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Early Devonian Conodonts and Ostracodes from Central Japan

By

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Abstract The occurrence of Early Devonian microfossils from the Fukuji Formation is reported. The conodonts from the lower part prove that this horizon is equivalent to the *eurekaensis* and *delta* Zones in Nevada, namely the late early and early late Lochkovian (the middle to late Gedinnian) while the ostracodes from the uppermost part of this Formation indicate the age to be the late Emsian.

Introduction

The Fukuji Formation is one of the most representative Devonian sequences in Japan, having been very famous for the occurrence of rich megafaunas. The Formation is virtually the only thick carbonate Devonian succession in Japan, to which many stratigraphical and paleontological contributions have been made, but many problems remain still open (For the review of the previous works on the Paleozoic in the Fukuji area prior to 1981 see IGO & ADACHI, 1981).

Almost all of the previous studies are based on megafossils and only a very few microfossil studies have ever been published (See below). Recently KUWANO (1986) presented a brief note on the occurrence of conodonts and ostracodes from this Formation. The present paper intends to describe the results of microfossil study in detail and to discuss the geological age of this Formation.

Outline of Geology

The studied area is in central Honshu, being located along the western margin of the backbone range of northern Middle Honshu (Fig. 1). Tectonically the area belongs to the Hida Outer Marginal Structural Belt which surrounds the Hida Metamorphic Complex terrane to the north.

The terrane of the Fukuji Formation is very narrow, being restricted to a nearly quadragular small area with a N-S width of about 500 meters and a E-W length of about 700 meters. The survey was carried out along the following two routes (Fig. 2): A. Along the lower reaches of the Ichinotani valley in the west, and B. Along the mountain path named the Fossil Promenade which ascends from the Fukuji village to reach the 1,381 meters high in the west. Except for these two routes no significant stratigraphical work is feasible due to worse exposure.

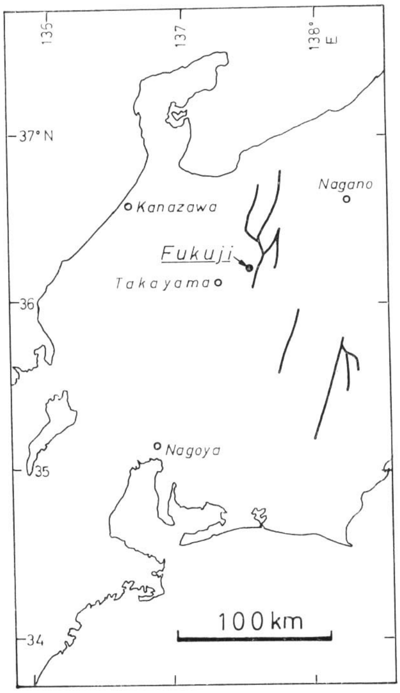

Fig. 1. Index map.

The Paleozoic strata developed along the surveyed routes are classified as follows (Fig. 3).

Permian?: Conglomerate beds represented by a small outcrop at Loc. B (Fig. 2).

Carboniferous: Ichinotani Formation. A highly fossiliferous, carbonate-prevailing sequence with abundant corals, fusulines and smaller foraminiferans.

Devonian: Fukuji Formation. A highly fossiliferous, carbonate-dominating succession with favositids, heliolitids, rugose corals, stromatoporoids, trilobites and brachiopods.

Silurian-Devonian?: A. Unnamed Formation: A highly fossiliferous limestone beds poorly exposed along the western part of the Fossil Promenade with abundant corals nd brachiopods (Locs. 2A–C and 5). B. Yoshiki Formation: A mudstone and tuff succession exposed in the lowermost reaches of the Ichinotani valley between Locs. C and D.

The sampling was made mainly from the Fukuji Formation (Fig. 2, Locs. 1 to 27).

Subdivision of the Fukuji Formation

Ichinotani: The Formation is about 75 meters thick, being subdivided into the following five members (Fig. 4).

Upper shaly member (Usm): 8.5 m
Upper carbonate member (Ucm): 38 m
Middle shaly member (Msm): 6 m
Lower carbonate member (Lcm): 11 m
Lower shaly member (Lsm): 10 m

These lithological units approximately correspond to the subdivisions proposed by the previous authors as follows.

This paper	KAMEI (1955)	OHNO (1977)	NIIKAWA (1980)
Usm	Bed 10	Bed M	D_4, upper part
Ucm	Beds 5 to 9	Beds J to L	D_4, middle and lower parts
Msm	Bed 4, upper part, or Bed 5		D_3
Lcm	Beds 1 to 3	Beds C and D	D_2
Lsm	(Not proposed)	Bed B	D_1

Remarks: OHNO's Bed A and NIIKAWA's D_5 probably belong to the present author's Unnamed Formation of questionable Silurian-Devonian age.

The carbonate members Lcm and Ucm are represented by thick-bedded to massive black to dark grey clayey limestone with frequent intercalations of thin black mudstone layers. The shaly members Lsm, Msm and Usm are composed mainly of black mudstone or black calcareous mudstone with a few small lenses of black clayey limestone. The limestone of this Formation is very clayey and carbonaceous, with numerous thin and short laminae, irregularly shaped patches and thin layers of black mudstone. The high organic clay content of limestone is vey characteristic, which suggests its deposition was not under shallow reefal and/or interreefal conditions but under more deep and intermittently becoming moderately anoxic conditions. In this point the limestone of the Fukuji Formation is quite contrasting to the light-colored limestone of the Unnamed Formation (See below).

The Fukuji Formation is not well exposed in the upstream of Loc. 21 and in the downstream of Loc. 27. The only exception is a very few outcrops of tuff between Locs. 20 and 21. The upper and lower limts af the Formation are not exposed so that the stratigraphical relationships to the other Paleozoic formations can not be determined.

IGO has long claimed that in the Ichinotani valley the Fukuji Formation is overturned to form a succession becoming younger in the upstream direction (IGO & ADACHI, 1981, 1987 *etc.*) but KAMEI (1955), OHNO (1977), NIIKAWA (1980) and others inclusive of the present author do not agree with him. RESEARCH GROUP FOR THE PALAEOZOIC OF FUKUJI (1973) has provided the evidence proving the normal attitude of succession in the Ichinotani valley.

Fossil Promenade: The Fukuji Formation is represented only by small, isolated outcrops of clayey limestone and dark-colored mudstone with lithologies similar to

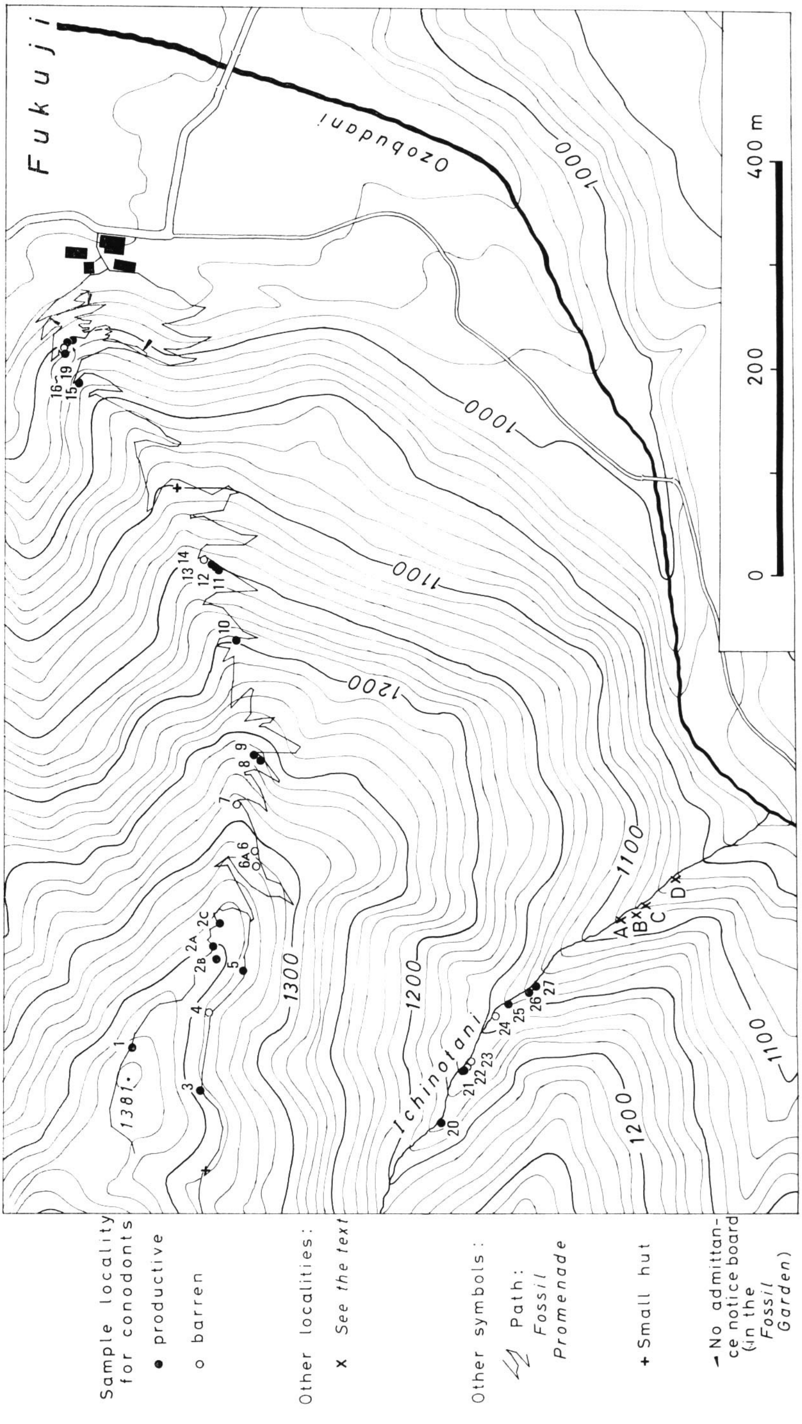

Fig. 2. Locality map. NIIKAWA (1980) collected Carboniferous corals from Loc. A but the outcrop is covered at present.

