Conodont faunas from Portugal and southwestern Spain

Part 2. A Famennian conodont fauna at Cabezas del Pasto*

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Boogaard, M. van den and L. J. G. Schermerhorn. Conodont faunas from Portugal and southwestern Spain. Part 2. A Famennian conodont fauna at Cabezas del Pasto. — Scripta Geol., 28: 1-36, figs. 1-5, pls. 1-17, 4 Tables, Leiden, March 1975.

A Famennian conodont fauna is described. The possible relationship between *Palmatodella* cf. *delicatula, Prioniodina? smithi* and other forms in Famennian faunas is discussed.

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* For Part. 3. Carboniferous conodonts at Sotiel Coronada see p. 37-43.

Introduction

The thick succession of geosynclinal strata cropping out in the Iberian Pyrite Belt (Fig. 1) is divided into three lithostratigraphic units: the *Phyllite-Quartzite Group* (abbreviated PQ) is at the base and is overlain by the *Volcanic-Siliceous Complex* (or VS), in turn covered by the *Culm Group*. The details of this classification and its history are discussed elsewhere (Schermerhorn, 1971). The time-stratigraphic correlation of the rock units is still only known in outline: the PQ is of Devonian and possibly older age (its base is not exposed), as Famennian faunas are found near its top in a few localities in Portugal and Spain. The VS, resting conformably on the PQ, is of Tournaisian and Early Viséan age. It locally contains Tournaisian to Early Viséan fossils and is conformably overlain by Culm with Late Viséan fossils.

Though the Culm is reasonably fossiliferous, fossils are notably scarce in the predominantly shaly, sandy and volcanic rocks of the PQ and the VS (taken together as sub-Culm). The occasional limestone lenses in these units therefore assume a special importance, because of their microfossil content, in particular conodonts. At first, only a few limestone occurrences in the PQ were known, in Portugal, containing *Clymenia laevigata* and other fossils of Late Devonian age. Afterwards, limestones enclosing Carboniferous faunas were discovered in Portugal (van den Boogaard, 1963). Lately more detailed mapping has revealed several more limestones in the Pyrite Belt. One of these, near Mértola in Portugal, was discovered by Fantinet (1971) who is preparing a detailed study of its Late Devonian fauna (personal communication).

Because of their interest for Pyrite Belt stratigraphy, a number of these Devonian and Carboniferous limestones and their faunas will be successively described in a series of notes of which the present one is the second. An already

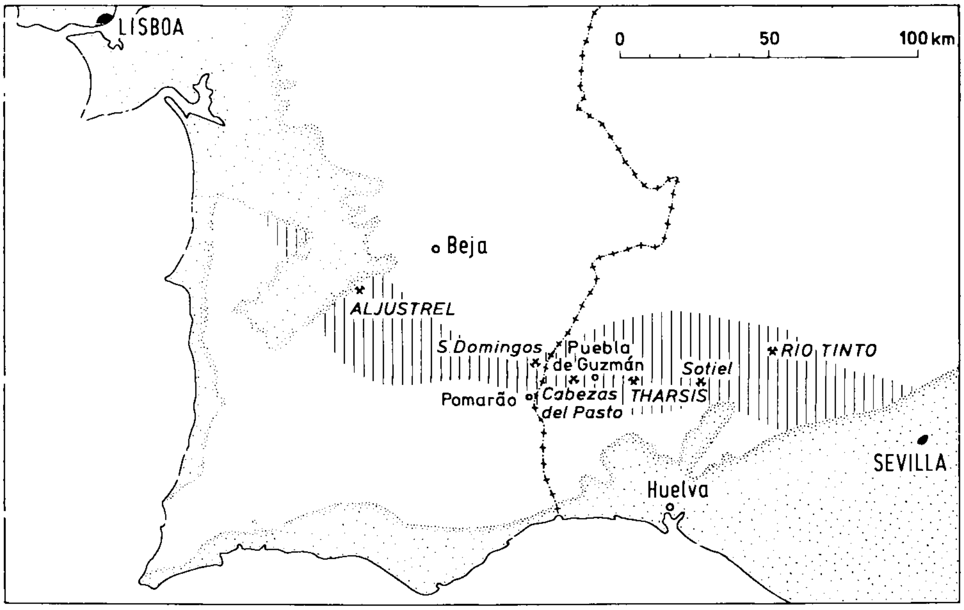

Fig. 1. The Iberian Pyrite Belt (vertical ruling). Mesozoic and later cover is stippled.

known, though unpublished, conodont assemblage from a limestone lens at Cabezas del Pasto in southwest Spain, has been restudied.

Acknowledgements

Thanks are due to Mr W. P. F. H. de Graaff for collecting the sample studied. Also we want to express our gratitude to Mrs C. Mulder-Blanken, Mr C. Bakker and the werkgroep Scanning Electronen Microscopie of the University of Amsterdam and to Mr H. Kammeraat of the Geological and Mineralogical Institute of the University of Leiden for taking the scanning electron micrographs.
Furthermore thanks are due to Dr J. H. Germeraad for critically reading part of the manuscript.

The numbers preceded by RGM are registration numbers of the Rijksmuseum van Geologie en Mineralogie.

GEOLOGICAL SETTING

Cabezas del Pasto is a small worked-out pyrite mine situated in the west of the Spanish Pyrite Belt, about 3 km west of Herrerías, an active pyrite mine. This is in the north limb of the large Puebla de Guzmán anticlinorium in sub-Culm strata, surrounded by Culm greywackes and slates (Fig. 2). This structure trends east-west, reaching about 50 km length. At its east end occur the large pyrite bodies at Tharsis, one of the major mines in the Pyrite Belt. The western tip extends across the frontier into Portugal, forming the plunging Pomarão anticlinorium (van den Boogaard, 1967).

In Spain the larger part of the anticlinorium was covered by the reconnaissance mapping of Doetsch (1953) and Höllinger (unpublished thesis, 1959). The latter recognized a broad anticlinorial core made up of thick phyllites and quartzites, designated D_1-D_5 ('tieferes Oberdevon'), mantled by a thin succession of phyllites (D_6-D_7) locally enclosing limestone lenses and associated with felsic and mafic eruptives. This sequence is in its turn covered by the Culm ('Unterkarbon'). Höllinger mapped limestone lenses in the south flank of the anticlinorium, near the Portuguese border (and their continuation at Pomarão has been known for a long time - see van den Boogaard, 1967), and at several places in the north flank, including occurrences near Cabezas del Pasto and as far east as Puebla de Guzmán. Several more limestone lenses are marked by Doetsch and by Höllinger in the area to the north, in Culm and sub-Culm strata, including two smaller sub-Culm anticlines which form the eastward continuation of the São Domingos structures across the border.

In Fig. 2 the limestones so far known from the Puebla de Guzmán anticlinorium have been plotted after Doetsch (1953), Höllinger (1959), and van den Boogaard (1967). The eastern part of the anticlinorium is mainly drawn after Febrel Molinero (1968). The stratigraphic succession is re-interpreted in terms of the Culm-VS-PQ subdivision set up in Portugal.

At Pomarão the Eira do Garcia Formation of phyllites and quartzites is the equivalent of the top of Höllinger's D_1-D_5 sequence. It is conformably overlain by the Nascedios Formation of phyllites with a discontinuous horizon of limestones dated as Middle to Late Famennian (van den Boogaard, 1963, 1967), corresponding to Höllinger's D_6 horizon. These two formations together make up the PQ,

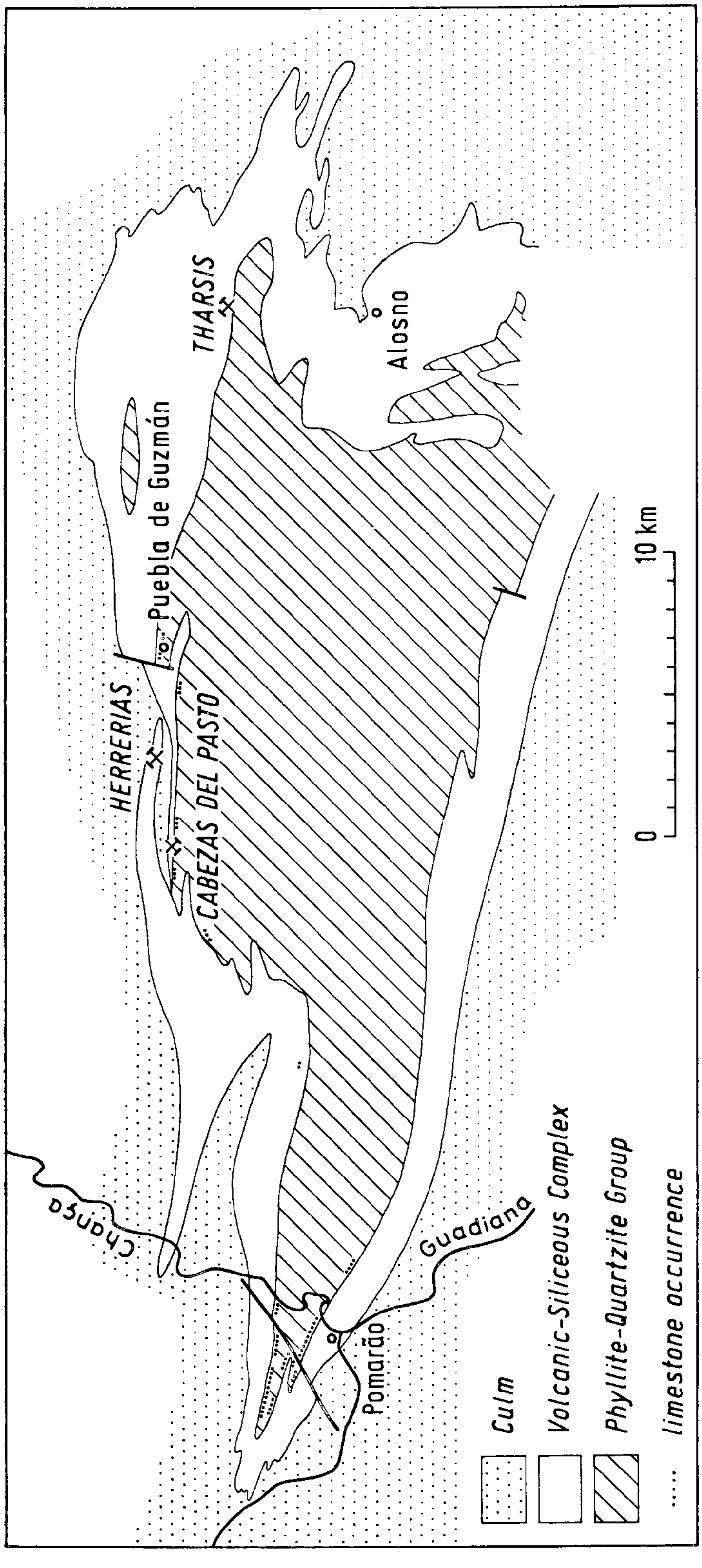

Fig. 2. The Puebla de Guzmán anticlinorium.

and are covered by volcanic and sedimentary formations belonging to the VS.

The limestone occurrences described by Höllinger occur at the Nascedios level, at the top of the PQ. Doetsch (1953) described several limestone lenses west of Cabezas del Pasto, which were quarried to some extent for lime-burning. Though he found only crinoids in them he considered a Devonian age most likely, and this was later borne out by the microfauna. Conodonts from these crinoidal limestones, sampled by Höllinger, were studied by Dr G. Bischoff who found the following species: *Angulodus walrathi* Hibbard, 1927; *Hindeodella germana* Holmes, 1928; *Lonchodina curvidens* Branson, 1934; *Nothognathella* n.sp.; *Ozarkodina regularis* Branson & Mehl, 1934; *Palmatolepis gracilis* Branson & Mehl, 1934; *P. perlobata* Ulrich & Bassler, 1926; *Polygnathus communis* Branson & Mehl, 1934; *P. pennatuloidea* Holmes, 1928; *Prioniodina smithi* Stauffer, 1938; *Roundya aurita* Sannemann 1955; *Spathognathodus stabilis* Branson & Mehl, 1934; *Tripodellus robustus* Bischoff, 1957. This fauna indicated a Late Famennian age. Earlier, Doetsch (1955) had discovered a poorly preserved fossil which he identified as a *Spirifer,* in phyllites with quartzite beds near Cabezas del Pasto, underlying the limestones, and he considered them to be of Early Silurian - i.e. Ordovician - age.

About 1 km west of the old mine at Cabezas del Pasto the maps of Doetsch and Höllinger mark several small limestone lenses which are re-examined in the present note. At the Cabezas del Pasto mine the pyrite occured as a few steeply dipping lenses, up to 12 m thick, interbedded in about 50 m of black phyllitic slates, here representing all of the VS. To the south are the phyllites and thick quartzites of the PQ and to the north are the Culm greywackes and slates (Finlayson 1910; Doetsch, 1953).

THE LIMESTONE OUTCROPS

Along the old railroad track, slightly over 1 km west of Cabezas del Pasto, are good limestone outcrops, and the sample investigated for its conodont content (indicated in Fig. 3) was here collected by Mr W. P. F. H. de Graaff in 1971. Subsequently the occurrence was visited and surveyed by one of us (L.J.G.S.) and the accompanying sketch map (Fig. 3) was made. The black slates of the VS at the mine are here much reduced (they do not crop out), and the Culm is almost in contact with the PQ. This may have a tectonic cause as the VS reappears somewhat more to the north with felsic volcanics.

The limestone lenses are intercalated in medium bluish grey, somewhat carbonaceous phyllites containing thin layers and lenticles of micaceous siltstone and occasional larger lenses of fine-grained quartzite. This is a typical PQ lithology, quite different from the black slates enclosing the ore at Cabezas del Pasto.

Limestone lens No. 1, 55 m long and up to 12 m thick, consists of a well-bedded coarse-grained calcarenite largely made up of crinoid debris, locally passing to calcirudite grade or to very fine-grained calcarenite and calcilutite. The beds are 2-30 cm thick, separated by brownish shale or calcareous shale laminae up to 3 cm thick, in places showing cross-lamination. Graded bedding is often seen, indicating that the beds are younger towards the north. At the base of a graded bed calcirudite of coarse calcarenite is found which may show scouring of underlying shale or calcilutite. This is expressed in irregular undulating erosive contacts; also some small loadcasts were observed. In addition, the coarse beds may carry angular intraclasts of calcilutite.

