

Middle Triassic Conodonts from Israel, Southern France and Spain (1)

von

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Zusammenfassung:

Es werden Conodonten beschrieben aus Ladinischen „Muschelkalk“-Folgen in Israel, Provence (Südfrankreich), Katalanien, Menorka, Mallorca und Jaen (Spanien).

Die zum Teil endemische Faunen-Vergesellschaftung ist charakteristisch für eine peri-alpine mediterrane Triasprovinz, für welche der Name sephardisch (von Sepharad: hebräisch für Spanien) vorgeschlagen wird.

Bisher wurden drei Conodonten-Vergesellschaftungs-Zonen ausgeschieden:

- a) eine untere „*murcianus*“-Zone in Israel und Andalusien.
- b) eine mittlere „*murcianus-mungoensis*“-Zone in Israel (HUDDLE 1970) und den Balearen.
- c) eine obere „*mungoensis*“-Zone in Nord-Ost Spanien.

Die aus Sardinien (CHERCHI 1967) und der Provence (HIRSCH 1971) bekannten Conodonten-Vergesellschaftungen zeigen enge Verwandtschaft zu dieser oberen Zone.

Systematische Paläontologie, Phylogenie, stratigraphische Korrelation und Paläogeographie werden kurz diskutiert.

Summary

Conodonts are reported from Ladinian „Muschelkalk-facies“-sequences in Israel, Provence (Southern France), Catalonia, Menorca, Mallorca and Andalusia (Spain). The faunal community is partly endemic and belongs to a peri-alpine mediterranean province, for which the term *sephardic* is proposed. Three conodont-assemblage-zones have been recognized:

- I. a lower *Pseudofurnishius murcianus*-zone in Israel and Andalusia,
- II. a middle *Pseudofurnishius murcianus* – *Tardogondolella Mungoensis*-zone in Israel and the Balearic Islands,
- III. an upper *Tardogondolella mungoensis*-zone in N. E. Spain.

The assemblages known from Sardinia and Provence have close affinities to the assemblage of *Tardogondolella mungoensis*.

Systematic paleontology, phylogeny, stratigraphic correlation and paleogeography are briefly discussed.

Introduction

Conodonts from the areas studied here were first reported from Arif en Naqa (Northern Sinai) by EICHER (1946), from Andalusia (S. E. Spain) by VAN DEN BOOGAARD (1966), from Catalonia (N. E. Spain) by HIRSCH (1966), from N. W. Sardinia by CHERCHI (1967), from Provence (S. France) by HIRSCH (1971).

The conodonts from Makhtesh Ramon (Israel) recorded by SOHN & REISS (1964) have been described by HUDDLE (1970). Additional conodonts were found in the lower

part of the Saharonim formation in Makhtesh Ramon (Southern Israel) by the author, together with I. ZAK and A. ROSENFELD (G. S. I. Jerusalem), in the Prebetic and Subbetic zones of S. E. Spain together with LOPEZ-GARRIDO (1971) and GARCIA-ROSELL (University of Granada), and in the Iberic ranges (from material of P. MARIN, Paris).

Recently, conodonts have been found in samples collected by the author in the Balearic islands Mallorca and Menorca.

Methods and techniques used

Samples of one or more kg. of limestone were prepared with the usual methods of dissolution. Gravity-enrichment was carried out with bromoform. For dissolution monochloroacetic acid, acetic acid and more recently formic acid, all of technical quality, have been used. Representative specimens were photographed with aid of scanning-electron-microscope (S. E. M.). These specimens are deposited under N° 0.37-0.40 and 0.127-0.134 in the Museum of Natural History (N. H. M. B.) of Basle (Switzerland).

Paleontology

Pseudofurnishius VAN DEN BOOGAARD, 1966

The aboral side is occupied by a large asymmetrical basal cavity in which the concentric lamellar structure of the unit is clearly visible.

Pseudofurnishius murcianus VAN DEN BOOGAARD, 1966, Pl. II., Figs. 3-8

1956 *Spathognathodus* sp. – DIEBEL, p. 432-433, pl. 4 Fig. 6-7

1966 *Pseudofurnishius murcianus* – VAN DEN BOOGAARD, p. 6-7, Pl. 1, Figs. 6-8; Pl. 2, Figs. 1-5.

