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## UPPER DEVONIAN CONODONTS FROM LADAKH, HIMALAYA, INDIA

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*Key-words:* Conodonta, Biostratigraphy, Chronostratigraphy, Devonian, Himalaya.

*Abstract.* The present paper describes Upper Devonian conodont fauna from the black and bluish limestone succession lying immediately above the Muth Quartzite exposed near the village Tanze, Luneak valley, Ladakh.

### Introduction.

A complete sequence of rocks ranging in age from Precambrian to Triassic is well exposed in the Luneak valley of Zanskar area, Ladakh. The stratigraphic sequence exposed in the area forms a northwestern continuation of the section exposed in the Spiti valley. The geology of this area has been discussed in detail by Gupta (1977).

The oldest rocks in the Luneak valley and its adjoining areas (Padam, Ichar and Doda) are represented by Suru Crystalline (Precambrian in age). This formation is overlain by the Phe Formation which is well exposed in Lingtichun (Kurgiakh) and Doda valleys ( $32^{\circ} 54' 45''$ ;  $77^{\circ} 34' 00''$ ) and has yielded few poorly preserved trilobites and primitive brachiopods suggesting Cambrian to Early Silurian age for it. The Phe Formation is overlain by Tanze Formation which is well exposed between Tanze ( $34^{\circ} 08' 30''$ ;  $77^{\circ} 13' 15''$ ) and Kurgiakh Chu village. The lower units of Tanze Formation are considered to be of early Late Silurian age whereas the upper units of this formation have yielded Middle Devonian fishes (Gupta & Janvier, 1981 a, b).

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### Age of the Muth Quartzite.

The Tanze Formation is overlain by the Muth Quartzite which has been assigned Middle to Upper Devonian age on the basis of fossils found in the Quartzite sequence exposed in different parts of Himalaya (Gupta, 1973). The Muth Quartzite in the Luneak valley is overlain by the Luneak Formation (1) which consists of a thick succession of fossiliferous grey to greyish, black and bluish limestone, slates, shales and quartzites. The lowermost units of black and bluish limestone lying immediately above the Muth Quartzite exposed near

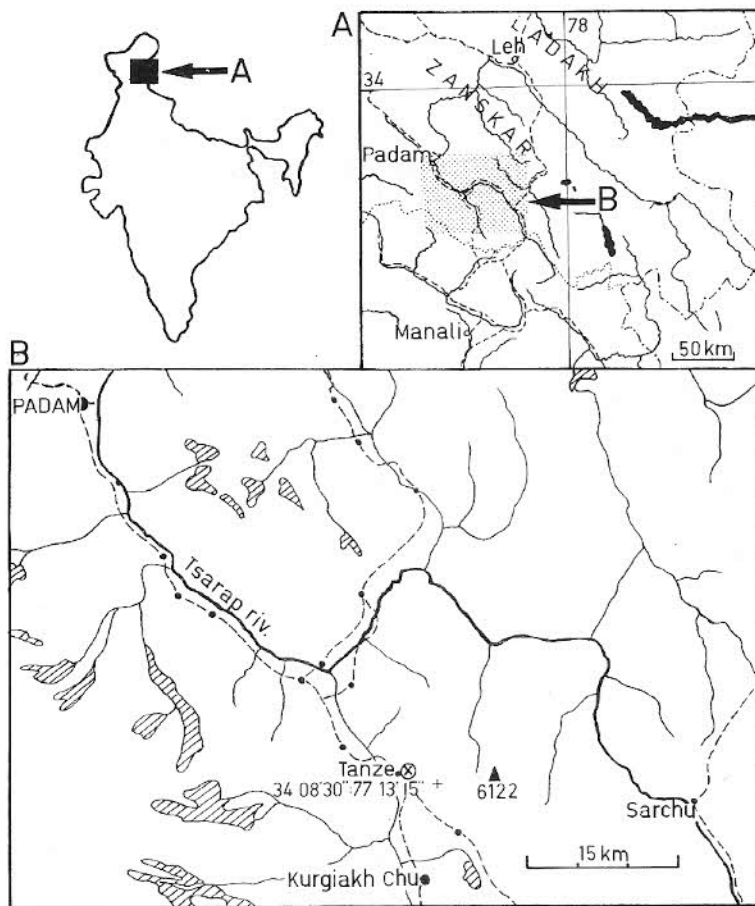


Fig. 1 – Geographical map showing location of fossiliferous outcrop. \* shows location of Fig. 2.