Lens No. 2 consists of a similar coarse crinoidal calcarenite. It shows a blunt west end; the eastern termination was not surveyed.

Lens No. 3, where the sample was taken, is 5 m thick and shows a similar lithology of well-bedded coarse crinoidal calcarenite, with calcilutite and shaly partings. Its eastern continuation was not surveyed. A few thin limestone intercalations appear farther north.

The sedimentary structures suggest that these carbonates were resedimented by turbidity currents in relatively deep water, among normal PQ mudstones. This may mean that the bioclastic and other debris derive from a shelf where crinoids grew, but the location of this source area is unknown as no sediment derivation directions could be reliably determined. The case for deep-water deposition of the PQ, advanced elsewhere (Schermerhorn, 1971), appears to be strengthened by these calciturbidites. It moreover implies a deep-water origin for the conformably overlying VS slates which contain the orebodies, and these are interpreted as pyritite, i.e. resedimented sulphidic ore of volcanic origin.

Palaeontology

A limestone sample of 7300 g has been dissolved with formic acid and the residue was found to contain about 4000 conodonts of which c. 3500 could be identified. These are listed with their form species names in Table 1. All figured specimens (pls. 1-17) are from this sample. The micrographs were taken with a Scanning Electron Microscope.

In the following part one of us (M.v.d.B.) will make some remarks upon several of the conodont forms and discuss the possible relationships between *Prioniodina? smithi*, *Palmatodella* cf. *delicatula* and some other forms.

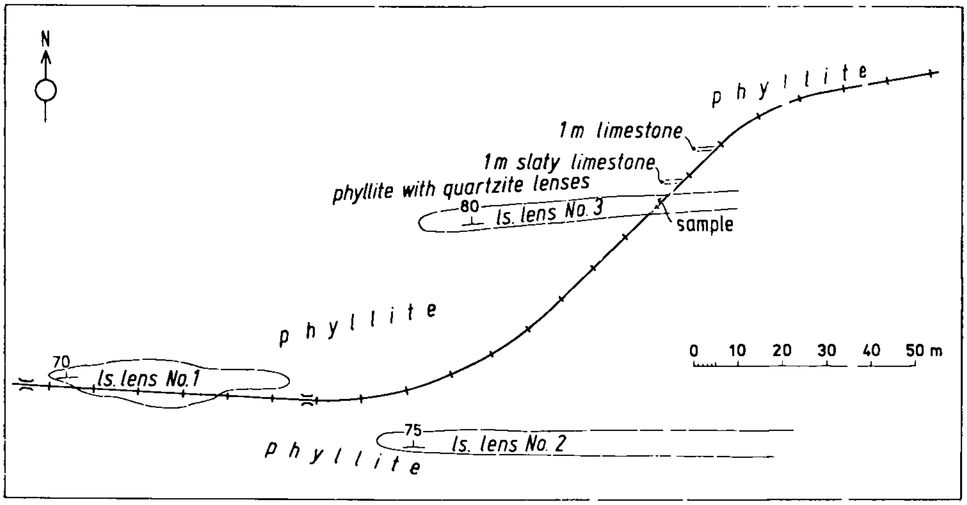

Fig. 3. Limestone occurrences west of Cabezas del Pasto.

Apatognathus varians varians Branson & Mehl, 1934
Plate 1, fig. 2.

1934 *Apatognathus varians* n.sp. — Branson & Mehl, pp. 201-202, pl. 17, figs. 1-3.
1969 *Apatognathus varians varians* Branson & Mehl — Druce, pp. 42, 43, pl. 1, figs. 16a, b.
For further references see the list of synonyms in Druce, 1969.

The specimens show all characteristics mentioned by Druce. The subparallel slender bars are of equal length and bear identical dentition. The denticles of the bars are minute and stand en echelon in groups of three. The apical denticle is much larger and curved inwards.

Diplododella aurita (Sannemann, 1955)
Plate 2, fig. 2.

1955 *Roundya aurita* n.sp. — Sannemann, p. 153, pl. 2, figs. 3a, b; pl. 5, fig. 11.
1968 *Diplododella aurita* (Sannemann) — Huddle, p. 12.

The specimens show the characteristics mentioned by Sannemann who also remarked that the smaller denticles of the anterior bars often are pressed out of the denticle rows. He therefore already supposed a relation with *Diplododella* in which genus it was placed by Huddle.

Falcodus variabilis Sannemann, 1955
Plate 1, fig. 1.

1955 *Falcodus variabilis* n.sp. — Sannemann, p. 129, pl. 4, figs. 1-4.

Most of our specimens seem to be identical to those described by Sannemann. Others, however, are more like those described as *Falcodus* cf. *F. variabilis* Sannemann by Druce, 1969. Sannemann considered the species to comprise variable forms. Because of transitional specimens which are difficult to ascribe to one particular form we have taken them together as *Falcodus variabilis,* although we suppose that they may belong to different conodont apparatuses. See also the discussion in the paragraph Conodont apparatus?

Icriodus sp.
Plate 2, fig. 1.

The fauna contains two small specimens of *Icriodus* which are rather poorly preserved and therefore could not be identified on specific level.

Ligonodina delicata Branson & Mehl, 1934
Plate 3, fig. 1.

1934 *Ligonodina delicata* n.sp. — Branson & Mehl, p. 199, pl. 14, figs. 22, 23.

The specimens conform to the description and figures given by Branson & Mehl, 1934.

Nothognathella ziegleri Helms, 1959
Plate 3, fig. 2.

1959 *Nothognathella ziegleri* n.sp. — Helms, pp. 645, 646, pl. 6, figs. 17-19.

Our specimens conform to the description given by Helms. The typical downflexed lateral process at the base of the main cusp (Apicallippe, Helms) is very pronounced in most specimens. In the figured specimen this apical process is still present but hardly pronounced because of a strong widening of the platform posterior to it.

Palmatodella cf. *delicatula* Bassler, 1925
Plate 4, fig. 2.

1959 *Palmatodella delicatula* Ulrich & Bassler — Helms, p. 648, pl. 2, figs. 21, 22; pl. 3, figs. 13, 15; pl. 5; figs. 11, 12, 21.
1963 *Palmatodella* cf. *delicatula* Ulrich & Bassler — van den Boogaard, p. 254, pl. 1, fig. 5.
cf. 1968 *Palmatodella delicatula* Bassler, 1925 — Huddle, pp. 27, 28, pl. 6, fig. 7.
For further references see list of synonyms in Huddle, 1968.

The specimens are identical to *Palmatodella* cf. *delicatula* Ulrich & Bassler, 1926 in van den Boogaard, 1963. According to Huddle, 1968 these latter specimens do not belong to *Palmatodella delicatula* because they lack the characteristic fan of posterior denticles. The posterior bar of the specimens described by van den Boogaard in 1963, of those of the present paper as well as of most of the specimens figured by Helms, 1959 is more elongated and less fan like than the posterior bar of *Palmatodella delicatula.*

For further remarks see the discussion in the paragraph Conodont-apparatus?

Palmatolepis gracilis gracilis Branson & Mehl, 1934
Plate 4, fig. 1; Plate 5, figs. 1, 2.

1934 *Palmatolepis gracilis* n.sp. — Branson & Mehl, p. 238, pl. 18, figs. 2, 8.
1966 *Palmatolepis gracilis gracilis* Branson & Mehl — Glenister & Klapper, pp. 814, 815, pl. 90, fig. 6.
For further references see list of synonyms in Glenister & Klapper, 1966.

Specimens of this species dominate the fauna. All specimens show the diagnostic characteristic given by Glenister & Klapper (1966): 'The keel of this species is offset in the central part of the platform by following the margin of the inner lobe'. According to Orr & Klapper (1968, p. 1071) this inner lobe of *Palmatolepis* is no inner lobe but an outer lobe, however.

One specimen was found to possess a lobe with a secondary carina (Plate 4, fig. 1).

For some further remarks concerning *Palmatolepis gracilis* see the paragraph Conodont apparatus?

Table 1. Form species present in the Cabezas del Pasto sample and number of specimens.

Angulodus walrathi (Hibbard, 1927)	11
Apatognathus varians varians Branson & Mehl, 1934	10
Bryantodus sp.	1
Diplododella aurita (Sannemann, 1955)	10
Falcodus variabilis Sannemann, 1955	74
Gnamptognathus lipperti (Bischoff, 1956)	2
Hibbardella sp.	12
Hindeodella sp.	35
Hindeodella subtilis Bassler, 1925	22
Icriodus sp.	2
Ligonodina delicata Branson & Mehl, 1934	16
Ligonodina sp.	8
Lonchodina sp.	9
Neoprioniodus sp.	12
Nothognathella sp.	1
Nothognathella ziegleri Helms, 1959	14
Ozarkodina elegans (Stauffer, 1938)	9
Ozarkodina sp.	66
Palmatodella cf. *delicatula* Bassler, 1925	180
Palmatolepis gracilis gracilis Branson & Mehl, 1934	1439
Palmotolepis maxima Müller, 1956	20
Palmatolepis perlobata schindewolfi Müller, 1956	247
Palmatolepis sp.	13
Polygnathus communis communis Branson & Mehl, 1934	56
Polygnathus sp.	26
Polygnathus styriacus Ziegler, 1957	196
Prioniodina? smithi (Stauffer, 1938)	108
Pseudopolygnathus sp.	48
Scutula bipennata Sannemann, 1955	29
Scutula tripodis Helms, 1959	7
Scutula venusta Sannemann, 1955	42
Spathognathodus amplus (Branson & Mehl, 1934)	8
Spathognathodus bohlenanus Helms, 1959	265
Spathognathodus inornatus (Branson & Mehl, 1934)	29
Spathognathodus sp.	7
Spathognathodus stabilis (Branson & Mehl, 1934)	233
Spathognathodus strigosus (Branson & Mehl, 1934)	49
Synprioniodina alternata Bassler, 1925	45
Tripodellus robustus Bischoff, 1957	154
Simple cones	55
Indet fragments	c. 500

Palmatolepis maxima Müller, 1956
Plate 12, fig. 2.

1956 *Palmatolepis (Palmatolepis) maxima* n.sp. — Müller, p. 29, pl. 9, figs. 37-40.

Our specimens show all the characteristics described by Müller and are therefore considered to be conspecific.

Palmatolepis perlobata schindewolfi Müller, 1956
Plate 6, figs. 1, 2.

1956 *Palmatolepis (Palmatolepis) schindewolfi* n.sp. — Müller, p. 27, 28, pl. 8, figs. 22, 23, 25-31; pl. 9, fig. 33.
1962 *Palmatolepis perlobata schindewolfi* Müller — Ziegler, pp. 70, 71, pl. 8, figs. 2-5.
For further references see list of synonyms in Ziegler, 1962.

The specimens show the characteristics mentioned by Müller (1956) and Ziegler (1962). The upper surface of young specimens is rather smooth. The adult specimens bear some nodes and a short secondary carina. The lobe is rather small and points posteriorly. Therefore the specimens are considered to belong to the subspecies *schindewolfi* for according to Ziegler (1962) the lobe of *P. perlobata perlobata* shows a tendency to be directed anteriorly. The posterior part of the platform is flexed upwards.

Polygnathus communis communis Branson & Mehl, 1934
Plate 7, figs. 1, 2.

1934 *Polygnathus communis* n.sp. — Branson & Mehl, p. 293, pl. 24, figs. 1-4.
1969 *Polygnathus communis communis* Branson & Mehl — Rhodes, Austin & Druce, pp. 182-184, pl. 12, figs. 2a-5c.
For further references see list of synonyms in Rhodes, Austin & Druce, 1969.

The platform of our specimens is smooth and its edges are upturned. The cavity on the aboral side is relatively large and situated at the junction of the platform and the blade. Posterior to this cavity the central part of the aboral surface of the unit is concave, which is characteristic for the species.

Polygnathus styriacus Ziegler, 1957
Plate 8, figs. 1, 2.

1957 *Polygnathus styriaca* n.sp. — Ziegler, pp. 47-48, pl. 1, figs. 12, 13.
1973 *Polygnathus styriacus* Ziegler — Ziegler, pp. 383-384, Polygnathus — plate 3, figs. 1, 2.
For further references see list of synonyms in Ziegler, 1973.

The specimens show all characteristics mentioned by Ziegler (1957 and 1973): The downward deflected smooth anterior third of the platform, the row of nodes on the inner platform which marks the line of deflection and the rather flat posterior two thirds of the platform which has an irregular nodose sculpture.

Prioniodina? smithi (Stauffer, 1938)
Plate 9, figs. 1, 2.

1938 *Prioniodus smithi* n.sp. — Stauffer, p. 441, pl. 50, fig. 26.
1969 *Prioniodina? smithi* (Stauffer) — Druce, p. 112, pl. 34, fig. 7; pl. 38, figs. 7a, b.
For further references see list of synonyms in Druce, 1969.

For some other remarks upon this form see the paragraph Conodont apparatus?

Pseudopolygnathus sp.
Plate 10, figs. 1, 2.

The fauna contains specimens of *Pseudopolygnathus* with an asymmetrical platform. The margin of the right side of the platform in both right and left forms is convex and widest at mid-length and extends farther to the anterior than does the left side. The margin of the left side of the platform is in most specimens widest close to the anterior. Both the right and left sides of the platform are ornamented with nodes or transverse ridges. In most specimens a distinct trough is present between the nodes of the margin and the carina in the anterior half of the left side of the platform. In mature specimens the basal cavity is as wide or nearly as wide as the platform. These specimens differ from *Pseudopolygnathus dentilineatus* Branson, 1934 in the larger number of nodes on the margins and the somewhat smaller basal cavity. They differ from *Pseudopolygnathus primus* Branson & Mehl, 1934 in having a larger basal cavity and less coarse nodes. They will however belong to the *Pseudopolygnathus prima* group (Voges, 1959).

Scutula bipennata Sannemann, 1955
Plate 11, fig. 1.

1955 *Scutula bipennata* n.sp. — Sannemann, p. 154, pl. 4, figs. 5, 8a, b, 9.

