Palaeobotanist 51(2002) : 57-72
0031-0174/2002/57-72 $2.00

Plant megafossil remains from Shemshak Formation of Jajarm area, NE Alborz, Iran

F. VAEZ JAVADI[1] AND M. GHAVIDEL SYOOKI[2]

[1]*Department of Geology, Teacher Training University, Tehran, Islamic Republic of Iran.*
[2]*National Iranian Oil Company, P.O.Box 1065, Tehran, Islamic Republic of Iran.*

(Received 18 October 2001; revised version accepted 20 August 2002)

ABSTRACT

Javadi FV & Syooki MG 2002. Plant megafossil remains from Shemshak Formation of Jajarm area, NE Alborz, Iran. Palaeobotanist 51 : 57-72.

The basal part of Shemshak Formation contains abundant well-preserved plant megafossils belonging to 17 taxa of various orders viz., Equisetales, Filicales, Bennettitales, Cycadales and Coniferales. On the basis of present study specially *Dictyophyllum exile, Equisetites arenaceus, Podozamites latissimus* and *Nilssonia polymorpha*, this part of the Shemshak Formation is dated as Rhaetian.

Key-words—Rhaetian Flora, Shemshak Formation, NE Alborz, Iran.

ईरान के उत्तर-पूर्वी अल बोर्ज़ के जाजर्म क्षेत्र के शेमशाक शैलसमूह से प्राप्त पादप गुरुपादपाश्म अवशेष

ऍफ़ वाएज़ जवादी एवं ऍम. गाविदेल स्यूकी

सारांश

शेमशाक शैलसमूह के आधारीय भाग के विभिन्न क्रमों के 17 वर्गकों से सम्बन्धित सुसंरक्षित प्रचुर पादप गुरुपादपाश्म, जैसे—इक्वीसिटेलीज़, फ़ाइलिकेलीज़, बेनीटाइटेलीज़, साइकेडेलीज़ तथा कोनिफ़ेरेलीज़ विद्यमान हैं। वर्तमान में विशेषकर *डिक्ट्योफ़िल्लम एक्ज़ाइली, इक्वीसिटाइटीज़ एरीनेशियस, पोडोज़ैमाइटीज़ लैटिसिमस* तथा *निल्ससोनिया पॉलीमॉर्फ़ा* पर किए गए अध्ययन के आधार पर शेमशाक शैलसमूह के इस भाग की आयु रीशियन के रूप में निर्धारित की गयी है।

संकेत शब्द—रीशियन वनस्पतिजात, शेमशाक शैलसमूह, उत्तर-पूर्वी अल बोर्ज़, ईरान.

INTRODUCTION

THE studied area is located at Ozon mountain 56°32' east longitude and 37°2' north latitude, 15 km northeastern of Jajarm. Jajarm is located at northwest of Khorasan Province at a distance of 175 km from Bojnurd city (Fig. 1). The altitude of the study area is about 1000 m above sea level.

The Shemshak Formation is well-exposed at Kuh-e-Ozon (Kuh: means mountain) which is about 800 km away from its type locality at Central Alborz. The Shemshak Formation has a thickness of 2080 m in Kuh-e-Ozon and it consists mainly of sandstones, grey shales intercalating with coal seams and a few limestone beds. The Shemshak Formation was identified in Kuh-e-Ozon by Afshar-Harb (1979) based on ammonite fossils and suggested Middle Toarcian-Lower Aalenian for this rock unit. Likewise, Soheili (1982) prepared a geographical map for this area and mentioned that there are no fossils in the basal part of this rock unit up to 750 m. However, based on ammonite fossils in the upper part of this rock unit, he has suggested Toarcian-Batonian.

It should be mentioned that Afshar-Harb and Soheili (p.c.) have reported only the occurrence of ammonite in some horizon of Shemshak Formation, but they did not report any plant megafossils from this Formation. In order to determine the precise age of Shemshak Formation, the authors studied the Formation and discovered plant megafossils at the basal part of this Formation (Fig. 2).

