesive sequence with a trend of nearly E-W direction, dipping as a whole 20 to 30 degrees gently northwards.

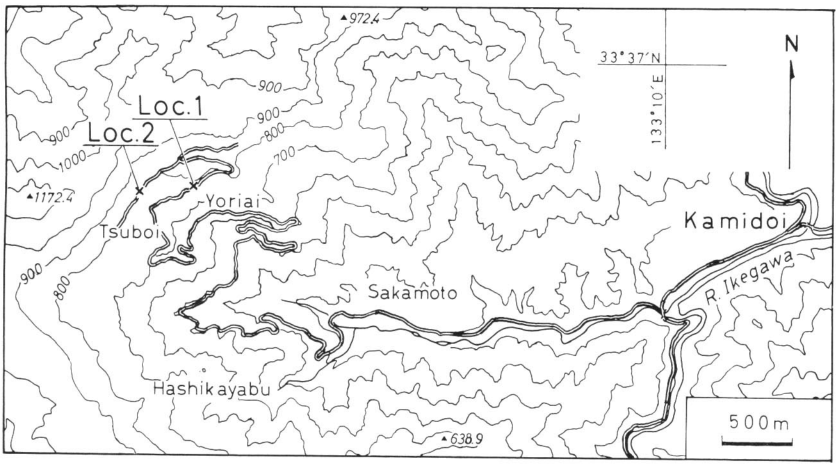


Fig. 2. Locality map.

Two opposing schemes of stratigraphic subdivision have been proposed since with regards to the said sequence (Table 1).

According to TSUKUDA the schistose limestone layer developed at Tsuboi just underlies the Mikabu greenrocks. He believed that the limestone layer is a topmost member of the Sambagawa crystalline schists as defined by him and illustrated that the limestone layer is developed at only one horizon in the environs of Tsuboi (TSUKUDA in TAKEDA *et al.*, 1977, p. 118, fig. 6).

Table 1. Stratigraphic subdivisions hitherto proposed.
Thickness is in metres.

TSUKUDA, 1976; TSUKUDA *in* TAKEDA *et al.*, 1977			SUZUKI, 1965**
Odamiyama Formation*	Kamiyakawa Formation*	Sambagawa crystalline schists	Kuzukawa Formation 600+
Mikabu greenrocks 300			
Sambagawa crystalline schists*			Omoiji Formation 600–700+

* Thickness is not given by TSUKUDA.

** SUZUKI (1964) proposed one more stratigraphic unit, *i.e.* the Karakoshi Formation which underlies the Omoiji Formation, as the lowest subdivision of his Sambagawa crystalline schists.

Another subdivision is that proposed by SUZUKI, who considered all the formations developed near Tsuboi to belong to the Sambagawa crystalline schists. He described that the sequence exposed near Tsuboi are an alternation of green schist and schistose limestone, which represent the upper part of his Kuzukawa Formation. He also illustrated at least three limestone layers to be intercalated within this sequence (SUZUKI, 1965, p. 298, fig. 2).

Apart from the said interpretations on the lithological succession there is another difference of opinion between them as for the geologic age estimation. The Kamiyakawa Formation has been considered to be the Permian, probably Middle Permian or earlier (KATTO *et al.*, 1961). SUZUKI did not correlate his stratigraphic units explicitly with the Kamiyakawa Formation but he noted that the sequences equivalent to his Kuzukawa and Omoiji Formations are developed in the North Subbelt, so that it is evident that SUZUKI's stratigraphic units are as a whole an equivalent of the Kamiyakaya Formation. From the above discussion it can be suggested that TSUKUDA considered implicitly the conodont-bearing limestone layer to be older than Early (?) to Middle Permian.

Samples and Method of Processing

Eleven rock samples were collected from Localities 1 and 2 at every 1 or 2 metre interval (Fig. 3). They weighed about 60 kg in total (in average about 5.5 kg per sample, ranging from 3.18 to 7.32 kg).

After digested with 20% acetic acid insoluble residue finer than 0.5 mm in diameter was separated, washed and dried to prepare the samples for heavy liquid

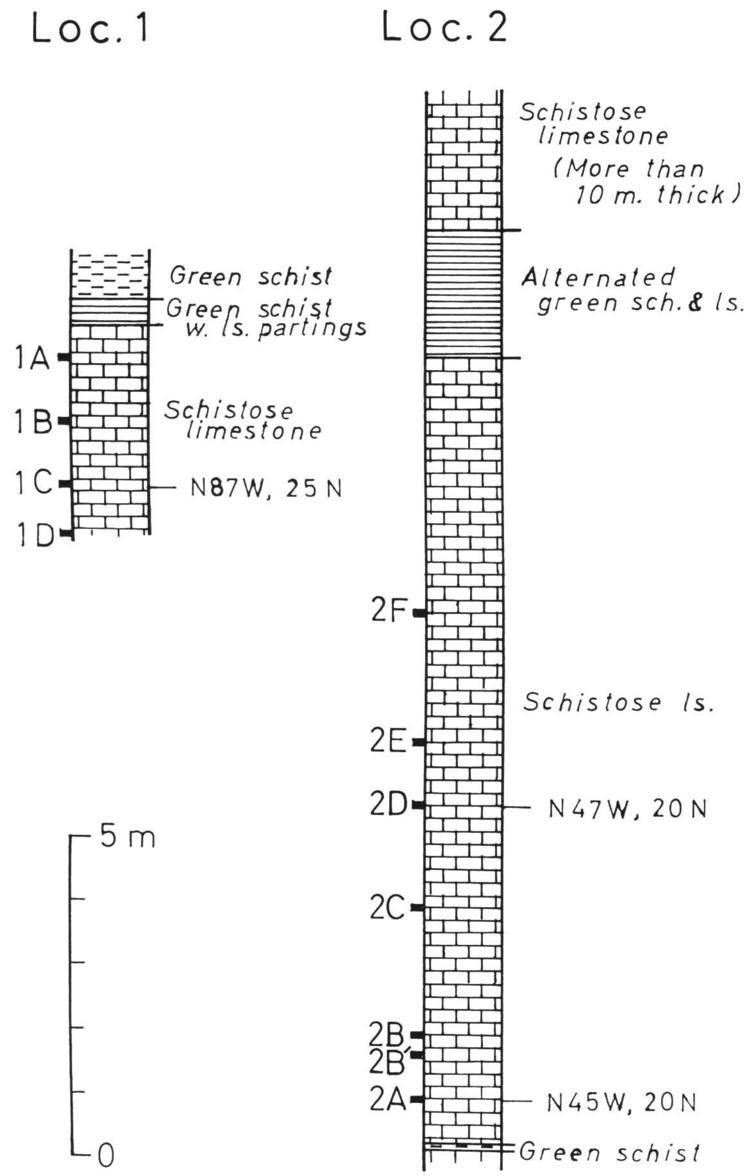


Fig. 3. Columnar sections at Tsuboi and the sampled horizons.

separation with tetrabromoethane. Obtained heavy fraction was small in amount in most of samples, but due to ill-preservation of conodont elements picking up under microscope was rather painstaking.