(1) Luneak Formation in the Luneak valley of Ladakh is homotaxial of the Lipak Formation of Spiti and Syringothyris Limestone of Kashmir.

the village Tanze ( $34^{\circ} 08' 30''$ ;  $77^{\circ} 13' 15''$ ) have yielded characteristic Upper Devonian conodonts belonging to the Lower *marginifera* Zone of Sandberg and Ziegler (1973). The different species of *Palmatolepis* described in the present paper mainly evolved from *Palmatolepis tenuipunctata* and *P. delicatula* stocks which were confined to the Lower *crepida* Zone. *Palmatolepis glabra* first appeared in the Upper *crepida* Zone and their different subspecies (*Palmatolepis glabra acuta*, *P. g. pectinata*, *P. g. prima* and *P. g. lepta*) are confined up to the Upper *marginifera* Zone. These forms seem to have evolved from *P. tenuipunctata* stock. *Palmatolepis klapperi* found associated with the conodont fauna from Tanze ranges from Lower *rhomboidea* Zone to Lower *marginifera* Zone. *Palmatolepis marginifera duplicata*, *P. stoppeli*, *P. quadrantinodosa quadrantinodosa*, *P. q. inflexoidea* found in the fauna are the characteristic forms of Lower *marginifera* Zone. All these forms with the exception of *P. marginifera duplicata* evolved from *P. delicatula* stock.

The conodont fauna is associated with rich assemblage of fishes and crinoids. The conodont fauna from this horizon is suggestive of Famennian age for the beds yielding them. The Muth Quartzite lying below the conodont bearing

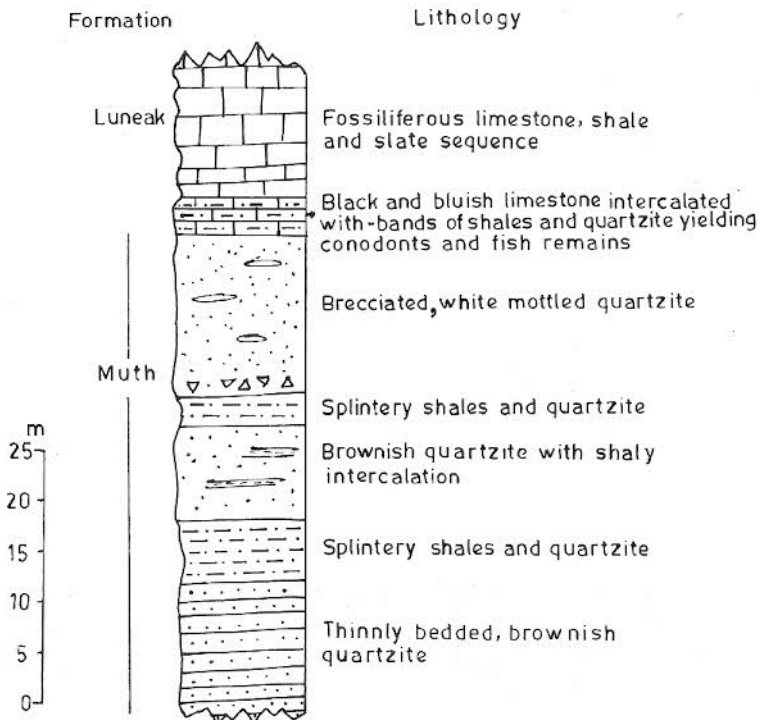


Fig. 2 — Stratigraphic column showing detailed lithological succession of Upper Devonian and Lower Carboniferous rocks exposed near Tanze.