1970 *Pseudofurnishius murcianus* – HUDDLE p. B129, Fig. 2 i-o.

Specimens belonging to this species can be subdivided into:

A) monoplatfom type

B) biplatform type

Each platform may bear one or more rows of well developed denticles. The compound conodonts found together with *Pseudofurnishius murcianus*, which seem to belong to the „apparatus“ of this species are few in number. They are:

Lonchodina mülleri TATGE

Enanthiognathus zieglerei (DIEBEL)

Hibbardella magnidentata (TATGE)

Hindeodella sp.

Occurrence: Cameroon (DIEBEL 1956), Andalusia (SIMON & BOOGAARD 1966), Israel and Sinai (EICHER 1946, HUDDLE 1970), Mallorca and Menorca.

Range: ? Upper Anisian, Lower Ladinian – lowermost Upper Ladinian

Gladigondolella MÜLLER, 1962

Platform bearing unit with minute fusiform to amygdaloid basal cavity. The platform has no lateral teeth or nodes. Number and size of teeth of the carina is variable.

Gladigondolella trümpyi HIRSCH, 1971

1967 *Polygnathus mungoensis* DIEBEL – CHERCHI, p. 229, Pl. 16, Figs. 5-17

1967 *Gondolella milleri* MÜLLER – CHERCHI, p. 230, Pl. 16, Figs. 18-20, Pl. 17, Figs. 1-3.

1971 *Gladigondolella trümpyi* – HIRSCH, p. 2, Pl. 1, Figs. 1-10

This species is subdivided into two subspecies:

Gladigondolella trümpyi trümpyi HIRSCH, 1971 Pl. I, Figs. 1-3

The platform occupies more than 4/5 of the total length of the unit. Number of the teeth 10-12, main cusp well developed in small specimens.

Gladigondolella trümpyi denticulata HIRSCH, 1971, Pl. I, Figs. 4-6

The platform occupies some 2/3 of total length of the unit. Number of teeth 15-17, no distinct main cusp developed.

Specimens of both subspecies have almost no deflection of the carina and platform (oral or aboral view). The arcuation of the unit (lateral view) is weak to medium. The position of the basal cavity is anterior. Ratio Height/total length, ranges from 1/3 to 1/3.5 and ratio width of platform/total length of unit has an average of 1/3.5.

For comparison, the type species *Gladigondolella tethydis* (HUCKRIEDE) – has a strong deflection, a strong arcuation and an almost central basal cavity.

The compound conodonts found together with *Gladigondolella trümpyi* are:

- Hindeodella triassica* MULLER,
- Enanthiognathus zieglerei* (DIEBEL)
- Prioniodella ctenoides* TATGE,
- Lonchodina mülleri* TATGE

Occurrence: Provence (Southern France) (HIRSCH 1970), Sardinia (CHERCHI 1967)

Range: ? Lower Ladinian – Upper Ladinian

Tardogondolella BENDER, 1967

Epigondolella MOSHER, 1968 is regarded as a junior synonym (ZIEGLER, 1969, p. 246).

A platform – bearing unit with minute fusiform to amygdaloid basal cavity. The platform is bordered by small teeth or nodes (called crenulation by MOSHER, 1970).

Tardogondolella mungoensis (DIEBEL), 1956

The variability of size, number of denticles, size of denticles, presence or absence of main cusp, number of lateral crenulations and size of platform allow the distinction of following two subspecies:

Tardogondolella mungoensis mungoensis (DIEBEL). subsp. nov. Pl. II, Figs. 1-2

1956 *Polygnathus mungoensis* – DIEBEL p. 431-432, Pl. 1, Figs. 1-20; Pl. 2, Figs. 1-4, pl. 3, Fig. 1; Pl. 4, Fig. 1.

– HUCKRIEDE 1958 Pl. 14, Figs. 23 a, b, 24 a, b.

1968 *Epigondolella mungoensis* – MOSHER p. 936-937, Pl. 116, Fig. 16-19.

1970 *Epigondolella mungoensis* – HUDDLE p. B127, Pl. Fig. 2 a-h.

The specimens belonging to this subspecies have numerous denticles on the carina (up to 17), and no main cusp is developed.