STRATIGRAPHY

The Shemshak Formation at Jajarm area consists mainly of sandstones, shales, coal seams and conglomerates in the lower part and has ammonites and bivalves limestones in the upper part. The Shemshak Formation lies disconformably on the Elika Formation and the upper contact of this formation is gradational with Bash-Kalateh Formation (Afshar-Harb, 1979). The Shemshak Formation begins with 16 m of alternating median-coarse grained sandstones and is followed by olive-grey shales which contain well-preserved abundant plant megafossils.

SYSTEMATIC DESCRIPTION

Order—EQUISETALES

Family—EQUISETACEAE

Genus—EQUISETITES Sternberg 1820

EQUISETITES ARENACEUS Brongniart 1828

(Pl. 1·1)

1964 *Equisetites arenaceus* Boureau; p. 432, figs 391-394.
1976 *Equisetites arenaceus* Bragin *et al.*; p. 11.
1976 *Equisetites arenaceus* Sadovnikov; p. 74, pl. 1, figs 9, 10.
1984 *Equisetites arenaceus* Vassiliev; pl. 2, fig. 1, text-fig. 3.
1997 *Equisetites arenaceus* Schweitzer *et al.*; p. 120, pl. 2, fig. 2.
1998 *Equisetites arenaceus* Kelber & van Konijnenburg-van Cittert; p. 21, figs 2-5.

Description—The specimen is a cast, 21 cm in length, 14 cm in diameter with several nodes and internodes in between. Internode is 3-4 cm in length with alternating ridges and furrows which are clear specially near the nodes. Ridges or furrows are 2-2·5 mm apart (4-5 per cm).

Comparison & Remarks—Equisetites beanii Seward 1894 has also such a large cast but differs in longer internodes (more than 9 cm) and closer furrows (0·3-0·5 mm) than those in *E. arenaceus*. Bragin *et al.* (1976) reported this species from the basal series of the Mesozoic sediments of Tazareh Coal Mine (Iran). Sadovnikov (1976) reported it from Upper Triassic strata of Tazareh. Vassiliev (1984) reported it from Rhaetian strata of Parvadeh Coal Mine (Iran). Schweitzer *et al.* (1997) mentioned this species from Norian of Tazareh.

Order—FILICALES

Family—DICKSONIACEAE

Genus—FERIZIANOPTERIS Fakhr 1977

FERIZIANOPTERIS UNDULATA Fakhr 1977

(Pl. 1·2; Fig. 3·12)

1977 *Ferizianopteris undulata* Fakhr ; p. 61, pls 10,11, figs 1a, b, 2 ; fig. 5H-J.

Description—Frond bipinnate, 21 cm long, 6-7 cm broad; rachis distinct, with longitudinal strations, 4-5 mm in width, secondary rachis arising at about right angles, alternate to subopposite, 1-2 mm in width. Pinnules attached at right angles to the secondary rachis by a slightly constricted base, set closely, opposite to alternate, margins undulate or irregulate, apices rounded, 2-3 mm in length, 2-2·5 mm in width. Venation