System	Series	Stages	Kashmir			Ladakh	Spiti	Kumaun
			Naubug	Lutherwan	Kishtwar			
Carboniferous	Lower	Tournaisian	Syringothyris Limestone	Syringothyris Limestone	Syringothyris Limestone	Luneak Formation	Lipak Formation	Kali Series
DEVONIAN	UPPER DEVONIAN	Famennian	MUTH QUARTZITE	MUTH QUARTZITE	Limestone interbedded with Upper units of Tanawals yielding conodonts of Lower <i>asymmetricus</i> Zone.	MUTH QUARTZITE	Dolomitic limestone interbedded within the Upper units of Muth Quartzite yielding conodonts.	MUTH QUARTZITE
	MIDDLE DEVONIAN	Frasnian		Siliceous Limestone yielding conodonts of <i>hermannicristatus</i> Zone.				
		Givetian						
		Couvinian	Naubug beds ?	Naubug beds				

Table 1 — Table showing correlation of Upper Devonian and Lower Carboniferous rocks of the Himalaya

beds may range in age from upper Middle (Givetian) to lower Upper (Frasnian) Devonian.

The beds yielding Upper Devonian conodonts are conformably overlain by the siliceous limestone which has yielded conodonts (*Siphonella* cf. *duplicata*, *S. cooperi*, *Spathognathodus campbelli*, *Gnathodus bilineatus*, *G. defectus*, *G. cf. delicatus*, *Elictognathus lacerata*, *Idiognathodus* cf. *delicatus*, *Pseudopolygnathus prima*, etc.), brachiopods (*Syringothyris cuspidata*, «*Rhynchonella*» sp., *Retichonetes* sp., *Derbyia* sp., etc.) and a few poorly preserved bryozoans (*Polypora* sp.) of Tournaisian to Viséan age (Gupta & Kachroo, 1977). The Luneak Formation is unconformably overlain by a thick succession of Ralakung Volcanics (1) of Permian age.

### Systematic description

#### *Palmatolepis* cf. *disparilis* Ziegler & Klapper, 1976

Pl. 31, fig. 6

1976 *Palmatolepis disparilis* Ziegler & Klapper, p. 119, pl. 1, fig. 18–22, 24–31.

Remarks. A broken specimen having oval shape platform, carina nearly straight and does not reach the posterior lip of the platform. Platform ornamented with number of very coarse nodes. The aboral side has a small elongated basal cavity raised above the lower level.

The specimen under description is comparable to *Palmatolepis disparaleva* but differ in having small basal pit and well differentiated outer platform lobe in the later.

#### *Palmatolepis glabra acuta* Helms, 1963

Pl. 30, fig. 1

1973 *Palmatolepis glabra acuta* – Sandberg & Ziegler, p. 114, pl. 2, fig. 5.

Remarks. Specimens large with narrow and elongated platform; posterior end of the platform tongue-shaped, throne-like projection of the inner platform margin pointing anteriorly and forming an acute angle with the blade. Posterior carina well developed. Large, elongated platform and an acute angle between parapet crest and blade that opens anteriorly by 45° distinguishes it from the other species.

*P. glabra acuta* evolved from the *P. glabra prima* and *P. glabra lepta* by the development of an acute angle between parapet and blade. *P. glabra acuta*

(1) Ralakung Volcanic Succession in the Luneak valley of Ladakh is considered homotaxial of the Panjal Volcanic Succession of Kashmir.

closely resembles to *P. glabra pectinata* but the two differ in the development of parapet crest which in the later is more parallel to the blade.

***Palmatolepis glabra lepta* Ziegler & Huddle, 1969**

Pl. 30, fig. 8

1973 *Palmatolepis glabra lepta* — Sandberg & Ziegler, p. 114, pl. 2, fig. 3, 16.

Remarks. *P. glabra lepta* is a subspecies of *P. glabra* with exceptional elongated and slender platform, having shagreen surface and triangular inner parapet bowed upward. Some specimens are characterized by the presence of short high parapet similar to that of *P. glabra pectinata*, but the specimens under description have a well developed slender platform. The present subspecies seems to have evolved from *P. glabra prima* by the development of triangular parapet. *P. glabra lepta* is distinguished from all other subspecies of *P. glabra* by the presence of extremely slender and elongated platform.

***Palmatolepis glabra pectinata* Ziegler, 1962**

Pl. 30, fig. 5

1973 *Palmatolepis glabra pectinata* — Sandberg & Ziegler, p. 104, pl. 2, fig. 4, 12 — 15, 29.

