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Palmatolepis (Conodonta; Late Devonian) from the Tabas Region, Eastern Iran

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Abstract

The present study has focused on *Palmatolepis*, the biostratigraphically most important conodont genus in the Late Devonian. The studied materials produced from the both stratotype section of the Shishtu Formation, eastern Iran, in the Ozbak-Kuh Mountains and sections at Howz-e-Dorah and from the intervening Niaz area.

Thirty species and subspecies of *Palmatolepis* have been produced: nine from the Ozbak-Kuh Mountains, thirteen from the Howz-e-Dorah section, and twenty two from small sections in the intervening Niaz area. Only Famennian forms of *Palmatolepis* were encountered in the Ozbak-Kuh Mountains, but the other two areas produced both Frasnian and Famennian species of *Palmatolepis*.

Keywords: *Devonian; Conodont; Palmatolepis; Iran; Tabas; Ozbak-Kuh; Shotori Range; Shishtu Formation.*

Introduction

The 543 meters Late Devonian Shishtu Formation of the Tabas region of eastern Iran was first described by Rutner *et al.* in the 1960's on the basis of exposures in the Ozbak-Kuh Mountains. Because the sequence is much faulted and complex in the Ozbak Kuh Mountains, the formation was not formally introduced. Better sections occur in the Howz-e-Dorah area in the southern Shotori Range about 150 km to the south (Fig.1). The sections referred to are described by Ashouri (2002a, 2002b). In the Ozbak-Kuh Mountains the Shishtu Formation consists of an alternation of shale, marl and limestone divisible into two subformations; Shishtu 1 and Shishtu 2; the boundary is drawn at the top of a distinctive black shale unit, called the Mush Horizon. The

Shishtu 1 Subformation consists of dark green shale with interbeds of quartzitic sandstones and fossiliferous limestones. Each subformation includes a goniatite horizon named the Goniatite horizon 1 and Goniatite horizon 2 respectively.

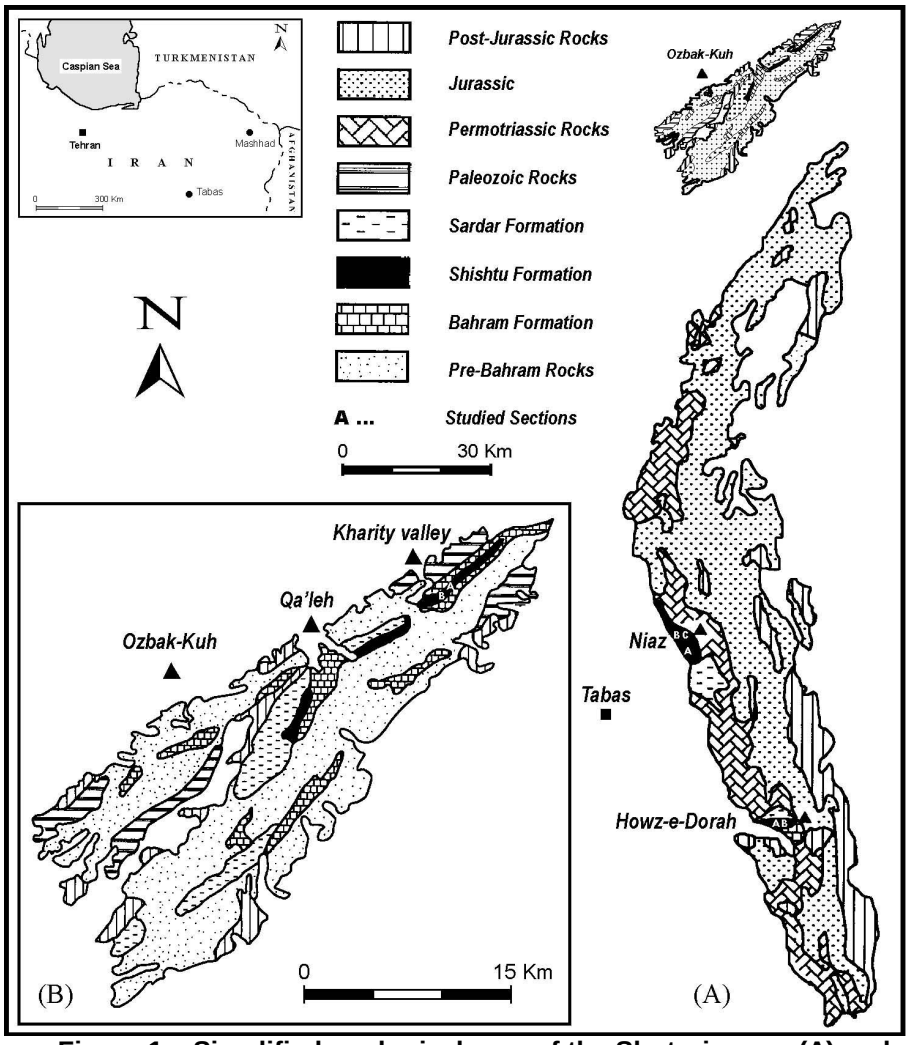


Figure 1 – Simplified geological map of the Shotori renge (A) and the Ozbak-Kuh Montains

A reference section for the Shishtu Formation was proposed by Stöcklin *et al.* (1965) in the Howz-e-Dorah area of the southern

Shotori Range about 150 km south of the Ozbak-Kuh Mountains. The sequence at Howz-e-Dorah includes a persistent 28-50 m interval with a notably diverse Late Devonian fauna called the Cephalopod Bed by Stocklin *et al.*; this horizon is readily discriminated throughout the Shotori Range. The "Cephalopod Bed" can be traced northwards along the western flank of the Shotori Range from Howz-e-Dorah as disconnected outcrops to the Niaz area in the middle part of the Shotori Range. Because of the presence of a thrust across the western flank of the Shotori Range, the unit is very disturbed. As noted by Ashouri (1997a) and Becker *et al.* (in press) there are lithological changes along strike; regional facies analysis is therefore called for.

The faunas (macro and micro) of the highly fossiliferous "Cephalopod Bed" have been the prime focus of attention; cephalopods have been examined by Walliser (1966), Yamini (1996), Yamini & Ashouri (1998), and Becker *et al*. (in press); brachiopods by Rastkar (1996), Ashouri & Rastkar (2000), trilobites by Feist *et al.* (1999) and corals by Flügel (1961). Microfossils have been studied by various authors: conodonts by Ashouri (1990, 1997a), Yazdi (1996, 1998, 1999) and Wendt *et al.* (1997), palynomorphs by Moussavi (1995) and Ghavidel Syooki & Moussavi (1996), and microgastropods by Ashouri (1997b).

The materials for this study have been obtained from both the type and reference sections of the Shihtu Formation in the Ozbak-Kuh Mountains and Howz-e-Dorah, and from the Niaz area located between them (Figs. 2 & 3). Only Famennian forms of *Palmatolepis* were encountered in the Ozbak-Kuh Mountains, but the other two areas produced both Frasnian and Famennian species of *Palmatolepis* (Figs 4, 5 & 6).