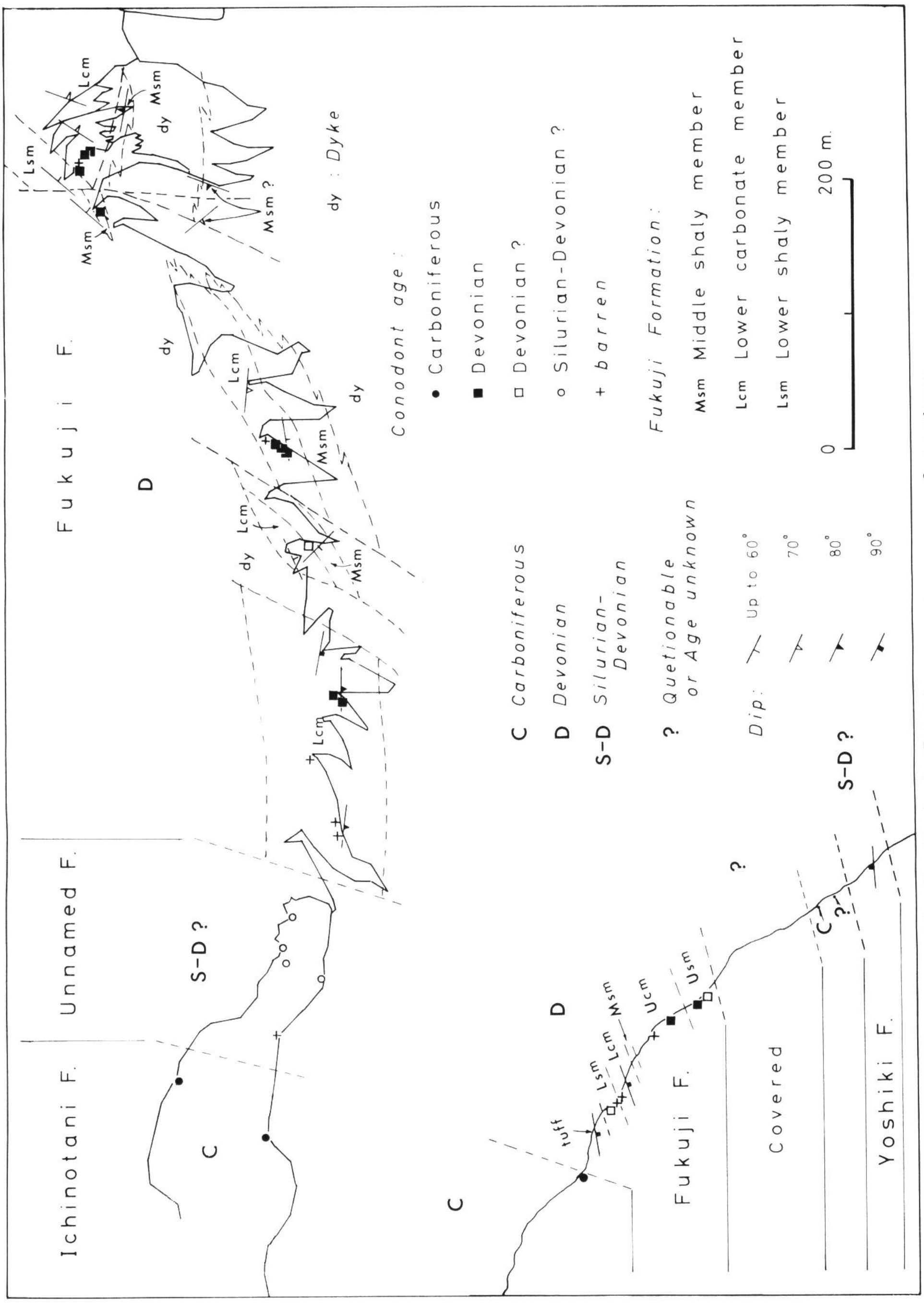

Fig. 3. Geological sketch map and ocurrence of conodonts.

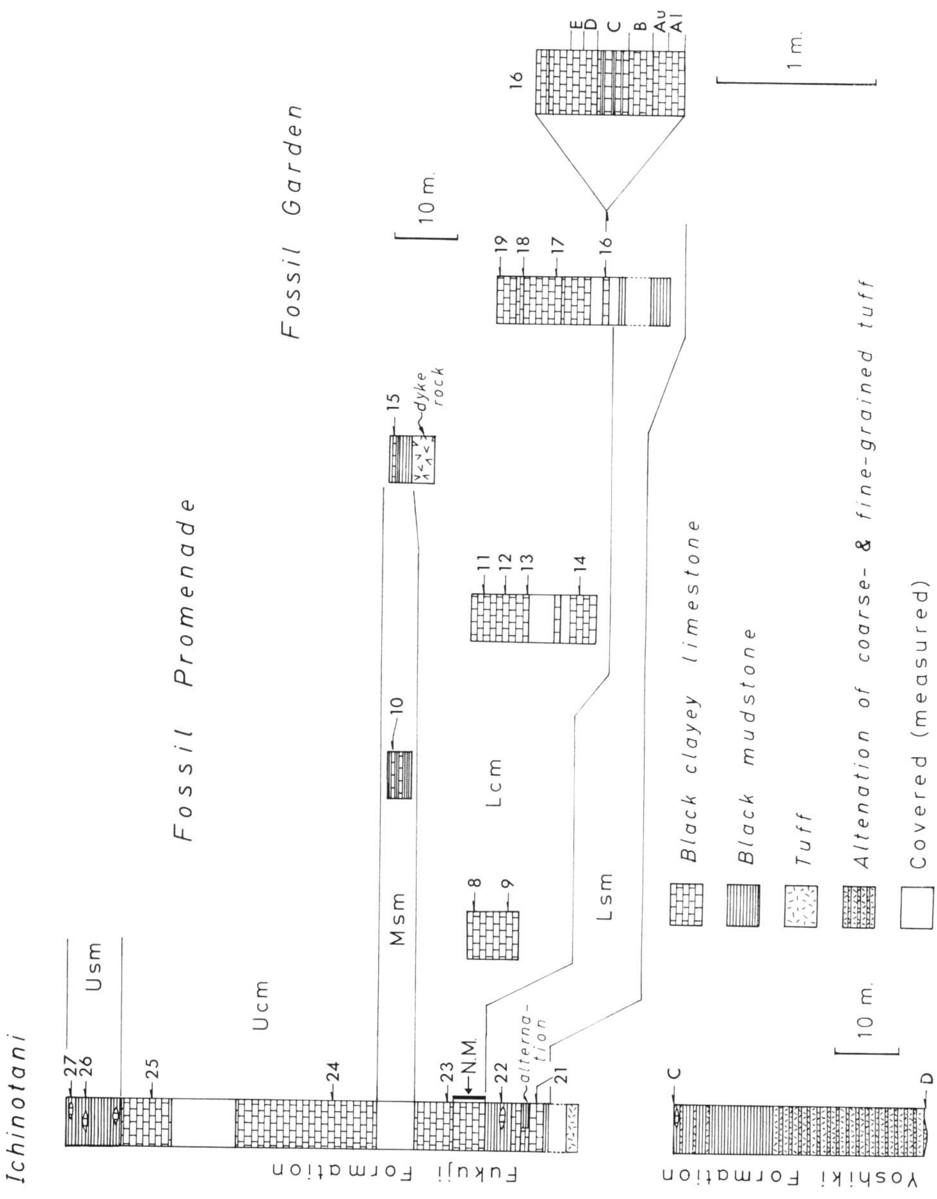

Fig. 4, Stratigraphical columns of the Fukuji and the Yoshiki Formations. For the symbols of lithological units see the text. N.M. denotes the outcrop of the National Natural Monument.

or the same as those developed along the Ichinotani valley. Extensive development of dyke rocks, in the eastern part in particular, prevents to establish the succession. Development of several estimated faults also makes the lithostratigraphical correlation between scattered outcrops very difficult (Figs. 3 and 4).

The only thick and successive sequence is developed in the easternmost part of the Promenade (Locs. 16 to 19). This succession represents the lowest part of the Fukuji Formation, being situated in the Fossil Garden, where the Lower shaly member (ca. 10 m thick) is conformably overlain by the Lower carbonate member (ca. 18 m thick).

Microfossils

Conodonts: From thirty localities thirty five smapls were collected, each of which weighed 1 to 3 kg (fig. 3). Nine samples were barren, the rest yielded few conodonts. The frequency of occurrence is mostly less than 0.5 element/kg.

A. Conodonts from the strata other than the Fukuji Formation.

Locs. 1, 3 and 20 in Table 1 are assigned to the Ichinotani Formation. The yield is very low but all the obtained conodonts are of the Carboniferous.

The conodonts of Locs. 2A–C and 5 are from the Unnamed Formation. The yield is very low and no diagnostic species have been recovered to fix the age as either the Silurian or the Devonian. The insoluble residues from these four samples are mainly composed of light brownish yellow clay flakes stained weakly with iron hydroxide, suggesting the deposition of limestone under oxidative conditions. They are very contrasting to the insoluble residues from clayey limestone of the Fukuji Formation mainly consisting of black carbonaceous mudstone flakes mixed with light grey silica fragments resulted from silica replacement of calcareous skeletons of megafossils.