Remarks. A subspecies of *P. glabra* having well developed carina posterior to the central node. Platform elongated, tongue shaped. The distinguishing feature in the subspecies under description is the development of the sharp parapet on its anterior half which is parallel to carina. This parapet is as high as carina in side view. The parallel nature of the parapet distinguished this subspecies from *P. glabra acuta* which is characterized by the development of an acute angle between parapet and blade. Aboral side has a well developed large heel. The parapet of *P. glabra pectinata* is larger than *P. glabra prima* and lies closer to the blade. *P. glabra pectinata* evolved from *P. glabra prima* by the development of parallel parapet from flat inner margin.

***Palmatolepis glabra prima* Ziegler & Huddle, 1969**

Pl. 30, fig. 3

1973 *Palmatolepis glabra prima* — Sandberg & Ziegler, p. 103, pl. 2, fig. 1, 2, 7–10, 11.

Remarks. A relatively slender subspecies of *P. glabra* with a rounded convex, inner platform margin, parapet anteriorly. This parapet is generally in the same plane as the outer platform margin and in some case it is oblique to the outer platform. The specimens are represented by both right and left forms.

Carina well developed reaching the posterior tip of the platform. This subspecies evolved from *P. tenuipunctata* by the reduction of outer lobe. The specimens of this species from Himalaya show much large variation than described by Sandberg and Ziegler (1973).

***Palmatolepis klapperi* Sandberg & Ziegler, 1973**

Pl. 30, fig. 7

1971 *Palmatolepis quadrantinodosa* aff. *inflexa* — Szulczewski, p. 39, pl. 15, fig. 8 (non pl. 15, fig. 9 = *P. glabra prima* Morphotype 2, sensu Sandberg & Ziegler, 1973).

Remarks. This species is most common and dominates the conodont fauna under description from Ladakh. The specimens are represented by both right and left forms with shagreen surface. The outer platform margin has distinctly convex curvature which is marked by the absence of a lobe. The specimens under description are identical to the description of *Palmatolepis klapperi* as given by Sandberg and Ziegler (1973) with the exception that the Himalayan specimens demonstrate wide variation in the shape of outer platform margin. The posterior part of Himalayan specimens is slightly broader than those described by Sandberg and Ziegler (1973). The bulge is very prominent in these specimens. Aboral side has a well developed heel. Angular junction of anterior and side margin can be seen on the oral side.

***Palmatolepis* cf. *limitaris* Ziegler & Klapper, 1976**

Pl. 31, fig. 4

1976 *Palmatolepis limitaris* Ziegler & Klapper, pp. 488–490, pl. 2, fig. 1, 2; pl. 3, fig. 1, 2.

Remarks. One broken specimen resembles closely *Palmatolepis limitaris* (Ziegler & Klapper, 1976). Platform triangular which is ornamented with very coarse nodes. Aboral side has elongated basal pit anteriorly and filled with secondary material. Keel sharp and raised. Carina does not reach the posterior tip of the platform.

***Palmatolepis marginifera duplicata* Sandberg & Ziegler, 1973**

Pl. 30, fig. 6

1962 *Palmatolepis quadrantinodosa marginifera* — Ziegler, pl. 7, fig. 8 (non fig. 6, 7, 9 = *marginifera marginifera*).

1973 *Palmatolepis marginifera duplicata* Sandberg & Ziegler, p. 105, pl. 3, fig. 15–19, 21–25; pl. 5, fig. 15.

Remarks. *P. marginifera duplicata* constitutes the subspecies of *P. marginifera* with shagreen surface. It has an elongated platform having a long bulge or secondary parapet running parallel to the carina on the outer side of the platform anterior to the central node, carina generally not developed posterior to the central node. The outline of the outer platform strongly convex posteriorly and concave anteriorly. An adcarinal groove developed between the carina and parapet. Specimens with two parapets have two adcarinal grooves. The top of parapets smooth. The present subspecies evolved from *P. klapperi* by thinning and heightening of the ramp to form a parapet parallel to carina and shedding of the posterior part of the carina.

Helms (1963) regarded *P. marginifera duplicata* as a descendant of *marginifera* stock but the transitional forms between the two are yet to be recognised.

***Palmatolepis perlobata perlobata* Ulrich & Bassler, 1926**

Pl. 31, fig. 7

1926 *Palmatolepis perlobata* Ulrich & Bassler, pp. 49–50, pl. 7, fig. 19, 22, 21 (?) (= reillustrated by Huddle, in Ziegler & Huddle, 1969, pl. 15, fig. 1–3).