Our specimens are similar to those described by Sannemann, especially to the one pictured as fig. 9 on plate 4. For some further remarks see paragraph Conodont apparatus?

Scutula venusta Sannemann, 1955
Plate 11, fig. 2.

E.P. 1955 *Scutula venusta* n.sp. — Sannemann, p. 155, pl. 4, fig. 7 (non fig. 6).
1959 *Scutula venusta* Sannemann — Helms, p. 657, pl. 2, figs. 13a, b.

The specimen designated by Sannemann as the holotype of *Scutula venusta* (pl. 4, figs. 6a, b) in reality is a specimen of *Scutula bipennata* one anterior branch being broken off (Lindström, 1964). The specimen of plate 4, fig. 7 of Sannemann is the characteristic asymmetric form of *Scutula venusta* which — save for the extra branch — resembles *Falcodus variabilis* (see Sannemann, 1955 and Helms, 1959). Our specimens seem to be conspecific with this asymmetric form.

Spathognathodus bohlenanus Helms, 1959
Plate 12, fig. 1.

1959 *Spathognathodus bohlenanus* n.sp. — Helms, p. 658, pl. 6, figs. 5-8.
1962 *Spathognathodus bohlenanus* Helms — Ziegler, p. 106-107, pl. 12, figs. 25, 26, 29-35.

The specimens conform to the description and figures given by Helms. The posterior third of the unit is slightly flexed inward and has small denticles which are much lower than those of the anterior two thirds. The denticle at the flexure point is slightly larger than the denticles immediately in front of it. The large basal cavity lies beneath this denticle. In oral view the outer lateral expansion of the basal cavity is directed obliquely backwards.

Spathognathodus inornatus (Branson & Mehl, 1934)
Plate 13, figs. 1, 2.

1934 *Spathodus inornatus* n.sp. — Branson & Mehl, p. 185, pl. 17, fig. 23.
1962 *Spathognathodus inornatus* (Branson & Mehl) — Ziegler, p. 111, pl. 12, fig. 24.
For further references see list of synonyms in Ziegler, 1962.

The specimens conform to the descriptions given by Branson & Mehl and Ziegler. They have a nearly straight aboral outline which rises slightly towards the anterior end. The oral outline rises regularly from the anterior end towards its highest point at about one third the length of the blade from the posterior end. From then on the outline drops rapidly towards the posterior end. The symmetrical basal cavity is found under the culmination of the denticles.

Spathognathodus stabilis (Branson & Mehl, 1934)
Plate 14, figs. 1, 2.

1934 *Spathodus stabilis* n.sp. — Branson & Mehl, p. 188, pl. 17, fig. 20.
1962 *Spathognathodus stabilis* (Branson & Mehl) — Ziegler, pp. 112-114, pl. 13. figs. 1-10.
For further references see list of synonyms in Ziegler, 1962.

Our specimens conform to the descriptions given by Branson & Mehl and Ziegler.

Spathognathodus strigosus (Branson & Mehl, 1934)
Plate 15, fig. 2.

1934 *Spathodus strigosus* n.sp. — Branson & Mehl, p. 178, pl. 17. fig. 17.
1962 *Spathognathodus strigosus* (Branson & Mehl) — Ziegler, pp. 111-112, pl. 12, figs. 21-23.
For further references see list of synonyms in Ziegler, 1962.

The specimens are conform to the descriptions given by Branson & Mehl and Ziegler. They show the nearly straight oral outline which gently descends from the highest point near the anterior end towards the posterior end. The about 24 denticles are laterally compressed and subequal in size. The aboral side is straight in the anterior half, it is slightly arched from about mid-length towards the posterior end. The basal cavity is very small.

Synprioniodina alternata Bassler, 1925
Plate 15, fig. 1.

1968 *Synprioniodina alternata* Bassler — Huddle, pp. 45-46, pl. 6, figs. 3-5, 12.
For further references see list of synonyms in Huddle, 1968.

Our specimens conform to the description given by Huddle. The anticusp generally has some denticles. The denticles on the posterior bar are slender and alternate in size.

Tripodellus robustus Bischoff, 1957
Plate 16, figs. 1, 2.

1957 *Tripodellus robustus* n.sp. — Bischoff, pp. 58, 59, pl. 6, fig. 40.
1969 *Tripodellus robustus* Bischoff — Druce, p. 139, pl. 41, figs. 2a-3.
For further references see list of synonyms in Druce, 1969.

Our specimens are conform those described by Bischoff. For the relation of this form species to other form species see discussion in paragraph Conodont apparatus?

Simple cones
Plate 17, figs. 1, 2.

Under this heading we comprise the simple cones found in our fauna. They are identical to the simple cones described by van den Boogaard (1963, p. 252, pl. 1, fig. 6) as *Drepanodus* ? sp. A. They have a wide and laterally compressed base. The basal cavity is rather deep and roughly triangular in cross section. The aboral margin is curved upwards, most strongly posteriorly. The antero-basal angle is less than 90°. The cusp is rather strongly recurved and not sharply offset from the base posteriorly. Its lateral faces are rounded and smooth. The anterior edge is sharp. The lower half of the posterior edge is rounded, the upper half is sharp.

Lindström (1973) has used the name *Drepanodus* for a genus of simple conodonts with an apparatus consisting of drepanodiform and oistodiform elements. This genus ranges from Early to Middle Ordovician. The genus name *Drepanodus* therefore should not be used for Devonian forms. For the time being we prefer to list the specimens as simple cones until the natural relations are known.

CONODONT APPARATUS ?

Glenister & Klapper (1966, p. 833) already questioned the generic designation of *Prioniodina? smithi*. Druce (1969, p. 112) suggests that *P.? smithi* may belong to the genus *Palmatodella*. Klapper & Philip (1972, p. 100) place *P.? smithi* as A_1 element in their type 1 conodont apparatus *Palmatodella* together with *Palmatolepis* (P element), *Nothognathella* (0_1 element), *Palmatodella* (N element), *Angu-*

Table 2. Localities and conodont zones of the samples used for the calculation of correlation coefficients.

Sample*	Weight dissolved rock (g)	Locality	Conodont Zone
G 1643	1640	Velez Rubio area, Spain	*Palmatolepis quadrantinodosa* Zone
GZn 51/2	95	Velez Rubio area, Spain	*Spathognathodus costatus* Zone
GZn 51/1	110	Velez Rubio area, Spain	*Spathognathodus costatus* Zone
G 1465	1350	Velez Rubio area, Spain	*Spathognathodus costatus* Zone
65Ca/745	800	Castells, Prov. Lerida, Spain	*Spathognathodus costatus* Zone
73/209	1350	La Lastra — Santibanez de Resoba, Spain	*Palmatolepis quadrantinodosa* — *Scaphignathus velifer* Zone
Prof. 1, lr. 2	940	Groszer Pal, Austria	*Spathognathodus costatus* Zone
Prof. 1, lr. 5	1660	Groszer Pal, Austria	*Spathognathodus costatus* Zone
19/9/26	3060	Ballberg near Balve, Germany	*Scaphignathus velifer* Zone
60	2000	Pomarao region, Portugal	*Scaphignathus velifer* Zone
151	350	Pomarao region, Portugal	*Polygnathus styriacus* — *Spathognathodus costatus* Zone
634	220	Pomarao region, Portugal	*Polygnathus styriacus* — *Spathognathodus costatus* Zone
660	900	Pomarao region, Portugal	*Polygnathus styriacus* — *Spathognathodus costatus* Zone
1114	1500	Pomarao region, Portugal	*Polygnathus styriacus* — *Spathognathodus costatus* Zone
1154	3500	Pomarao region, Portugal	*Polygnathus styriacus* — *Spathognathodus costatus* Zone
1187	640	Pomarao region, Portugal	*Polygnathus styriacus* — *Spathognathodus costatus* Zone
1272	1500	Pomarao region, Portugal	*Polygnathus styriacus* — *Spathognathodus costatus* Zone
1278	390	Pomarao region, Portugal	*Polygnathus styriacus* — *Spathognathodus costatus* Zone
1345/1	390	Pomarao region, Portugal	*Polygnathus styriacus* — *Spathognathodus costatus* Zone
1345/2	450	Pomarao region, Portugal	*Polygnathus styriacus* — *Spathognathodus costatus* Zone
1362	1350	Pomarao region, Portugal	*Polygnathus styriacus* — *Spathognathodus costatus* Zone
1362/1	1500	Pomarao region, Portugal	*Polygnathus styriacus* — *Spathognathodus costatus* Zone
1362/b	1300	Pomarao region, Portugal	*Polygnathus styriacus* — *Spathognathodus costatus* Zone
1366	200	Pomarao region, Portugal	*Polygnathus styriacus* — *Spathognathodus costatus* Zone
1386	260	Pomarao region, Portugal	*Polygnathus styriacus* — *Spathognathodus costatus* Zone
C.d.P.	7300	Cabezas del Pasto, Spain	*Polygnathus styriacus* Zone

* The samples 60, 660, 1114, 1154 and 1272 are stored in the Geological Institute of the University of Amsterdam, registration nrs. PA 2844 — PA 3087. The other samples are stored in the Netherlands National Museum of Geology and Mineralogy, Leiden. Registration nrs. RGM 172 802 — 172 885, 172 945 — 172 965, 172 995 — 173 064, 173 208 — 173 522, 173 583 — 173 711.

lodus (A_2 element) and *Scutula* (A_3 element). Ziegler (1972) doubts the participation of *Palmatolepis* in this multielement and places together nothognathelliform, falcodiform, palmatodelliform and scutuliform elements and suggests that *P. smithi* may have functioned as a palmatodelliform element.

In Upper Devonian conodont faunas from southern Portugal (see van den Boogaard, 1963) the numbers of specimens of *Palmatodella* cf. *delicatula* and *Prioniodina? smithi* show an approximately one to one relation. In other samples in our collection from southern Portugal and southern Spain both species seem to show the same relation. To investigate whether this relation was purely accidental or a really existent one, one of us (M. v. d. B.) tried Winder's method of calculating correlation coefficients (Winder, 1974). For the calculation some faunas from Austria, Germany and northern Spain have been used besides the Upper Devonian faunas from southern Portugal and southern Spain (see Table 2). Calculated are correlation coefficients for individuals of those form species that occur in most of the samples: *Palmatolepis gracilis, Prioniodina? smithi, Palmatodella* cf. *delicatula, Tripodellus robustus, Falcodus variabilis, Spathognathodus stabilis* and a simple cone species. Furthermore were included in the calculations *all* individuals respectively belonging to the genera *Palmatolepis, Spathognathodus, Ozarkodina* and *Polygnathus*. First, because it is conceivable that specimens which seem to belong to one form species very well may represent elements of different multielement species. If for example there would exist a natural relationship between *Palmatodella* and *Palmatolepis* morphologically similar forms of *Palmatodella* may belong to different species of *Palmatolepis*. Second, in the case of *Polygnathus* and *Ozarkodina* because none of the form species belonging to these two form genera occurred in more than half of the samples. Because of this and because no natural relationship is supposed to exist between p.e. *Polygnathus* and *Palmatodella* low correlation coefficients would be expected. That needed to be verified, for in case high correlation coefficients would result from the calculations than other than natural relationships e.g. ecological or sedimentological relations would be involved. *Scutula venusta* and *Scutula bipennata* were taken together because many specimens were broken to such an extent that species recognition was impossible. For the numbers of specimens recognized in the samples see Table 3.

Like Winder we calculated the correlation coefficients between pairs of elements on numbers of individuals per 100 g calculated to two decimal places using the formula:

$$r = \frac{N\Sigma xy - \Sigma x\Sigma y}{\sqrt{[N\Sigma x^2 - (\Sigma x)^2]\,[N\Sigma y^2 - (\Sigma y)^2]}}$$

N is the number of samples and x and y are the number of individuals in each sample. The results are shown in Table 4.

We found high correlation coefficients > 0.900 between *Prioniodina? smithi* and each of the following forms *Falcodus variabilis, Scutula, Tripodellus robustus, Palmatodella* cf. *delicatula, Palmatolepis gracilis* and the total of *Palmatolepis* species. In fact all these forms show high correlation coefficients between them except for pairs containing *Scutula,* which have somewhat lower coefficients.

The high correlation coefficients between pairs of the elements *Palmatolepis, Palmatodella* cf. *delicatula, Prioniodina? smithi, Falcodus variabilis* and *Scutula* support their arrangement in one apparatus as done by Klapper & Philip (1972,

Table 3. Distribution and frequency of the species and genera used for the calculation of correlation coefficients.

	Palmatolepis (all species)	*Palmatolepis gracilis*	*Prioniodina? smithi*	*Palmatodella delicatula*	*Tripodellus robustus*	*Scutula venusta* + *bipennata*	*Falcodus variabilis*	*Spathognathodus stabilis*	*Spathognathodus* (all species)	*Ozarkodina* (all species)	*Polygnathus* (all species)	Simple cone
G 1643	1515	245	97	105	51	118	93	--	294	228	152	20
GZn 51/2	27	11	1	1	1	2	3	--	43	9	--	3
GZn 51/1	33	33	2	4	2	2	1	6	21	1	23	1
G 1465	144	125	18	27	15	20	8	129	222	100	6	11
65Ca/745	52	52	17	16	12	4	5	94	406	47	196	27
73/209	44	--	3	1	1	1	--	--	45	34	12	--
Prof.1,lr.2	232	232	17	34	26	10	6	--	856	98	2	11
Prof.1,lr.5	407	385	94	87	77	57	66	82	660	156	188	11
19/9/26	195	27	5	5	9	6	6	2	20	5	41	12
60	283	120	8	6	11	11	2	2	2	8	13	3
151	124	87	5	6	10	2	2	4	14	5	4	--
634	660	528	30	39	43	17	24	86	363	23	42	19
660	294	229	19	17	30	18	11	41	80	6	25	1
1114	1014	820	60	65	80	26	22	117	232	14	111	41
1154	1030	760	90	86	96	37	50	136	241	22	198	57
1187	214	204	20	12	12	6	5	20	76	10	39	13
1272	760	700	70	63	74	26	27	279	438	49	2	6
1278	284	254	5	5	13	12	8	58	114	17	199	19
1345/1	1008	910	51	40	85	47	43	64	840	50	138	44
1345/2	75	63	9	7	8	9	6	58	58	6	42	2
1362	62	51	5	9	8	1	7	21	33	7	4	1
1362/1	190	135	10	7	10	9	7	65	160	15	55	7
1362/b	49	46	3	4	2	3	1	50	53	10	4	1
1366	208	145	13	8	9	12	7	15	84	12	10	10
1386	79	76	10	13	6	6	6	7	46	9	37	7
C.d.P.	1719	1439	108	180	154	71	74	233	592	75	279	55

p. 100). In this apparatus they also placed a nothognathellan element. *Nothognathella,* however, is rare in our samples and has therefore not been included in the calculations. The high correlation coefficients between pairs of the element *Tripodellus robustus* and the elements mentioned above suggest that *Tripodellus robustus* also would belong to the same apparatus. High coefficients are however also found between *T. robustus* and *Spathognathodus.* Also rather high are the coefficients between *Spathognathodus* and the simple cones and most of the other elements mentioned above. Assuming, as is generally believed, that *Spathognathodus* and the simple cones belong to other apparatuses than the one above, we must consider the possibility that the high correlation coefficients reflect ecological or sedimentological relations rather than one representing a natural assemblage. By taking samples from different localities we have to some extent tried to eliminate environmental influences although, with an exception perhaps for sample 65Ca/745, all faunas do belong to the *Palmatolepis* biofacies of Seddon & Sweet (1971) or biofacies III (Druce, 1973).