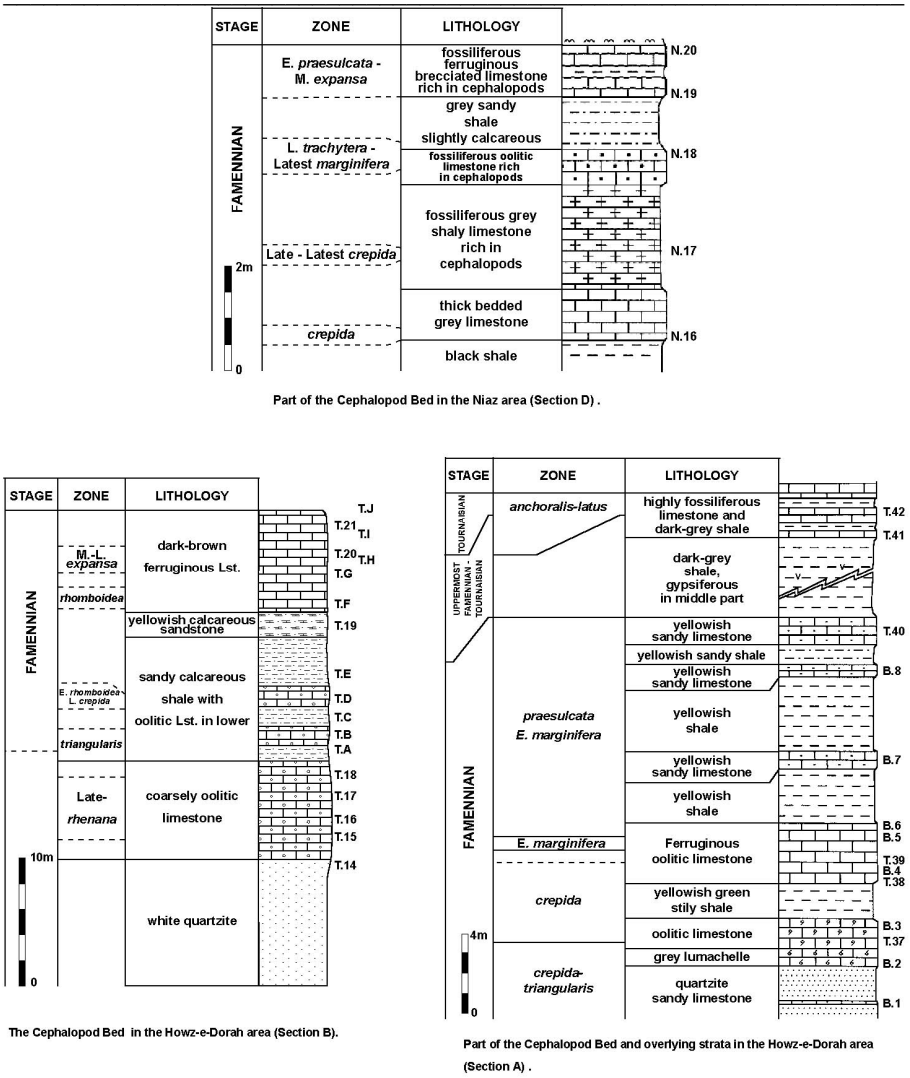
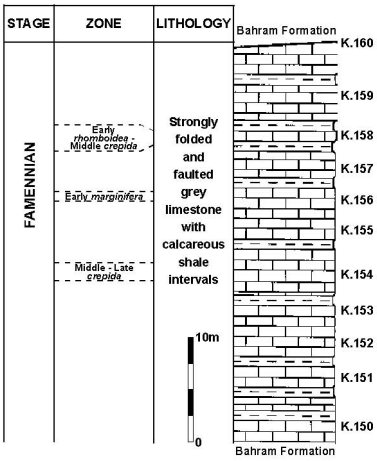
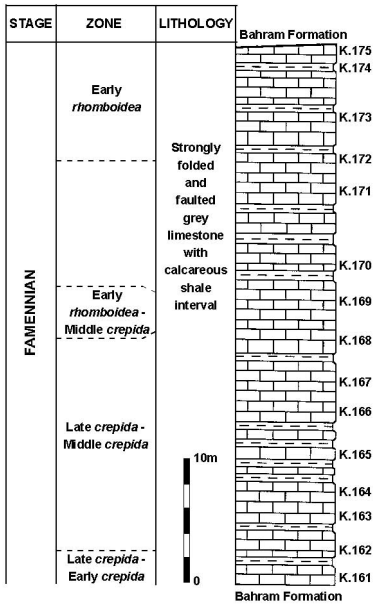


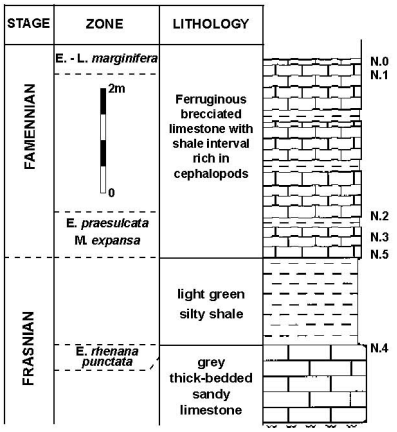
Figure 2- Studied stratigraphical column sections



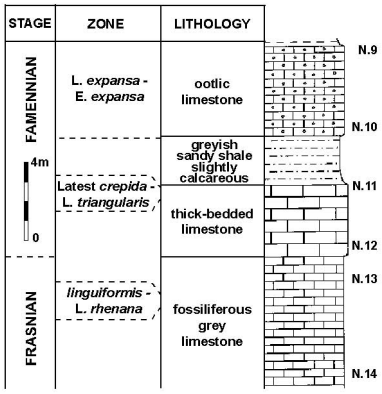
Part of the Shishtu Formation in the Kharity valley, Ozback-Kuh Mountains (Section B).



Part of the Shishtu Formation in the Kharity valley, Ozback-Kuh Mountains (Section C).



Part of the Cephalopod Bed overthrust by Frasnian strata in the Niaz area (Section A).



Overturned section of part of the Cephalopod Bed in the Niaz area (Section C).

Figure 3 - Studied stratigraphical column sections

Samp. Number / Taxa	A					B					
	T.15	T.16	T.A	T.D	T.G	B.2	T.37	T.38	T.39	B.5	B.6
Palmatolepis glabra tenuipuctata						κ			κ		
Palmatolepis hassi	κ	κ									
Palmatolepis triangularis			κ				κ				
Palmatolepis quadrantinodosalobata				κ			κ	κ			
Palmatolepis glabra prima				κ							
Palmatolepis minuta minuta					κ						
Palmatolepis rhomboidea					κ						
Palmatolepis subperlobata							κ				
Palmatolepis perlobata perlobata										κ	
Palmatolepis wolskaja											κ

Figure 4. Distribution of *Palmatolepis* species in the Howz-e-Dorah area sections.

Samp. Number / Taxa	A				B			C		
	N.0	N.1	N.2	N.3	N.9	N.10	N.11	N.17	N.18	N.19
Palmatolepis quadrantinodosa inflexoidea	κ									
Palmatolepis perlobata cf. Sigmoidea	κ									
Palmatolepis glabra glabra	κ									
Palmatolepis glabra prima	κ									
Palmatolepis stoppeli	κ									
Palmatolepis glabra pectinata	κ	κ								
Palmatolepis glabra distora	κ	κ								
Palmatolepis perbolata schindewolfi	κ	κ			κ				κ	
Palmatolepis quadrantinodosa inflexa	κ	κ								
Palmatolepis gracilis gracilis	κ		κ	κ						
Palmatolepis perbolata groosi		κ						κ		
Palmatolepis perbolata helmsi		κ								
Palmatolepis minuta schlezia		κ								
Palmatolepis glabra acuta		κ								
Palmatolepis perbolata maxima		κ								
Palmatolepis gracilis sigmoidalis			κ							
Palmatolepis perlobata expansa						κ				
Palmatolepis quadrantinodosalobata							κ			
Palmatolepis minuta minuta							κ	κ		
Palmatolepis perlobata perlobata								κ		
Palmatolepis glabra tenuipunctata								κ		

Figure 5. Distribution of *Palmatolepis* species in the Niaz area sections.

Samp. Number / Taxa	A		B							
	K.154	K.156	K.161	K.162	K.163	K.165	K.168	K.169	K.172	K.174
Palmatolepis quadrantinodosa quadrantinodosa		κ	κ		κ			κ		κ
Palmatolepis glabra tenuipunctata			κ	κ	κ					
Palmatolepis termini termini	κ			κ	κ					
Palmatolepis quadrantinodosalobata	κ			κ	κ			κ		
Palmatolepis crepiada				κ			κ			
Palmatolepis subperlobata						κ				
Palmatolepis rhomboidea									κ	

Figure 6. Distribution of *Palmatolepis* species in the Ozbak-Kuh Mountains sections.

Taxonomy

Thirty species and subspecies of Palmatolepis have been produced: nine from the Ozbak-Kuh Mountains, thirteen from the Howz-e-Dorah section, and twenty two from small sections in the intervening Niaz area.

The figured specimens herein are housed in the department of geology of Ferdowsi University of Mashhad, Mashhad, Iran with the Prefix AFUM.

Family PALMATOLEPIDAE SWEET, 1988
Genus *Palmatolepis* ULRICH & BASSLER, 1926

Palmatolepis crepida SANNEMANN, 1955

Pl. 4, figs. 4-5

Synonymy: Schülke (1995, p. 32).

Remarks: Two specimens were available, but both have the posterior and anterior ends broken. They are close to the specimen illustrated by Ziegler (1962b, Pl. 6, fig. 18).

Range and Occurrence: The two specimens came from two samples from the Ozbak-Kuh Mountains. The species appears in the *crepida* Zone**,** extending into the Early *rhomboidea* Zone.

Palmatolepis gigas MILLER & YOUNGQUIST, 1947

Pl. 4, figs. 6-7

Synonymy: Schülke (1995, p.36).