The crenulation bordering the platform consists of an irregular number of nodes (4 nodes or more on one side).

The ratio height/total length is 1/4.

Occurrence: Cameroon (DIEBEL, 1956), Israel and Sinai (EICHER, 1946; HUDDLE, 1970), Augusta mountain range (Nevada) (MOSHER, 1968), Iberic ranges, Catalanian coastal ranges, Menorca and Mallorca (Spain).

Range: Top lower Ladinian – Upper Ladinian.

Tardogondolella mungoensis catalana (HIRSCH), subsp. nov. Pl. I, Figs. 7-10

1966 *Gondolella catalana* – HIRSCH p. 87-90, Pl. 1, Figs. 1-4

Specimens belonging to this subspecies have a carina with up to 12 sharp denticles. The fourth denticle, above the basal cavity is developed as a main cusp. The ratio height/total length is 1/2,5. The crenulation is shallow and very irregular (comprising up to 4 nodes on each side).

Occurrence: N. E. Spain, Balearic islands.

Range: Uppermost lower Ladinian ? – Upper Ladinian.

Discussion:

Tardogondolella mungoensis differs from *T. abneptis* (HUCKRIEDE) by its longer and narrower platform (up to 2/3 and 1/3-1/2 of total length respectively – both ratios being 1/2 in *T. abneptis*).

The number of denticles on the carina and of nodes bordering the platform in *T. abneptis* is less regular than in *T. mungoensis*. Both have a strong deflection of the platform and a medium arcuation of the unit.

Tardogondolella mungoensis differs from *Gladigondolella trümpyi* by its stronger deflection and by having a crenulation on the platform. The decreasing number of nodes bordering the platform, from more than 4 in *Tardogondolella mungoensis mungoensis*, through up to 4 in *Tardogondolella mungoensis catalana* to none in *Gladigondolella trümpyi* suggests an evolutionary trend among these species.

The amount of compound conodonts found in the assemblages studied here is much smaller than those recorded from „tethyan“ or „germanic“ assemblages. Specimens of the following species were recorded here:

Hindeodella triassica MULLER

Prioniodella ctenoides TATGE

Enanthiognathus zieglerei (DIEBEL)

Lonchodina mülleri TATGE

Ozarkodina sp.

Stratigraphy

A. Eastern Mediterranean – Section of Makhtesh Ramon (Israel)

An almost complete section of the Middle Triassic crops out in the Ramon cirque, some 90 km south of Beersheva in the Central Negev (Israel). Conodont-bearing layers were found in the Saharonim-Formation at Har Gevanim (Makhtesh Ramon).

Stratigraphy after ZAK (1964) and DRUCKMAN (1969).

Top: Mohilla Formation (207 m) Upper Triassic, Evaporites.

Saharonim Formation: (165 m) subdivided into:

4. Limestone member (29,5 m)
3. Limestone – Gypsum member (57,5 m)
 - (b) some 5 m below the top of this member *Clionites rarecostatus* PARNES and *Protrachyceras sirenitifforme* PARNES (PARNES, 1962) of Lower Carnian age were encountered.
 - (a) 12 m and 8 m above the base HUDDLE (1970) found CONODONTS. The lower sample (USGS 29777) contains *Pseudofurnishius murcianus* BOOGAARD (43 specimens) and *Tardogondolella mungoensis* (DIEBEL) (45 specimens).
2. Limestone-marl member (40,5 m)
 - (b) 8 m below the top. HUDDLE (1970) found in a sample (USGS 29779) 3 specimens of *Pseudofurnishius murcianus* BOOGAARD
 - (a) 17 m above the base, in the *Ceratites* beds, sample S. 50 yielded 56 specimens of *Pseudofurnishius murcianus* BOOGAARD
1. Fossiliferous limestone-member (37,5 m)
 - (b) in the upper 10 m CONODONTS were found:
 - in sample S. 42 16 specimens of *Pseudofurnishius murcianus* BOOGAARD and 3 specimens of *Tardogondolella mungoensis mungoensis* (DIEBEL) and in sample S. 39 *Pseudofurnishius murcianus* BOOGAARD. This interval yielded a rich cephalopod assemblage (described by PARNES, 1962) comprising among others *P. curionii* var. *ramonensis* and *P. cf. hispanicum* of Lower Ladinian age.
 - (a) According to BROTZEN (1956) the lower Part (20 m) contains cephalopods belonging to *Paraceratites* sp. of Upper Anisian age.