Consequently we may conclude that the high correlation coefficients obtained above do not prove but also do not contradict the opinion of Klapper & Philip

Table 4. Correlation coefficients for several species and genera from the samples listed in Table 2.

	Palmatolepis (all species)	*Palmatolepis gracilis*	*Prioniodina ? smithi*	*Palmatodella delicatula*	*Tripodellus robustus*	*Scutula venusta* + *bipennata*	*Falcodus variabilis*	*Spathognathodus stabilis*	*Spathognathodus* (all species)	*Ozarkodina* (all species)	*Polygnathus* (all species)
Simple cone	0.885	0.906	0.823	0.714	0.869	0.827	0.848	0.657	0.878	0.573	0.664
Polygnathus (all species)	0.485	0.527	0.413	0.370	0.447	0.511	0.468	0.460	0.483	0.303	
Ozarkodina (all species)	0.576	0.494	0.641	0.618	0.550	0.733	0.727	0.321	0.701		
Spathognathodus (all species)	0.862	0.896	0.839	0.797	0.915	0.798	0.861	---			
Spathognathodus stabilis	0.750	0.777	0.706	0.745	0.741	0.523	0.654				
Falcodus variabilis	0.942	0.897	0.947	0.901	0.911	0.940					
Scutula venusta + *bipennata*	0.879	0.828	0.902	0.786	0.852						
Tripodellus robustus	0.959	0.979	0.936	0.888							
Palmatodella delicatula	0.909	0.874	0.936								
Prioniodina ? smithi	0.935	0.910									

(1972) that *Palmatolepis, Palmatodella delicatula, Prioniodina smithi, Falcodus variabilis* and *Scutula* are elements of one conodont apparatus, be it then that — considering the great difference in numbers generally found between *Palmatolepis* and the other components — one probably has to assume that one single conodont animal possessed several pairs of *Palmatolepis* elements against one or two pairs of the other elements.

Age of the limestone

Because of the presence of *Polygnathus styriacus* the fauna belongs to the *Polygnathus styriacus* Zone. The relatively numerous *Spathognathodus bohlenanus* and also pseudopolygnathids resembling *Pseudopolygnathus dentilineatus* suggests that the fauna belongs to the middle or upper part of the *Polygnathus styriacus* Zone or in cephalopod-stratigraphy to the Lower *Gonioclymenia* Zone (Famennian). This limestone lens at Cabezas del Pasto therefore very probably belongs to the same limestone horizon as is found more westerly in the Pomarao region and which contained faunas of nearly the same composition (van den Boogaard, 1963, 1967).

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Manuscript received 3 January 1975.

Plate 1

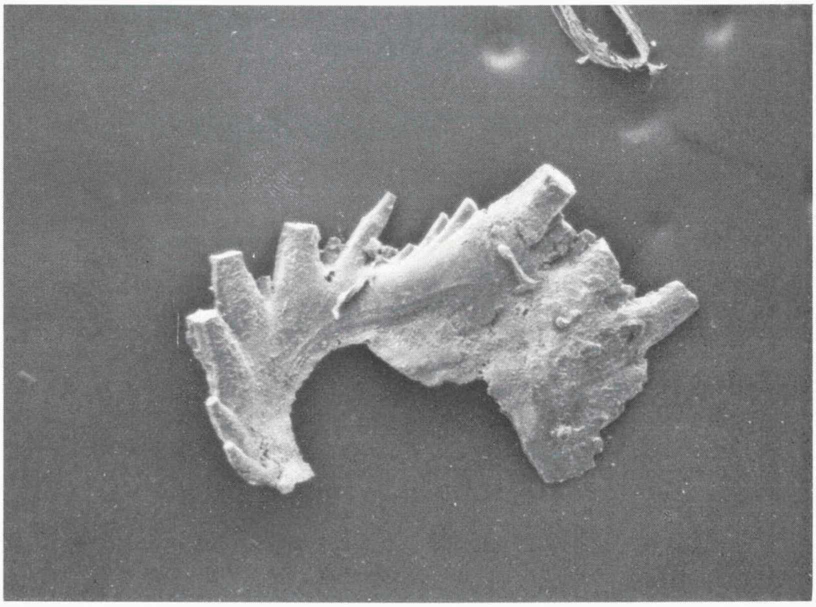

Fig. 1. *Falcodus variabilis* Sannemann. Lateral view, 100 x. RGM 173 691.

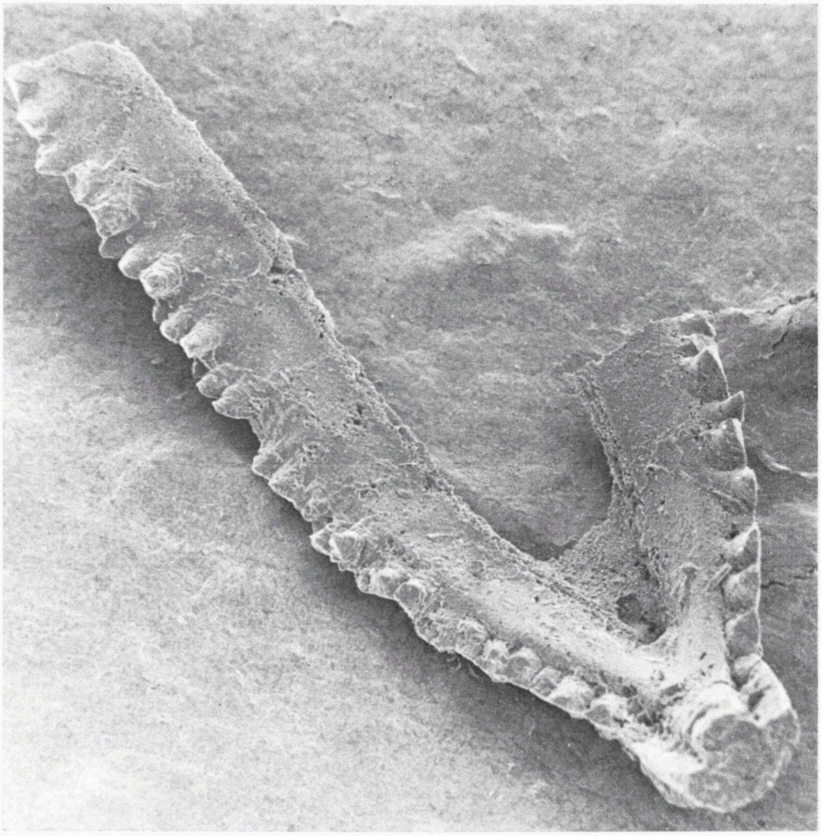

Fig. 2. *Apatognathus varians varians* Branson & Mehl. Inner lateral view, 200 x. RGM 173 707.

Plate 2

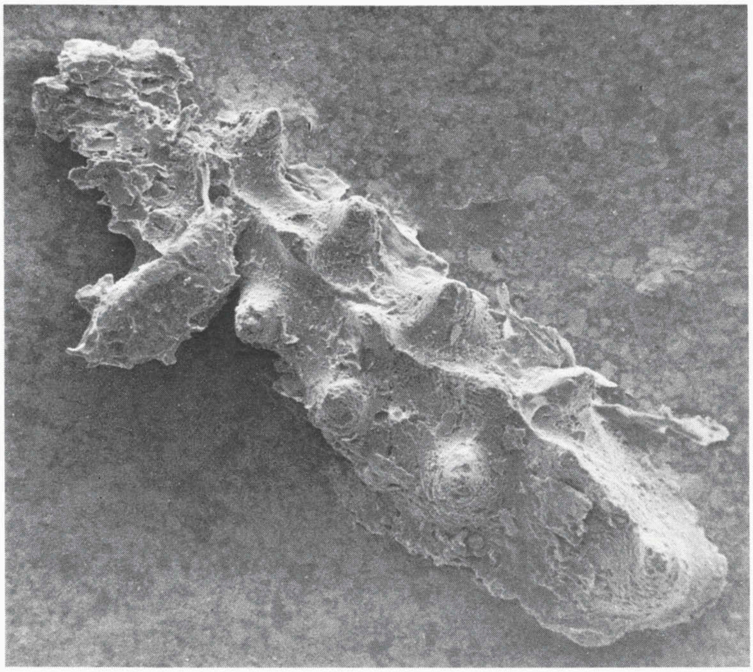

Fig. 1. *Icriodus* sp. Oral view of specimen RGM 173 708, 200 x.

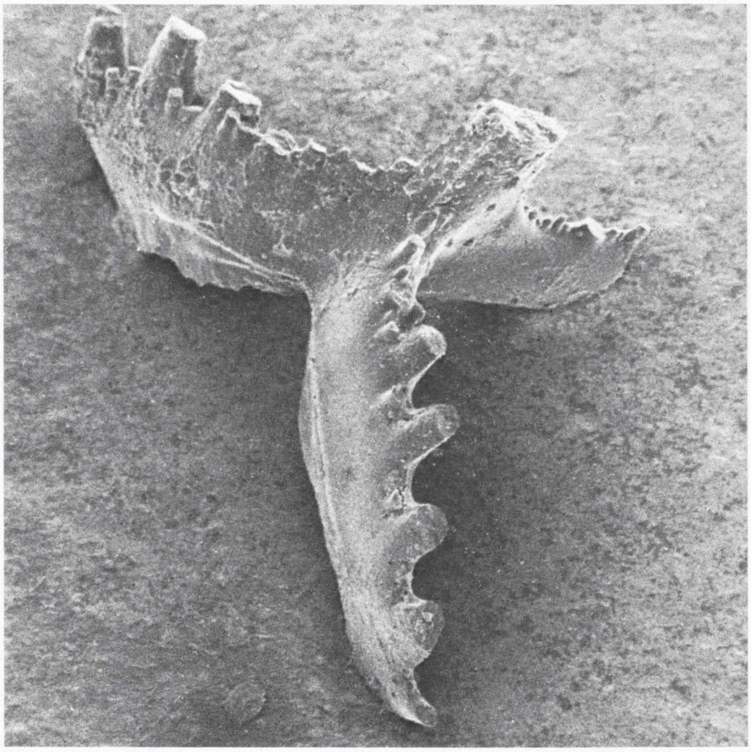

Fig. 2. *Diplododella aurita* Sannemann. Oblique oral view, 145 x. RGM 173 705.

Plate 3

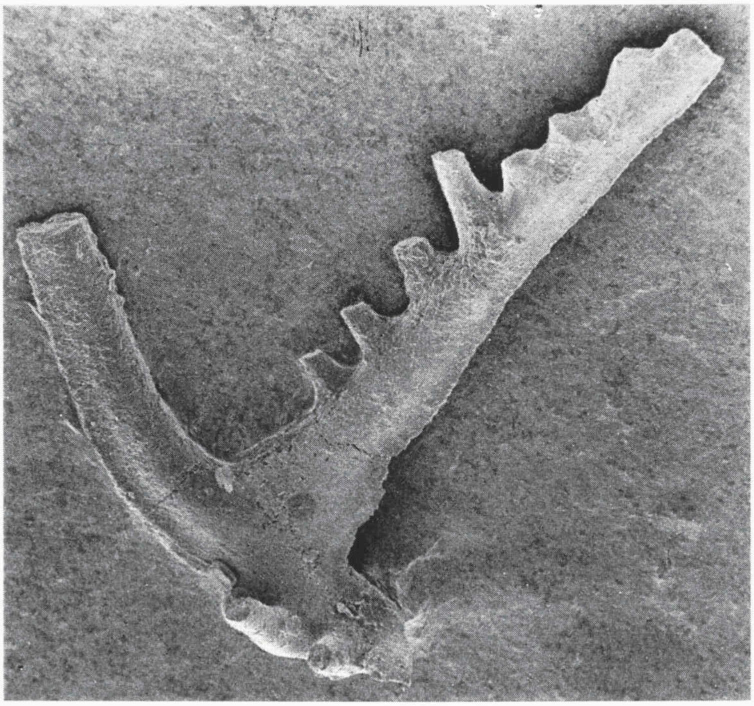

Fig. 1. *Ligonodina delicata* Branson & Mehl. Inner lateral view of specimen RGM 173 707, 100 x.