Remarks: Two specimens were available, one (Pl. 4, fig. 7), missing its blade at the anterior end, is very similar to a specimen illustrated by Ulrich & Bassler (1926). It is also very similar to the specimen assigned by Ziegler (1958, Pl. 7, fig. 6) to *Pa. hassi*, but it has much coarser sculpture and a more developed outer lobe than the *Pa. hassi*. The second specimen (Pl. 4, fig. 6), although with a relatively large

platform, has a very well developed outer lobe and distinctly coarse sculpture on the upper surface.

Range and Occurrence: The species *Pa. gigas* only occurs in a single sample of this study; Cephalopod Bed, Niaz area. The species occurs from the *rhenana* Zone to the *linguiformis* Zone.

Palmatolepis glabra glabra ULRICH & BASSLER, 1926
Pl. 1, fig. 11

Synonymy: Metzger (1994, p. 639).

Remarks: A single fragmentary specimen with its anteriormost end and posterior end missing. It is rather similar to one illustrated by Scott & Collinson (1959, Pl. 75, fig. 22).

Range and Occurrence: "Cephalopod Bed" in the Niaz area. The subspecies seems to range through the *rhomboidea* to Early *marginifera* zones.

Palmatolepis glabra acuta HELMS, 1963
Pl. 1, figs. 17-18

Synonymy: Ziegler (1977, p. 294).

1994 *Palmatolepis glabra acuta* HELMS, 1963-Metzger, Pl. 7, fig. 17

Remarks: Two specimens, one (Pl. 1, fig. 17), an incomplete anterior half, is rather long (2.2 mm) and a relatively wide (1.3 mm). The second specimen (Pl. 1, fig. 18) with the posterior tip and anterior of the inner platform missing, is a significantly smaller specimen, 1.4 mm long and 0.6 mm wide.

Range and Occurrence: Two specimens from a single sample of the "Cephalopod Bed" in the Niaz area. The species ranges from the Late *crepida* Zone into the Late *marginifera* Zone.

Palmatolepis glabra distorta BRANSON & MEHL, 1934
Pl. 1, figs. 12-14

Synonymy: Ziegler (1977, pp. 298-299).

Remarks: Three fairly well preserved specimens. The best preserved (Pl. 1, fig. 12) has a relatively strong bulge on the outer platform and a sharp crest parapet for nearly half the length of the specimen. Another specimen (Pl. 1, fig. 13) has a distinct bulge in the outer platform and a long parapet, pectiniform in its posterior half. The third specimen (Pl. 1, fig. 14) has a weak bulge at the anterior end of the outer platform, and the parapet is weakly denticulate in the posterior half, and is short compared to the other specimens; it may be viewed as a transitional to *Pa. gl. pectinata.*

Range and Occurrence: Two samples from Niaz and one from Howz-e-Dorah, both from the "Cephalopod" Bed. The range of this subspecies is Early *marginifera* Zone into the Early *trachytera* Zone.

Palmatolepis glabra pectinata ZIEGLER, 1962
Pl. 1, figs. 15-16

Synonymy: Mawson & Talent (1997, 224).

1999 *Palmatolepis glabra pectinata*, ZIEGLER, 1962 – Yazdi, Pl. 9, fig 20–21.

Remarks: One specimen (Pl. 1, fig. 15) has part of its anterior missing and has a well developed pectinate parapet, more distinct posteriorly. The second specimen (Pl. 1, fig. 16), is rather similar but slightly broken posterior to the central nodes.

Range and Occurrence: *Pa. gl. pectinata* was obtained from two samples of the Cephalopod Beds in the Niaz area. The subspecies range starts in the Late *crepida* Zone and extends through to the *marginifera* Zone.

Palmatolepis glabra prima ZIEGLER & HUDDLE, 1969

Pl. 1, figs. 8–10

1994 *Palmatolepis glabra prima* ZIEGLER & HUDDLE, 1969- Metzger 1996 Pl. 7, fig 11,14,15

Synonymy: Schülke (1995, p. 37).

Remarks: Three specimens of *Pa. gl. prima* were obtained. One (Pl. 1, fig. 8) is nicely preserved and closely resembles the holotype but is slightly more slender and shows very delicate undulations on the posterior half of the parapet crest. The second specimen (Pl. 1, fig. 9) is similar to the specimen of Morphotype 1 illustrated by Sandberg & Ziegler (1973, Pl. 3, fig. 8). The third specimen (Pl. 1, fig. 10) has portion of the inner platform missing; It is similar to one illustrated by Sandberg & Ziegler (1973, Pl. 3, fig. 11) as Morphotype 2.

Range and Occurrence: Three samples from Niaz, Howz-e-Dorah and the Ozback-Kuh Mountains, the first two from the "Cephalopod Bed". The subspecies ranges from Late *crepida* to Late *marginifera* zones, with Morphotype 1 ranging from the Late *crepida* Zone through to the Late *rhomboidea* Zone, and Morphotype 2 from the Late *crepida* through to the Early *rhomboidea* Zone.

Palmatolepis glabra tenuipunctata SANNEMANN, 1955

Pl. 1, figs. 1-7

Synonymy: Schülke (1995, p. 38).

1999 *Palmatolepis tenuipunctata* SANNEMANN, 1955 – Yazdi, Pl. 10, fig 10–12.
1999 *Palmatolepis tenuipunctata* SANNEMANN, 1955 – Talent *et al*., Pl. 7, fig. 2.

Remarks: Seven specimens of *Pa. gl. tenuipunctata* were obtained. Two (Pl. 1, figs. 1–2) have similar morphological variation to one

illustrated by Ziegler (1962b, Pl. 4, fig. 10). Two other specimens (Pl. 1, figs. 3-4) have a very smooth shagreen-like upper surface with a relatively thin, gently crenulated blade and has a very weak ridge-like carina. The last three specimens (Pl. 1, figs. 5-7) are more slender and have a weaker outer lateral lobe.

Range and Occurrence: *Pa. gl. tenuipunctata* occurs in six samples from three areas: three samples from the "Cephalopod Bed"; two from Howz-e-Dorah and one from Niaz. The three other samples are from the Ozbak-Kuh Mountains. The species occurs from the base of the *triangularis* Zone to the top of the *crepida* Zone.

Palmatolepis gracilis gracilis BRANSON & MEHL, 1934

Pl. 4, figs. 16-22

Synonymy: Ziegler (1977, p. 315-316).

1997 *Palmatolepis gracilis gracilis* BRANSON & MEHL, 1934a – Molloy *et al.*, Pl. 4, fig. 3.

Remarks: Two forms of platform are represented among the specimens: forms with or without a raised rounded marginal rim on the upper surface. A specimen with this feature has shagreen-like ornament on the rim only; it is distinctive in size of the platform and position of the anterior margin of the plate; it is similar to the neotype designated by Mehl and Ziegler (1962) Some specimens (Pl. 4, figs. 16-18) have a very narrow plate with the anterior margin terminating halfway along the conodont. Others (Pl. 4, figs. 17-19) have a wider platform, the anterior margin terminating mid-way between the central node and the anterior end of the blade. These specimens resemble one illustrated by Ziegler (1962). In the second group, two specimens (Pl. 4, figs. 20-21) have a relatively symmetrical tongue-shaped platform with shagreen-like ornament marginally. A single specimen (Pl. 4, fig. 22) with a distinct asymmetrical platform has a marginal crimp on the upper surface.

Range and Occurrence: *Pa. gr. gracilis* occurs in five samples from two sections in the Niaz area, all from the "Cephalopod Bed". The

species range is from the Late *rhomboidea* Zone to the *praesulcata* Zone.

Palmatolepis gracilis expansa SANDBERG & ZIEGLER, 1979

Pl. 4, fig. 23

Synonymy: Sandberg & Ziegler (1979, p. 178).

Remarks: A single specimen similar to one illustrated by Sandberg & Ziegler (1979, Pl. 1, fig. 8).

Range and Occurrence: Niaz area. The subspecies ranges through the *expansa* Zone.

Palmatolepis gracilis sigmoidalis ZIEGLER, 1962

Pl. 4, figs. 24-26

Synonymy: Ziegler (1977, p. 323-324).

Remarks: Three specimens were obtained. One (Pl. 4, fig. 24) has a small platform terminating just anterior to the central node. The second specimen (Pl. 4, fig. 25) has a wider platform but both the platform and blade are strongly sigmoidal. The third specimen (Pl. 4, fig. 26) has a small platform without a rim; the platform and the blade are not twisted as in the other specimens. It is considered to be transitional from *Pa. gracilis. gracilis* to *Pa. gracilis sigmoidalis.*

Range and Occurrence: Three specimens from a single sample of the "Cephalopod Bed" in the Niaz area. According to Sandberg and Ziegler (1979) the subspecies ranges through the *expansa* and *praesulcata* zones.