Bottom: Gevanim Formation, Anisian (of which 118 m exposed). Clastics and limestones.

B. Western Mediterranean

I. Catalanian coastal range (N. E. Spain)

VIRGILI (1958 and 1962) gave the following sequence:

Top K: „Keuper“ Marls and dolomites

M–3 „Upper Muschelkalk“

- (d) beds with *Cassianella*
- (c) bed with *Protrachyceras*
- (b) fucoid limestones with *Daonella lomelli*
- (a) basal dolomite

- M-2 „Middle Muschelkalk“ Tramo rojo intermedio: red beds & evaporites
 M-1 „Lower Muschelkalk“
- (d) dolomite with *Diplopora*
 - (c) fucoid-limestones
 - (b) bed with *Paraceratites*
 - (a) bed with *Mentzelia*

Bottom B: „Bunter“ clastics, red beds.

Tardogondolella mungoensis catalana was found in bed M3b with *D. lomelli* at Mora de Ebro and Coll de Jou (Sierra de la LLaveria) (HIRSCH 1966).

Later *T. mungoensis mungoensis* has also been found in samples from Coll de Jou.

II. Betic cordilleras (Andalusia – S. E. Spain)

Pseudofurnishius murcianus BOOGAARD has been recorded from numerous localities of the betic and subbetic zones. (SIMON, 1966 VAN DEN BOOGAARD, 1966)

Sequence of Hornos-Siles (Jaen)

The following sequences was described (LOPEZ-GARRIDO, 1971) from the neighbourhood of Orcera.

Formation of Hornos-Siles:

- (c) shales and sandy shales (300 m)
- (b) shale and limestone member (70 m) (including 3 limestone horizons of 20,5 and 5 m)
- (a) sandy – shaly member (25 m exposed)

The three limestone layers yielded conodonts, all of which belong to *Pseudofurnishius murcianus* BOOGAARD.

The same limestones contain a rich fauna of bivalves and two specimens of ammonites: „*Ceratites*“ sp. (2) and *Protrachyceras* cf. *hispanicum* (3)

III. Balearic islands

No recent stratigraphy was published on the Triassic outcrops of Mallorca and Menorca.

1. Mallorca

HOLLISTER (1934) described a „Muschelkalk“-section near the monastery of Lluch:

- Top: reddish marls and yellow dolomites („Keuper“)
- 56 m dolomites
- 0,40 m marly layer with *Daonella*
- 37 m dolomites

Bottom: reddish beds „Rot“.

(2) This specimen was formerly recorded (LOPEZ-GARRIDO, 1969) as afin. *Progonoceratites*, but further preparation revealed that this specimen is not related to this genus. (Personal communication of A. Parnes, Geological Survey of Israel).

(3) Preliminary determination by H. RIEBER (University of Zurich).

Along the road Lluch-Soler, at Escorca, 200 m N. E. of Km 24, few decimeters of an helminthoid-limestone were found interbedded in hard dolomites. This limestone yielded *Pseudofurnishius murcianus* BOOGAARD (3 specimens)

Tardogondolella mungoensis mungoensis (DIEBEL) (3 specimens)

Tardogondolella mungoensis catalana (HIRSCH) (3 specimens)

2. Menorca

a) Ses Coves Velles (Covas Veyas)

Along the road Mahon-Fornells, 1800 m N. W. of the junction to Arenal d'en Castell, the following section was described by HOLLISTER (1934):

Top: dolomitic limestones
25 m yellowish dolomites, nodular limestones and thin marls
2 m hard limestone with CONODONTS
23 m helminthoid, marly thin bedded limestones
2 m marly limestone, comprising a rich cephalopod fauna with *Protrachyceras curionii* and *Protrachyceras hispanicum* (HOLLISTER, 1934; SCHMIDT, 1936)
25 m limestones, marly toward top, massive toward bottom
1 m yellow dolomite

Bottom: reddish marls „Rot“ and „Bunter“-sandstones.
Conodonts were found only in the 2 m hard limestone, they comprise 1 specimen of *Pseudofurnishius murcianus* and 50 specimens of both *Tardogondolella mungoensis mungoensis* and *Tardogondolella mungoensis catalana*.

b) Monte Toro

Along the road from Mercadal to Mte. Toro a sequence, similar to that of the „Upper Muschelkalk“ M 3 of Catalonia is exposed.