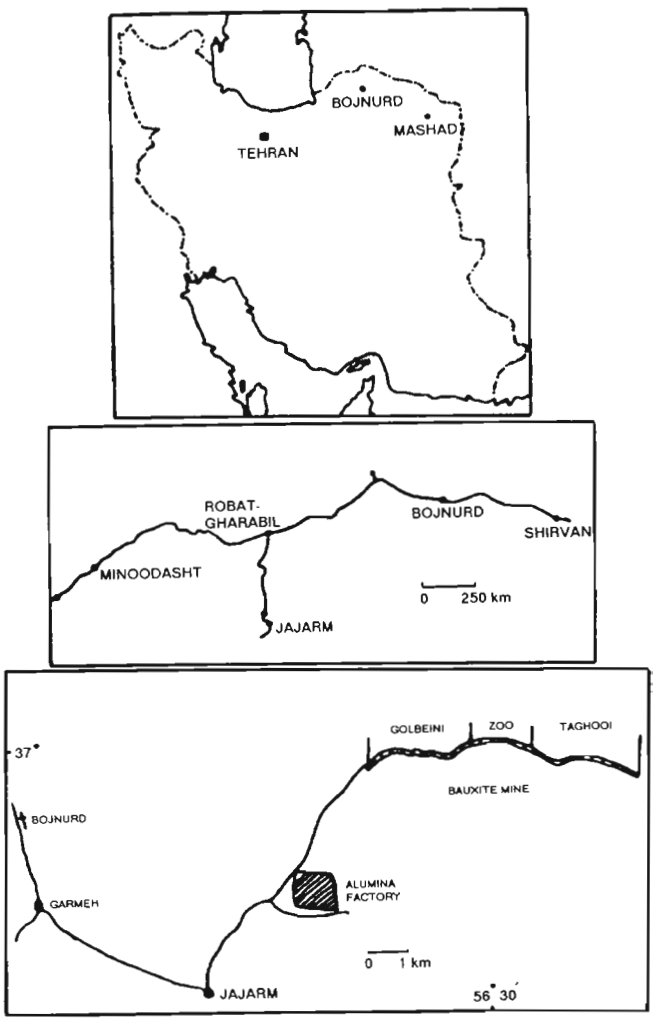


Fig. 1—Location map of study area.