Palmatolepis hassi MÜLLER & MÜLLER, 1957

Pl. 1, figs. 19-20

Synonymy: Klapper & Becker (1999, p. 344).

1997 *Palmatolepis hassi* MÜLLER & MÜLLER, 1957-Over, Pl. 6, figs. 2-3.

Remarks: Two specimens of *Pa. hassi* are available. One (Pl. 1, fig. 19) is better preserved, displaying closer tubercles on the upper surface and being rather similar to the specimen illustrated by Ulrich & Bassler (1926) in their evolutionary table. The second specimen (Pl. 1, fig. 20) has part of the posterior half and anterior end missing; its upper surface has tubercles scattered almost regularly over the entire platform.

Range and Occurrence: Two samples from the lower part of the "Cephalopod Bed" at Howz-e-Dorah. The range is Early *hassi* Zone through to the end of the *rhenana* Zone.

Palmatolepis minuta minuta BRANSON & MEHL, 1934

Pl. 4, figs. 8-10

Synonymy: Schülke (1995, p. 42).

1997 *Palmatolepis minuta minuta* BRANSON & MEHL, 1934a – Mawson & Talent, Pl. 16, fig 8, 11.
1997 *Palmatolepis minuta minuta* BRANSON & MEHL, 1934a – Molloy *et al.*, Pl. 4, fig. 1.
1999 *Palmatolepis minuta minuta* BRANSON & MEHL, 1934a– Talent *et al.*, Pl. 7, fig. 1.
1999 *Palmatolepis minuta minuta* BRANSON & MEHL, 1934a – Yazdi, Pl. 9, fig 18-19, Pl. 10, fig 1-3.

Remarks: Three specimens, one (Pl. 4, fig. 10) with shagreen ornament on the platform and a denticulated blade in the anterior half, gradually passing into a gently crenulated ridge. It has a gently crenulated ridge carina gradually decreasing in height from the central node and, in the posterior half, lying in a very gentle depression. A specimen (Pl. 4, fig. 8), missing part of the anterior of the blade, has a gently crenulated blade and ridged carina. The third specimen (Pl. 4, fig. 9) has shagreen ornament on the platform, a bulge on the anterior outer platform, and a ridge with a weak carina not lying in a depression; the inner platform of the lateral side, near the central node,

is concave.

Range and Occurrences: Three samples: two from the Niaz area, one from the Howz-e-Dorah area. The subspecies is long-ranging, from the *hassi* Zone to the *trachytera* Zone.

Palmatolepis minuta schleizia HELMS, 1963

Pl. 4, figs. 11-12

Synonymy: Ziegler (1977, p. 341-342).

1994 *Palmatolepis minuta schleizia* HELMS, 1963-Metzger, Pl. 8, fig 16,17.

Remarks: Two specimens, one (Pl. 4, fig. 11), missing its anterior end, has shagreen ornament on the platform and a weak lateral lobe; it has a denticle on the inner side of the central node looking like an incipient secondary carina. The second specimen (Pl. 4, fig. 12), missing its posterior end, and with, anteriorly, a shagreen surface on the margin of the platform.

Range and Occurrence: "Cephalopod Bed" in the Niaz area. The subspecies ranges from the Late *rhomboidea* to *postera* zones.

Palmatolepis perlobata perlobata ULRICH & BASSLER, 1926

Pl. 3, figs. 1-2

Synonymy: Schülke (1995, p. 43)

Remarks: Two specimens; one fragmentary (Pl. 3, fig. 2) with the anterior end as well as the end of the lateral lobe broken, is similar to one illustrated by Szulczewski (1971, Pl. 14, fig. 4); the other with a missing posterior end (Pl. 3, fig. 1). The latter is 2.6 mm long and is the longest specimen of *Palmatolepis* encountered in this study. Its upper surface is evenly ornamented by granules. The outer lobe has a sharp tip.

Range and Occurrence*:* Two specimens from the "Cephalopod Bed", one from the Niaz area and another one from the Howz-e-Dorah area. The species ranges from *Pa. triangularis* Zone to the *crepida* Zone,

with some forms in the Early *marginifera* Zone.

Palmatolepis perlobata grossi ZIEGLER, 1960

Pl. 3, figs. 4-5

Synonymy: Ziegler (1977, p. 353-354).

Remarks: Two specimens; one is questionable. One of these (Pl. 3, fig. 4) conforms in all aspects with the original diagnosis for the subspecies. A questionably weak carina is visible running a short distance from the central node, but in side view there appears to be a very gentle depression joining the blade just anterior to the central node, a feature present in *Pa. rugosa*. The questionable specimen (Pl. 3, fig. 5) is ornamented by very rounded nodes on the upper surface, forming a marginal row on the gentle parapet of the inner platform. The carina runs to the posterior tip, and the secondary carina continues to the tip of a small outer lobe. The fauna associated with this specimen shows a much older range (Upper *crepida* Zone) than the standard zonation for the species.

Range and Occurrence: Two samples from the "Cephalopod Bed" in the Niaz area. The subspecies ranges from the Late *marginifera* to Late *trachytera* zones.

Palmatolepis perlobata maxima MÜLLER, 1956

Pl. 3, fig. 3

Synonymy: Metzger (1994, p. 636).

Remarks: A single specimen with the lateral lobe and both posterior and anterior ends missing, but conforming well with the original diagnosis.

Range and Occurrence: The "Cephalopod Bed" in the Niaz area. The subspecies ranges from the Late *marginifera* Zone into the middle of the *expansa* Zone.

Palmatolepis perlobata schindewolfi MÜLLER, 1956

Pl. 3, figs. 8-15

Synonymy: Ziegler (1977, p. 361-362).

1999 *Palmatolepis perlobata schindewolfi* MÜLLER, 1956 – Yazdi, Pl. 10, fig. 4.

Remarks: Eight specimens, two of which (Pl. 3, figs. 9, 11) are close to the specimen illustrated by Austin *et al.* (1985, Pl. 4, fig. 16). Another specimen (Pl. 3, fig. 8) differs slightly in having very sparse faint granules mainly on the outer lobe margin and on the inner platform margin. Another (Pl. 3, fig. 10) has gradual tapering of the posterior end of the platform rather than terminating abruptly as in previous specimens. Two specimens (Pl. 3, figs. 12-13), questionably referred to this subspecies, has a very sharp triangular outer lobe with a depression in the position of the secondary carina. This depression runs just anterior of the central node—as in *Pa. rugosa.* These specimens show coarser ornament on the outer lobe and on the inner platform anterior of the central node.

Range and Occurrence: Five samples from the "Cephalopod Bed" in the Niaz area. This subspecies appeared in the Late *crepida* Zone, persisting to the end of the *expansa* Zone.

Palmatolepis perlobata sigmoidea ZIEGLER, 1962

Pl. 3, fig. 6

Synonymy: Ziegler (1977, p. 365).

1999 *Palmatolepis perlobata sigmoidea* ZIEGLER, 1962 – Yazdi, Pl. 10, fig. 5.

Remarks: Only a single fragmentary specimen conforming in all aspects with the original description.

Range and Occurrence: "Cephalopod Bed", Niaz area. The subspecies ranges from the Early *marginifera* Zone to the Late *postera* Zone.

Palmatolepis quadrantinodosa quadrantinodosa Branson & Mehl, 1934

Pl. 2, figs. 1-6

Synonymy: Mawson & Talent (1997, 226).

Remarks: Six specimens, one (Pl. 2, fig. 1) with ornament of short ridges on the anterior inner platform converging posteriorly to nodes, and another (Pl. 2, fig. 2) with a relatively well developed parapet with obscure nodes. An incomplete specimen (Pl. 2, fig. 3) has two rows (one not very distinct) of nodes, and another (Pl. 2, fig. 4) has the anterior of the inner platform bulge-like; it bears scattered nodes reduced in size posteriorly.

Range and Occurrence: Six samples from the Ozbak-Kuh Mountains. The subspecies is restricted to the Early *marginifera* Zone with rare occurrences in the Late *rhomboidea* Zone.

Palmatolepis quadrantinodosa inflexa MÜLLER, 1956

Pl. 2, figs. 9-10

Synonymy: Mawson & Talent (1997, 226).