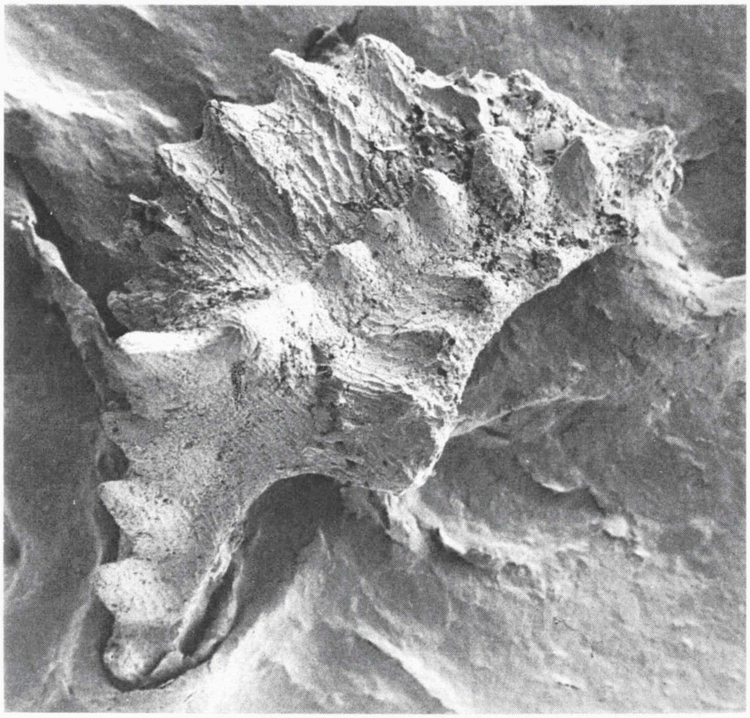

Fig. 2. *Nothognathella ziegleri* Helms. Oblique oral view of specimen RGM 173 709, 180 x.

Plate 4

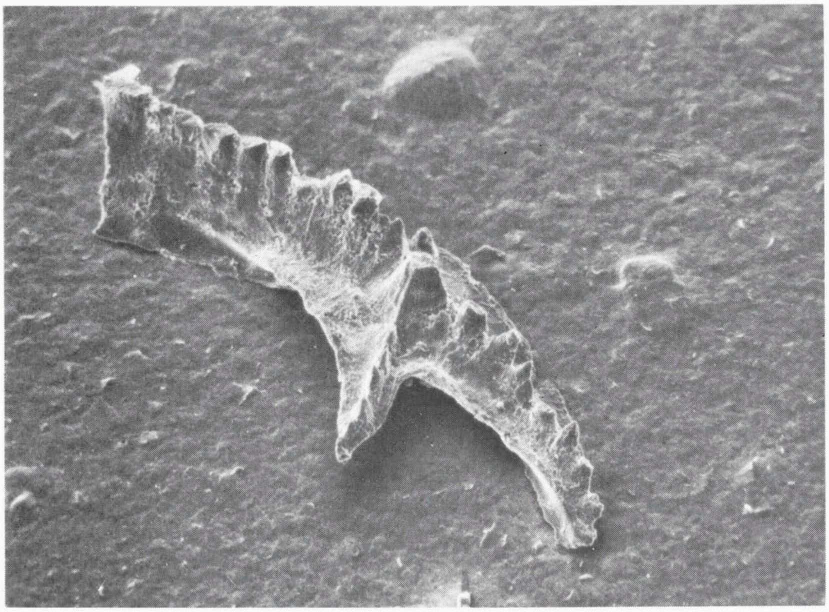

Fig. 1. *Palmatolepis gracilis gracilis* Branson & Mehl. Posterior upper view of aberrant specimen with secondary carina (RGM 173 704), 110 x.

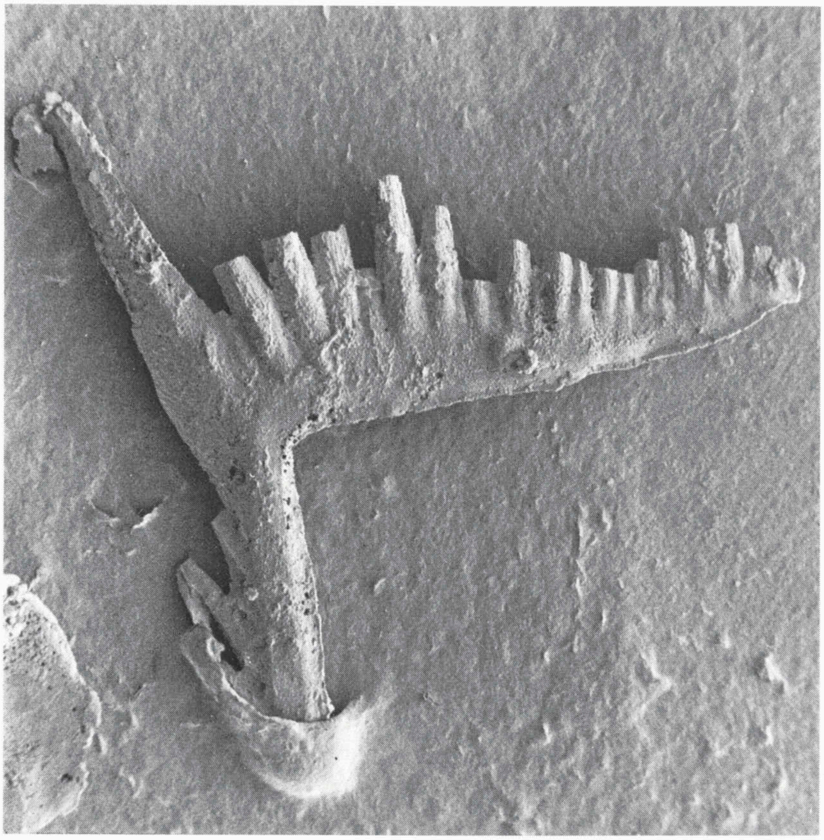

Fig. 2. *Palmatodella delicatula* Bassler. Lateral view of specimen RGM 173 701, 100 x.

Plate 5

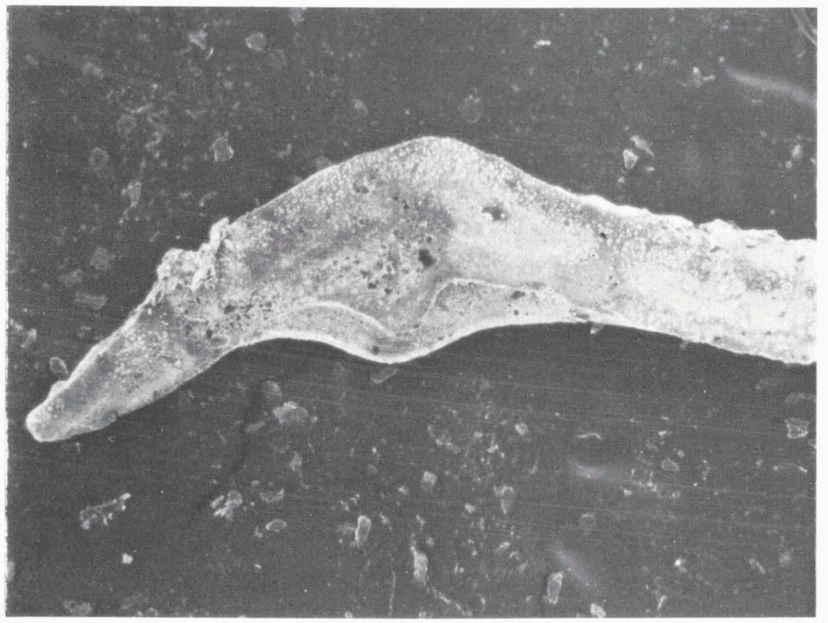

Fig. 1. *Palmatolepis gracilis gracilis* Branson & Mehl. Aboral view of specimen RGM 173 687, 110 x.

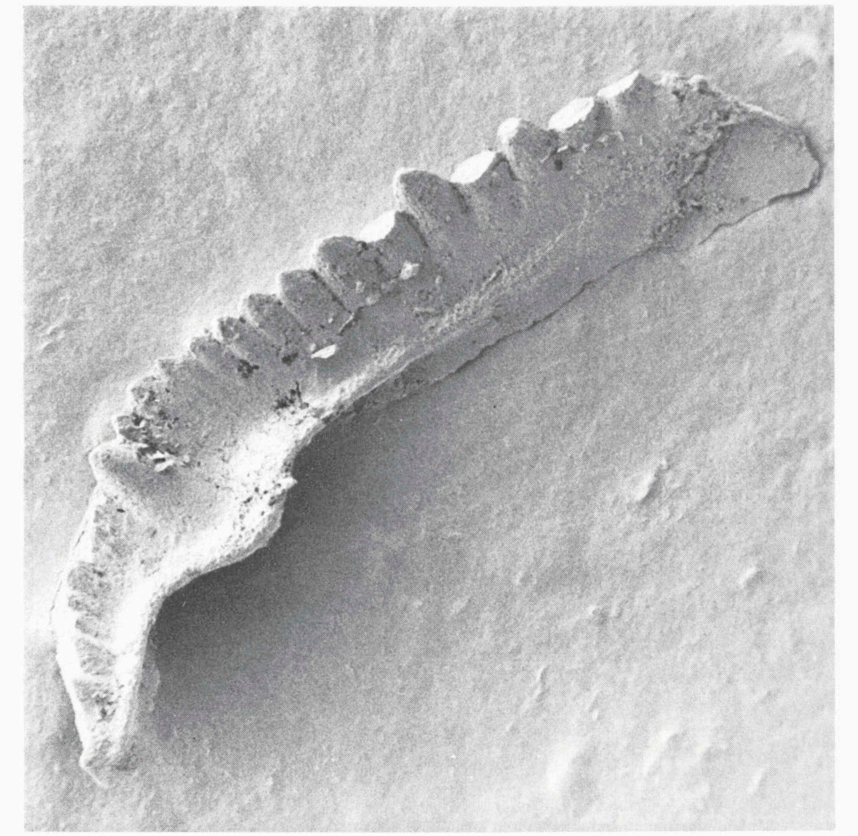

Fig. 2. *Palmatolepis gracilis gracilis* Branson & Mehl. Lateral view of specimen RGM 173 701, 125 x.

Plate 6

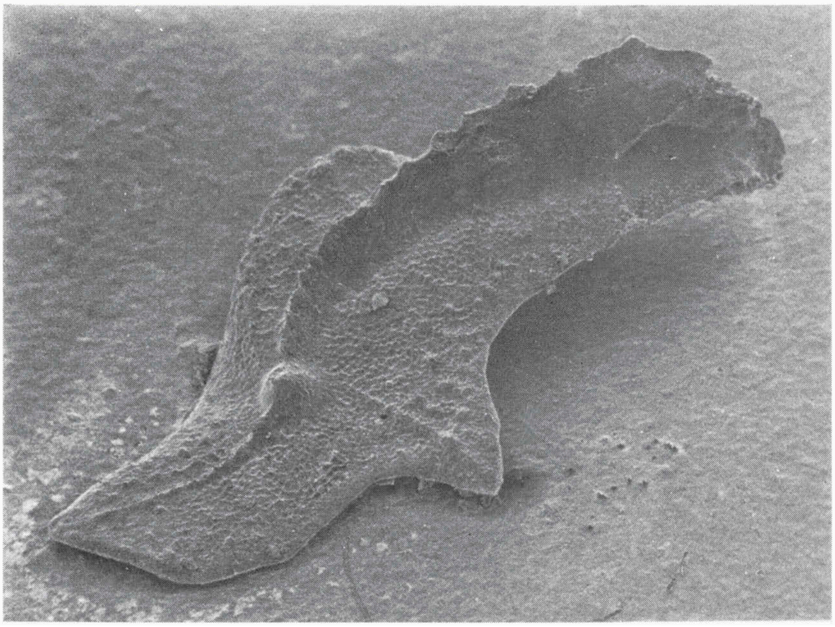

Fig. 1. *Palmatolepis perlobata schindewolfi* Müller. View of oral side of specimen RGM 173 707, 75 x.

Fig. 2. *Palmatolepis perlobata schindewolfi* Müller. View of oral side of specimen RGM 173 701, 50 x.

Plate 7

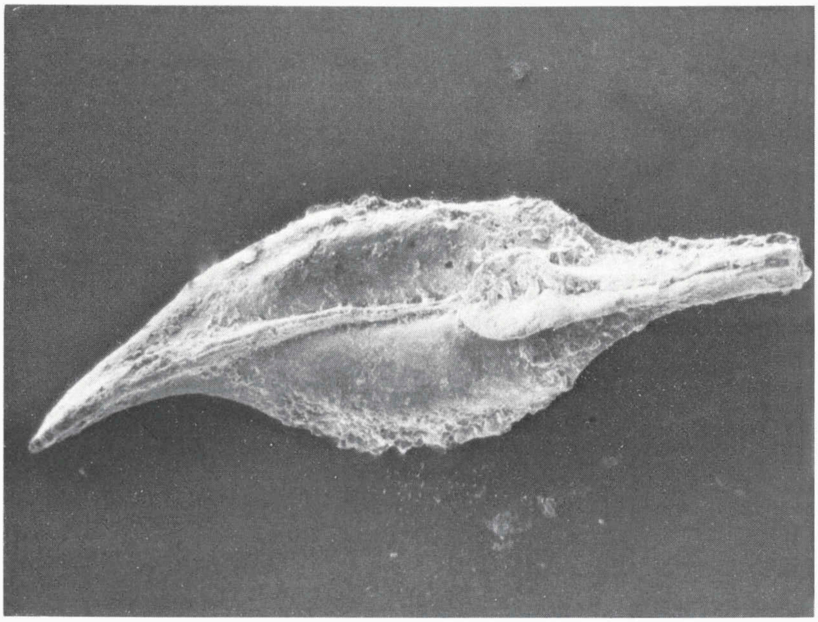

Fig. 1. *Polygnathus communis communis* Branson & Mehl. View of aboral side of specimen RGM 173 683, 200 x.