Most of recovered conodont elements are fragmented or more or less strongly deformed, being light grey in colour or almost colourless (or opaque white of EPSTEIN *et al.*, 1977, p. 2, fig. 1 m), in other words they are assignable to the grades 6 and 7 in terms of Colour Alteration Index of EPSTEIN *et al.* (1977).

Conodont Fauna and its Geologic Age

Examination of heavy fraction and identification were made for the fraction coarser than 0.15 mm in diameter. The results are summarized in Table 2.

Table 2. Conodonts from Tsuboi.

Sample no.	1A	1B	1D	2A	
Weight of sample in kg.	7.32	5.61	5.48	5.28	
Species					Total
Epigondolella abneptis	—	5	1	2	8
E. cf. *abneptis*	—	2	—	2	4
E. cf. *angusta*	—	1	—	—	1
E. primitia	—	4	1	1	6
E. pseudodiebeli	1	1	1	—	3
E. cf. *pseudodiebeli*	—	3	—	1	4
E. sp. A	—	2	1	—	3
E. cf. sp. A	—	—	—	2	2
E. spp. indet.	—	6	7	1	14
Neospathodus? spp. indet.	—	—	2	—	2
Gen. et spp. indet.	—	5	1	4	10
Total	1	29	14	13	57

As shown in the Table the obtained fauna is characterized by complete absence of compound elements and predominance of epigondolellid-type platform elements. No platform elements certainly assigned to the genera other than *Epigondolella* were found except for a few questionable neospathodids and neogondolellids.

Absence of compound forms can be interpreted as a result of destruction by strong tectonic stresses during regional metamorphism. The fact that the recovered platform elements mostly have lost their free blade is an evidence that supports this assumption. While, the dominance of epigondolellids suggests that the composition of obtained fauna represents at least partly its primary composition so far as the platform elements are concerned, because five distinct morphotaxonomic groups, i.e. *abneptis*, cf. *angusta*, *primitia, pseudodiebeli* and sp. A were distinguished.

Among the species listed in Table 2 *Epigondolella abneptis* (HUCKRIEDE) is most abundant. As has been discussed by many authors (*e.g.* MOSHER, 1968, 1973; SWEET *et al.*, 1971; KOZUR, 1972 *etc.*) this species is one of the most excellent guide species of the late Middle to Late Triassic, more precisely saying the age spanning from the latest Karnian to the latest Norian.

Subdominant species, *Epigonodolella primitia* MOSHER and *E. pseudodiebeli* (KOZUR) also indicate the Middle to Late Triassic. Both of them are characteristic of the time interval ranging from the latest Karnian to the earliest Norian (or *macrolobatus* to *kerri* Zones).

Worth notice is that the high-Norian species such as *Epigondolella bidentata* MOSHER and *E. mosheri* (KOZUR & MOSTLER) were not found. From these data it is concluded that the conodont fauna in concern indicates the conodont-bearing limestone layer to be of the latest Karnian to the earliest Norian age. Absence of neospathodids may also hold this assumption.

Geological Significance of the Discovery of Triassic Conodonts from the Mikabu Greenrocks

Occurrence of the latest Karnian to the earleiest Norian conodonts can be evaluated from several viewpoints of geology. Conodont occurrence from the terrane of high-pressure metamorphics is in itself a matter of great interest, which will lead to a well-evidenced stratigraphic correlation between metamorphic and non-metamorphic seqences in the same orogenic belt.

With regards to the tectogenetic history of Southwest Japan the meanings of this finding can be summarized from two viewpoints, *i.e.* establishing standard succession of the original rocks of the Sambagawa metamorphics, and elucidating the geotectonic history of the Sambagawa Metamorphic Belt.

The original rocks of the Sambagawa metamorphics have been inferred to be the Carboniferous to Permian (MINATO *et al.*, eds., 1965; ICHIKAWA *et al.*, eds., 1970) but the obtained result proves that at least a part of this metamorphics have been deposited during the Middle to Late Triassic. In consequence, the age of Sambagawa metamorphism should be limited to the age later than the earliest Norian.

As reported by the present author (KUWANO & SUYARI, 1979) there are developed conodont-bearing Triassic sediments rather widely in the northern half of the North Subbelt of the south-adjacent Chichibu Belt. From the conodonts these sediments are supposed mostly to be of Middle to Late Triassic age, so that it is reasonable to conclude that during the late Middle and Late Triassic Period geosynclinal conditions have prevailed at least in the southern half of the Sambagawa Metamorphic Belt and in the northern half of the North Subbelt of the Chichibu Belt.

The obtained result obliges the age estimation by the previous authors cited in Table 1 to be emended. Also the various schemes of geohistorical development hitherto proposed by many authors should be re-examined, *e.g.* the stratigraphic relations between the Mikabu rocks and the Palaeozoic sediments developed in western Shikoku (KASHIMA, 1969). KASHIMA (1969) discussed the stratigraphy of the Late Palaeozoic sequences in western Shikoku and correlated the greenrocks intercalated within his Saitaro Formation to the Mikabu greenrocks distributed in central and eastern Shikoku. He dated the Saitaro Formation as the Late Carboniferous to

Early Permian, but if the greenrocks of Saitaro Formation is correlatable to the Mikabu rocks in central Shikoku there arises a discrepancy relating to the age assignment.

Another difficulty is that of the geologic age of the Odamiyama Formation cited in Table 1. According to KASHIMA (1969) the Odamiyama ic covered by the Saitaro conformably in western Shikoku, so that it must be older than the Late Carboniferous. As shown in Table 1, TSUKUDA placed the Odamiyama together with the Kamiyakawa just above the Mikabu greenrocks. However, the Kamiyakawa has been assigned to the Early (?) to Middle Permian (KATTO *et al.*, 1961). These dicrepancies are considered to have resulted from an inadequate amount of biostratigraphic evidences from the Sambagawa Metamorphic Belt as well as from the northern half of the North Subbelt of the Chichibu Belt.