1976 *Palmatolepis perlobata perlobata* – Druce, pl. 67, fig. 2–5 (= *P. perlobata schindewolfi*).

Remarks. A subspecies of *P. perlobata* having a large and wide platform with a strong outer lobe. The platform has coarse grained surface. Secondary carina moderately well developed. Carina usually low crest and does not reach the posterior end of the platform. The outer lobe and anterior rim have cluster or nodes. Aboral side marked by the presence of a strongly developed secondary keel. The nominate subspecies of *Palmatolepis perlobata* grades into *P. perlobata schindewolfi* but the former is characterized by the presence of strongly developed outer lobe, coarse ornamentation and usually large platform. *P. perlobata schindewolfi* is comparatively marked by less coarsely ornamented, narrow platform.

***Palmatolepis perlobata schindewolfi* Müller, 1956**

Pl. 31, fig. 5

1974 *Palmatolepis perlobata schindewolfi* – Dreesen & Duser, pl. 7, fig. 15–17.

1976 *Palmatolepis perlobata perlobata* – Druce, p. 67, fig. 5 a–c.

Remarks. A subspecies of *P. perlobata* having a large, elongated, undulating platform with gently shagreen surface. Carina in curved anterior to the central node. Secondary carina not developed. Inner or outer lobe moderately large,



maximum width anterior to central node. Aboral side with a strongly developed secondary keel near the margin. This subspecies seems to have evolved from the nominate subspecies but it can be distinguished in having smaller lateral lobe and less coarsely ornamented surface.

***Palmatolepis quadrantinodosa inflexoidea* Ziegler, 1962**

Pl. 30, fig. 2

1973 *Palmatolepis quadrantinodosa inflexoidea* – Sandberg & Ziegler, p. 118, pl. 4, fig. 1–3.

Remarks. This species is represented by a single specimen having shagreen platform without the development of parapet. Blade sigmodial, central node situated much posteriorly as compared to other subspecies of *Palmatolepis quadrantinodosa*. Carina weakly developed posterior to central node. The subspecies of *P. quadrantinodosa* under description is characterized by very elongated platform as compared to the other subspecies. The Himalayan specimen resembles *P. glabra prima* but the former can be distinguished by more posteriorly situated central node and absence of parapet.

***Palmatolepis quadrantinodosa quadrantinodosa* Branson & Mehl, 1934**

Pl. 31, fig. 2

1934 *Palmatolepis quadrantinodosa* Branson & Mehl, p. 235, pl. 18, fig. 3, 7, 20.

1956 *Palmatolepis (Palmatolepis) inflexa* Müller, 1956, pl. 10, fig. 7, 10.

1973 *Palmatolepis (Palmatolepis) quadrantinodosa quadrantinodosa* – Sandberg & Ziegler, p. 105, pl. 3, fig. 27–30.

Remarks. Platform oval, shagreen with inner half having rows by nodes parallel to carina. Carina strongly curved anteriorly, generally absent posteriorly. In some specimens (fig. 2) there are cluster of nodes on the anterior part or short ridges transverse to the blade. This subspecies comprises of two morphotypes that evolved simultaneously from *P. stoppeli* by conversion of ramp like inner platform to rows of nodes or ridges and *P. quadrantinodosa inflexa* by development of nodes and/or short ridges on the bulge like inner platform. The forms with rows of nodes that run parallel to the blade are characterised by the absence of carina posterior to the central node, whereas those with short transverse ridges have only a weak carina reaching close to the posterior end of the platform.

***Palmatolepis stoppeli* Sandberg & Ziegler, 1973**

Pl. 31, fig. 3

1973 *Palmatolepis stoppeli* Sandberg & Ziegler, p. 106, pl. 3, fig. 1–11; pl. 5, fig. 13.

Remarks. Platform nearly rounded with shagreen surface outer half beginning at anterior end of the blade. There is not much variation in the shape of the platform. Outer platform margin strongly convex. The inner platform formed by high ramp terminating between the central node and the posterior end of the platform. The ramp or parapet does not extend posterior to the central node. Well developed keel present on the aboral side. The present subspecies evolved from *P. quadrantinodosa inflexa* by an upward bulging of the inner platform. Most of the specimens have very weak or no carina posterior to the central node. *P. marginifera marginifera* differs from Himalayan specimens in having extension of parapet posterior of central node. In addition *P. marginifera marginifera* is marked by the presence of a straight carina posterior to the central node.