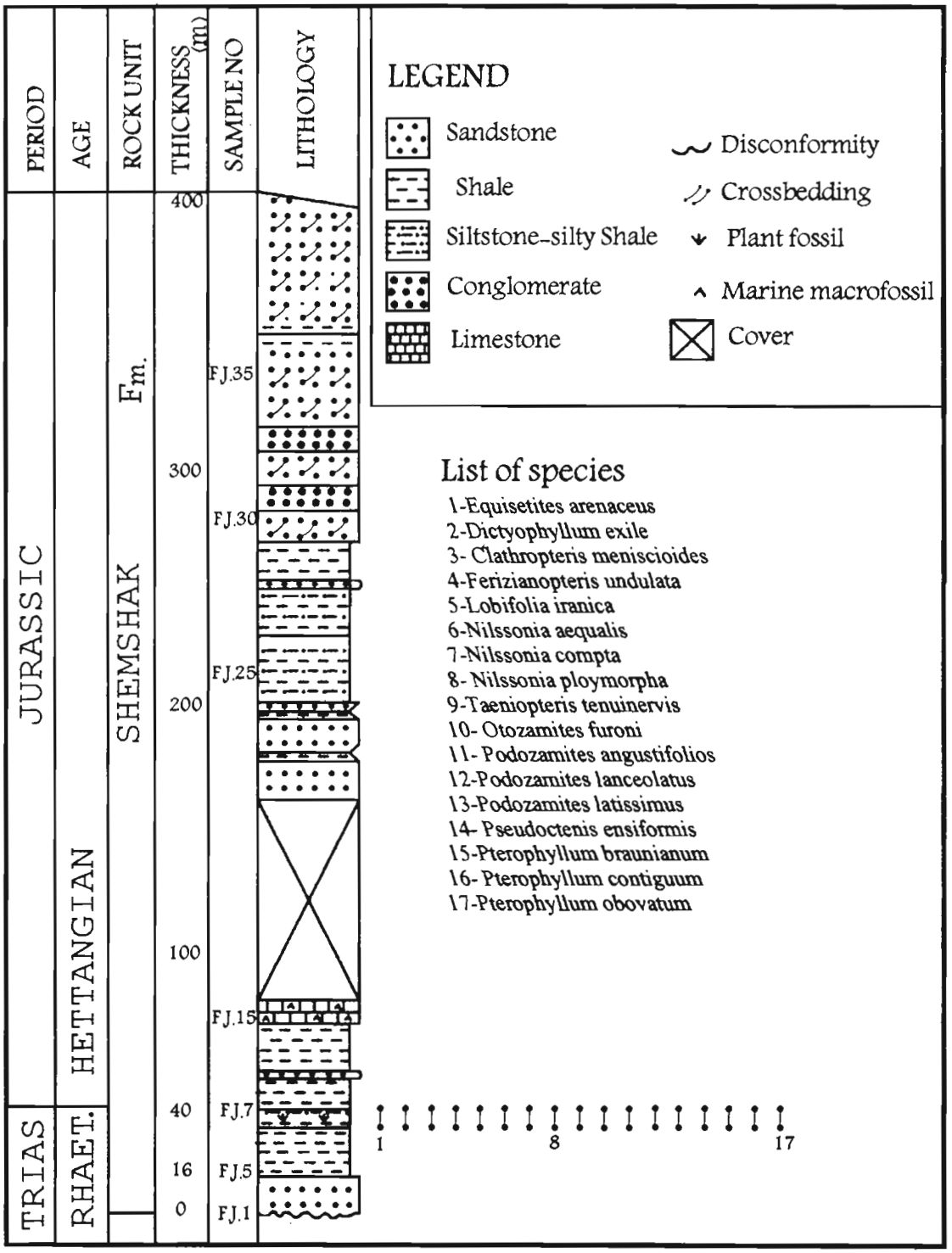


Fig. 2—Stratigraphical column of Shemshak Formation and the plant megafossils bearing horizon in Jajarm.

sphenopteroid, main midrib passes to somewhat one-half of the pinnule length; lateral veins branch dichotomously once or twice.

Comparison & Remarks—This specimen has more closely set pinnules and broader pinnule base than Fakhr's specimen. This specimen *Sphenopteris* spp. In having broader

pinnule bases and right angle attaching to rachis. Fakhr (1977) reported this species from Lias-Dogger strata of Ferizi (Iran).

Genus—LOBIFOLIA Rasskazova & Lebedev 1968

LOBIFOLIA IRANICA Fakhr 1977

(Pl. 1·4; Fig. 3·11)

1977 *Lobifolia iranica* Fakhr ; p. 61, pl. 13, figs 1-3.

Description—Frond bipinnate, incomplete; primary rachis straight, 1 cm in width, with longitudinal striations; secondary rachis arising at a right angle, 1-2 mm in width; pinnae alternate; pinnules opposite, attached at about a right angle by a broad base to the secondary rachis, 9-10 mm in length, 7-8 mm in width, margins entire or finely undulate, with rounded apices. Midvein is not visible, lateral veins forked twice or three times.

Comparison & Remarks—Lobifolia (Eboracia) doruda (Barnard) Rasskazova & Lebedev 1968 resembles the present species but it can be distinguished from *L. iranica* in having only once forked lateral veins and the pinnules attached at an angle of 50°-60° Fakhr (1977) reported this species from Rhaeto-Lias strata of Ziaran (Iran).

Family—DIPTERIDACEAE

Genus—CLATHROPTERIS Brongniart 1828

CLATHROPTERIS MENISCOIDES (Brongniart 1825) Brongniart 1828

(Pl. 2·2)

1825 *Filicites meniscoides* Brongniart; p. 200; Atlas; pl. 12 (in Harris 1931, p.88).
1847 *Clathropteris meniscoides* Germar; p. 117, pl. 16, figs 1-4.
1911 *Clathropteris meniscoides* Thomas; p. 55, pl. 8, fig. 1.
1931 *Clathropteris meniscioides* Harris; p. 88, pl. 15, fig. 1.
1940 *Clathropteris meniscoides* Ôishi; p. 214, pl. 5, fig. 4.
1949 *Clathropteris meniscoides* Sze; pl. 1, fig. 5; pl. 4, fig. 1.
1950 *Clathropteris meniscoides* Lundblad; p. 27.
1964 *Clathropteris meniscoides* Kilpper; p. 37, figs 15, 16.
1968 *Clathropteris meniscoides* Kon'no; p. 100, pl. 2, figs 2-6; text-fig. 3.
1968 *Clathropteris meniscoides* Assereto *et al.*; p. 11, tab. 1a.
1977 *Clathropteris meniscoides* Fakhr; p. 75, pl. 22, figs 1-3; fig. 8G.
1977 *Clathropteris meniscoides* Corsin & Stampfli; p. 523, pl. 1, fig. 6.

Description—Leaf big in size, petiole not preserved; pinnae elongate-lanceolate, attaining a width about 13-14 cm and a length of ca. 20 cm, lamina contiguous, margins toothed, length of tooth and that of its supporting lateral vein reaching 24 mm and 65 mm respectively. Thus division of pinna-lamina into teeth extending less than one-third of total length of supporting lateral vein; marginal teeth triangular, acutely pointed; rachis of pinna rather slender, 1-2 mm in width; lateral veins about 0·2-0·4 mm across, arising from rachis at angles of 40°-60°, at intervals of 15-20 mm; tertiary veins arising from lateral vein at about a right angle, slightly flexuous, giving off a few quaternary veins, forming quadrate or polygonal reticulation of about 3 to 4 mm in width. First type rectangular mesh of about 6-8 mm broad, 12-14 mm long.