As the author has concluded (KUWANO & SUYARI, 1978, 1979) the Mikabu greenrocks in Shikoku are not an igneous formation of one and the same age but comprise at least two separate igneous sequences formed independently in the Middle Carboniferous and the Middle to Late Triassic Periods. The situations described above can be explained more reasonably by the author's view that the Mikabu greenrocks is nothing but a collective name for several greenrock bodies of different ages that are developed along the boundary between the Sambagawa Metamorphic Belt and the North Subbelt of the Chichibu Belt.

Systematic Palaeontology

The conodonts described below are all from the schistose limestone layer that belongs to the upper part of SUZUKI's (1965) Kuzukawa Formation exposed in the Tsuboi area (Figs. 2 and 3; see also Appendix). The geologic age inferred from these conodonts is the latest Karnian to the earliest Norian (see above). All the matrials studied are reposed in the Micropalaeontological Collection of the National Science Museum, Tokyo, with the code MPC and the serial numbers.

Epigonodolella MOSHER, 1968

Epigonodolella abneptis (HUCKRIEDE, 1958)
Pl. 1, figs. 1–7; Pl. 4, figs.4, 7; Text-fig. 4a–e

Polygnathus abneptis HUCKRIEDE, 1958, p. 156, pl. 12, figs. 30–34; pl. 14, figs. 1, 2, 13, 16–22, 27, 32, 47–57.

Gladigondolella abneptis HAYASHI, 1968, pl. 2, figs. 6–8; NOGAMI, 1968, p. 122, pl. 8, figs. 1–5.

Epigonodolella abneptis MOSHER, 1968, p. 936, pl. 118, figs. 22–30; MOSHER, 1970, pl. 110, figs. 14, 15, 18, 20, 21; SWEET *et al.*, 1971, pl. 1, figs. 18, 27; KOZUR & MOSTLER, 1972, pl. 2, figs. 9–12; KRYSTYN, 1973, pl. 4, figs. 1–3; MOSHER, 1973, p. 159, pl. 18, figs. 6, 12–14, 16, 17; WANG & WANG, 1976, p. 403–404, pl. 4, figs. 17–19; text-fig. 14; SWEET *in* ZIEGLER, ed., 1977, p. 151, pl. 1, fig. 4.

Tardogondolella abneptis BENDER, 1970, p. 531, pl. 59, fig. 21; KOZUR & MOSTLER, 1971, pl. 2, figs. 7, 9.

Metapolygnathus abneptis abneptis KOZUR, 1972, pl. 6, figs. 10–12; pl. 7, figs. 12–18.

Remarks: Although the elements assigned here to *E. abneptis* are all incomplete, mostly lacking free blade, they are characterized by squared posterior margin of platform, a carina rapidly increasing its height anteriorly, and rather high denticles which are developed near posterior-lateral corner of platform. Y-formed basal cavity, one of the diagnostic features of this species, can not be observed in almost all of the obtained elements due to ill-preservation. But there was found a specimen with a narrow, deep median furrow and a shallow basal cavity widening posteriorly, although posterior-lateral corners of basal cavity are not preserved (Pl. 1, fig. 1b; Pl. 4, fig. 7).

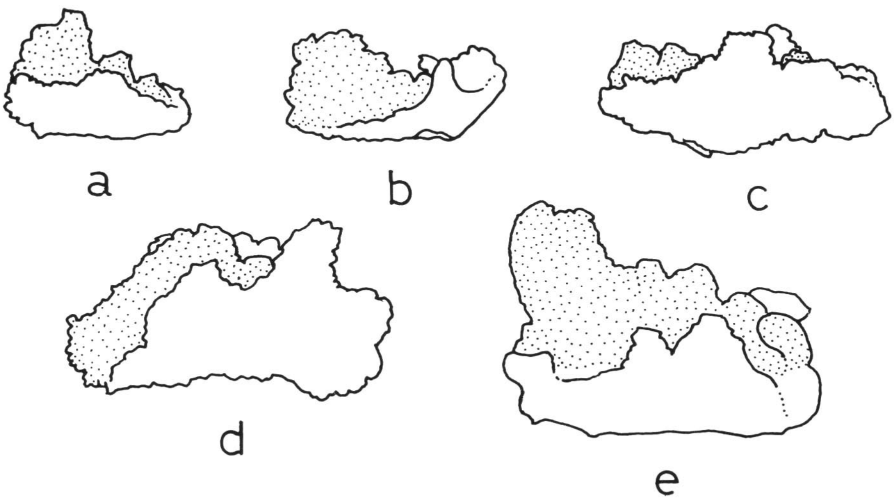


Fig. 4. *Epigondolella abneptis* (HUCKRIEDE). Lateral views. ×100.
a, MPC 1856 (Pl. 1, fig. 5c); b, MPC 1854 (Pl. 1, fig. 4c); c, MPC 1855 (Pl. 1, fig. 3c); d, MPC 1853 (Pl. 1, fig. 2c); e, MPC 1852 (Pl. 1, fig. 1c).
In Figs. 4 to 9 the right side is the posterior direction and carina is dotted. The numbers of plate and figure in parentheses indicate the SEM-micrographs that correspond to the line drawings in text-figures.

Repository: Seven figured hypotypes, MPC 1852 to 1858. One unfigured hypotype, MPC 1859.

Epigondolella cf. *abneptis* (HUCKRIEDE, 1958)

Repository: Four unfigured hypotypes, MPC 1860 to 1863.

Epigonodolella cf. *angusta* (KOZUR, 1972)
Pl. 3, fig. 4; Text-fig. 5

Metapolygnathus angustus KOZUR, 1972, p. 9, pl. 7, fig. 19.
Epigondolella angusta SWEET *in* ZIEGLER, ed., 1977, p. 153, pl. 2, fig. 4.

Remarks: This species is represented by only one incomplete element only with a part of carina and right anteroir part of platform preserved. Right anterior corner of platform is rounded quadrate, posterior part of carina being composed of a few, discrete high triangular denticles, thus it resembles *E. angusta*. But it lacks posterior end of platform and bears denticles (two low and one small but high) along posterior margin of platform, of these the latter feature is not observed in the holotype of *E. angusta*.

Repository: One figured hypotype, MPC 1864.