***Polygnathus delicatulus* Ulrich & Bassler, 1926**

Pl. 30, fig. 4

1926 *Polygnathus delicatulus* Ulrich & Bassler, p. 45, pl. 7, fig. 9, ?10 (reillustrated by Huddle, in Ziegler & Huddle, 1969, pl. 14, fig. 20, 22–24).

Remarks. Specimens represented by both left and right forms, the posterior end of platform down curved, carina slightly incurved posteriorly. Free blade long and lenceolate with fused denticles. Platform nearly symmetrical, margins of platform with transverse ridges or nodes which are separated from carina by the presence of a trough. Aboral side marked by the presence of sharp, raised keel with an elongated basal cavity situated anteriorly. The specimen under description from Himalayas are closely related to *Polygnathus pennatulus* but differs in having markings more delicate and arranged more transversely. The upper surface of *Polygnathus delicatulus* has close resemblance to *P. melhi* (Thompson, 1967, p. 48) but the two differ in the presence of sharp, raised keel in *P. delicatulus*. In contrast the pit in *P. melhi* is more extensive posteriorly which is set in a narrow pseudokeel.

***Polygnathus linguiformis linguiformis* Hinde, 1879**

Pl. 30, fig. 9

1879 *Polygnathus linguiformis* Hinde, p. 367, pl. 17, fig. 15.

1971 *Polygnathus linguiformis linguiformis* — Klapper, p. 64, pl. 2, fig. 18, 19, 22–40; pl. 3, fig. 13–15.

Remarks. Specimens represented by both left and right forms having well developed tongue-like process bent downwards posteriorly. The posterior side marked by the presence of large number of transverse ridges running through the entire width of this process. The forms are asymmetrical with well develop-

ed carina and adcarinal groove. The basal cavity on the aboral side very small and much closer to the anterior end of the platform with the development of very well keel. The specimens from Himalaya are identical with the forms described by Ziegler and Klapper, 1976 as *Polygnathus linguiformis*.

***Polygnathus* cf. *robusticostatus* Bischoff & Ziegler, 1957**

Pl. 31, fig. 1

1957 *Polygnathus robusticostatus* Bischoff & Ziegler, pp. 95–96, pl. 3, fig. 4–9.

1971 *Polygnathus robusticostatus* - Klapper, p. 66, pl. 3, fig. 28–33.

Remarks. Platform thick with a high blade at the anterior end. Carina terminates at the posterior end of the platform. Denticles discrete and pointed platform widest in the midlength tapering posteriorly and forming heart shape outline with the development of coarse nodes anteriorly. Aboral surface marked by large basal cavity elliptical in shape and located between the midlength and anterior end of the platform. *P. robusticostatus* differs from *P. angustipennatus* Bischoff & Ziegler, 1957 in having broader platform and a shorter free blade. In view of the inadequate material it is not possible to make definite specific assignments.