A barren sample from Loc. 4 also contains oxidized clay fragments similar to those described above from the Unnamed Formation, on the basis of which the limestone of this locality was assigned to the Unnamed Formation.

B. Conodonts from the Fukuji Formation.

Although the obtained conodonts are few in number the following five assemblages have been recognized (In ascending order with the localities which have yielded the diagnostic forms).

I. *Icriodus postwoschmidti* Assemblage
  Lower part of Lcm: 16A1 to 16E

II. Lower *Ozarkodina pandora* group Assemblage
  Middle part of Lcm: 9, 11 to 13 and 18

III. *Amydrotaxis johnsoni* Assemblage
  Upper part of Lcm: 8 and 19.

IV. Upper *Ozarkodina pandora* group Assemblage
  Msm: 15

Table 1. Conodonts

Species	Locality 1	2A	2B	2C	3	5	8
Amydrotaxis johnsoni (KLAPPER) Pb							1
Sa							1
Belodella triangularis (STAUFFER) s.f.		2					
Gnathodus? spp. indet. Pa	2						
Hindeodus? sp. indet. Sc?					1		
Icriodus postwoschmidti MASHKOVA I							
I. cf. *postwoschmidti* MASHKOVA I							
I. cf. *woschmidti woschmidti* ZIEGLER I							
I. sp. (aff. *angustoides* CARLS & GANDL?) I							
I. sp. cordylodiform M							1
I. spp. indet. I							
Idiognathodus sinuosus ELLISON & GRAVES Pa					1		
Ozarkodina excavata excavata (BRANSON & MEHL) Pb							1
Sa-b		1					
Sb						1	
Sc			1			1	
O. cf. *excavata excavata* (BRANSON & MEHL) Pb							
O. pandora MURPHY, MATTI & WALLISER Pa alpha morph							2
O. cf. *pandora* Pa alpha morph							
O. pandra Pa morph nova 1 & 2							
O. cf. *pandora* Pa morph nova 1							
O. cf. *pandora* Pa morph nova 2							
O. remscheidensis (ZIEGLER) Pa							1
O. cf. *remscheidehsis* (ZIEGLER) Pa							
O. sp. A Pb							1
O. sp. B Pb							
O. spp. indet. Pa							8*
Pb							
O.? sp. nov. Pa							
O.? sp. Pb?							2
Oulodus sp. A Sb							1
O. sp. B walliseriform Pa				1			
Panderodus spp. s.f.							
Pedavis? sp. M							
Rotundacodina carlsi DRYGANT s.f.							1
R.? sp. s.f.							1
Streptognathodus lateralis HIGGINS & BOUCKAERT Pa	1						
Gen. et spp. indet. Pa?							
Pb?							
M?							
Sc?	1						
TOTAL	4	3	1	1	2	2	21

* Mainly *pandora* group.

from the Fukuji area.

Promenade														Ichinotani				
9	10	11	12	13	15	16A l	16A u	16B	16C	16D	16E	18	19	20	21	25	26	27
													1					
														4				
						2	1	4	2	3	1							
							1	1										
						1		1										
																1		
						3	4	6		3								
													1					
1													1				1	
2				1				1					1					
					1							3						
													2					
		1	1															
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						1		4		2	4*		4*					
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	2	2		7		8	1	30		1	1					7	5	1
						1		1		1								
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			1															
1																		
4	2	3	2	9	2	16	7	49	2	11	7	3	13	4	1	8	6	1

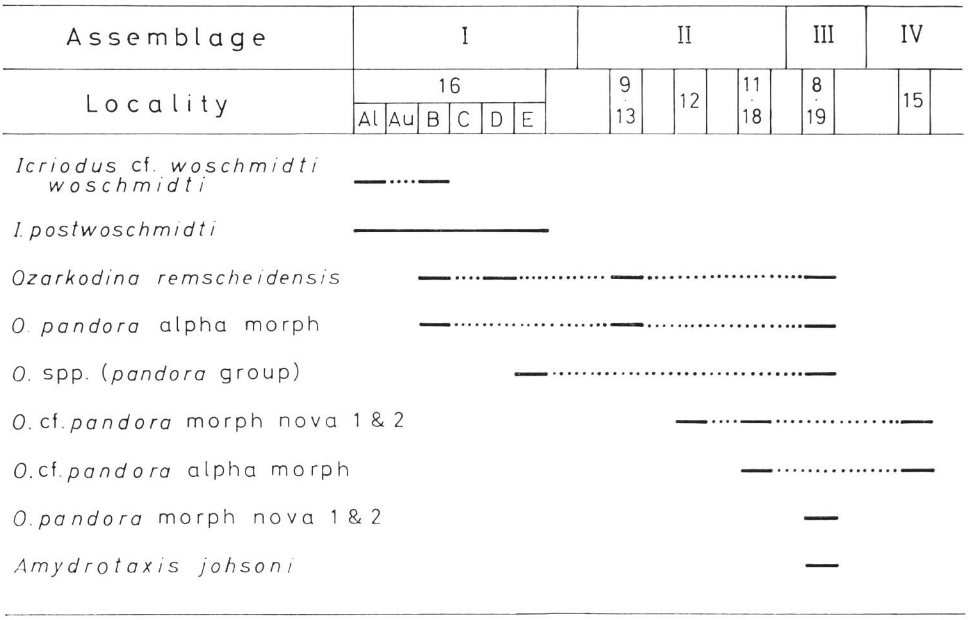

Fig. 5, Composite range chart of selected conodonts from the Lower carbonate and the Middle shaly members. For the Assemblages I to IV see the text.

V. *Icriodus* aff. *angustoides* Assemblage
Upper part of Ucm: 25

Among these I to IV are from the Promenade and V from the Ichinotani valley. In Fig. 5 are shown the ranges of the representative species of Assemblages I to IV.

I. postwoschmidti Assemblage: It is generally accepted that the Silurian-Devonian boundary is marked by the appearance of a graptolite *Monograptus uniformis*. This boundary is included in the conodont zones defined by the range of *Icriodus woschmidti woschmidti* or *I. woschmidti hesperius*. Both of these subspecies have the range from the top Pridolian to lowest Lochkovian, spanning the Latest Silurian to the Earliest Devonian (SCHÖNLAUB, 1985; SCHÖNLAUB *in* CHULPÁČ *et al.*, 1985). *I. postwoschmidti* is known usually from the post-*woschmidti* Interval just overlying the *woschmidti* or *hesperius* Zones (ZIEGLER *in* ZIEGLER, ed., 1975). The near equivalent of the post-*woschmiditi* Interval in Nevada is named the *eurekaensis* Zone although *I. postwoschmidti* has not been found. *I. postwoschmidti* was recorded from the equivalent of *eurekaensis* Zone in Spain (KLAPPER & ZIEGLER, 1979) and from the near equivalent of post-*woschmidti* Interval, namely the upper half of lower Lochkovian of the Barrandian area in Czechoslovakia (CHULPÁČ, 1977). BROADHEAD & MCCOMB (1983) show that *I. postwoschmidti* is restricted to the *eurekaensis* Zone, although DRYGANT (1984) reported this species from a little higher horizon, namely his late Gedinnian. On the basis of these records the *Icriodus postwoschmidti* Assemblage in Fukuji can be assigned to the late early Lochkovian and to the *eurekaensis* Zone.

Amydrotaxis johnsoni Assemblage: *A. johnsoni* is one of the zone indices of the *delta* Zone in Nevada (KLAPPER & MURPHY, 1980; MURPHY & MATTI, 1982; MURPHY & BERRY, 1983) so that the *A. johnsoni* Assemblage in Fukuji can be correlated to a part of the *delta* Zone although many ancyrodelloidiids such as *A. omus*, *A. transitans*, *A. eleanorae*, *A. asymmetricus* and and ozarkodinid such as *O. stygia*, all well known from the *delta* Zone and its equivalent, are not yet found in the Fukuji area.

Lower *Ozarkodina pandora* group Assemblage: This assemblage may be correlated to the uppermost part of *eurekaensis* Zone because of its occurrence from the interval between the above discussed two assemblages but this correlation raises a problem about the range of *Ozarkodina pandora* alpha morph in the Fukuji area.

In Nevada this morph and *Ancyrodelloides omus* range from the topmost horizon of the *eurekaensis* Zone to the overlying *pesavis* and *sulcatus* Zones (MURPHY & MATTI, 1982; MURPHY & BERRY, 1983), In contrast in the Carnic Alps and the Barrandian area in Czechoslovakia this morph appears later than in Nevada, later than the first appearance of the above-mentioned ancyrodelloidiids and ozarkodinid, with the range spanning from the uppermost Lochkovian to the lower Pragian (SCHÖNLAUB *in* CHULPÁČ *et al.*, 1985), namely the correlative to the upper *pesavis* and the lower *sulcatus* Zones in Nevada.

As for the *O. pandora* group as a whole it is noticed that in the Carnic Alps *O.* cf. *pandora* appears at the level a little lower than the appearance of *Ancyrodelloides transitans* and *Ozarkodina stygia* (SCHÖNLAUB, 1985; the Oberbuchach II section). This suggests the *pandora* group appeared there in the lower or the lowest part of the *delta* Zone just like in Nevada. In the Fukuji area the appearance of *O. pandora* alpha morph seems to be earlier than in any of the areas above referred to. It occurs from the interval of *I. postwoschmidti* Assemblage (Loc. 16B) so that the range should be extended downward further into the *eurekaensis* Zone at least in the Fukuji area.