Remarks: Two specimens, one (Pl. 2, fig. 10) rather similar to one illustrated by Sandberg & Ziegler (1973, Pl. 4, fig. 7) with a wider platform and the anterior inner platform parapet-like, separated from the blade by a wider shallow adcarinal groove developed close to the central node.

Range and Occurrence: "Cephalopod Bed", Niaz area. The subspecies ranges from uppermost Late *rhomboidea* Zone into the Early *marginifera* Zone.

Palmatolepis quadrantinodosa inflexoidea ZIEGLER 1962

Pl. 2, figs. 7-8

Synonymy: Mawson & Talent (1997, 226).

Remarks: Two specimens, both with a carina. The carina of one (Pl. 2, fig. 7) is a weak ridge failing to reach the posterior tip; the other (Pl. 2, fig. 8) has a narrower posterior end and a stronger carina formed of

distinct denticles.

Range and Occurrence: Both specimens are from a single sample from the "Cephalopod Bed" in the Niaz area. The subspecies is restricted to the Early *marginifera* Zone.

Palmatolepis quadrantinodosalobata quadrantinodosalobata Sannemann, 1955

Pl. 2, figs. 11-23

Synonymy: Schülke (1995, p. 43).

1999 *Palmatolepis quadrantinodosalobata* SANNEMANN, 1955 – Yazdi, Pl. 10, figs 8, 9.

Remarks: *Pa. quadrantinodosalobata quadrantinodosalobata* is the most abundant *Palmatolepis* subspecies encountered in this study. One specimen (Pl. 2, fig. 11) has a rounded outer lobe with a cluster of distinctly coarse nodes. In some specimens (Pl. 2, figs. 12-16) the clusters consist of a few to several moderate nodes. Unlike previous specimens having a rounded lateral lobe directed laterally, two specimens (Pl. 2, figs. 18-19) have the lateral lobe directed posteriorly. One specimen (Pl. 2, fig. 17) has a thick platform with a large central node which, instead of a carina, has a longitudinal depression continuing to the posterior tip. A specimen lacking a lateral lobe (Pl. 2, fig. 20) has a more slender platform compared with other specimens. One specimen (Pl. 2, fig. 21) is ornamented by coarse nodes posterior to the central node of both the inner and outer platform. These conform with the characteristics of a group denoted by Ziegler (1962b) as *Pa. triangularis* to *Pa. quadrantinodosalobata quadrantinodosalobata***.** Two specimens are questionably referred to the species (Pl. 2, figs 22-23).

Range and Occurrence: Ten samples from six section. Three samples from Howz-e-Dorah area and one from the Niaz area, came from the "Cephalopod Bed". The other six samples are from the Ozbak-Kuh Mountains. The species ranges from the *crepida* Zone into the lower part of the Early *rhomboidea* Zone.

Palmatolepis rhomboidea SANNEMANN, 1955

Pl. 4, figs. 13-15

Synonymy: Metzger (1994, p. 638).

1997 *Palmatolepis rhomboidea* SANNEMANN, 1955 – Molloy *et al.*, Pl. 4, fig. 2.

Remarks: Three specimens. One with broken posterior end (Pl. 4, fig. 13) has a flat to concave and rounded outer platform; it has a low, short bulge in the anterior of the inner platform and a very distinct central node. Another (Pl. 4, fig. 15) has the first two denticles at the anterior end of the blade located in an open space; a relatively well-developed bulge is present anteriorly on the inner platform. The third specimen (Pl. 4, fig. 14) has a fairly rounded platform with a well-developed short parapet in the anterior of the inner platform, and a shallow adcarina on each side of the platform anteriorly.

Range and Occurrence: Two samples: one from the "Cephalopod Bed" at Howz-e-Dorah, the other from the Ozbak-Kuh Mountains. The species ranges from the Early *rhomboidea* Zone into the Early *marginifera* Zone.

Palmatolepis subperlobata BRANSON & MEHL, 1934

Pl. 1, figs. 21-22

Synonymy: Over (1997, p. 170).

1999 *Palmatolepis subperlobata* BRANSON & MEHL, 1934– Yazdi, Pl. 10, fig 6,7,14.

Remarks: The two specimens available are typical for the species but the posterior tip of the platform, if not very gently flexed downwards, is horizontal. A few delicate tubercles are displayed chiefly on the anterior of the inner platform. This may be construed as a tendency toward *Pa. quadrantinodosalobata.*

Range and Occurrence: One specimen from the "Cephalopod Bed"

at Howz-e-Dorah, the other from the Ozbak-Kuh Mountains. The species range is Early *triangularis* Zone to Late *crepida* Zone.

Palmatolepis termini termini SANNEMANN, 1955

Pl. 3, figs. 16-20

Synonymy: Schülke (1995, p. 53).

Remarks: Five specimens, all close to the diagnosis of the species. Two specimens (Pl. 3, figs. 17-18) have a very delicate ridge-forming carina on the otherwise horizontal surface. Other specimens (Pl. 3, figs. 16, 19) have the carina in a very gentle depression, and one (Pl. 3, fig. 20) has no carina at all.

Range and Occurrence: Three samples from the Ozbak-Kuh Mountains. The subspecies is restricted to the Middle and Late *crepida* Zone.

Palmatolepis triangularis SANNEMANN, 1955

Pl. 4, figs. 1-2

Synonymy: Over & Rhodes (2000, p. 106).

Remarks: The two specimens are similar to those illustrated by Szulczewski (1971, Pl. 14, fig. 5).

Range and Occurrence: "Cephalopod Bed", Howz-e-Dorah area. The species ranges from the base of the *triangularis* Zone to the Middle *crepida* Zone.

Palmatolepis wolskajae OVNATANOVA, 1969

Pl. 4, fig 3

Synonymy: Metzger (1994, p. 639).

1994 *Palmatolepis wolskajae* OVNATANOVA, 1969 - Metzger, Pl. 7, fig 8,9,13.

Remarks: The one specimen available fits well with the original

diagnosis in having elongate even shagreen ornament on the platform, with the anterior inner platform swollen and separated from the blade by an adcarinal groove. It has a sigmoidal blade, large central node, weak carina and small outer lobe.

Range and Occurrence: "Cephalopod Bed", Howz-e-Dorah. It is not known outside the *crepida* Zone (Ziegler 1977). It is known from the Zadonsk horizon in Russia, the Middle to Upper *crepida* Zones in North America, and has been previously reported from the Niaz area (Yazdi 1999).

Conclusion

Thirty species and subspecies of *Palmatolepis* have been discriminated, 13 from the Howz-e-Dorah section, 9 from the Ozbak-Kuh Mountains, and 22 from several small sections in the Niaz area. The Howz-e-Dorah and Niaz areas produced both Frasnian and Famennian species of *Palmatolepis* whereas only Famennian forms of *Palmatolepis* were encountered in the Ozbak-Kuh Mountains.

Acknowledgments

Thirty species and subspecies of *Palmatolepis* have been discriminated, 13 from the Howz-e-Dorah section, 9 from the Ozbak-Kuh Mountains, and 22 from several small sections in the Niaz area. The Howz-e-Dorah and Niaz areas produced both Frasnian and Famennian species of *Palmatolepis* whereas only Famennian forms of *Palmatolepis* were encountered in the Ozbak-Kuh Mountains (Figs. 3, 4 & 5).

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EXPLANATIONS OF PLATES OF *PALMATOLEPIS*

Plate 1

Figs. 8, 9, 10, 12, 17, 18, 19 x30; figs. 4, 5, 11, 14, 21 x40; figs. 2, 3, 6, 7, 13, 16 x45; figs. 1, 10, 15, 20, 22 x60.

Palmatolepis glabra tenuipunctata SANNEMANN, 1955

Fig. 1. Upper view of AFUM619. N. 17, Niaz area.
Fig. 2. Upper view of AFUM620. B. 2, Howz-e-Dorah area.
Fig. 3. Upper view of AFUM621. T. 39, Howz-e-Dorah area.
Fig. 4. Upper view of AFUM622. T. 39, Howz-e-Dorah area.
Fig. 5. Upper view of AFUM623. K. 161, Ozbak-Kuh Mountains.
Fig. 6. Upper view of AFUM624. K. 163, Ozbak-Kuh Mountains.
Fig. 7. Upper view of AFUM625. K. 162, Ozbak-Kuh Mountains.

Palmatolepis glabra prima ZIEGLER & HUDDLE, 1969

Fig. 8. Upper view of AFUM546. N. 0, Niaz area.
Fig. 9. Upper view of AFUM547. K. 174, Ozbak-Kuh Mountains.
Fig. 10. Upper view of AFUM548. T. D, Howz-e-Dorah area.