Comparison & Remarks—Clathropteris platyphylla Goeppert 1846 resembles this species. *C. platyphylla* as described by Zeiller (1902-03) in further details, appears to differ in arising the lateral veins at angles of 60°-70° instead of 40°-60°. Kon'no (1968) brought *C. platyphylla* under synonymy list of *C. meniscoides*. Vozenin-Serra & De Franceschi (1999) cited these are two different species and noted that the lateral veins in *C. platyphylla* arise at angle of 75° and the proportion of length of tooth to its supporting lateral vein is about 1/8 to 1/13. *C. meniscoides* also differs from *C. elegans* Ôishi 1941 in having more distinct quarternary veins. These meshes are thin and not visible in *C. elegans*. *C. walkeri* as described by Ash (1969, p. 41) does not present a similar distinctive reticulation and pinna apices. This species has a wide geographical distribution. In Iran, it is reported from Zirab (Kilpper, 1964); Qazvin and Nur Valley (Assereto *et al.*, 1968).

CLATHROPTERIS sp.

(Pl. 1.3)

Description—Pinna incomplete; main vein is 2 mm in width; lateral veins arise at a right angle to form rectangular nets with 10 x 11 mm dimension; tertiary veins arise from rectangular or sometimes polygonal meshes 5 x 11 mm in dimension. The surface of specimen is covered completely by collapsed pores.

Genus—DICTYOPHYLLUM Lindley & Hutton 1843

DICTYOPHYLLUM EXILE (Brauns 1862) Nathorst 1878

(Pl. 3·2)

1862 *Camptopteris exilis* Brauns; p. 54, pl. 13, fig. 11.
1878 *Dictyophyllum exile* (Brauns) Nathorst; p. 39, pl. 5, fig. 7.
1926 *Dictyophyllum exile* Harris; p. 64, pl. 1, figs 1, 2.
1931 *Dictyophyllum exile* Harris; p. 80, pl. 18, figs 15, 16.
1950 *Dictyophyllum exile* Lundblad; p. 28, pl. 3, fig. 12.
1970 *Dictyophyllum exile* Boureau; p. 347.
1977 *Dictyophyllum exile* Fakhr; p. 72, pl. 20, figs 2-5; fig. 6E.

Description—Sterile leaf shown in Pl. 3·2 bearing 8-9 pinnae; rachis is about 7 cm length, 3 mm width; the web of basal lamina of adjacent pinnae is negligible about 1-2 cm in