In Nevada there is a horizon which yields *Ozarkodina remscheidensis* only between the level of disappearance of *Ozarkodina eurekaensis* and the level of appearance of *Amydrotaxis johnsoni*, namely the upper part of the *eurekaensis* Zone (the upper part of *uniformis* graptolite Zone; MURPHY & MATTI, 1982; MURPHY & BERRY, 1983). If the upper limit of *I. postwoschmidti* in Fukuji correlates to the upper limit of *O. eurekaensis* this *O. remscheidensis* interval in Nevada may be correlated to the Lower *O. pandora* group Assemblage interval in Fukuji.

Upper *Ozarkodina pandora* group Assemblage: The age of this assemblage and the upper age limit of the underlying *Amydrotaxis johnsoni* Assemblage remain as open problems. *A. johnsoni* ranges from the *delta* to the lower *sulcatus* Zones in Nevada. The most part of the *delta* Zone is characterized by the Pa alpha morph of *A. johnsoni* while from the top of the *delta* Zone to the lower part of the *sulcatus* Zone by the Pa beta morph of the same species. It is unfortunate that no Pa elements have been found yet in the Fukuji area, so that the exact correlation is impossible. Taking into account that the stratigraphical interval of the *A. johnsoni* Assemblage is very thin in Fukuji, this assemblage and the overlying Upper *O. pandora* group Assemblage altogether might be assigned to the *delta* Zone although no positive data have been obtained yet.

Icriodus aff. *angustoides* Assemblage: This assemblage is tentatively defined by the occurrence of a small fragment of I element only, but if this speciemen belongs to *I. angustoides angustoides* it might be correlated to the *pesavis* and *sulcatus* Zones, namely the late late Lochkovian and the early Pragian (the latest Gedinnian and the early Siegenian) (KLAPPER & ZIEGLER, 1979; BROADHEAD & MCCOMB, 1983).

Summarizing the above the Lower carbonate member and the Middle shaly member are assignable to the late early and the early late Lochkovian, being approximately paralleled to the *eurekaensis* and the *delta* Zones in Nevada (the middle to late Gedinnian). The upper part of the Upper carbonate member might be correlated to the late late Lochkovian to the early Pragian, but it needs further studies.

Discussion: IGO *et al.* (1975) illustrated *Ozarkodina remscheidensis* and *Icriodus woschmidti woschmidti* from the lower part of the Fukuji Formation. The sampled horizon is the lower part of the present author's Lower carbonate member, probably being the same as Loc. 16. Their *I. w. woschmidti* can not be assigned to either *I. w. woschmidti* or *I. w. hesperius*. The figured two icriodiid elements might be transitional forms between *I. w. woschmidti* and *I. postwoschmidti* or slightly aberrant *postwoschmidti* judged from well developed spur.

OHNO (1977) reported the occurrence of *Icriodus rectangularis* or *I. huddlei curvicauda* from a little higher horizon without giving illustrations. These icriodids are distinct species from *I. postwoschmidti* and were not found by the present author. Having suspicted IGO *et al.*'s identification OHNO did not agree with their age assignment of the lowermost carbonate horizon to the earliest Gedinnian. OHNO referred the Fukuji Formation as a whole to the Siegenian to the Emsian but his conclusions that the lower part of this Formation is assigned to the Siegenian can not be supported because of the occurrence of *I. postwoschmidti*.

Recently IGO & ADACHI (1987) have reported again the occurrence of *I. woschmidti* from the lowermost carbonate horizon of the Fukuji Formation. The figured specimen is very well preserved, having a very widely expanded basal cavity with a well developed spur and a more or less distinct sinus and also having a wide and distinct postero-lateral process which bears a few small nodes. These morphological features are not characteristic either of *I. w. woschmidti* (Compare with the holotype, ZIEGLER *in* ZIEGLER, ed., 1975, pl. 5, fig. 1) or of *I. w. hesperius* (KLAPPER & MURPHY, 1975, pl. 11, fig. 13, the holotype). To the present author's opinion this icriodid should be assigned to *I. postwoschmidti*.

The lower age limit of the carbonate part of this Formation is thus the middle Gedinnian (the late early Lochkovian), not the earliest Gedinnian as IGO *et al.* (1975) and IGO & ADACHI (1987) have concluded. No conodonts have ever been found from the exposed lowest part of this Formation, namely the Lower shaly member, and there remains a possibility that the earliest Gedinnian might be included in this horizon.

The informations about the conodont occurrence as related to the upper age limit of the Fukuji Formation were given by IGO *et al.* (1975). On the basis of occurrence of *Panderodus striatus striatus* and *Panderodus subquadratus* they suggested that the upper part of the Fukuji Formation might be assigned to the late Emsian. These conodonts are from Bed 9 of KAMEI (1955), namely the top of the Upper carbonate member of the present author. It is interesting that the late Emsian ostracode assemblage has been found from Loc. 26 which belongs to the Upper shaly member (KAMEI's Bed 10) as described below and that these late Emsian conodonts and osstracods have been collected from the nearby horizons although IGO *et al.* did not give the exact locality of the above-mentioned panderodontids.

Ostracodes: A sample from the Upper shaly member of the Fukuji Formation (Loc. 26) has yielded a very rich silicified and partially pyritized ostracode fauna (Pls. 5 to 9). The results of identification are shown in Table 2.

The previous records of several identified species are as follows.

Acravicula? moniellana

Late Emsian of Spain (BECKER & SÁNCHEZ DE POSADA, 1977); Early and late Emsian of France (FEIST & GROOS-UFFENORDE, 1979)

Ampuloides avus

Late Lochkovian to late Pragian of East Germany (I. ZAGORA, 1967); Siegenian and Emsian of the Carnic Alps; late Lochkovian and Pragian of West Germany; middle Emsian of Sahara (BANDEL & BECKER, 1975); Early and late Emsian of France (FEIST & GROOS-UFFENORDE, 1979)

Berounella spinosa

Pragian of West Germany (GROOS-UFFENORDE & JAHNKE, 1973); Siegenian of the Carnic Alps (BANDEL & BECKER, 1975); Late Emsian of Spain (BECKER & SÁNCHEZ DE POSADA, 1977); Emsian (and early? Eifelian) of Australia (REYNOLDS, 1978); Early and late Emsian of France (FEIST & GROOS-UFFENORDE, 1979)

Nezamyslia walliseri

Late Emsian of France (FEIST & GROOS-UFFENORDE, 1979)

Tricornina robusticerata

Frasnian of East Germany (BLUMENSTENGEL, 1969); Emsian (and early? Eifelian) of Australia (REYNOLDS, 1978); Early and late Emsian of France (FEIST & GROOS-UFFENORDE, 1979); Earliest late Famennian of Belgium (DREESEN *et al.*, 1985)

Tricornina? caurina

Emsian of western Canada (BERDAN & COPELAND, 1973)

From these stratigraphical distribution this ostracode assemblage can be surely assigned to the late Emsian.

There has been only one paper on the ostracode from the Fukuji Formation (HAMADA, 1959). He described a new leperditiid but this species has not been found later and its exact locality and horizon can not be confirmed at present, so that this only record is useless for age assignment and long-distance correlation.

Table 2. Ostracodes from the Fukuji Formation, Loc. 26.

Acanthoscapha cf. *acris* BLUMENSTENGEL
A. sp. A
A. sp. B
A. sp. C
A. sp. D
A. sp. E
Acravicula? moniellana BECKER & SÁNCHEZ DE POSADA
A.? sp.
Ampuloides avus I. ZAGORA
Aparchites cf. *crumena* (KUMMEROW)
A.? sp.
Amphissella? sp. A
Baschikirina sp. A
B. sp. B
B.? sp.
Berounella spinosa (BLUMENSTENGEL)
Cavanites? sp. A
C.? sp. B
Ctenoloculina cf. *myurilobota* KESLING
Hibbardia sp. A
H. sp. B
Kirkbyella (Berdanella) sp. A
K. (B.) sp. B
Krausella? sp.
Monoceratina sp. A
M. sp. B
Nezamyslia walliseri GROOS-UFFENORDE
N. sp. A
Parabolbina sp. A
P. sp. B
Schohariella sp. A
Semibolbina? sp. A
Tricornina robusticerata BLUMENSTENGEL
T. sp.
T.? caurina BERDAN & COPELAND
Genus indet. sp. A
Genus indet. sp. B
Genus indet. sp. C
Genus indet. sp. D
Genus indet. sp. E
Genus indet. sp. F
Genus indet. sp. G

Geological Age of the Fukuji Formation

The geological age of this Formation has long been in dispute. The estimated age is the Siegenian to the early? Eifelian (KOBAYASHI & HAMADA, 1974, trilobites), the Siegenian to the Emsian (RESEARCH GROUP FOR THE PALAEOZOIC OF FUKUJI, 1973, rugose corals; OHNO, 1977, brachiopods) and the earliest Gedinnian to the late Emsian?, IGO *et al.*, 1975, conodonts). The present study has revealed that the lowermost carbonate part of the Formation is assignable to the late early Lochkovian by conodonts and the uppermost shaly part to the late Emsian by ostracodes.

Recently new informations on the occurrence of megafossils from Fukuji are rapidly increasing, *e.g.* a bellerophotacean gastropod (KASE *et al.*, 1985; from the Lsm), spyroceratid orthocone cephalopods (NIKO & NISHIDA, 1986; from the Lsm), receptaculitids (NIKO & HAMADA, 1987: from the Lsm?) and a hyolith (KASE *et al.*, 1987: from the Msm). All of these papers are concerned with the first discovery of these taxa from Japan or from the Japanese Devonian and it seems too early to make more precise age assignment on the basis of these new informations.

Although the age of the basalmost part of the Fukuji Formation (the Lsm) is still unknown and the stratigraphical relations to the under- and overlying strata can not be determined, this Formation can be assigned to the Early Devonian as a whole. It awaits further studies to recognize the Silurian-Devonian boundary in the studied area. The search for the monograptid graptolites and other effective marker taxa is needed.