Palmatolepis glabra glabra ULRICH & BASSLER, 1926

Fig. 11. Upper view of AFUM551. N. 0, Niaz area.

Palmatolepis glabra distorta BRANSON & MEHL, 1934

Fig. 12. Upper view of AFUM541. N. 1, Niaz area.
Fig. 13. Upper view of AFUM542. N. 0, Niaz area.
Fig. 14. Upper view of AFUM543. B. 5, Howz-e-Dorah area.
Fig. 15. Upper view of AFUM544. N. 0, Niaz area.

Palmatolepis glabra pectinata ZIEGLER, 1962

Fig. 16. Upper view of AFUM545. N. 1, Niaz area.

Palmatolepis glabra acuta HELMS, 1963

Fig. 17. Upper view of AFUM549. N. 1, Niaz area.
Fig. 18. Upper view of AFUM550. N. 1, Niaz area.

Palmatolepis hassi MÜLLER & MÜLLER, 1957

Fig. 19. Upper view of AFUM559. T. 15, Howz-e-Dorah area.
Fig. 20. Upper view of AFUM558. T. 16, Howz-e-Dorah area.

Palmatolepis subperlobata BRANSON & MEHL, 1934

Fig. 21. Upper view of AFUM609. K. 165, Ozbak-Kuh Mountains.

Fig. 22. Upper view of AFUM610. T. 37, Howz-e-Dorah area.

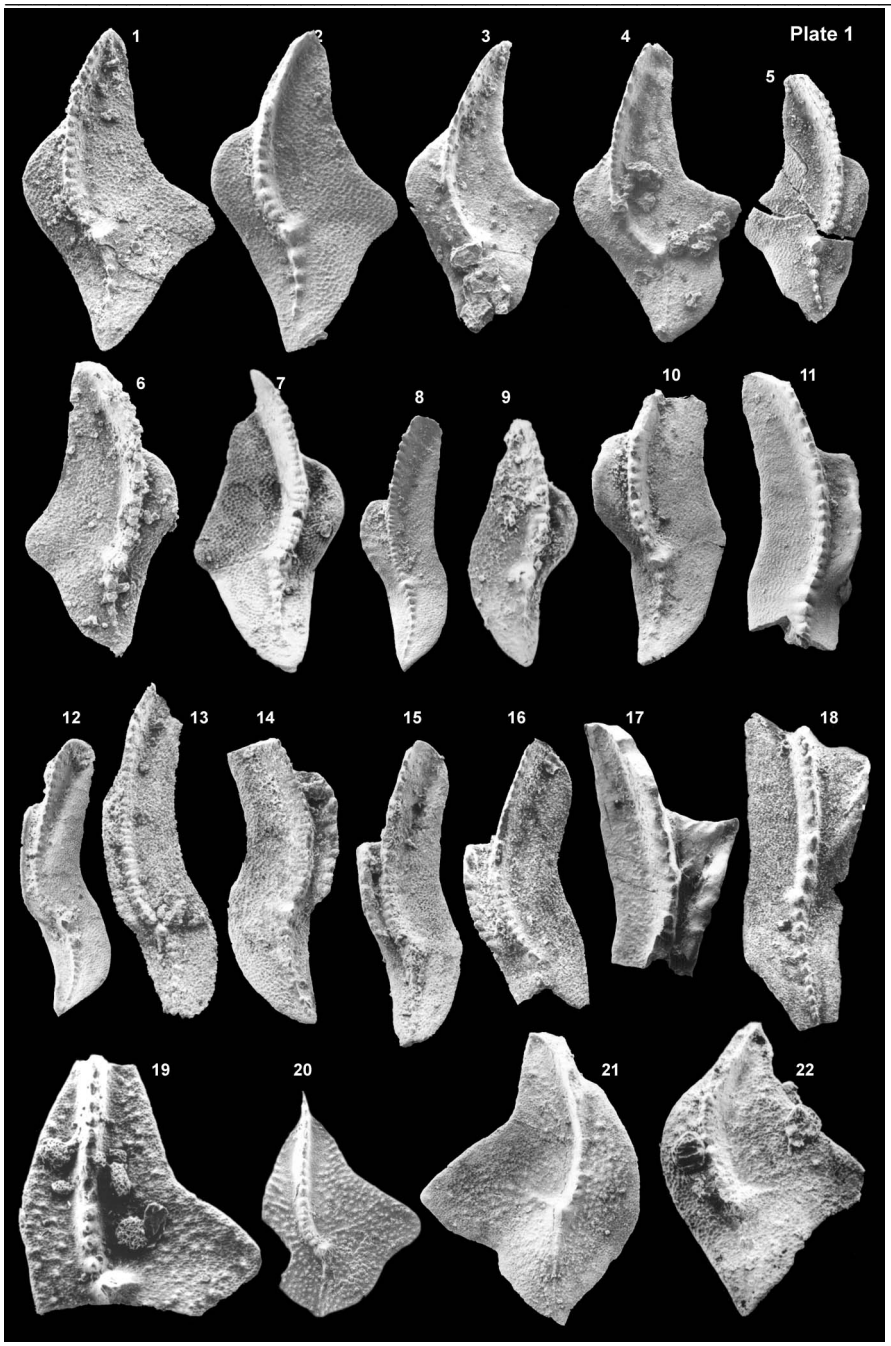
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Plate 2

Figs. 7, 9 x25; figs. 8, 13, 23 x40; figs. 1, 4, 11, 17, 20, 21 x45; figs. 5, 6, 10, 11, 12, 14, 15, 16, 17, 18, 19, 22, x60; figs. 2, 3, x75.

Palmatolepis quadrantinodosa quadrantinodosa BRANSON & MEHL, 1934 Plate

Fig. 1. Upper view of AFUM578. K. 163, Ozbak-Kuh Mountains.
Fig. 2. Upper view of AFUM579. K. 169, Ozbak-Kuh Mountains.
Fig. 3. Upper view of AFUM580. K. 174, Ozbak-Kuh Mountains.
Fig. 4. Upper view of AFUM581. K. 161, Ozbak-Kuh Mountains.
Fig. 5. Upper view of AFUM582. K. 156, Ozbak-Kuh Mountains.

Palmatolepis cf. *quadrantinodosa quadrantinodosa* BRANSON & MEHL, 1934 Plate

Fig. 6. Upper view of AFUM583. K. 162, Ozbak-Kuh Mountains.

Palmatolepis quadrantinodosa inflexoidea ZIEGLER 1962b Plate 31, figs. 7-8

Fig. 7. Upper view of AFUM585. N. 0, Niaz area.
Fig. 8. Upper view of AFUM584. N. 0, Niaz area.

Palmatolepis quadrantinodosa inflexa MULLER, 1956b Plate 28, figs. 12-14

Fig. 9. Upper view of AFUM554. N. 1, Niaz area.
Fig. 10. Upper view of AFUM553. N. 0, Niaz area.

Palmatolepis quadrantinodosalobata quadrantinodosalobata SANNEMANN, 1955a

Fig. 11. Upper view of AFUM586. K. 169, Ozbak-Kuh Mountains.
Fig. 12. Upper view of AFUM587. K. 163, Ozbak-Kuh Mountains.
Fig. 13. Upper view of AFUM588. K. 163, Ozbak-Kuh Mountains.
Fig. 14. Upper view of AFUM589. K. 163, Ozbak-Kuh Mountains.
Fig. 15. Upper view of AFUM590. K. 163, Ozbak-Kuh Mountains.
Fig. 16. Upper view of AFUM591. K. 163, Ozbak-Kuh Mountains.
Fig. 17. Upper view of AFUM631. T. 38, Howz-e-Dorah area.
Fig. 18. Upper view of AFUM611. T. D, Howz-e-Dorah area.
Fig. 19. Upper view of AFUM612. N. 11, Niaz area.
Fig. 20. Upper view of AFUM614. T. 85, Ozbak-Kuh Mountains.
Fig. 21. Upper view of AFUM615. T. 37, Howz-e-Dorah area.
Fig. 22. Upper view of AFUM617. K. 162, Ozbak-Kuh Mountains.
Fig. 23. Upper view of AFUM618. K. 174, Ozbak-Kuh Mountains.