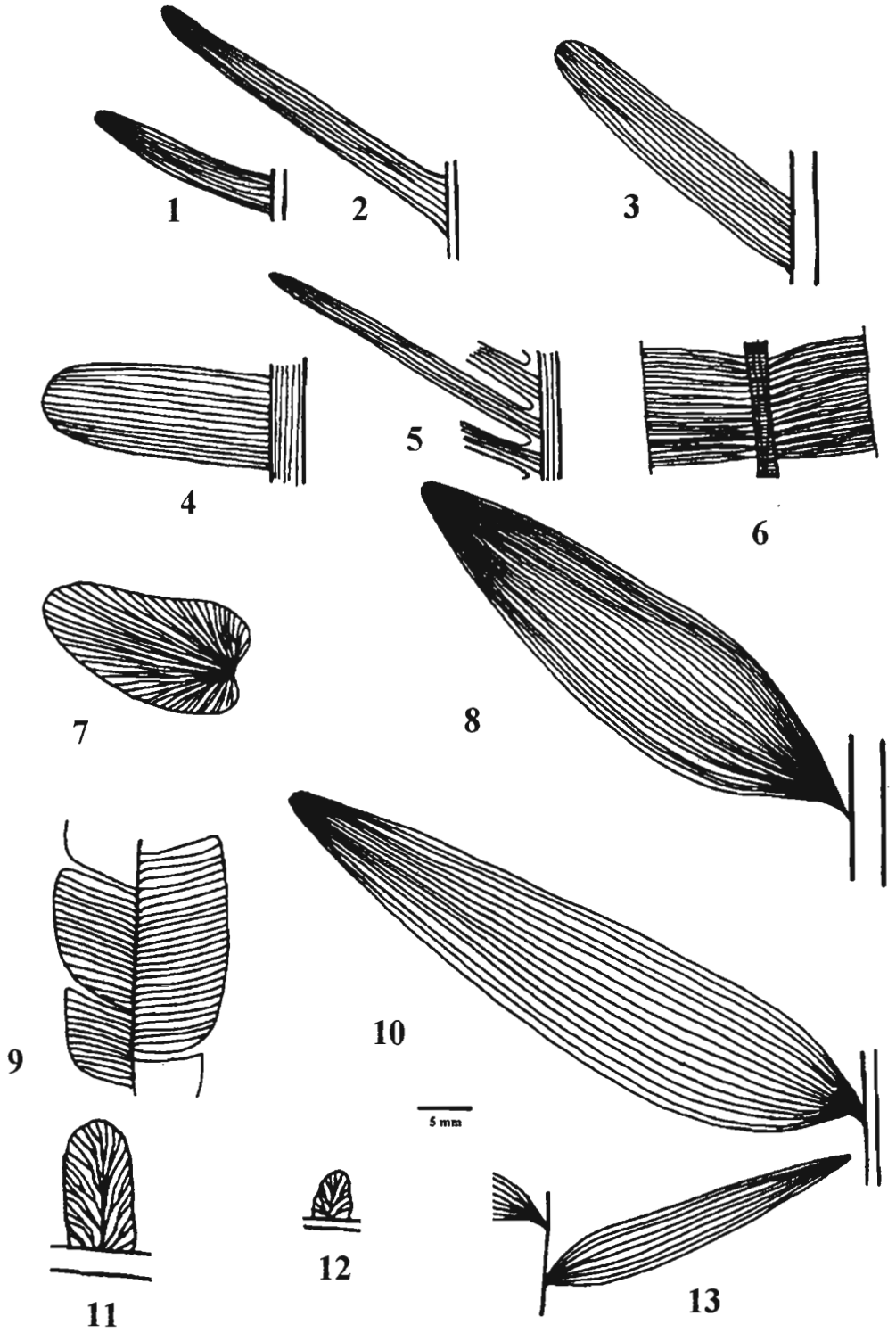


Fig. 3—**1**. *Pterophyllum obovatum*, **2**. *Pterophyllum contiguum*, **3**. *Nilssonia aequalis*, **4**. *Nilssonia compta*, **5**. *Pterophyllum braunianum*, **6**. *Taeniopteris tenuinervis*, **7**. *Otozamites furoni*, **8**. *Podozamites lanceolatus*, **9**. *Nilssonia polymorpha*, **10**. *Podozamites latisimus*, **11**. *Lobifolia iranica*, **12**. *Ferizianopteris undulata*, **13**. *Podozamites angustifolius*.