Acknowledgements

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Explanations to the Plates

All figures are the back scattering images of Au-coated specimens by the use of JEOL T-300 scanning electron microscope. MPC denotes National Science Museum (Tokyo), Micropaleontology Collection.

Plate 1

Figs. 1–8. *Icriodus postwoschmidit* MASHKOVA. Eight incomplete I elements with basal cavity flare lacking. Upper view. 2: Loc. 16Al, MPC 3809. 3, 5, 6: Loc. 16B, MPC3810, 3812, 3813. 8: Loc. 16C, MPC3815. 1, 4, 7: Loc. 16D, MPC3808, 3811, 3814.

9–11. *Amydrotaxis johnsoni* (KLAPPER). 9, 10: Pb element. Outer lateral and upper views. The basal cavity is partially broken off at the middle part of left (inner) side (Fig. 10). Loc. 8, MPC3801. 11: A broken Sa element. Oblique posterior view. Loc. 19, MPC3802.

All are from the Fukuji Formation. 1–9, ×77; Others, ×103.

Plate 2

Figs. 1–6. *Ozarkodina remscheidensis* (ZIEGLER). Three Pa elements. Lateral and upper views. 1, 4: A broken specimen. Loc. 16B, MPC3855. 2, 5: Loc. 16D, MPC3856. 3, 6: Loc. 8, MPC3857.

7. *Pedavis?* sp. M element. Posterior view. Loc. 16B, MPC3887.

8. *Idiognathodus sinuosus* ELLISON & GRAVES. Pa element. Upper view. Loc. 3, MPC3831.

9. *Streptognathodus lateralis* HIGGINS & BOUCKAERT. Pa element with posterior end broken off. Upper view. Loc. 1, MPC3893.

Figs. 8 and 9 are from the Carboniferous Ichinotani Formation. Others from the Fukuji Formation. 1, 2, 4, 5, 9, ×77; Others, ×103.

Plate 3

Figs. 1–8. *Ozarkodina pandora* MURPHY, MATTI & WALLISER. Four Pa elements alpha morph. Lateral and upper views. 1, 4: Loc. 9, MPC3841. 2, 5: Loc. 8, MPC3842. 3, 6: A broken specimen. Loc. 8, MPC3843. 7, 8: A broken specimen. Fig. 7 is the slightly oblique lateral view. Loc. 13, MPC3844.

9. *Amydrotaxis johnsoni* (KLAPPER). Sa element. Posterior view. Loc. 8, MPC3803.

All are from the Fukuji Formation. 1, 3, 4, 6–8, ×77; Others, ×103.

Plate 4

Figs. 1, 4. *Ozarkodina pandora* MURPHY, MATTI & WALLISER. A broken Pa element alpha morph. Lateral and upper views. Loc. 19, MPC3845.

2, 3, 5, 6. *O. pandora* MURPHY, MATTI & WALLISER. Two broken Pa elements morph nova. Lateral and upper views. Loc. 19. 2, 5: Morph nova 1. The right (outer) side basal cavity flare is missing (Fig. 5). MPC3850. 3, 6: Morph nova 2. The antero-lateral part of right (outer) side basal cavity flare is broken off (Fig. 6). MPC3853.

7. *Ozarkodina* sp. B. Pb element. Lateral view. Loc. 19, MPC3860.

8. *Ozarkodona* cf. *excavata excavata* (BRANSON & MEHL). Pb element. Lateral view. Loc. 19, MPC4840.

9. *O. excavata excavata* (BRANSON & MEHL). Sc element. Lateral view. Loc. 2B, MPC3834.

Fig. 9 is from the Unnamed Formation (Silurian-Devonian?). Others from the Fukuji Formation. 3, 6, ×51; 2, 7, 9, ×77; Others, ×103.

Plate 5

All the ostracodes and a trilobite on Plates 5 to 9 are from the Fukuji Formation, Loc. 26.

Fig. 1. *Acanthoscapha* sp. A. MPC3900.
2. *A*. sp. B. MPC3902.
3. *A*. sp. C. MPC3904.
4. *A*. sp. D. MPC3907.
5. *A*. sp. E. MPC3908.
6. *Acravicula? moniellana* BECKER & SÁNCHEZ DE POSADA. MPC3909.
7. *Ampuloides avus* I. ZAGORA. MPC3914.
8. *Aparchites* cf. *crumena* (KUMMEROW). MPC3917.
9. *A.?* sp. MPC3918.
10. *Amphissella?* sp. MPC3919.
1, ×51; 2, 8, 9, ×103; Others, ×77.

Plate 6

Fig. 1. *Baschkirina* sp. A. MPC3923.
2. *B*. sp. B. MPC3928.
3–6. *Berounella spinosa* (BLUMENSTENGEL). Lateral and dorsal views. 3, 4: MPC3935. 5, 6: MPC3936.
7, 8. *Cavanites?* sp. A. 7: MPC3948. 8: A specimen with antero-dorsal corner missing. MPC3949.
9, 10. *Cavanites?* sp. B. 9: MPC3950. 10: MPC3951.
11. *Ctenoloculina* cf. *myurilobota* KESLING. MPC3953.
1, ×103; 2, 9, ×77; Others, ×51.

Plate 7

Fig. 1. *Hibbardia* sp. A. MPC3954.
2, 3. *H*. sp. B. MPC3956, 3957.
4. *Kirkbyella (Berdanella)* sp. A. specimen with postero-dorsal corner broken. MPC3962. [*K. (B.)* cf. *verticalis* (CORYELL & CUSKLEY)] A
5. *K. (B.)* sp. B. MPC3965. [*K. (B.)* cf. *quadrata* (CRONEIS & GUTKE)]
6. *Monoceratina* sp. A. MPC3967.
7. *M*. sp. B. MPC3968.
8. *Nezamyslia walliseri* GROOS-UFFENORDE. A broken specimen. MPC3967.
9. *N*. sp. A. A broken specimen. MPC3970.
1, ×103; 8, ×51; Others, ×77.

Plate 8

Fig. 1. *Parabolbina* sp. A. MPC3973.
2. *P*. sp. B. MPC3975.
3. *Schohariella* sp. A. MPC3977.
4. *Semibolbina?* sp. A. MPC3980.
5, 6, *Tricornina robusticerata* BLUMENSTENGEL. Lateral and dorsal views. MPC3981.
7, *T.? caurina* BERDAN & COPELAND. MPC3984.
8. Genus indet. sp. A. MPC3986.
9. Genus indet. sp. B. MPC3987.
10. Genus indet. sp. C. MPC3988.
1, 2, 5–7, ×51; 3, ×39; 4, 9, ×77; 8, 10, ×103.

Plate 9

Fig. 1. Genus indet. sp. D. MPC3989. [*Pseudoparaparchites?*]
2, 4. Genus indet. sp. E. MPC3990, 3991. [*Bicornina?*]
3. Genus indet. sp. F. MPC3992. [*Pseudoparaparchites?*]
5. *Acanthoscapha* cf. *acris* BLUMENSTENGEL. MPC4898.
6. Trilobita gen. et sp. indet. MPC3993.
7. *Krausella?* sp. MPC3966.
8. *Berounella spinosa* (BLUMENSTENGEL). MPC3937.
9. *Baschkirina* sp. B. MPC3929.
10. *Acravicula? moniellana* BECKER & SÁNCHEZ DE POSADA. MPC3910.
1, 5, ×103; 2–4, 6, 10, ×77; 7–9, ×51.