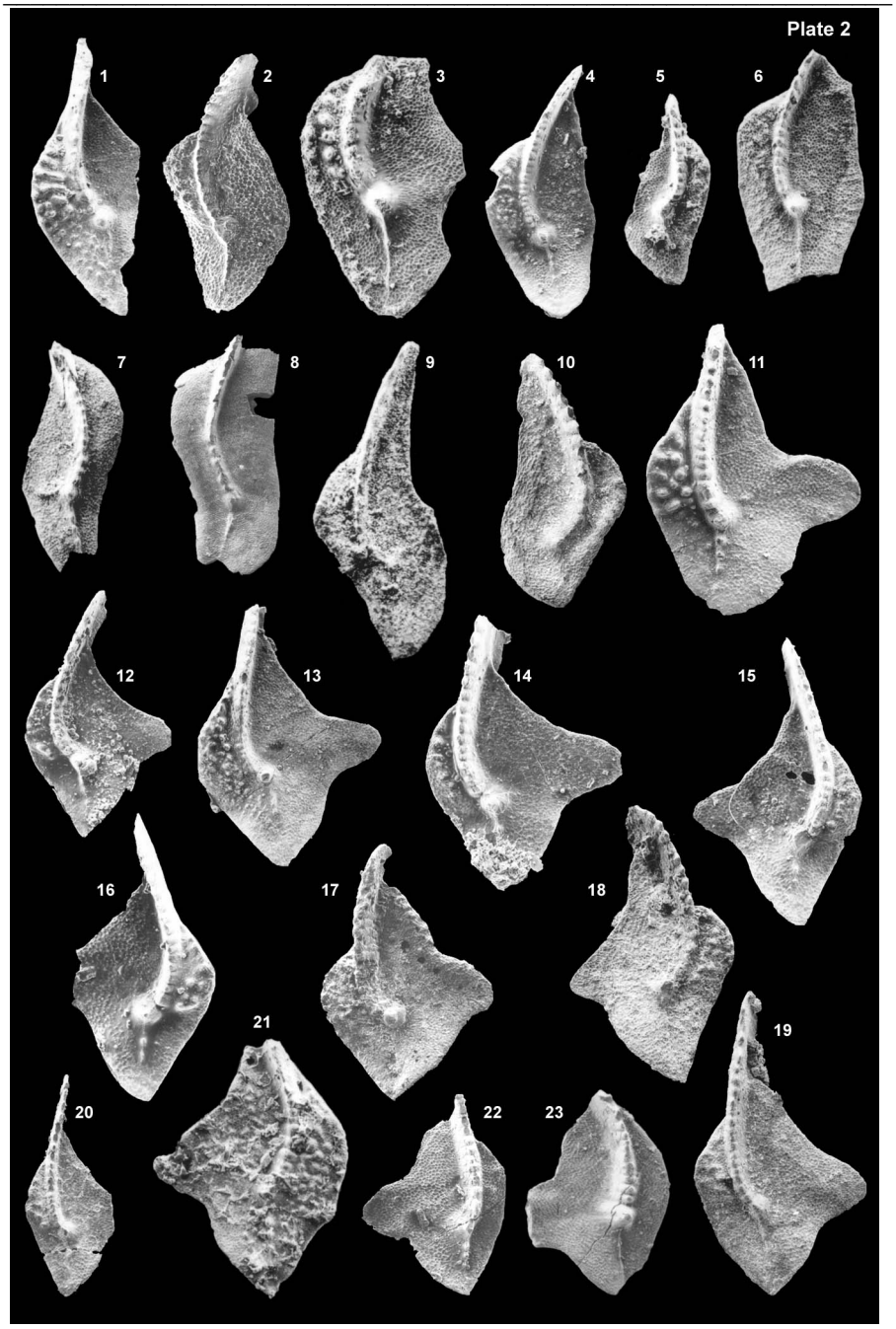
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Plate 3

Fig. 4 x15; fig. 2 x20; figs. 1, 3, 6, 7, 13, 21 x25; figs. 5, 8, 9, 10, 11, 12, 22 x30; fig. 14 x40; fig. 15 x45; figs. 16, 17, 18, 20 x60; fig. 19, 23, 24 x75.

Palmatolepis perlobata perlobata ULRICH & BASSLER, 1926

Fig. 1. Upper view of AFUM602. B. 5, Niaz area.

Fig. 2. Upper view of AFUM601. N. 17, Howz-e-Dorah area.

Palmatolepis perlobata maxima MÜLLER, 1956b

Fig. 3. Upper view of AFUM649. N. 1, Niaz area.

Palmatolepis perlobata grossi ZIEGLER, 1960

Fig. 4. Upper view of AFUM650. N. 1, Niaz area.

Fig. 5. Upper view of AFUM651. N. 17, Niaz area.

Palmatolepis perlobata sigmoidea ZIEGLER, 1962

Fig. 6. Upper view of AFUM603. N. 0, Niaz area.

Palmatolepis perlobata helmsi ZIEGLER 1962b

Fig. 7. Upper view of AFUM795. N. 1, Niaz area.

Palmatolepis perlobata schindewolfi MÜLLER 1956

Fig. 8. Upper view of AFUM593. N. 0, Niaz area.

Fig. 9. Upper view of AFUM594. N. 1, Niaz area.

Fig. 10. Upper view of AFUM595. N. 0, Niaz area.

Fig. 11. Upper view of AFUM592. N, 1, Niaz area.

Fig. 12. Upper view of AFUM596. N. 0, Niaz area.

Fig. 13. Upper view of AFUM597. N. 1, Niaz area.

Fig. 14. Upper view of AFUM599. N. 15, Niaz area.

Fig. 15. Upper view of AFUM600. N. 9, Niaz area.

Palmatolepis termini termini SANNEMANN, 1955

Fig. 16. Upper view of AFUM606. K. 162, Ozbak-Kuh Mountains.

Fig. 17. Upper view of AFUM604. K. 154, Ozbak-Kuh Mountains.

Fig. 18. Upper view of AFUM605. K. 162, Ozbak-Kuh Mountains.

Fig. 19. Upper view of AFUM607. K. 163, Ozbak-Kuh Mountains.

Fig. 20. Upper view of AFUM608. K. 162, Ozbak-Kuh Mountains.

Palmatolepis sp.

Figs. 21. Upper view of AFUM731. B. 7, Howz-e-Dorah area.

Palmatolepis sp.

Figs. 22. Upper view of AFUM732. B. 3, Howz-e-Dorah area.

Palmatolepis sp.

Fig. 23. Upper view of AFUM733. K. 169, Ozbak-Kuh Mountains.

Fig. 24. Upper view of AFUM734. K. 169, Ozbak-Kuh Mountains.

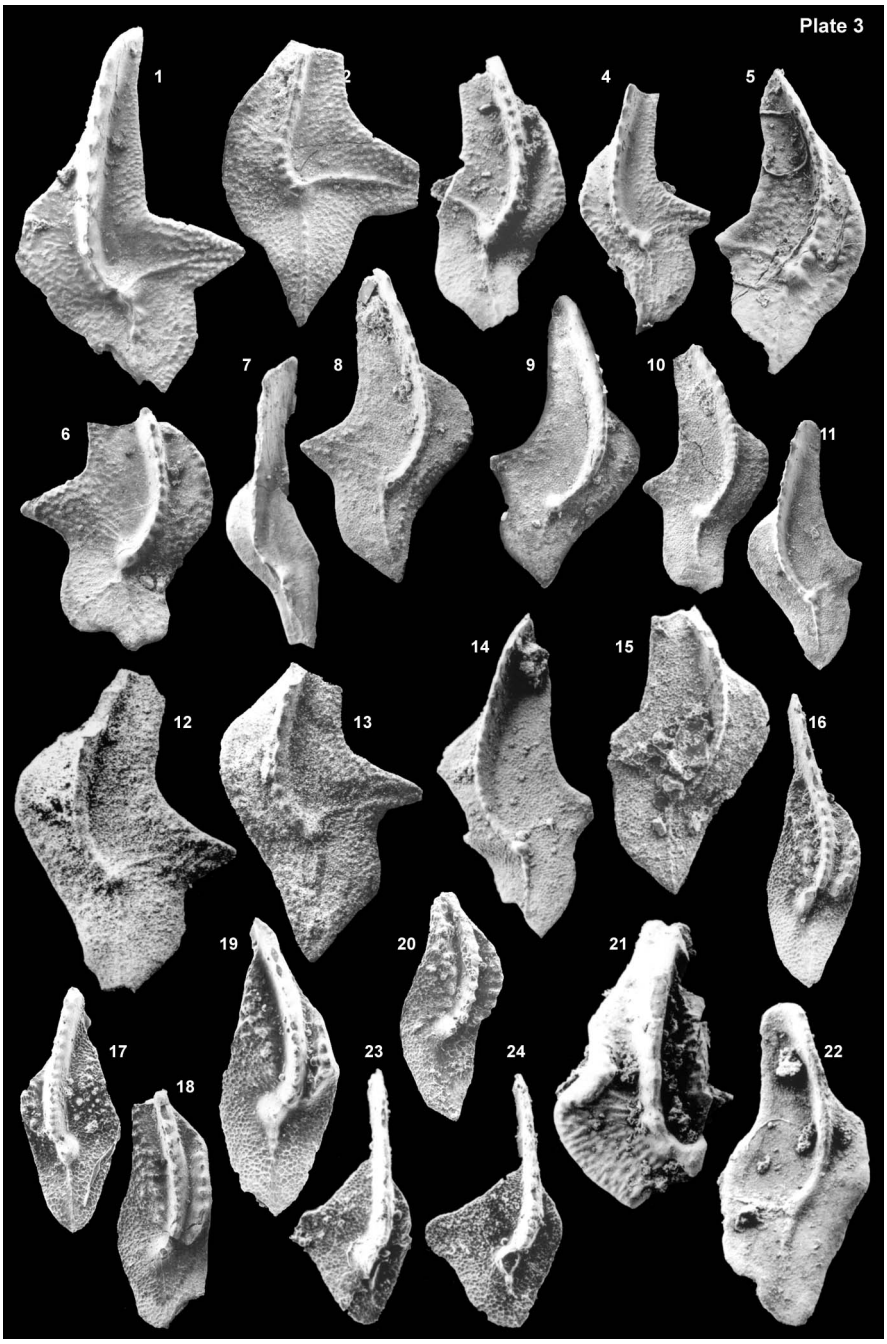
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Plate 4