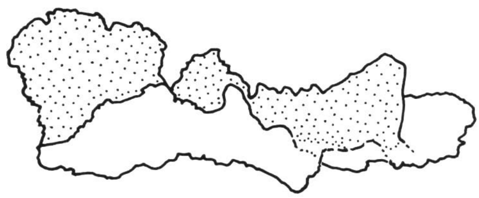


Fig. 5. *Epigondolella* cf. *angusta* (KOZUR). Lateral view. ×100. MPC 1864 (Pl. 3, fig. 4c).

Epigondolella primitia MOSHER, 1970
Pl. 1, fig. 8; Pl. 2, figs. 1–3, 6; Text-fig. 6a–e

Epigondolella primitia MOSHER, 1970, p. 740, pl. 110, figs. 7–13, 16, 17; MOSHER, 1973, p. 161, pl. 18, figs. 1–5, 7–11; SWEET *in* ZIEGLER, ed., 1977, p. 193, pl. 2, fig. 3.
Gladigondolella abneptis NOGAMI, 1968, pl. 8, fig. 8.
Epigondolella n. sp. A SWEET *et al.*, 1971, pl. 1, figs. 8, 10.
Tardogondolella nodosa nodosa KOZUR & MOSTLER, 1971, pl. 2, figs. 10, 11, 13.

Remarks: This species is represented by several incomplete elements lacking posterior end of platform. Carina increases in height very gradually, anterior end of platform lacks spike-like high denticles. Posterior part of platform is not tapered. From these features the obtained elements are distinguished from *Epigondolella multidentata* MOSHER, 1970. Platform margin bears two or three low denticles, basal cavity being represented by slightly raised keel with a rather deep median groove although not so clear due to ill-preservation (Pl. 4, fig. 6).

KRYSTYN (1973) regarded *E. primitia* as a synonym of *Epigonodolella nodosa* (HAYASHI, 1968). But the latter species has a quadrate platform with rounded corners, so that KRYSTYN's assignment can not be justified.

Repository: Five figured hypotypes, MPC 1865 to 1869. One unfigured hypotype, MPC 1870.

Epigonodolella pseudodiebeli (KOZUR, 1972)
Pl. 3, figs. 1–3; Text-fig. 7a–c

Metapolygnathus spatulatus pseudodiebeli KOZUR, 1972, p. 8, pl. 4, fig. 5.
Epigondolella pseudodiebeli SWEET *in* ZIEGLER, ed., 1977, p. 195, pl. 2, fig. 1.
Gladigondolella abneptis NOGAMI, 1968, pl. 8, fig. 6.
Tardogondolella abneptis BENDER, 1970, p. 531, pl. 58, figs. 29, ?30.
Tardogondolella diebeli KOZUR & MOSTLER, 1971, p. 13, pl. 2, fig. 3.
Epigondolella diebeli KOZUR & MOSTLER, 1972, pl. 2, fig. 3.

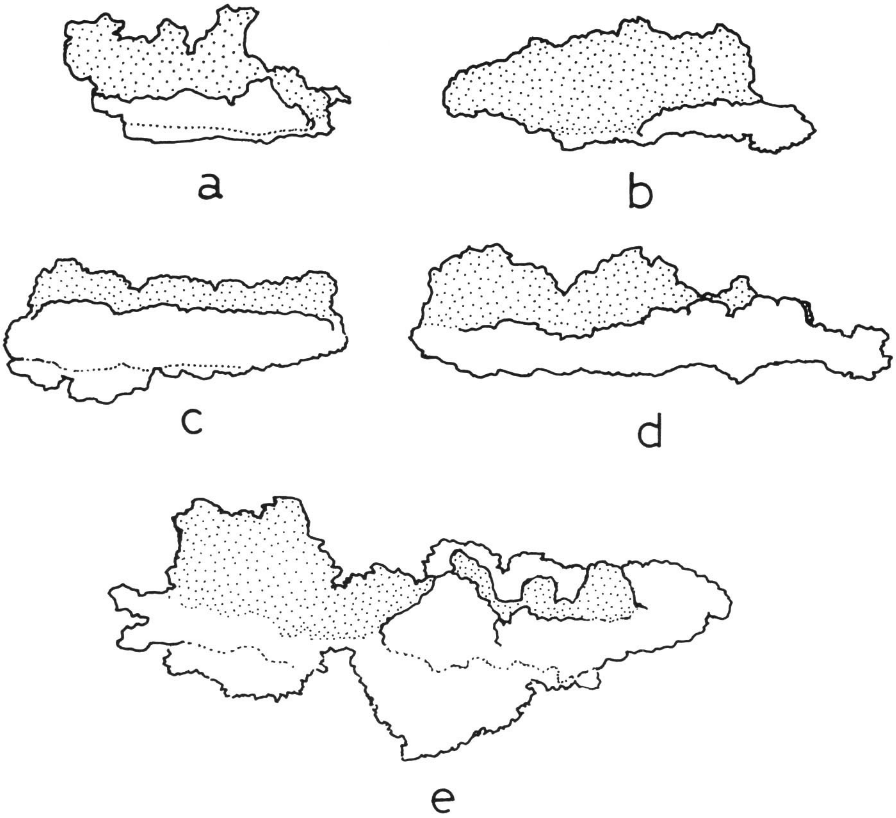


Fig. 6. *Epigondolella primitia* MOSHER. Lateral view. ×100.
a, MPC 1867 (Pl. 2, fig. 6c); b. MPC 1866 (Pl. 2, fig. 3c); c, MPC 1865 (Pl. 2, fig. 2c); d, MPC 1869 (Pl. fig. 1c); e, MPC 1868 (Pl. 1, fig. 8c).

Remarks: Laterally curved, broadly wedge-shaped platform and transverse ridges developed in the middle part of platform are characteristic of the obtained elements. They are characterized also by a carina gradually increasing in height so far as the preserved part is concerned. Preservation of basal cavity is not well but a flat keel gradually widening posteriorly is observed (Pl. 4, fig. 5). This species can be distinguished from *Epigondolella diebeli* (KOZUR & MOSTLER, 1971) by having a larger width to length ratio of platform.

Repository: Three figured hypotypes, MPC 1876 to 1878.

Epigondolella cf. *pseudodiebeli* (KOZUR, 1972)
Pl. 3, fig. 5

Repository: One figured hypotype, MPC 1879. Three unfigured hypotypes, MPC 1880 to 1882.