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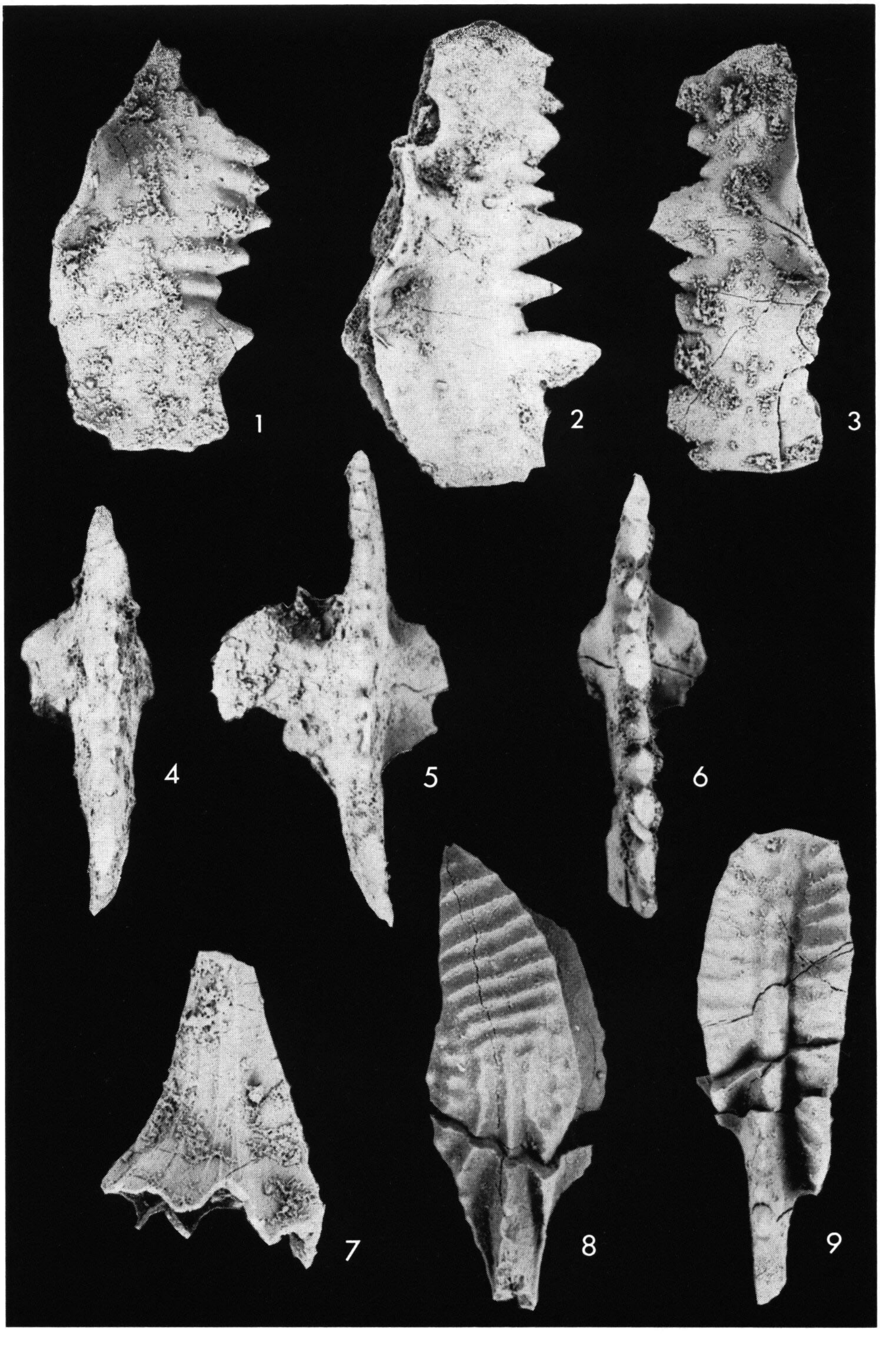
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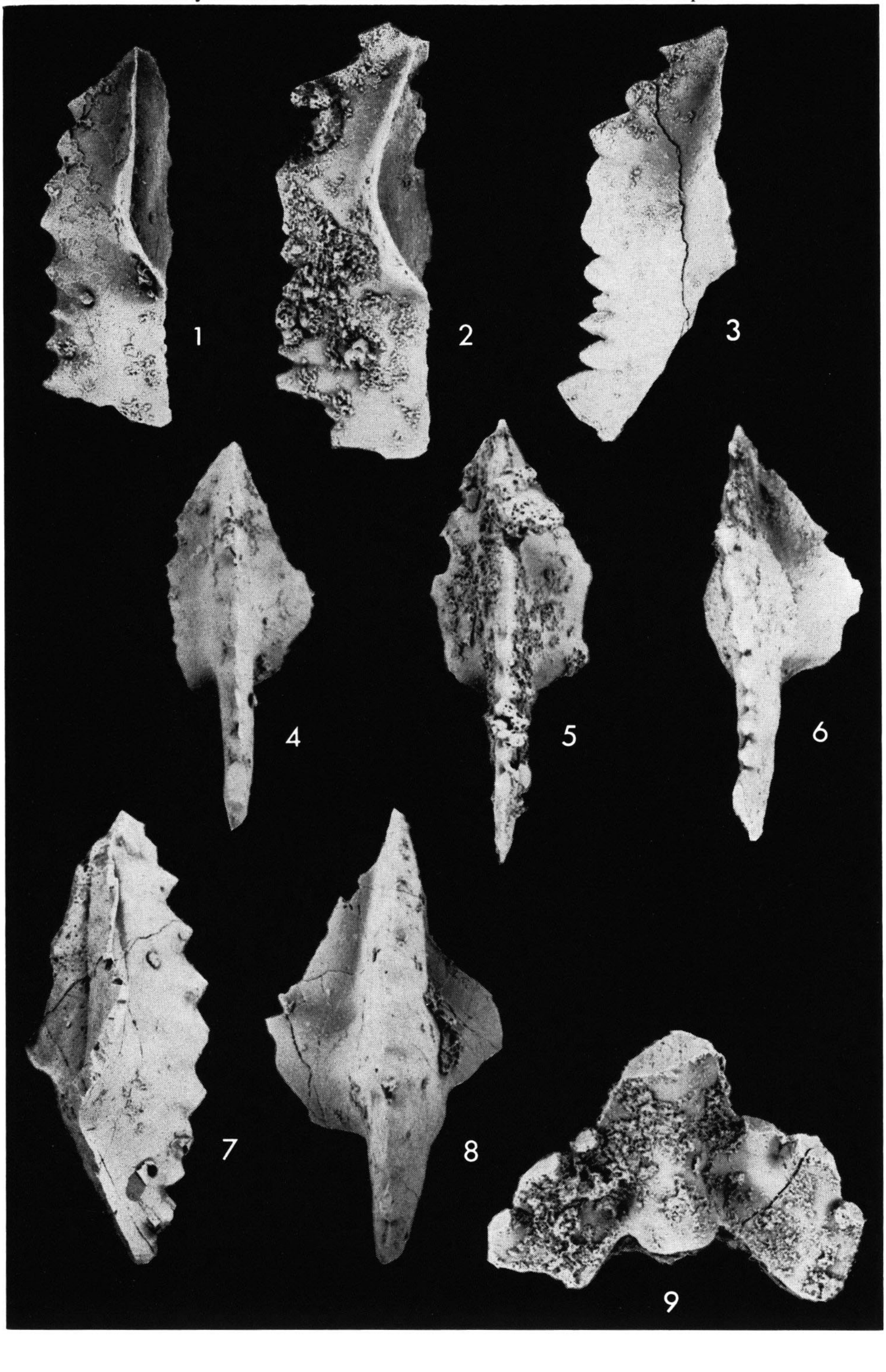
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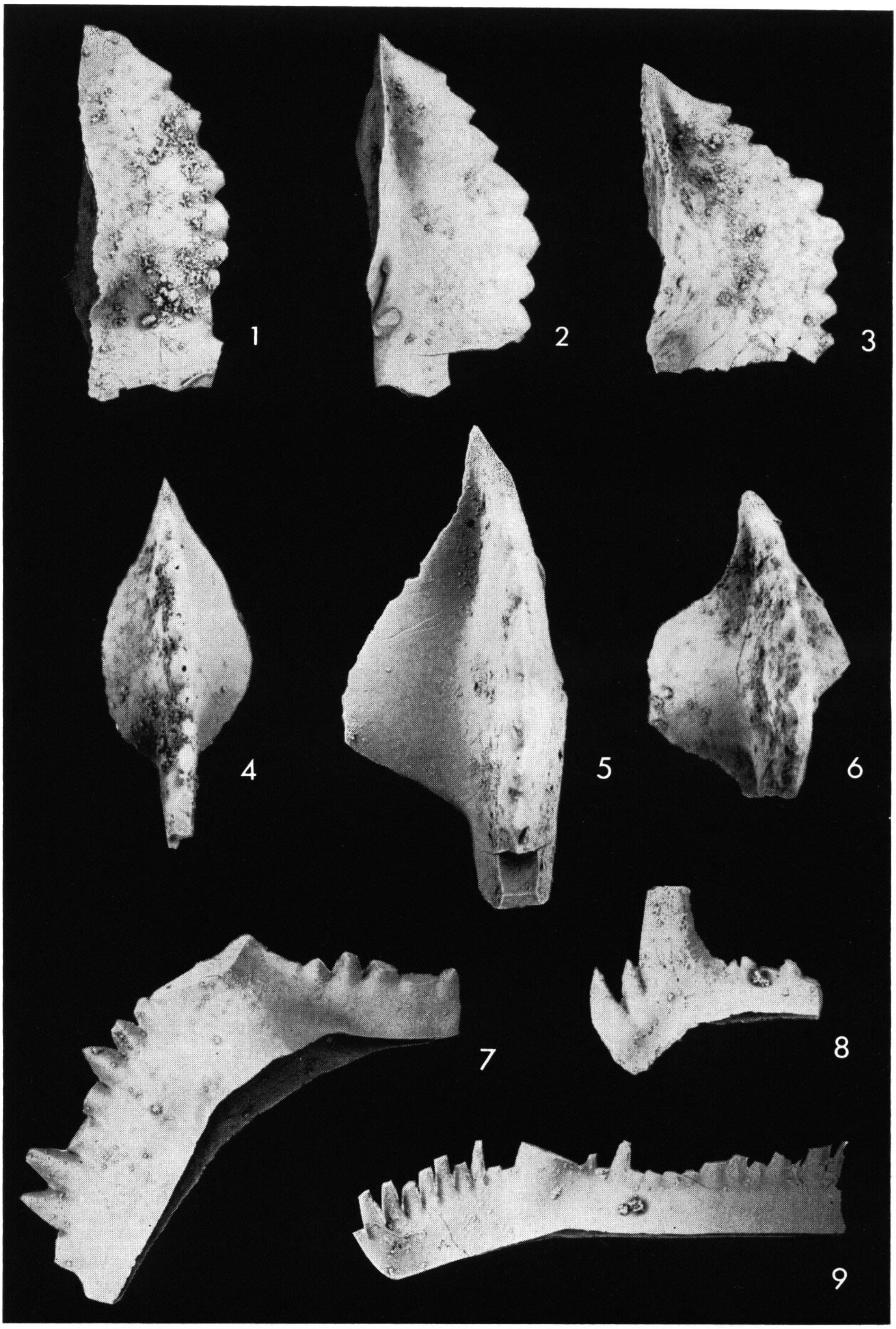
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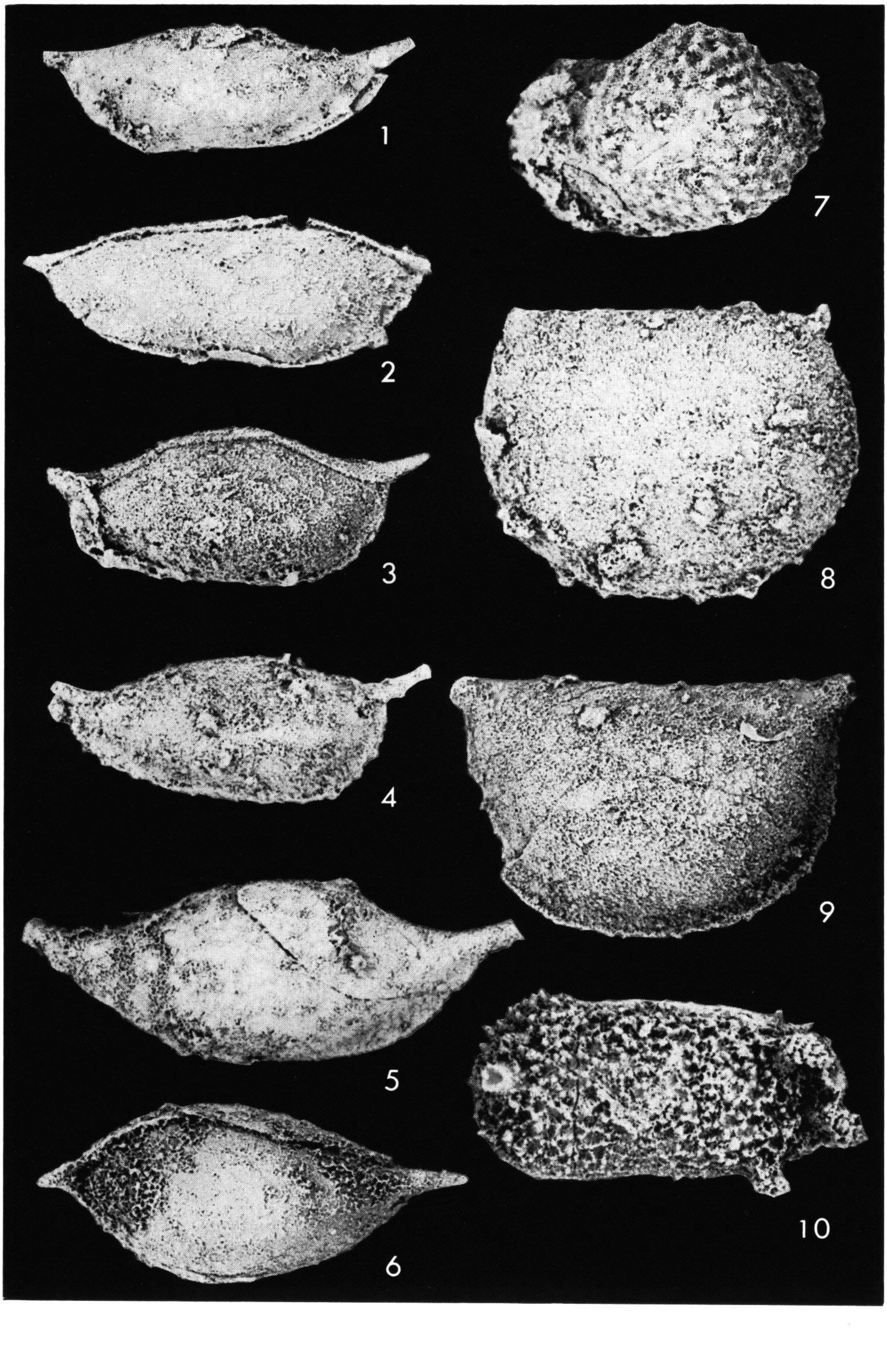