Fig. 2 x25; figs. 1, 6, 7 x30; figs. 5, 12, 25, 26 x40; figs. 3, 4, 8, 11, 17, 18, 22 x45; figs. 9, 10, 15, 16, 19, 23, 24 x60; figs. 13, 14, 20, 21 x75.

Palmatolepis triangularis SANNEMANN, 1955

Fig. 1. Upper view of AFUM626. T. 37, Howz-e-Dorah area.

Fig. 2. Upper view of AFUM627. T. 37, Howz-e-Dorah area.

Palmatolepis wolskajae OVNATANOVA, 1969

Fig. 3. Upper view of AFUM631. B. 6, Howz-e-Dorah area.

Palmatolepis crepida SANNEMANN, 1955

Fig. 4. Upper view of AFUM633. K. 168, Ozbak-Kuh Mountains.

Fig. 5. Upper view of AFUM632. K. 162, Ozbak-Kuh Mountains.

Palmatolepis gigas MILLER & YOUNGQUIST, 1947

Fig. 6. Upper view of AFUM628. N. 8, Niaz area.

Fig. 7. Upper view of AFUM629. N. 8, Niaz area.

Palmatolepis minuta minuta BRANSON & MEHL, 1934.

Fig. 8. Upper view of AFUM556. N. 17, Niaz area.

Fig. 9. Upper view of AFUM557. T. G, Howz-e-Dorah area.

Fig. 10. Upper view of AFUM555. N .11, Niaz area.

Palmatolepis minuta schleizia HELMS, 1963

Fig. 11. Upper view of AFUM560. N. 1, Niaz area.

Fig. 12. Upper view of AFUM561. N. 1, Niaz area.

Palmatolepis rhomboidea SANNEMANN, 1955

Fig. 13. Upper view of AFUM563. T. G, Howz-e-Dorah area.

Fig. 14. Upper view of AFUM565. K. 172, Ozbak-Kuh Mountains.

Fig. 15. Upper view of AFUM564. T. G, Howz-e-Dorah area.

Palmatolepis gracilis gracilis BRANSON & MEHL, 1934

Fig. 16. Side view of AFUM566. N. 3, Niaz area.

Fig. 17. Side view of AFUM567. N. 19, Niaz area.

Fig. 18. Side view of AFUM569. N. 2, Niaz area.

Fig. 19. Side view of AFUM570. N. 2, Niaz area.

Fig. 20. Side view of AFUM571. N. 0, Niaz area.

Fig. 21. Side view of AFUM572. N. 0, Niaz area.

Fig. 22. Side view of AFUM573. N. 19, Niaz area.

Palmatolepis gracilis expansa SANDBERG & ZIEGLER, 1979

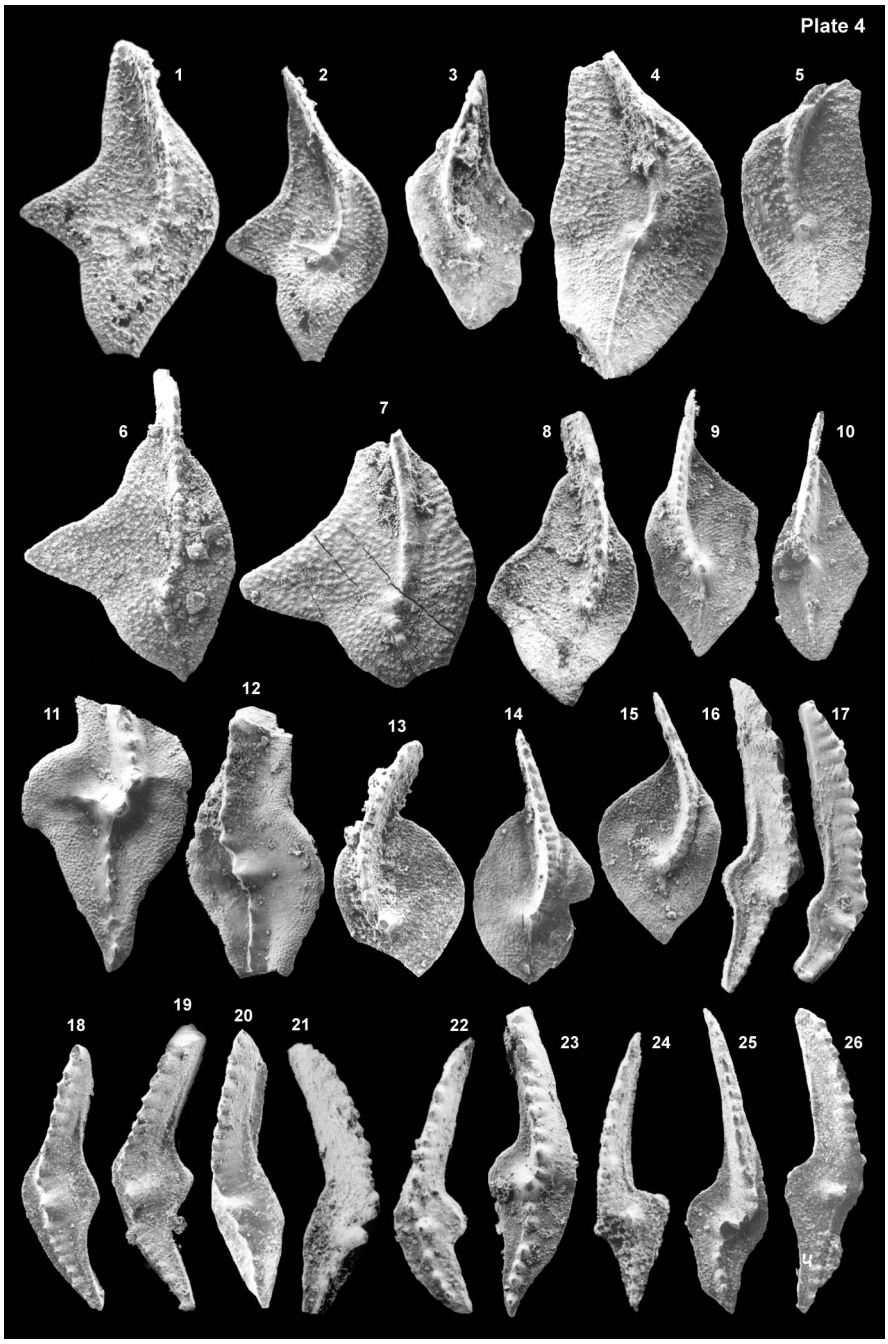
Fig. 23. Oblique upper view of AFUM574. N. 10, Niaz area.

Palmatolepis gracilis sigmoidalis ZIEGLER, 1962b

Fig. 24. Side view of AFUM575. N. 2, Niaz area.

Fig. 25. Oblique upper view of AFUM576. N.2, Niaz area.

Fig. 26. Side view of AFUM577. N. 2, Niaz area.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