Top: marly limestones and dolomites of „Keuper“ (in stone quarry).

c) marly limestone with *Protrachyceras* sp. (4) and one fragment of a platform-conodont.

Protrachyceras vilanovae recorded by SCHMIDT (1936) from Mte. Toro, seems to originate from this layer.

b) yellow marly limestones with abundant very large specimens of *Daonella lomelli* WISMANN (4). One sample yielded *Tardogondolella mungoensis catalana* (HIRSCH) and one specimen of cf. *Neospathodus microdus* (MOSHER, 1968; pl. 115, Fig. 3, 4, 8). Holothuriensclerites (Family Theelidae) were also found in this bed.

a) massive dolomitic limestones at the bottom. (Base unexposed)

IV. Provence (Southern France)

CARON (1967-1969) described the following section in the area of Toulon:

Top (K) marls („Keuper“) and gypsum, with on top „Rhätian“ beds.

(4) Determination by H. RIEBER (University of Zurich)

- (M 3) Formation IV: dolomitic beds
- Formation III: algal limestones and fossiliferous marls
- Formation II: Fossiliferous limestones and marls
- (M 2) Formation I: massive dolomites and evaporites
- (M 1) gray helminthoid limestones

Bottom (B) conglomerates and arkosic sandstones.

Conodonts (HIRSCH, 1971) were found in Formation II, only. They belong to the assemblage of *Gladigondolella trümpyi*.

C. Age

1. The ammonites found in the Hornos-Siles Formation (Jaen, Andalusia) and in the fossiliferous limestone member of the Saharonim Formation (Ramon, Southern Israel) suggest a Lower Ladinian age for these strata, which bear an assemblage of conodonts belonging almost only to *Pseudofurnishius murcianus* BOOGAARD.
2. *Pseudofurnishius murcianus* BOOGAARD occurs together with *Tardogondolella mungoensis* (DIEBEL) in Coves Velles (Menorca) above the layer of „Upper Fassanian“ age (SCHMIDT, 1936), and in the limestone-gypsum-member of the Saharonim Formation (Ramon), some 40 m below Lower Carnian ammonites.
3. The beds with *Daonella lomelli*, in Menorca, in the Catalonian and Iberic ranges contain a conodont assemblage comprising only *Tardogondolella mungoensis* (DIEBEL). These beds, as well as the overlying beds with *P. vilanova*, *P. hispanicum* and *H. pradoi* are considered by VIRGILI (1958, 1962) to be of Upper Ladinian age. Furthermore, MOSHER and SWEET (1970, 1971) consider *Tardogondolella mungoensis* as characteristic for Upper Ladinian strata.

Three assemblage-zones can be distinguished:

- I. *Pseudofurnishius murcianus*-zone (Lower Ladinian)
- II. *Pseudofurnishius murcianus*-*Tardogondolella mungoensis*-zone (passage-beds Lower – Upper Ladinian)
- III. *Tardogondolella mungoensis*-zone (MOSHER, 1968) (Upper Ladinian)

Paleogeography

The distribution of conodont-assemblages in the Ladinian fossiliferous limestone of the circum-mediterranean countries considered here shows that the main-occurrence of this facies took place in the Levant, Andalusia and the Balearic islands, during the Lower Ladinian and in the Levant, the Balearic islands, N. E. Spain (in the Iberic and catalonian ranges overlying the Tramo rojo intermedio evaporites and detritics, VIRGILI 1958, 1962), Provence and Sardinia, during the Upper Ladinian.

The facies of the newly created stratotypes (5), as well as those of the sequences still called „Muschelkalk“ are from many points of view, similar to the facies described from the Muschelkalk-formations of the germanic province.