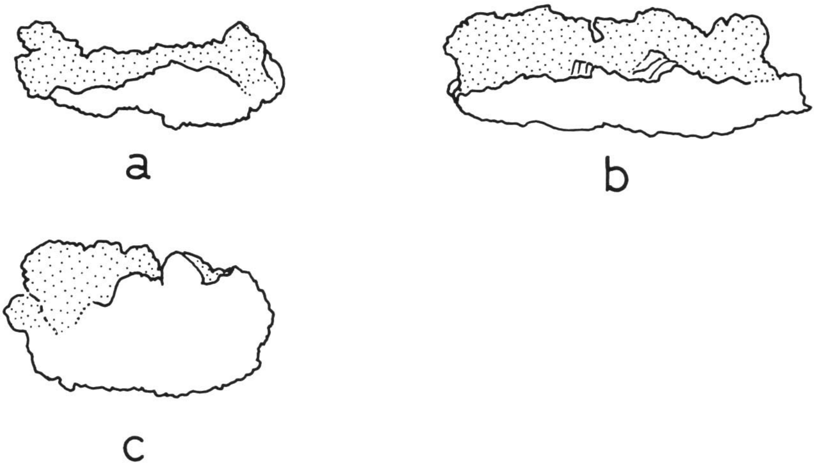


Fig. 7. *Epigondolella pseudodiebeli* (KOZUR). Lateral views. ×100.
a, MPC 1876 (Pl. 3, fig. 3c); b, MPC 1878 (Pl. 3, fig. 1c); c, MPC 1877 (Pl. 3, fig. 2c).

Fig. 8. *Epigondolella* sp. A. Lateral views. ×100.
a, MPC 1871 (Pl. 2, fig. 5c); b, MPC 1872 (Pl. 2, fig. 4c).

Epigondolella sp. A
Pl. 2, figs. 4, 5; Text-fig. 8a, b

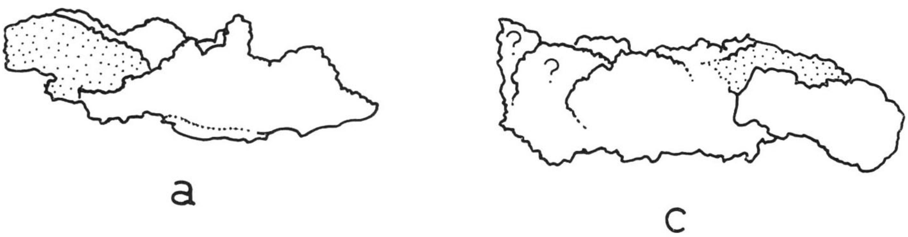
Remarks: This species is distinguished from other epigondolellids by having a laterally compressed platform that bears a few, high denticles along its lateral margins. Lateral compression might have resulted from tectonic stresses but it seems to be a primary character of this species. Basal cavity is very indistinct but it is likely that a keel with a shallow median groove runs longitudinally. This species resembles a little *Epigondolella primitia* described above but incompleteness of the obtained elements makes exact identification difficult.

Repository: Two figured hypotypes, MPC 1871 and 1872. One unfigured hypotype, MPC 1873.

Epigondolella spp. indet.
Pl. 3, fig. 6; Pl. 4, figs. 1, 3, 8; Text-fig. 9a, b

Remarks: Ten odd epigondolellid-type elements were recovered. They are probably assignable to several forms but due to ill-preservation exact identification was impossible. Among these indeterminabl eforms three elements are illustrated herein.

Repository: Three figured hypotypes, MPC 1884 to 1886. Eleven unfigured popotypes, MPC 1883, 1887 to 1896.



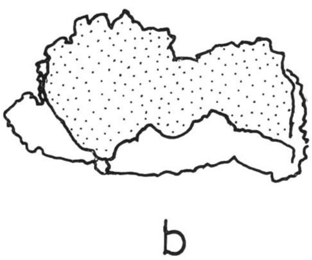


Fig. 9. Lateral views of epigondolellids and an indeterminable platform element. ×100. a, b — *Epigondolella* spp. indet. a, MPC 1884 (Pl. 4, fig. 1c); b, MPC 1885 (Pl. 4, fig. 3c). c — Gen. et sp. indet. MPC 1901 (Pl. 4, fig. 2c).

Gen. et spp. indet.
Pl. 4, fig. 2; Text-fig. 9c

Repository: One figured hypotype, MPC 1901. Nine unfigured hypotypes, MPC 1899, 1900, 1902 to 1908.

Appendix: Description of Localities

Loc. 1: A small, low road-side cutting along the Oda-Ikegawa Route of Regional Road for Forestry Development. Located about 380 metres NEE of the office building of the Tsuboi Pilot Farm of Highland Agriculture. Strike N 60°W, dip 30°N. Since this outcrop is isolated from other outcrops nearby inclusive of that of Loc. 2 exact correlation of the limestone layers between this locality and Loc. 2 is difficult. But these limestone layers probably belong to the same stratigraphic horizon as inferred from the general trend of the strata developed in this area.

Loc. 2: A point near the northeastern end of a high road-side cutting along the road above-mentioned. Located about 200 metres NWW of the office of the Tsuboi

Pilot Farm. Strike N 45°W, dip 20°N. Schistose limestone is continuously cropped out for about 200 metres southwards from Loc. 2 along the above-mentioned road. Near the south end of this large outcrop the limestone layer shows a strike of E-W, dipping about 70° northwards. Southward dipping high-angle step faults are developed in the limestone layer but the amount of displacement is small.

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Explanation of Plates

All the figures are SEM-micrographs of the elements coated with Au by the use of ion sputtering instrument. Unless otherwise noted a, b and c denote respectively the upper, lower and lateral views of the same element. The upper and lower views are oriented as the posterior part directed upwards. Arrows attached to lateral views indicate the posterior direction of the elements marked. Other lateral views are illustrated as the posterior part oriented to the right. The numbers and letters in parentheses that follow the locality number are the number of rock samples.

Plate 1

Figs. 1–7. *Epigondolella abneptis* (HUCKRIEDE). ×60.

1 — Element lacking free blade. Loc. 2 (2A). Hypotype, MPC 1852; 2 — Weakly deformed element lacking right anterior part of platform. Marginal denticles are developed unequally on the left and right margins, of which the former bears no distinct denticles. Loc. 2 (2A). Hypotype, MPC 1853; 3 — Nearly complete element. Loc. 1 (1B). Hypotype, MPC 1855; 4 — Right half of platform is not preserved. Fig. 4b is oblique lower view. Loc. 1 (1D). Hypotype, MPC 1854; 5 — Left side of platform is lacking. Loc. 1 (1B). Hypotype, MPC 1856; 6, 7 — Upper views of platform fragments retaining the squared posterior margin. Loc. 1 (1B). Hypotypes, MPC 1857 and 1858.