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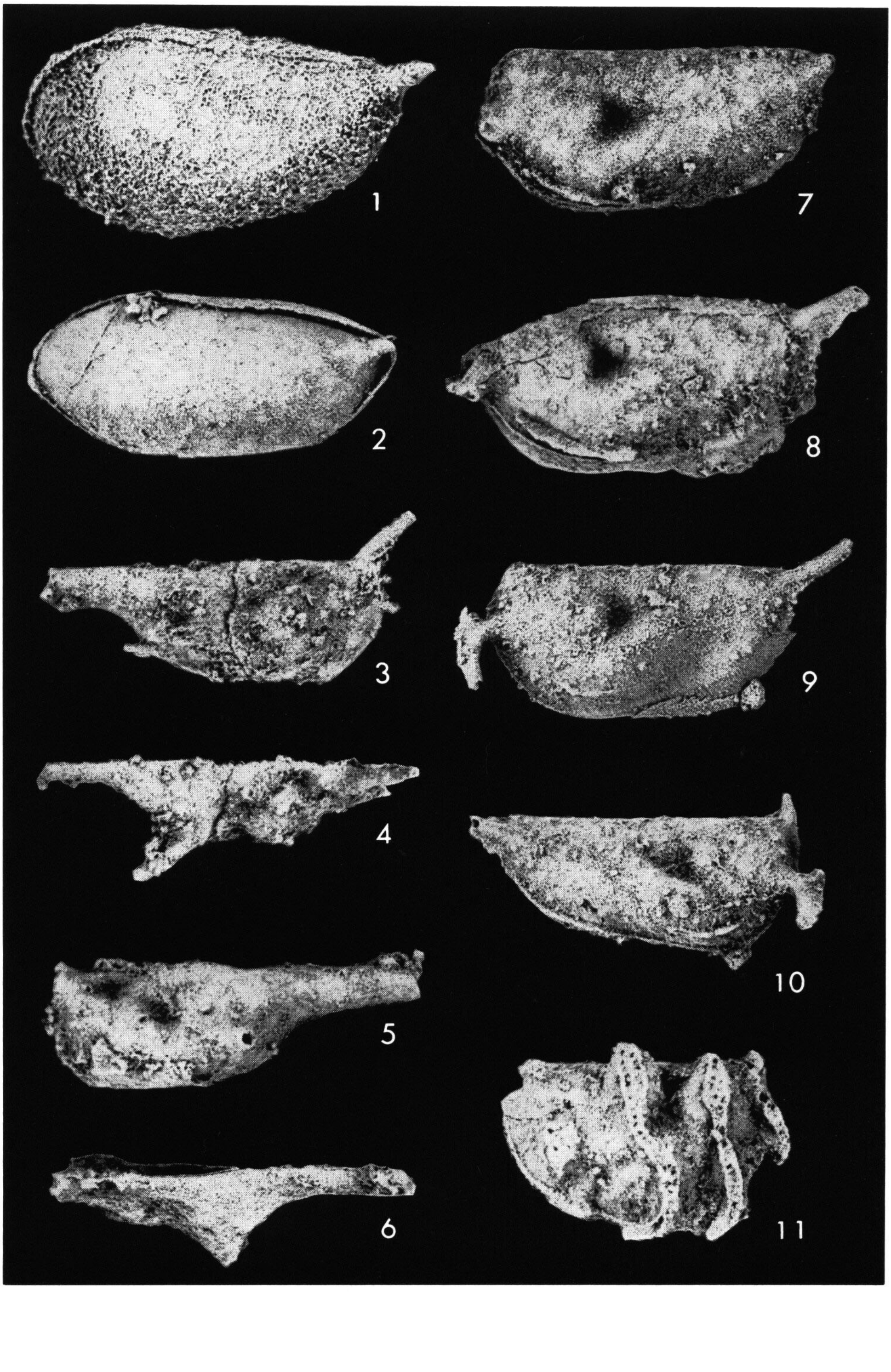
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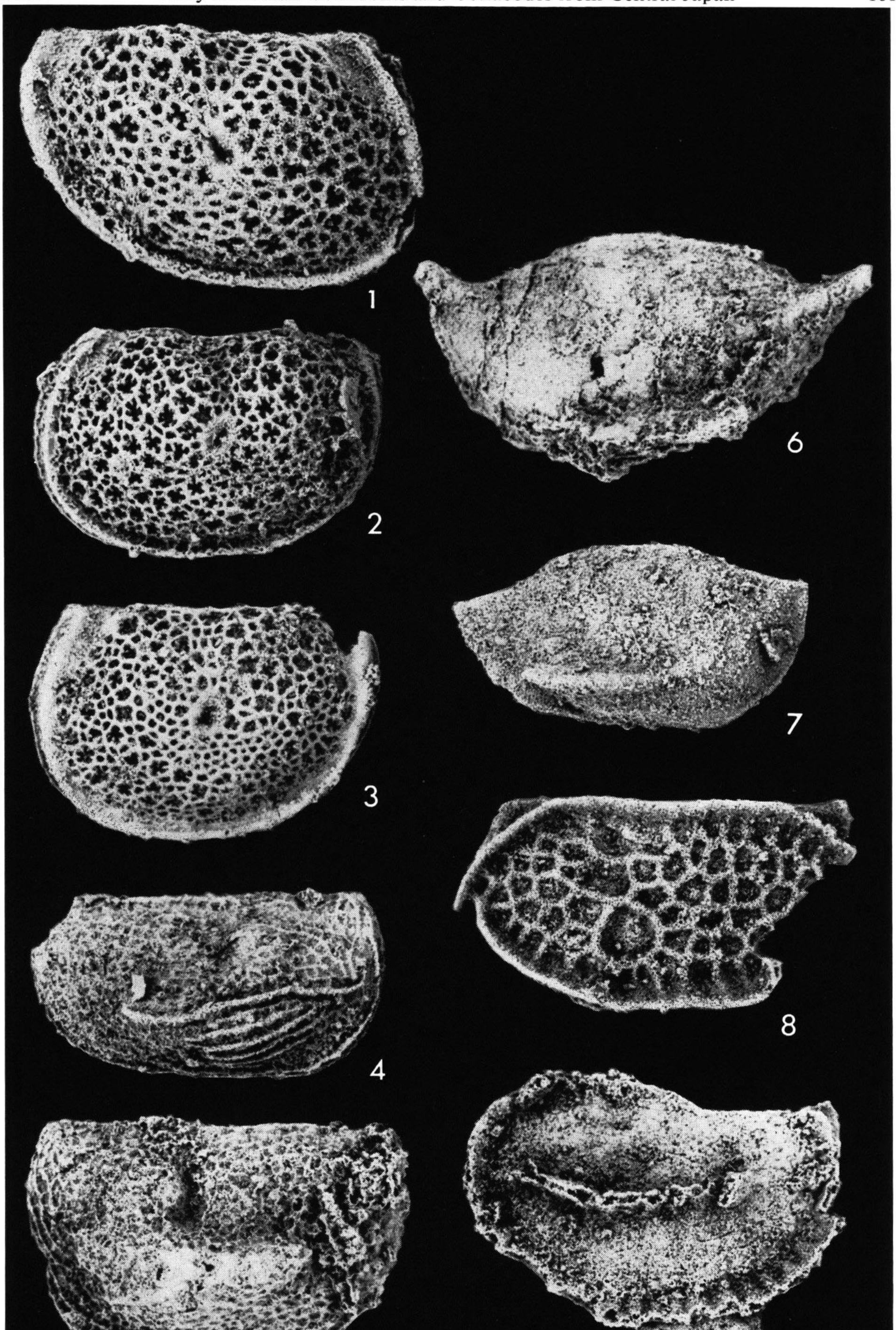
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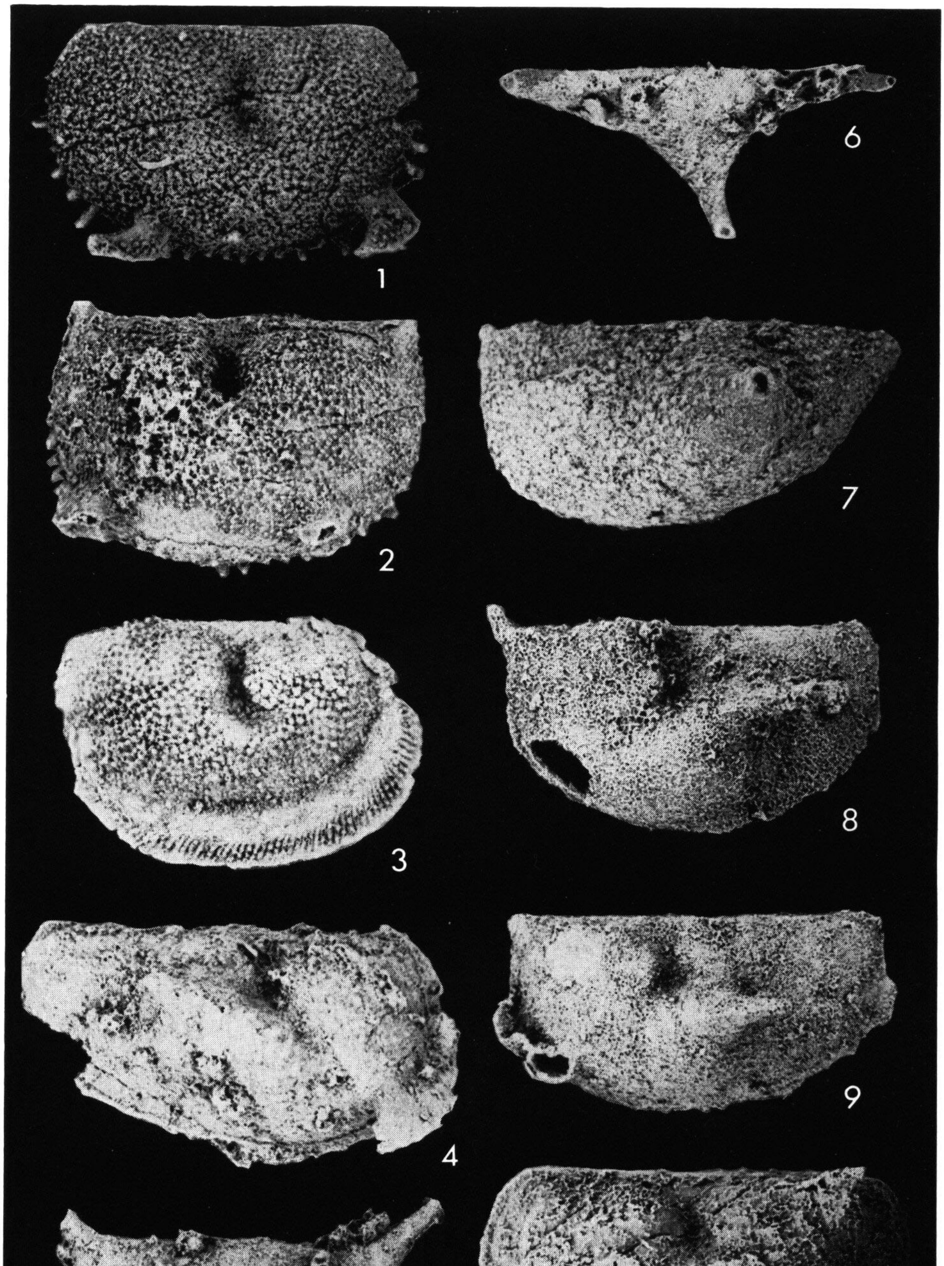
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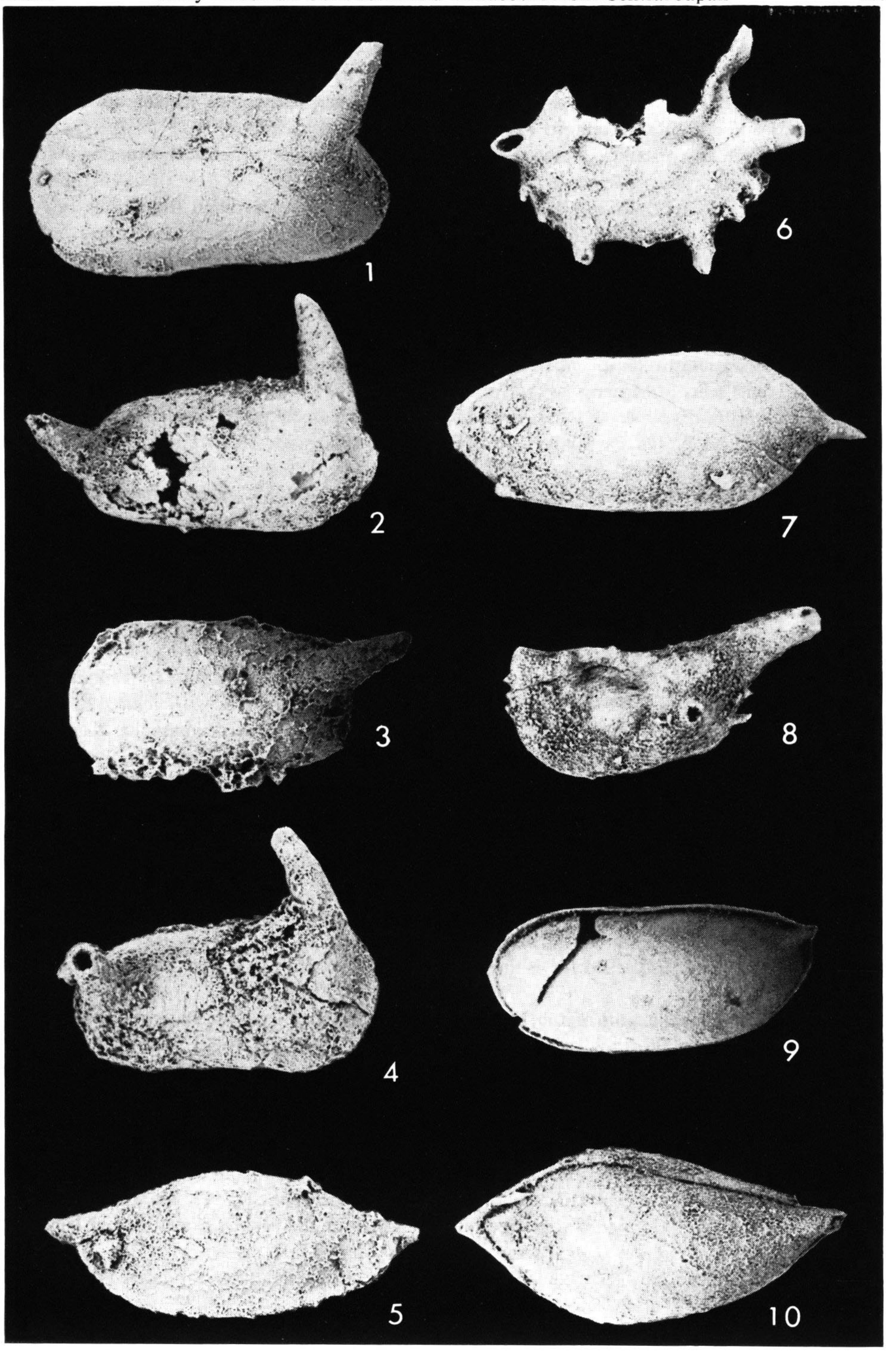
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Postscript: A further study on the ostracodes from the Fukuji Formation has revealed that: i) The limestone from Loc. 26 yields *Praepilatina*, *Svantovites?* and several other genera not listed up in Table 2, and ii) From at least two localities other than Loc. 26 are found silicified ostracodes with a more or less high frequency. The study is in progress and the results will be published in the near futre.