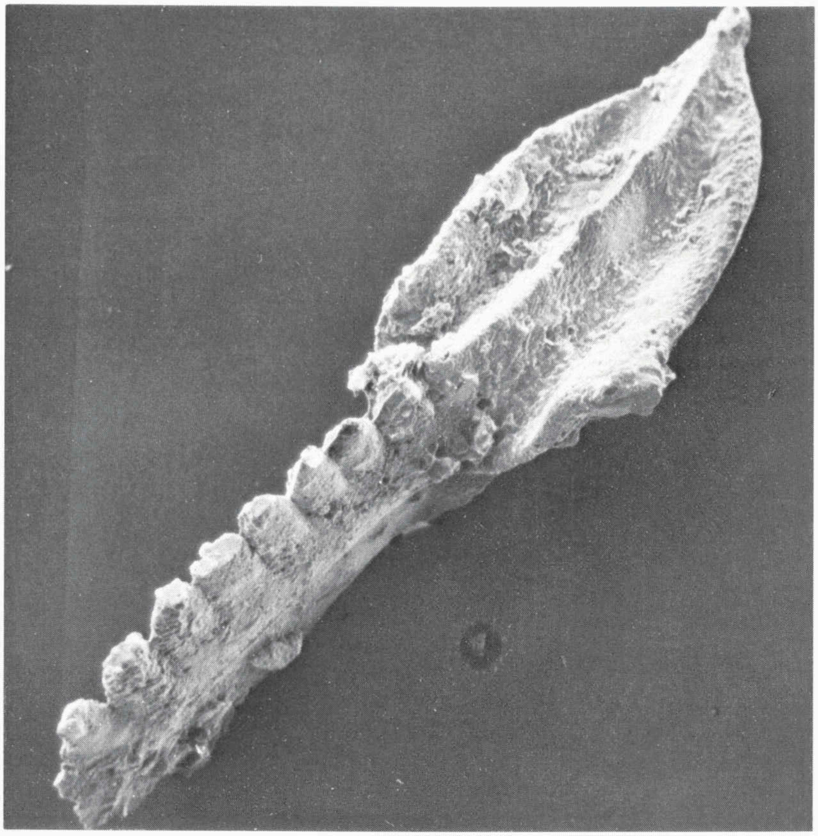

Fig. 2. *Polygnathus communis communis* Branson & Mehl. View of oral side of specimen RGM 173 689, 200 x.

Plate 8

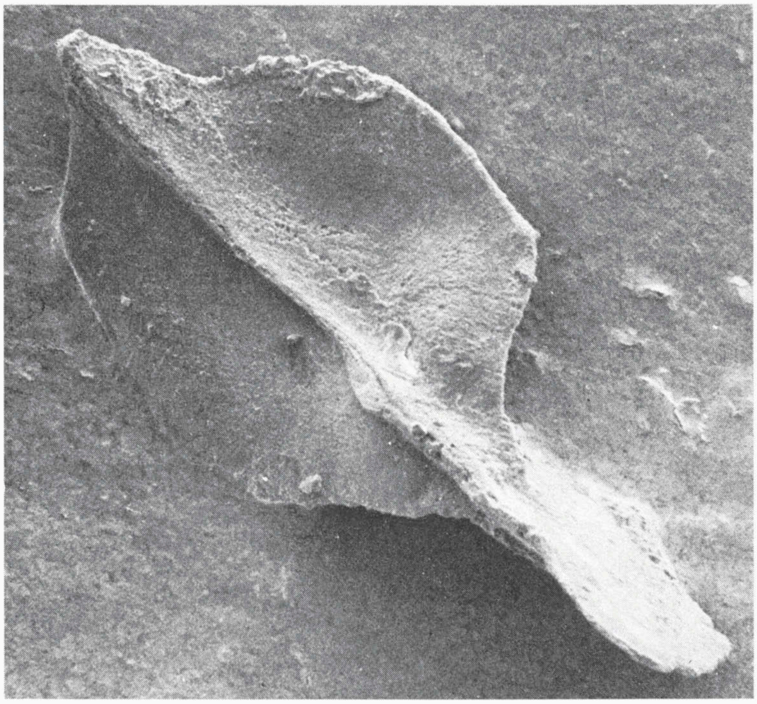

Fig. 1. *Polygnathus styriacus* Ziegler. View of aboral side of specimen RGM 173 708, 140 x.

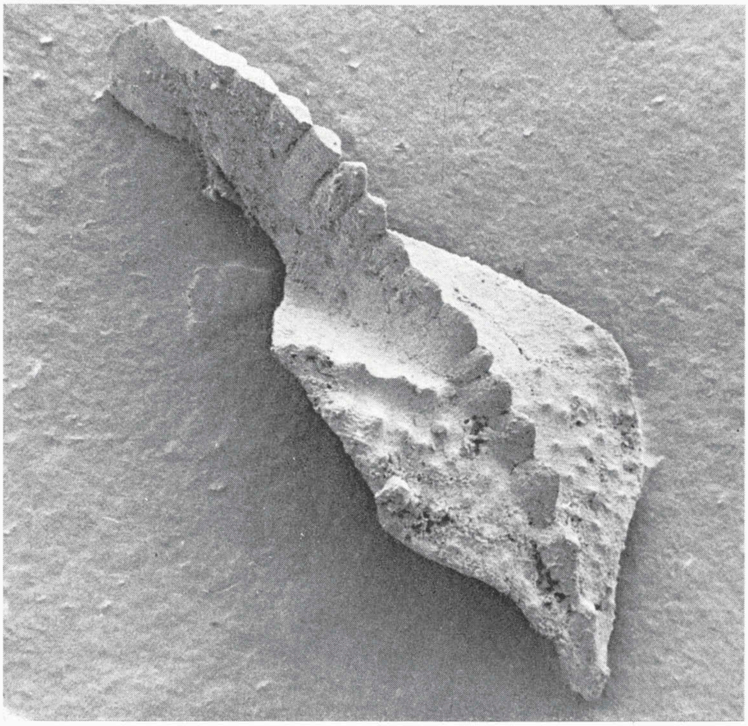

Fig. 2. *Polygnathus styriacus* Ziegler. View of oral side of specimen RGM 173 701, 120 x.

Plate 9

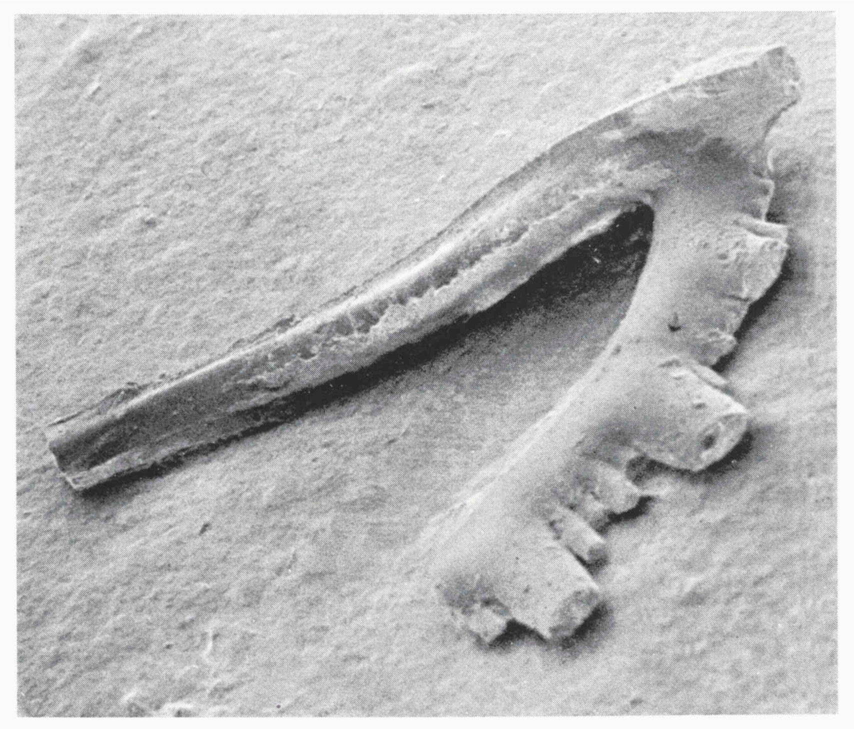

Fig. 1. *Prioniodina? smithi* (Stauffer). Inner lateral view of specimen RGM 173 708, 150 x.

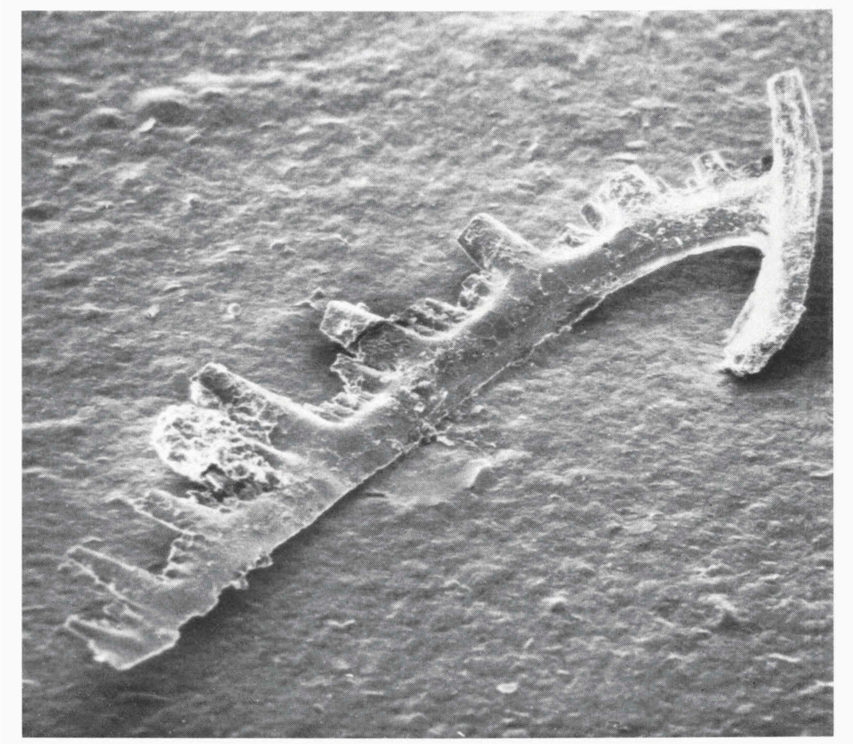

Fig. 2. *Prioniodina? smithi* (Stauffer). Inner lateral view of specimen RGM 173 703, 100 x.

Plate 10

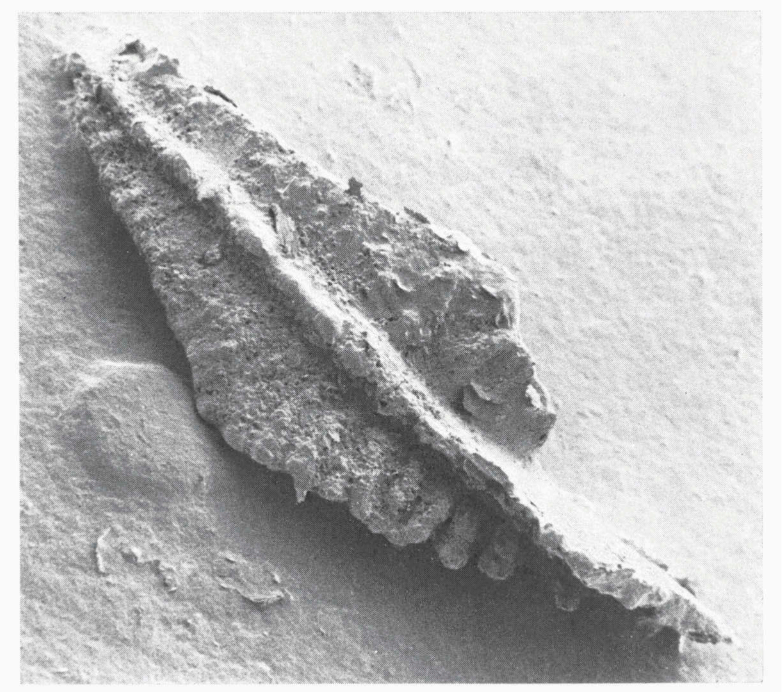

Fig. 1. *Pseudopolygnathus* sp. Oral view of specimen RGM 173 710, 100 x.

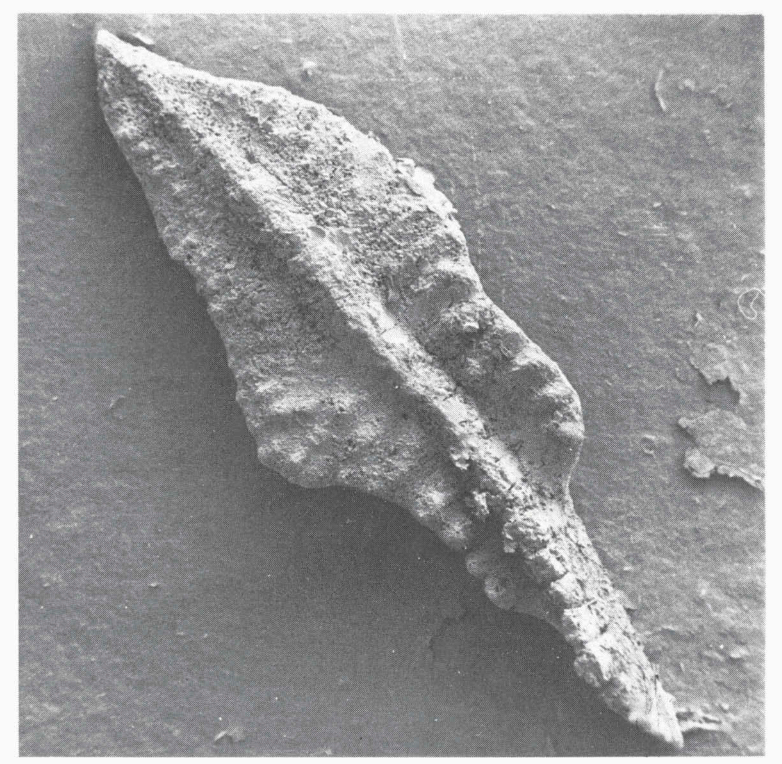

Fig. 2. *Pseudopolygnathus* sp. Oral view of specimen RGM 173 711, 90 x.