(5) Azizia Fm. in Lybia and Tunisia, (BUROLLET, 1963, BUSSON, 1970) Hornos-Siles Formation in Andalusia (LOPEZ-GARRIDO, 1971) Saharonim-Formation in Israel (ZAK, 1964) Hisban-Formation in Jordan (DANIEL, 1961)

On the other hand many authors (6) noticed the „alpine“ and „tethyan“ character of the invertebrate-fauna, and it seems characteristic that, a large percentage of specimens belong to endemic species, some of which occur as well in the Spanish, the North African and the Levantine region. In order to express the particular character of the conodont-assemblages and to avoid further confusion among the terms „germanic“, „alpine“, (AUBOUIN, 1960), „tethyan“ and „mediterranean“ applied to the areas considered here the term *S e p h a r d i c* (7) is proposed.

Conclusions

1. The „western-mediterranean-african-north-american“ province proposed by KOZUR & MOSTLER (1971) for the Ladinian stage must be splitted into:
 - a) a North-American province characterised by *Gondolella mombergensis* TATGE in the lower Ladinian, *G. mombergensis* and *Tardogondolella mungoensis* in the Upper Ladinian; (MOSHER, 1968; HUDDLE, 1970)
 - b) a Sephardic province characterised by *Pseudofurnishius murcianus* in the Lower Ladinian, *Tardogondolella mungoensis* & *Gladigondolella trümpyi* in the Upper Ladinian.
2. DIEBEL's (1956) assemblage from Cameroon, comprising *P. murcianus* and *T. mungoensis*, corresponds well to the fauna of the middle assemblage-zone of the sephardic province. This suggests that the strata in which these conodonts were primarily deposited were of Lower to Upper Ladinian age.
3. For purposes of description the platform-conodonts described here have to be classified into three form-genera: *Pseudofurnishius*, *Gladigondolella* and *Tardogondolella*. (Form-Taxonomy)
4. No element belonging to the „natural faunal assemblage“ of *Gladigondolella tethydis* (HUCKRIEDE, 1958) (KOZUR & MOSTLER, 1971) has been found in samples from the sephardic province. All compound-conodonts belong to the multielement *Enanthiognathus zieglerei* (KOZUR & MOSTLER, 1971). The occurrence of almost the same compound conodonts together with *Pseudofurnishius murcianus*, *Tardogondolella mungoensis* and *Gladigondolella trümpyi* suggests that the assemblages from the sephardic province described here, are related to the „natural-faunal-assemblage“ *Gondolella navicula* proposed by HUCKRIEDE (1958).

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(6) MOJSISOVICS, 1881; SCHMIDT, 1936, 1937; VIRGILI, 1958; HINKELBEIN, 1965; LERMAN, 1960; PARNES, 1962; HUDDLE, 1970; LOPEZ-GARRIDO, 1971.

(7) After the distribution of the Sephardim (from Sepharad, the Hebrew name of Spain)

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Explanation to plates

PLATE I

- Figures 1-3 *Gladigondolella trümpyi trümpyi* HIRSCH (Provence, Southern France)
 1. lateral, 150 X, NHMB N° 0.129
 2. latero-oral, 105 X, NHMB N° 0.127
 3. aboral, 135 X, NHMB N° 0.128
- Figures 4-6 *Gladigondolella trümpyi denticulata* HIRSCH (Provence, Southern France)
 Holotype NHMN N° 0.130
 4. lateral, 90 X;
 5. oral, 90 X;
 6. latero-aboral, 75 X

- Figures 7-10 *Tardogondolella mungoensis catalana* (HIRSCH) (Coll de Jou, Tarragona, Spain)
7. lateral, 110 X, NHMB N° 0.38
8-10. transition between *T. mungoensis catalana* and
T. mungoensis mungoensis: 100 X, NHMB 0.40
8. latero-aboral;
9. almost oral;
10. almost lateral

PLATE II

- Figures 1-2 *Tardogondolella mungoensis mungoensis* (DIEBEL) (Coll de Jou, Tarragona, Spain)
75 X, NHMB N° 0.132
1. lateral;
2. oral
- Figures 3-8 *Pseudofurnishius murcianus* BOOGAARD
3. *bi-platform-type*; NHMB N° 0.134 (Har Gevanim, Maktesh Ramon, Isreal) 95 X, oral
4-8 *mono-platform-type*: NHMB N° 0.133 (Jaen, Spain)
4. oral, 110 X;
5. oro-lateral, 110 X;
6. lateral, 150 X;
7. detail of basal cavity, 400 X;
8. lateral-aboral, 100 X.