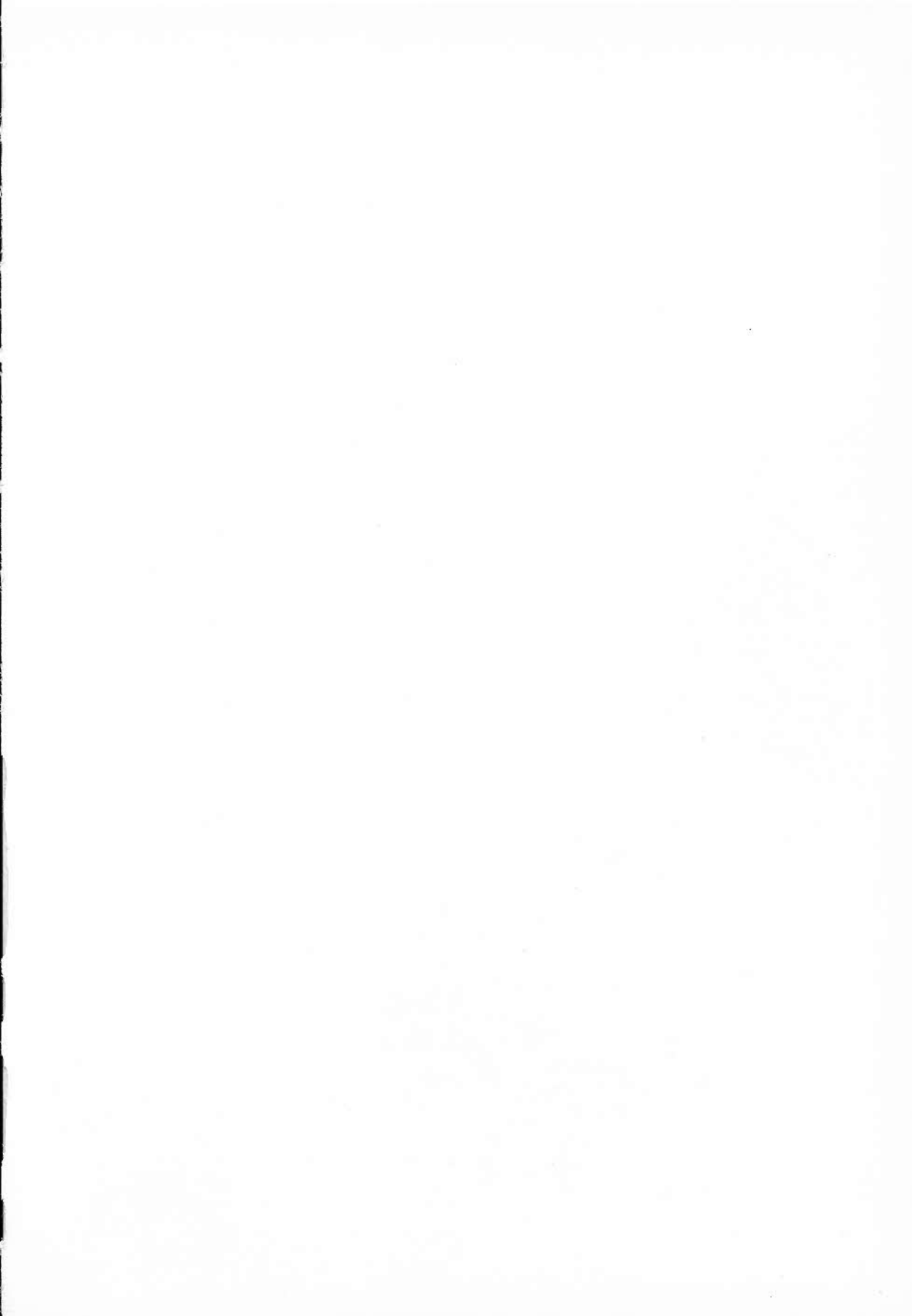
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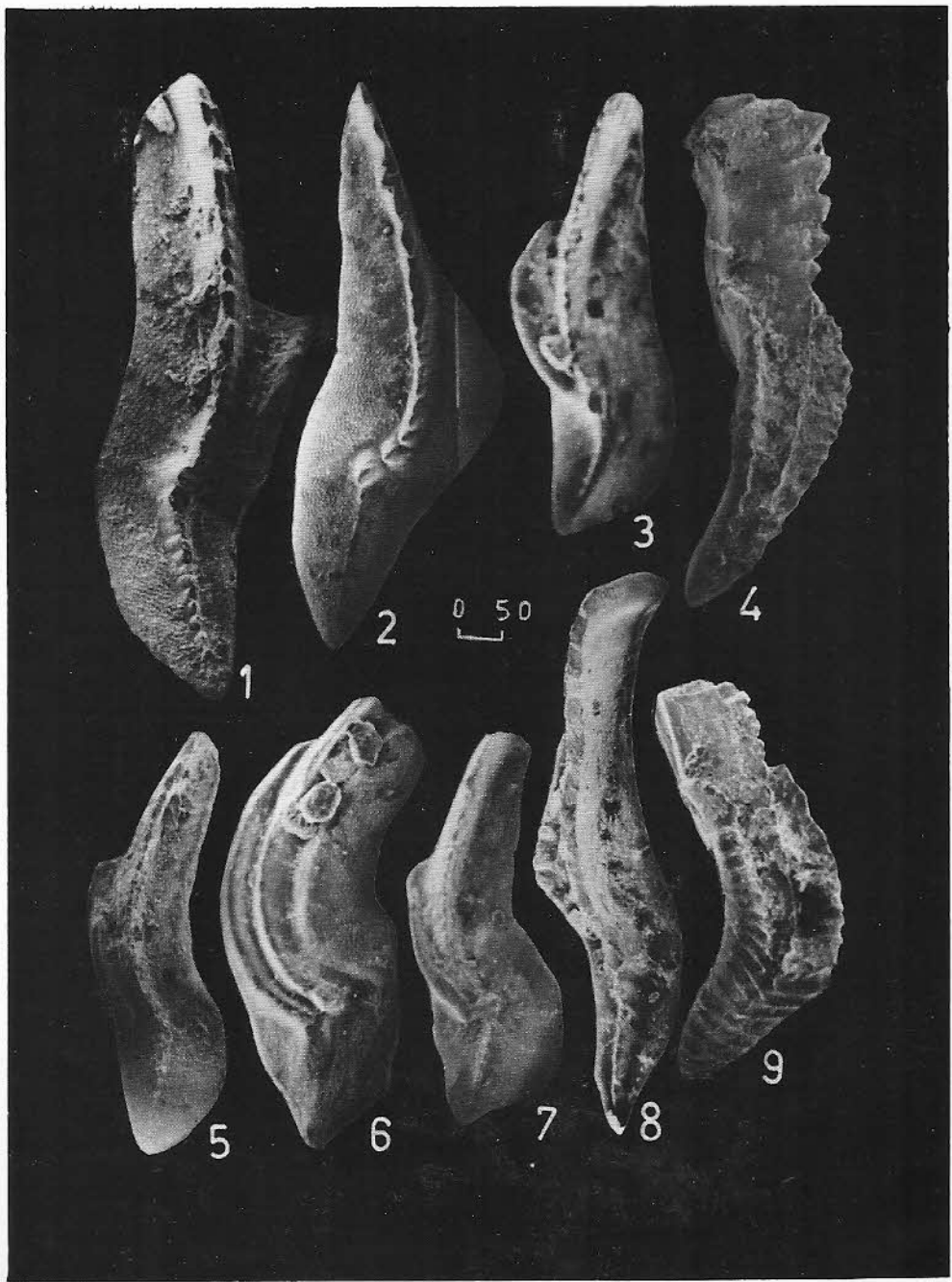
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## PLATE 30