Plate 11

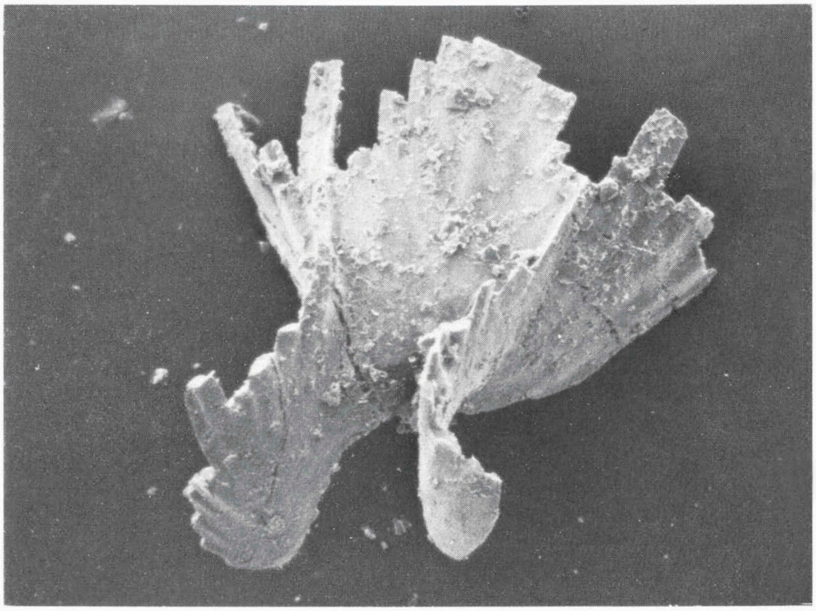

Fig. 1. *Scutula bipennata* Sannemann. Anterior view of specimen RGM 173 696, 200 x.

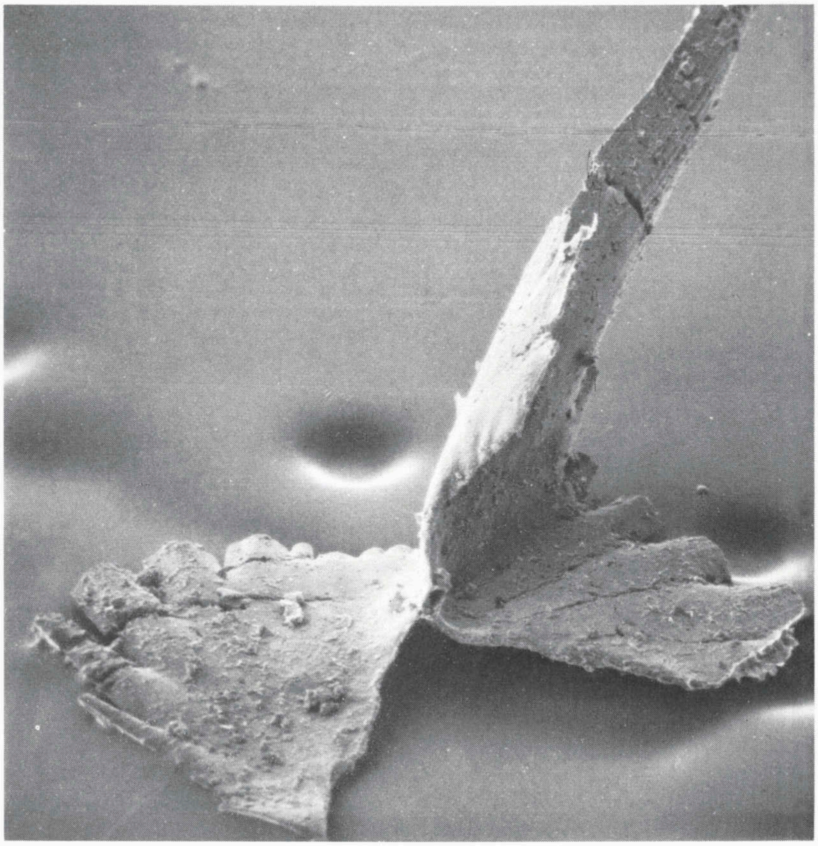

Fig. 2. *Scutula venusta* Sannemann. Oblique aboral view of specimen RGM 173 695, 200 x.

Plate 12

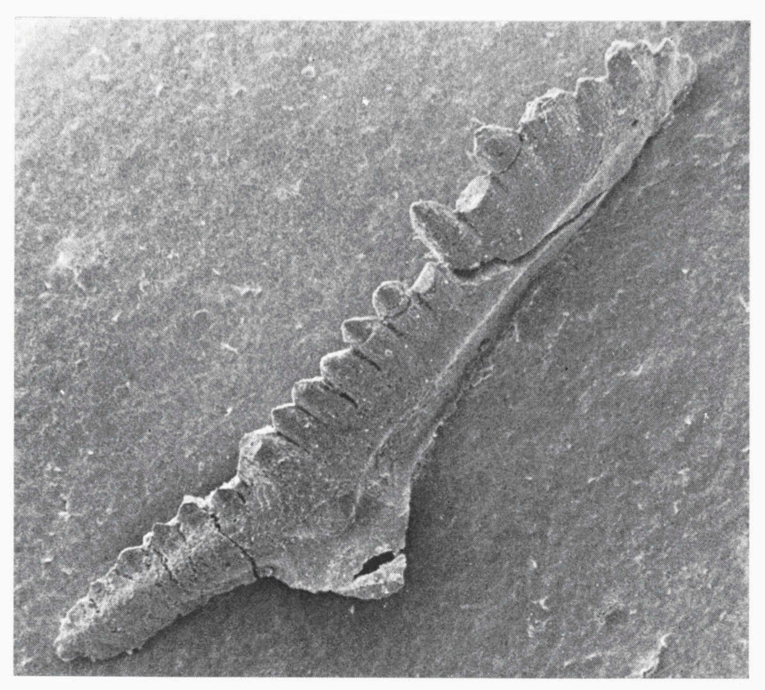

Fig. 1. *Spathognathodus bohlenanus* Helms. Oblique view of outer lateral side of specimen RGM 173 703, 140 x.

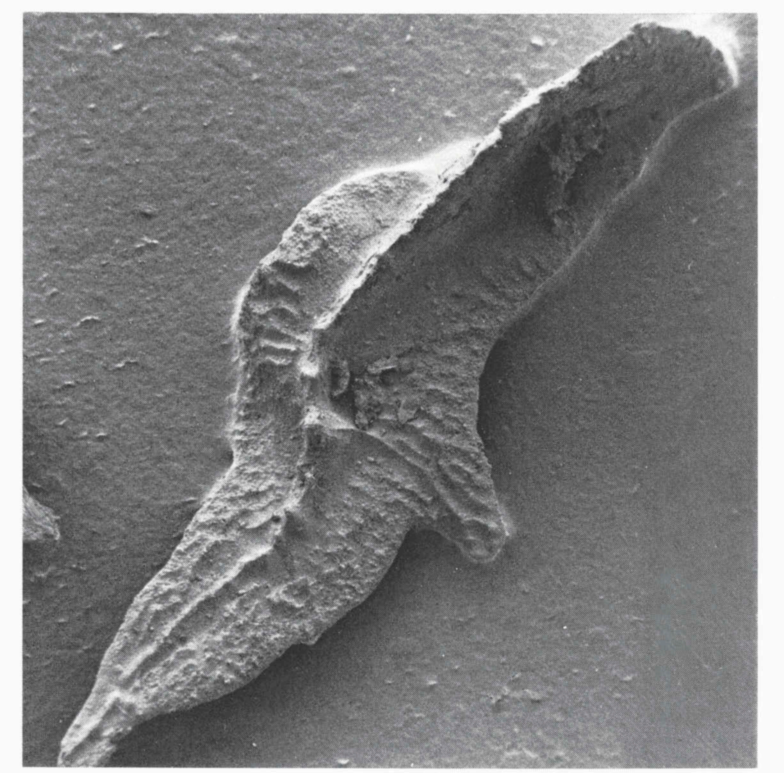

Fig. 2. *Palmatolepis maxima* Müller. View of oral side of specimen RGM 173 701, 40 x.

Plate 13

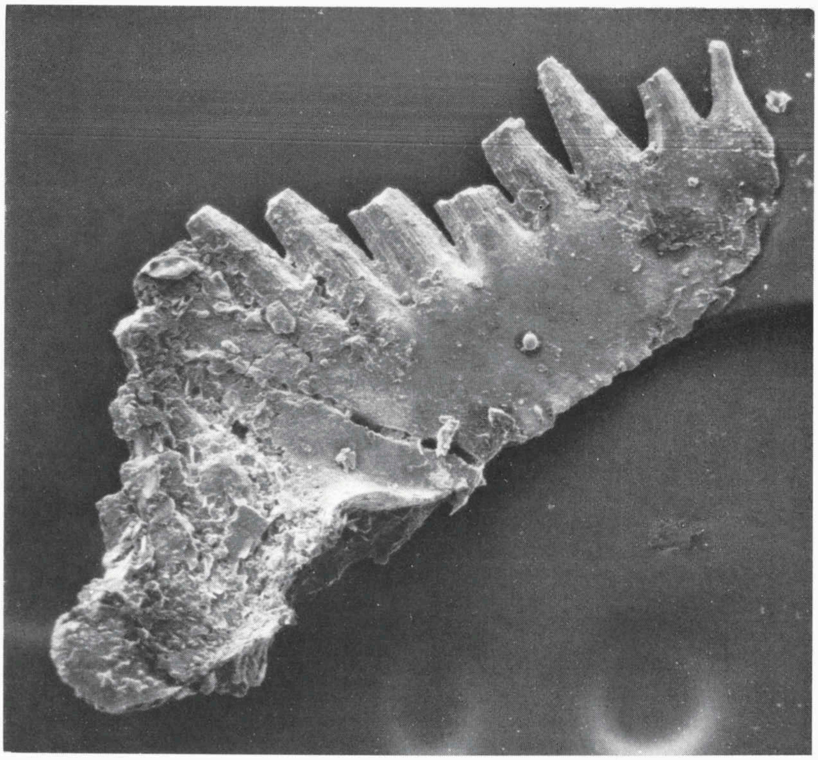

Fig. 1. *Spathognathodus inornatus* (Branson & Mehl). Lateral view of specimen RGM 173 681, 200 x.

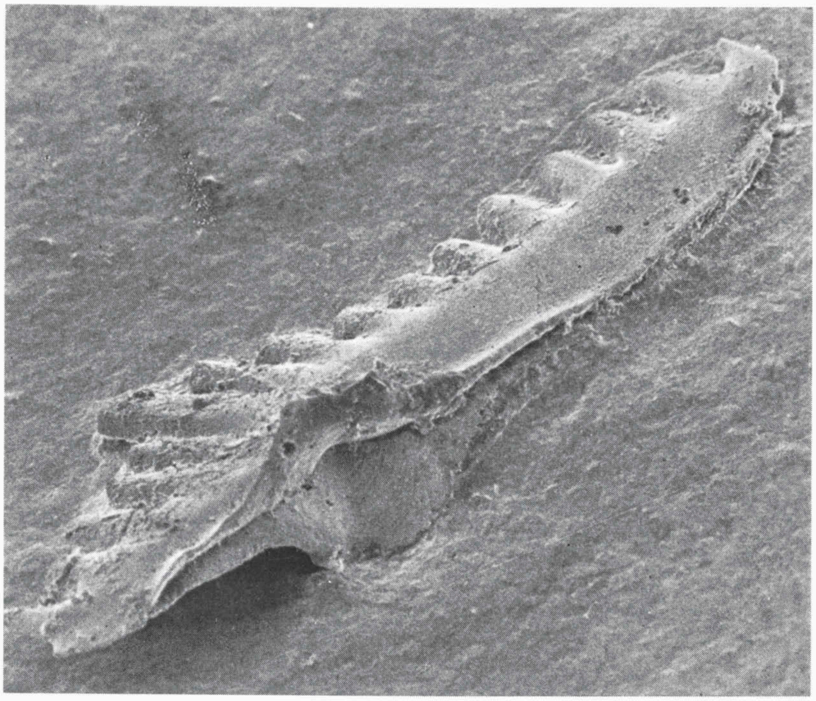

Fig. 2. *Spathognathodus inornatus* (Branson & Mehl). View of aboral side of specimen RGM 173 707, 130 x.

Plate 14

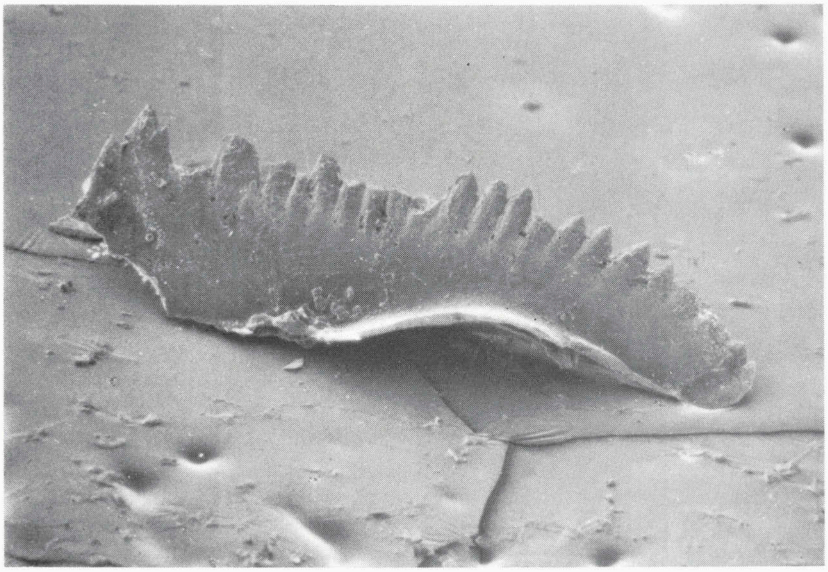

Fig. 1. *Spathognathodus stabilis* (Branson & Mehl). Lateral view of specimen RGM 173 699, 100 x.