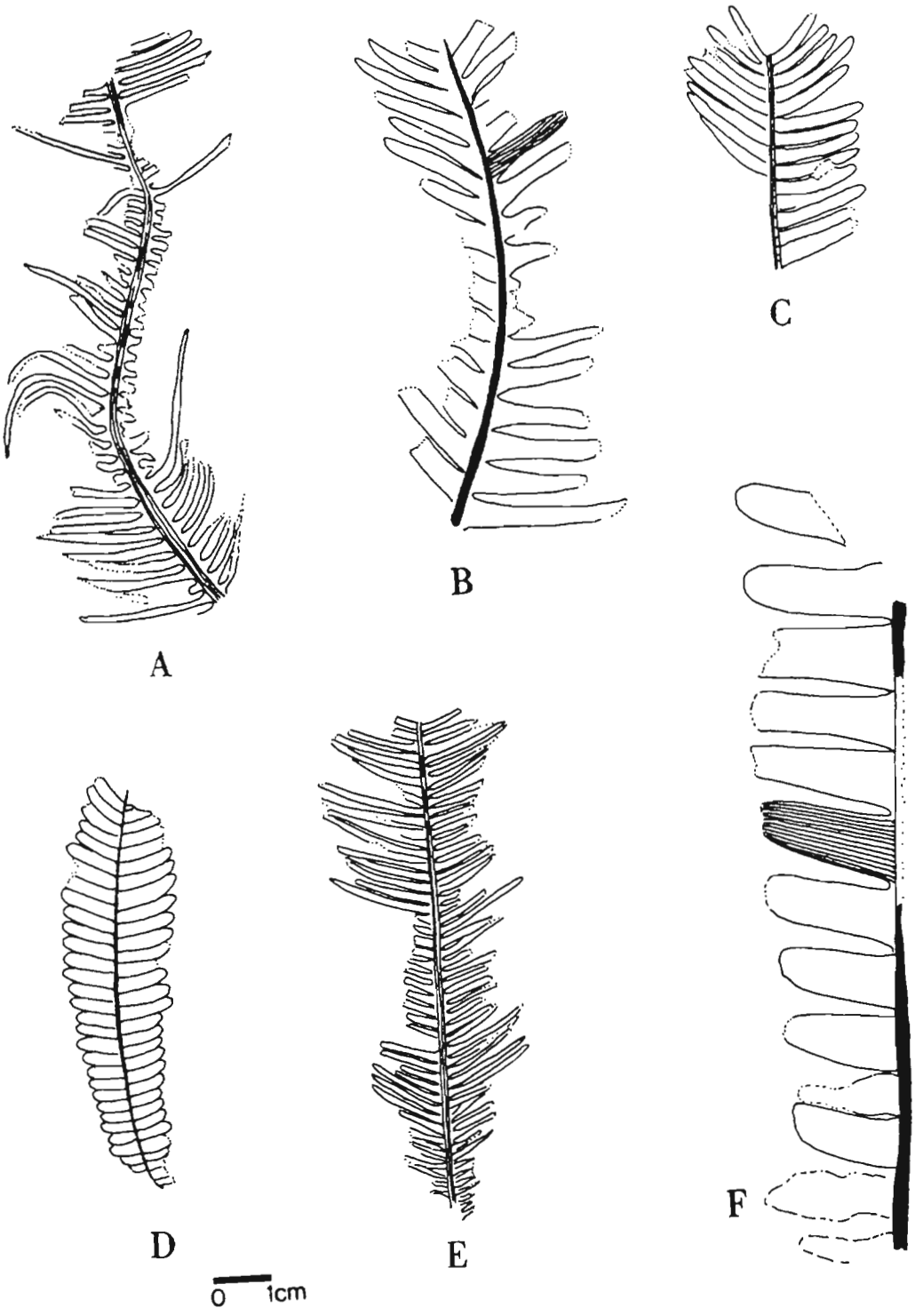


Fig. 4—**A, E.** *Pterophyllum braunianum*, **B.** *Pseudoctenis ensiformis*, **C.** *Pterophyllum contiguum*, **D.** *Pterophyllum obovatum*, **F.** *Nilssonia compta*.

PLATE 1

1. *Equisetites arenaceus* Brongniart 1828.
2. *Ferizianopteris undulata* Fakhr 1977.
3. *Clathropteris* sp.
4. *Lobifolia iranica* Fakhr 1977.

1

2

3

4

PLATE 1

width; pinnae narrow, pinnules with acute to obtuse apices; pinna-rachis strong, giving off the midribs of pinnules at angles of 40°-50° at intervals of 8-9 mm. The division of pinna-lamina into teeth extending to one-third or less than of total length of supporting lateral vein. Secondary veins of pinnule from polygonal meshes, with one row of specially large-sized primary meshes on each side of midrib.

Comparison—Dictyophyllum falcatum Natio 1968 and *Dictyophyllum nathorsti* Zeiller 1903 are similar to *D. exile*. As Kon'no (1968) described *D. falcatum* was distinguished from *D. exile* by bearing less pinnae (12-13), shorter arms (10-13 mm), having a negligible web of basal lamina as separated from each other completely by narrow gaps or distinct grooves; and narrower, falcate pinnules. *D. nathorsti* in comparison to *D. exile* has a basal lamina web about 5-8 cm width (according to Zeiller, 1903); division of teeth reaches to ½ (1/3-2/3), and shorter pinnae bearing arms (8-12 cm long). The division of teeth in *D. exile* reaches to 1/3. Furthermore, the length of rachis bearing pinnae is about 20 cm (according to Fakhr, 1977), and the main rachis is 1 cm, while it is 6-10 mm (according to Zeiller, 1903) in *D. nathorsti*.