- Fig. 1 – *Palmatolepis glabra acuta* Helms. Oral view.
- Fig. 2 – *Palmatolepis quadrantinodosa inflexoidea* Ziegler. Oral view.
- Fig. 3 – *Palmatolepis glabra prima* Ziegler & Huddle. Oral view.
- Fig. 4 – *Polygnathus delicatulus* Ulrich & Bassler. Oral view.
- Fig. 5 – *Palmatolepis glabra pectinata* Ziegler. Oral view.
- Fig. 6 – *Palmatolepis marginifera duplicata* Sandberg & Ziegler. Oral view.
- Fig. 7 – *Palmatolepis klapperi* Sandberg & Ziegler. Oral view.
- Fig. 8 – *Palmatolepis glabra lepta* Ziegler & Huddle. Oral view.
- Fig. 9 – *Polygnathus linguiformis linguiformis* Hinde. Oral view.



## PLATE 31

Fig. 1 – *Polygnathus* cf. *robusticostatus* Bischoff & Ziegler. Oral view.

Fig. 2 – *Palmatolepis quadrantinodosa quadrantinodosa* Branson & Mehl. Oral view.

Fig. 3 – *Palmatolepis stoppeli* Sandberg & Ziegler. Oral view.

Fig. 4 – *Palmatolepis* cf. *limitaris* Ziegler & Klapper. Oral view.

Fig. 5 – *Palmatolepis perlobata schindewolfi* Müller. Oral view.

Fig. 6 – *Palmatolepis* cf. *disparilis* Ziegler & Klapper. Oral view.

Fig. 7 – *Palmatolepis perlobata perlobata* Ulrich & Bassler. Oral view.