Fig. 8. *Epigondolella primitia* MOSHER. ×60.

8 — Weakly deformed element lacking right posterior corner of platform. Loc. 1 (1B). Hypotype, MPC 1868.

Plate 2

Figs. 1–3, 6. *Epigondolella primitia* MOSHER. ×60.

1 — Posterior end and left half of platform are lost. Loc. 1 (1B). Hypotype, MPC 1869; 2 — Right margin of platform is broken off. Loc. 2 (2A). Hypotype, MPC 1865; 3 — Posterior end of platform is not preserved. Loc. 1 (1B). Hypotype, MPC 1866; 6 — Left half of platform is lost. Loc. 1 (1B). Hypotype, MPC 1867.

Figs. 4, 5. *Epigondolella* sp. A. ×60.

4 — Element only with the middle part of platform preserved. Loc. 1 (1B). Hypotype, MPC 1872; 5 — Element with weakly deformed posterior part. Loc. 1 (1B). Hypotype, MPC 1871.

Plate 3

Figs. 1–3. *Epigondolella pseudodiebeli* (KOZUR). ×60.

1 — Fig. 1a is oblique upper view. Loc. 1 (1D). Hypotype, MPC 1878; 2 — Asymmetrically deformed element. Loc. 1 (1A). Hypotype, MPC 1877; 3 — Deformed element. Loc. 1 (1B). Hypotype, MPC 1876.

Fig. 4. *Epigondolella* cf. *angusta* (KOZUR). ×60.

4 — Element only with right anterior platform margin preserved. Loc. 1 (1B). Hypotype, MPC 1864.

Fig. 5. *Epigondolella* cf. *pseudodiebeli* (KOZUR). ×60.

5 — Vertically compressed and flattened element. Loc. 1 (1B). Hypotype, MPC 1879.

Fig. 6. *Epigondolella* sp. indet. ×60.

6 — Very ill-preserved element. Loc. 2 (2A). Hypotype, MPC 1886.

Plate 4

Figs. 1, 3. *Epigondolella* spp. indet. ×60.

1 — Obliquely compressed element with free blade pushed down horizontally. Loc. 1 (1B). Hypotype, MPC 1884; 3 — Left margin of platform is not preserved. Loc. 1 (1D). Hypotype, MPC 1885.

Fig. 2. Gen. et sp. indet. ×60.

2 — Very ill-preserved element. Loc. 2 (2A). Hypotype, MPC 1901.

Figs. 4, 7. *Epigondolella abneptis* (HUCKRIEDE).

4 — Enlarged lower view of the element illustrated as Plate 1, fig. 3. Basal cavity is indistinct. MPC 1855. ×120; 7 — Enlarged lower view of the element illustrated as Plate 1, fig. 1. Note a lateral widening of keel near the posterior end of platform. MPC 1852. ×180.

Fig. 5. *Epigondolella pseudodiebeli* (KOZUR). ×120.

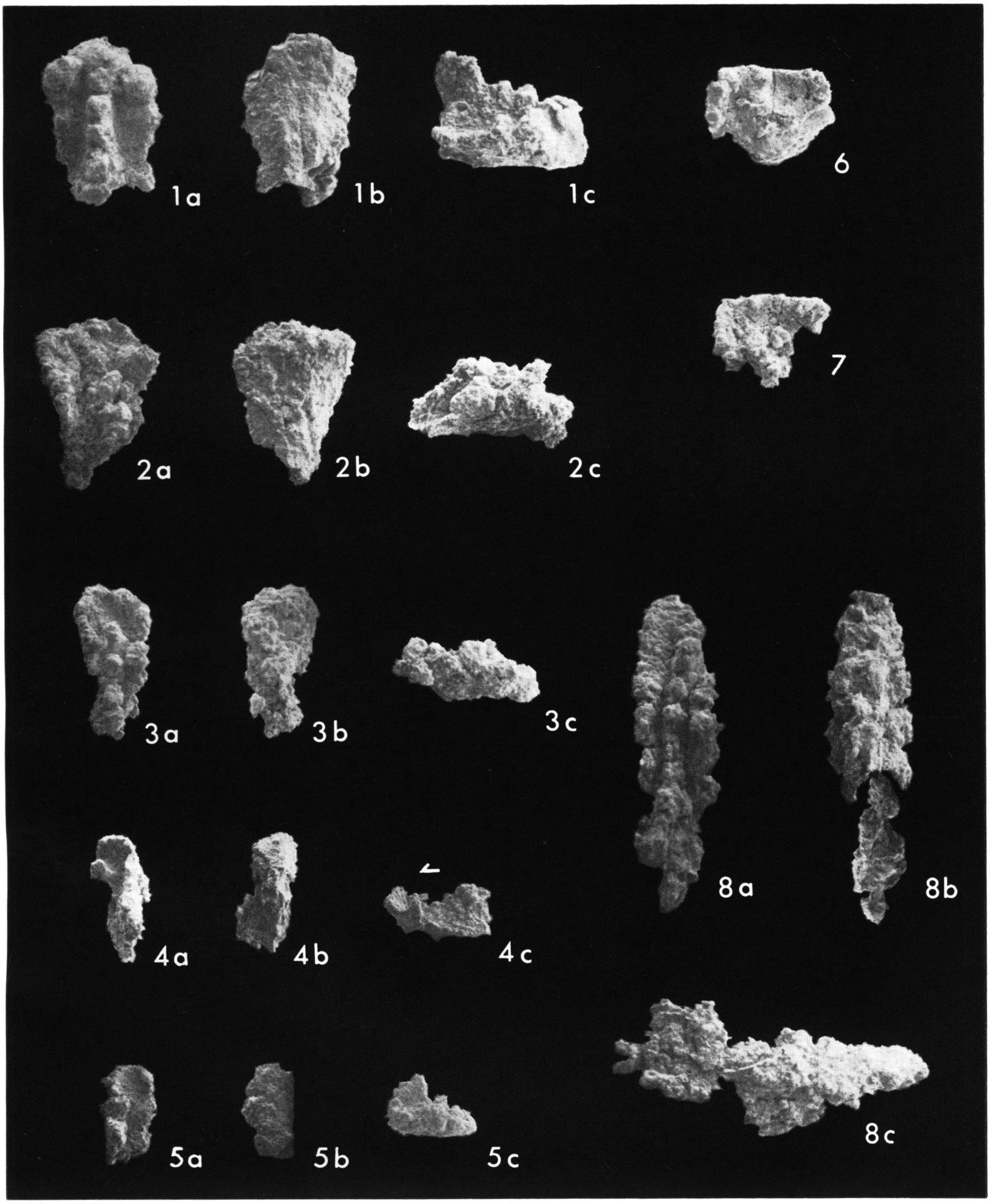
5 — Enlarged lower view of the element illustrated as Plate 3, fig. 1. The figure is set as the posterior end of platform oriented to the right. MPC 1878.