SEM—Micrographs:

Films N° 6-414, 6-415, 6-584 deposited at the Federal Institute of Technology, (Institute of Electron-microscopy), Zurich (Hönggerberg)

Plate I

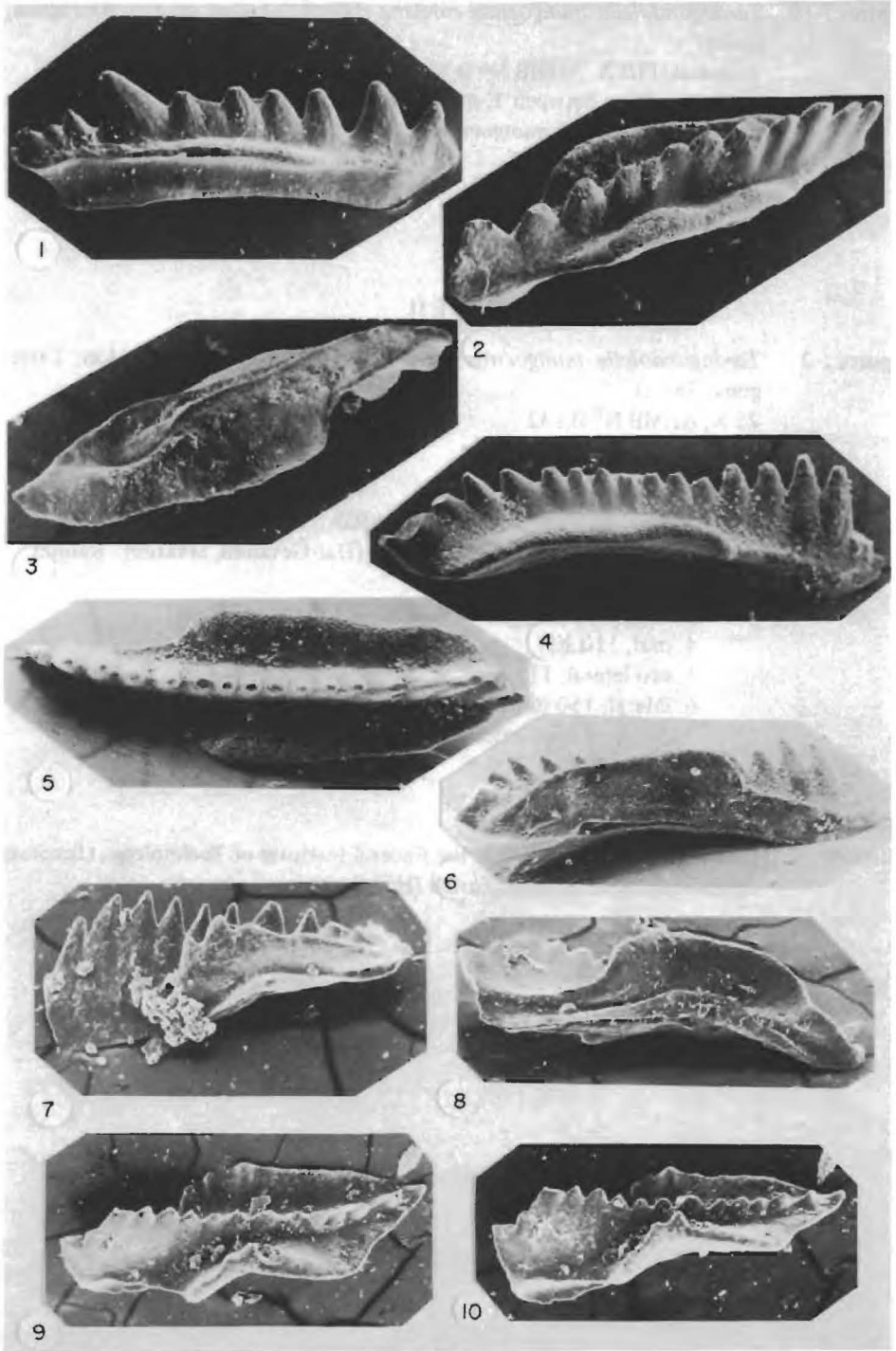


Plate II