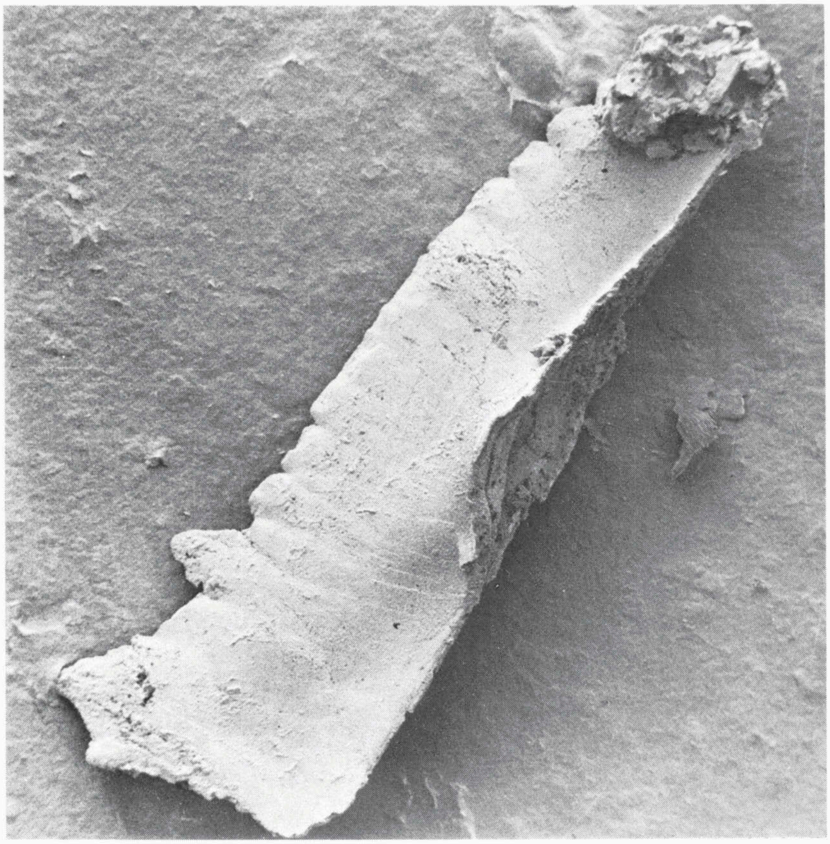

Fig. 2. *Spathognathodus stabilis* (Branson & Mehl). Lateral view of specimen RGM 173 701. 100 x.

Plate 15

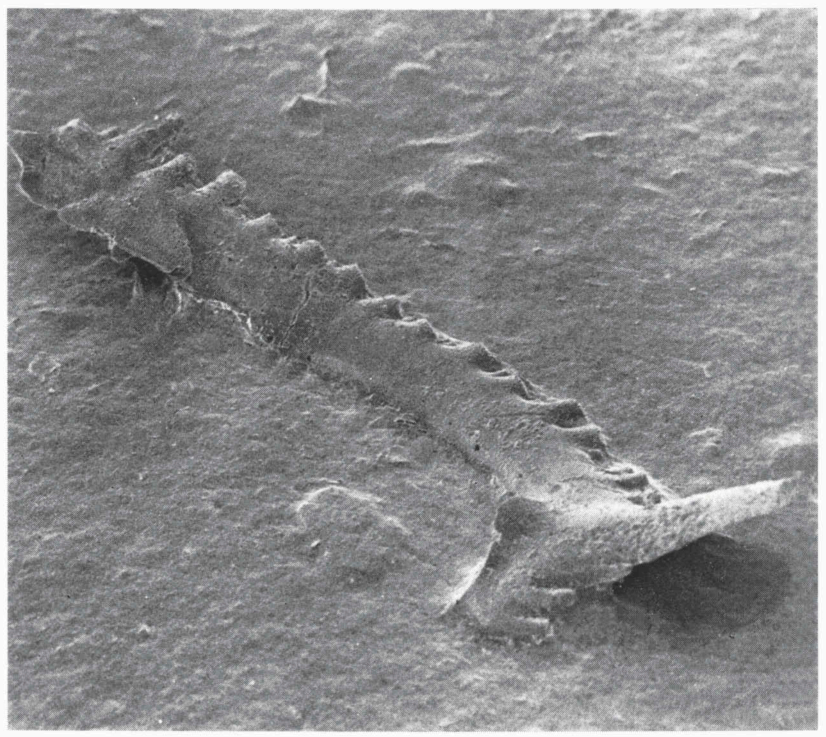

Fig. 1. *Synprioniodina alternata* Bassler. Lateral view of specimen RGM 173 705, 100 x.

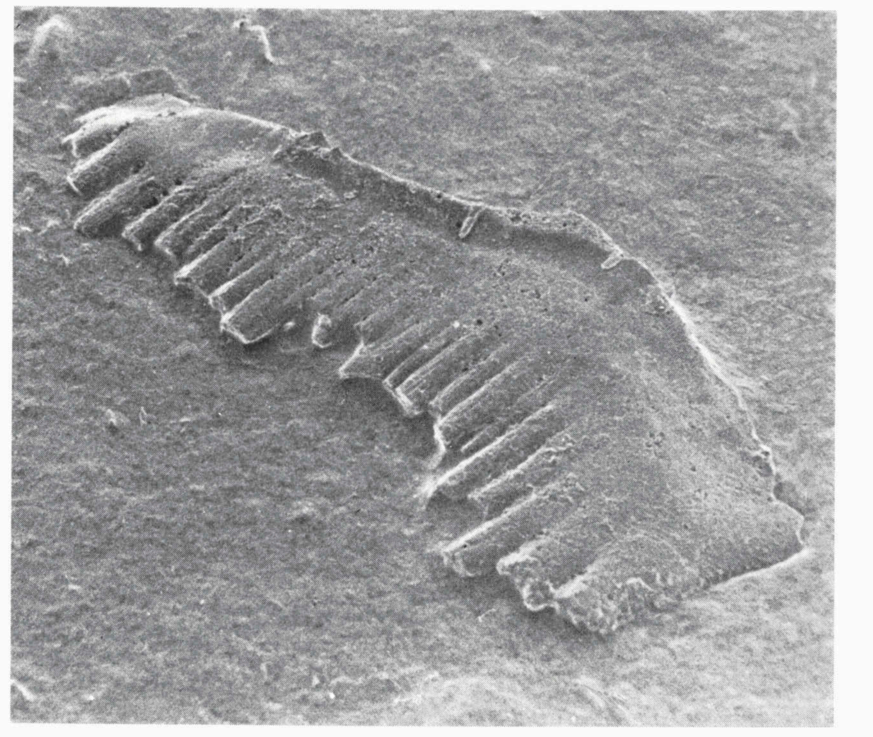

Fig. 2. *Spathognathodus strigosus* (Branson & Mehl). View of lateral side of specimen RGM 173 707, 140 x.

Plate 16

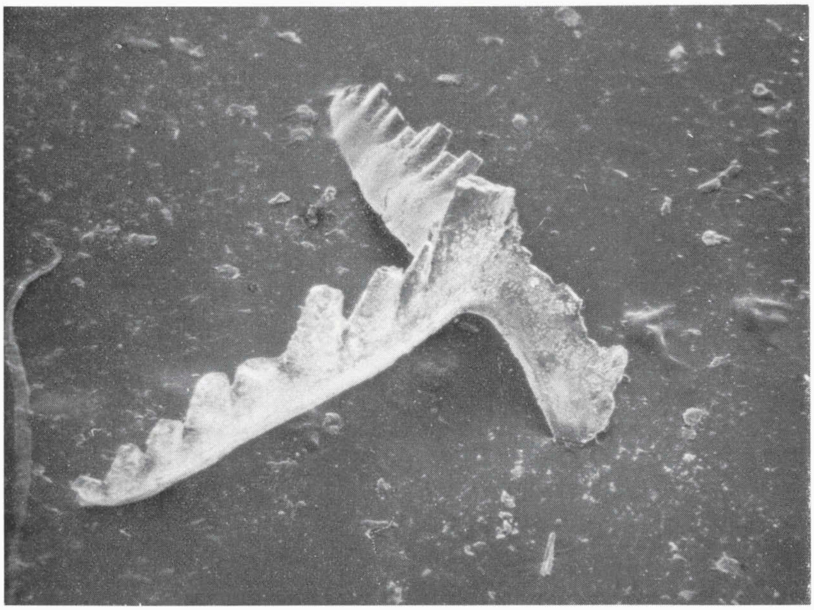

Fig. 1. *Tripodellus robustus* Bischoff. Oblique oral view of specimen RGM 173 694, 110 x.

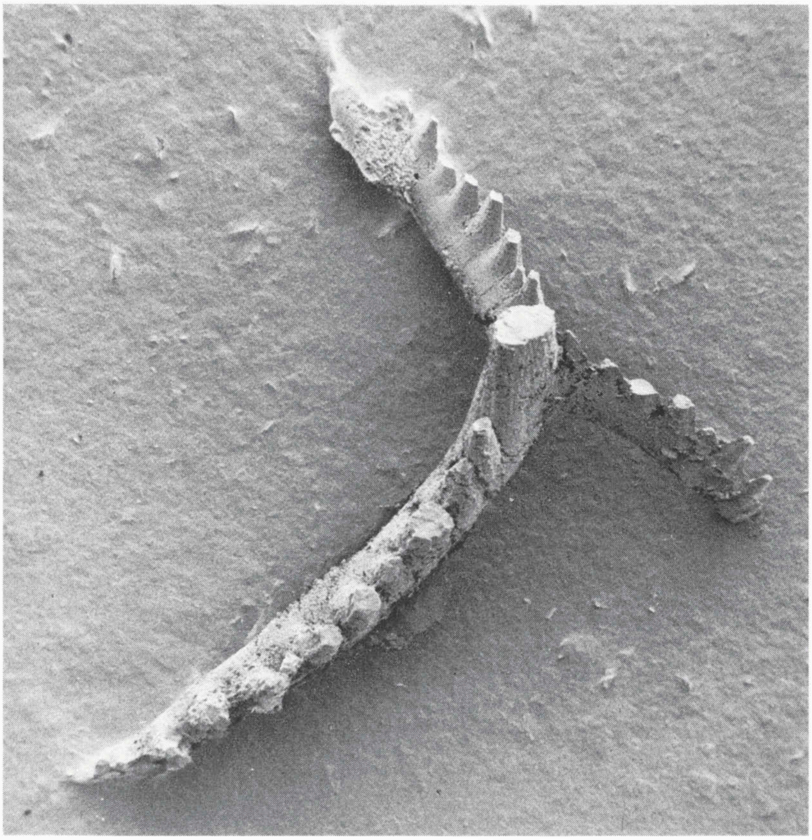

Fig. 2. *Tripodellus robustus* Bischoff. Oral view of specimen RGM 173 708, 140 x.

Plate 17

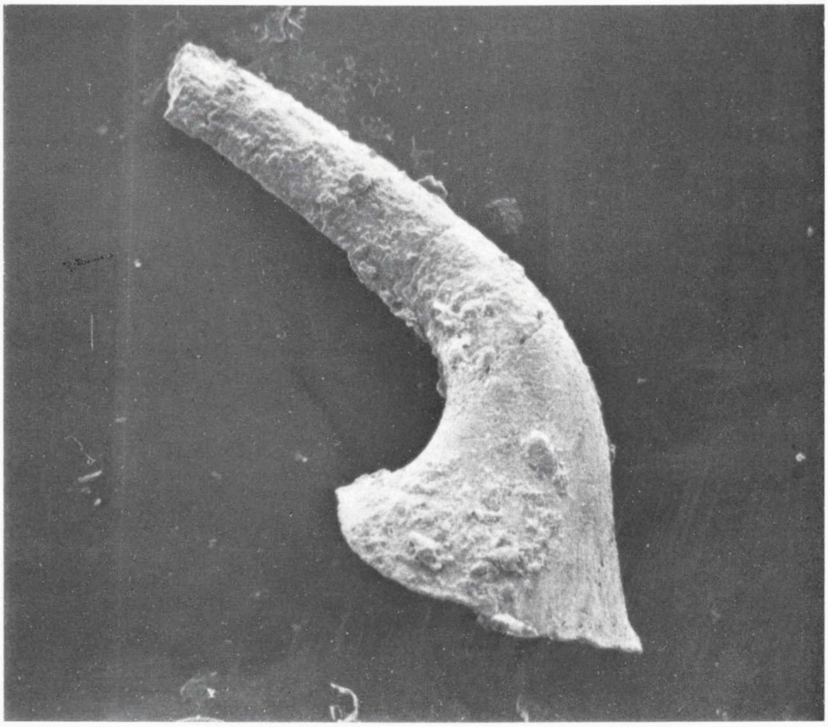

Fig. 1. Simple cone. Lateral view of specimen RGM 173 682, 200 x.

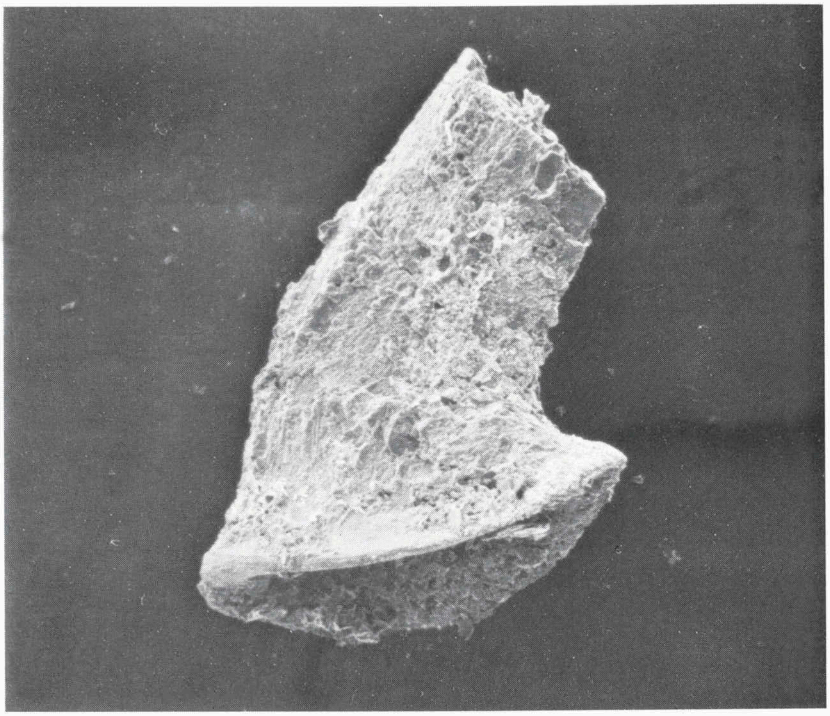

Fig. 2. Simple cone. Lateral view of specimen RGM 173 698, 200 x.