Fig. 6. *Epigondolella primitia* MOSHER. ×120.

6 — Enlarged lower view of the element illustrated as Plate 2, fig. 1. Note narrow and raised keel with a deep median furrow. Posterior part of keel is indistinct due to ill preservation. MPC 1869.

Fig. 8. *Epigondoblella* sp. indet. ×180.

8 — Enlarged lateral view of the element illustrated as Plate 3, fig. 6. In spite of strong recrystallisation a part of carina as well as remnant of platform are distinctly observed. MPC 1886.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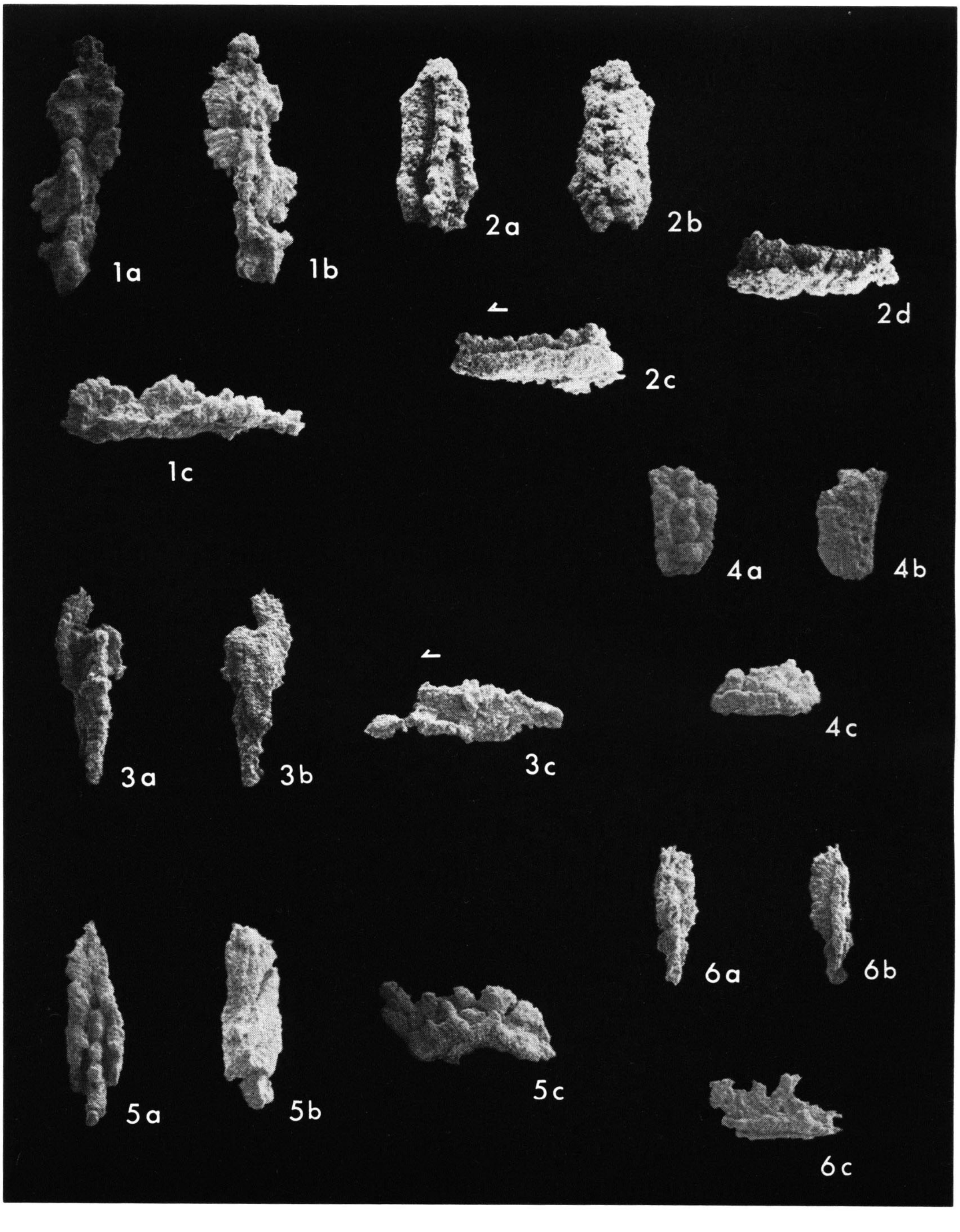
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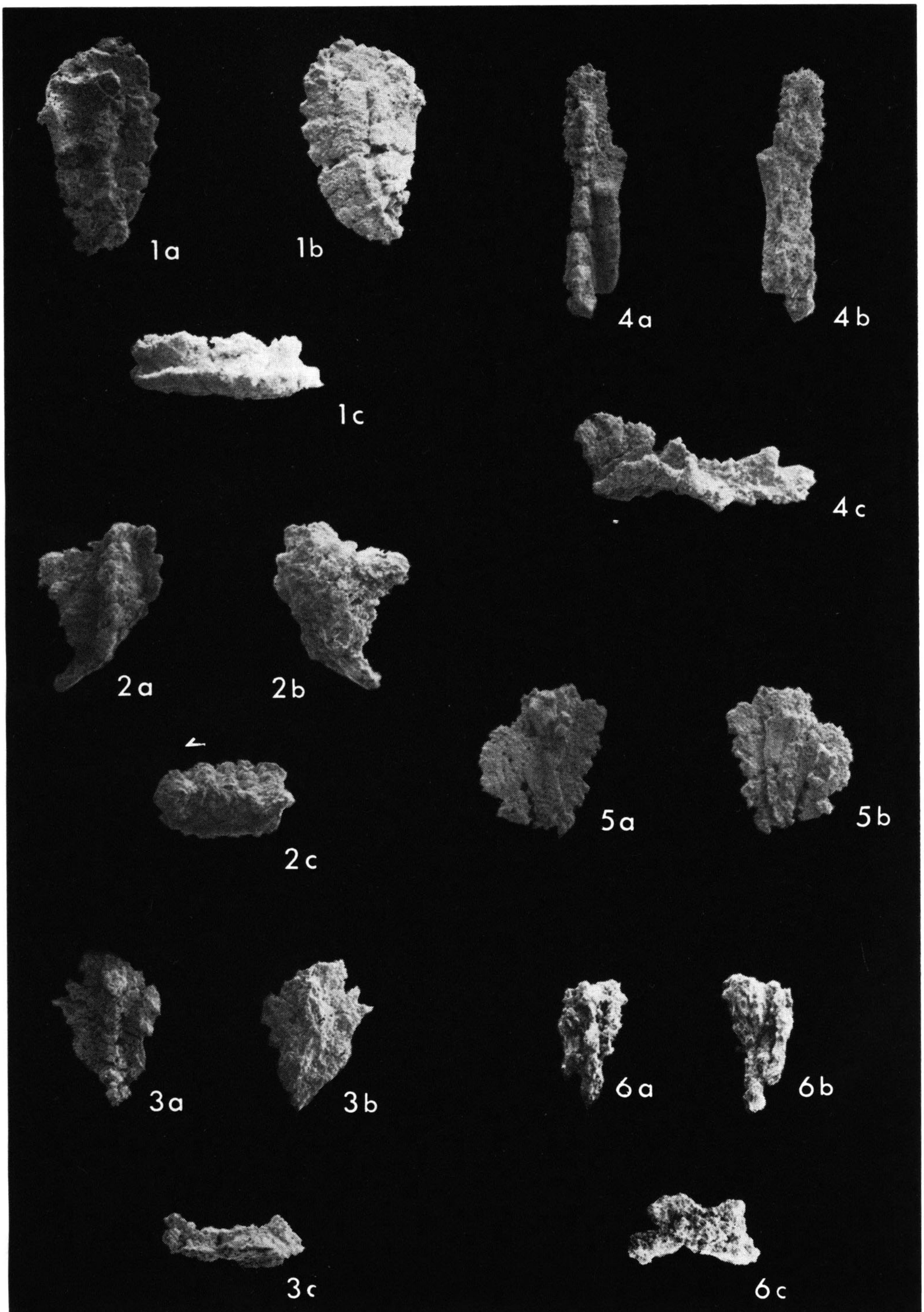
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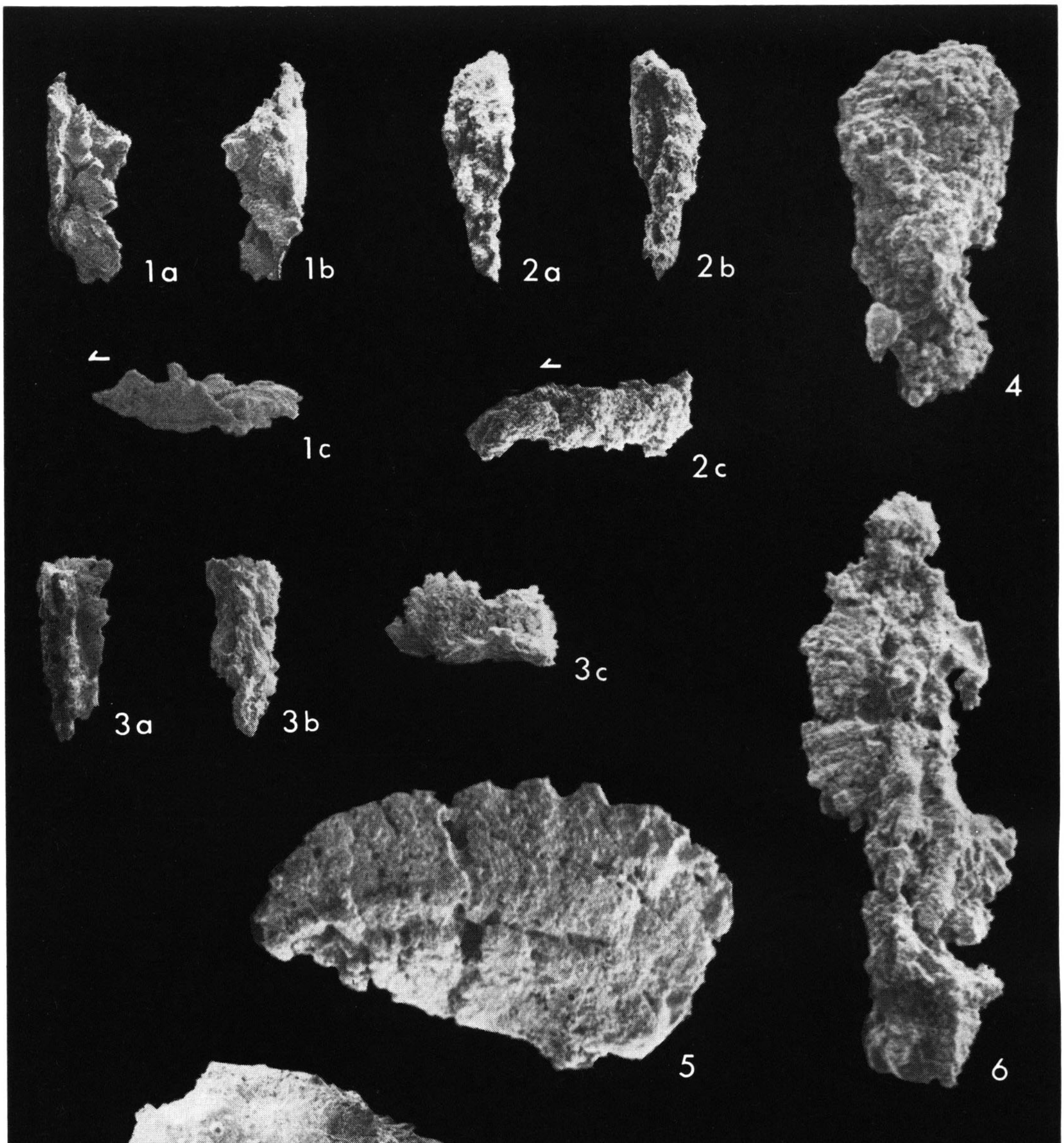
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