Genus—TAENIOPTERIS Brongniart 1828

TAENIOPTERIS TENUINERVIS Brauns 1862

(Pl. 2·1; Fig. 3·6)

1862 *Taeniopteris tenuinervis* Brauns; p. 50, pl. 13, figs 1-3.
1867 *Taeniopteris tenuinervis* Schenk; pl. 25, figs 3-4.
1985 *Taeniopteris tenuinervis* Vassiliev; p. 75, pl. 37, figs 1, 2.

Description—Leaf linear, 22 cm long and 2 cm wide, midrib clear, tapering gradually towards apex with two fine longitudinal striae. Lateral veins are simple or forked once, 24-25 per cm.

Remarks—This species is reported from Rhaetian of Iran (Schenk, 1867; Vassiliev, 1985)

Class—GYMNOSPERMOPSIDA

Order—BENNETTITALES

Genus—OTOZAMITES Braun 1843

OTOZAMITES FURONI Boureau *et al.* 1950

(Pl. 4·5; Fig. 3·7)

1950 *Otozamites furoni* Boureau *et al.*; p. 229, pl. 7, fig. 39.

Description—Frond pinnate, 3·5 cm long, 2·5 cm broad, pinnules ovate, 12 x 6 mm in size, margins entire, apex rounded, base auriculate, close, alternate and cover proximal face of the rachis at an angle of 80°. Veins divergent, arising from a point at the base of the pinnule, dichotomous three times. The density of veins in the middle part of the pinnule is 18-20.

Comparison & Remarks—Otozamites eichwaldi Fakhr 1977 and *Otozamites indosinensis* Zeiller 1903 came closer to *O. furoni*. *O. eichwaldi* differs by its smaller pinnules size (4-6 x 9 mm) and venation with once or twice forked and a density about 13-15 per pinnule. *O. indosinensis* differs by its ovate-linear pinnules (10-13 x 4-5 mm) and veins are once or twice forked veins. *Otozamites kachchhensis* Bose & Banerji 1984 differs in having somewhat rhomboidal or slightly falcate shape and the veins forked once or twice (Bose & Banerji, 1984). This species is reported from Liassic strata of Rudbar, Iran by Boureau *et al.* (1950).

Genus—PTEROPHYLLUM Brongniart 1828

PTEROPHYLLUM BRAUNIANUM (Braun 1843) Goeppert 1843

(Pl. 3·5; Fig. 3·5; Fig. 4A, E)

1843 *Ctenis angusta* Braun; p. 39, pl. 11, figs 1a, b, 3.
1843 *Pterophyllum braunianum* (Braun) Goeppert; p. 134.
1867 *Pterophyllum braunianum* Schenk; p. 164, pl. 38, figs 1-10.
1914 *Pterophyllum angustum* Gothan; p. 134, pl. 26, fig. 3.
1919 *Pterophyllum angustum* Antevs; p. 30, pl. 4, figs 3-7.
1940 *Pterophyllum angustum* Ôishi; p. 340.
1976 *Pterophyllum braunianum* Sadovnikov; p. 93, pl. 4, fig. 5.

Description—Leaf linear-lanceolate as a whole, pinnate, 9 cm in length, 3-3·5 cm in breadth; rachis nearly 1 mm wide, with fine longitudinal striations; pinnae sparsely set, opposite or alternate, attached laterally to the rachis at an angle of about 75°-80°, narrow, gradually tapering at apex, with an even base, 19-21 mm in length, 1·5-2 mm in width. Veins parallel, fine, simple or rarely forked only once, 4-5 per pinna.

Comparison & Remarks—Pterophyllum bavieri Zeiller 1903 and *Pterophyllum jaegeri* Brongniart 1828 somewhat resemble *P. braunianum* but *P. bavieri* differs from *P. braunianum* by its closer pinnae than in the present specimen and the proportion of length to width of pinnae is about 10-15 times. Both the earlier pinnae are attached at right angles to rachis. The pinnae in *P. contiguum* Schenk are shorter and wider than in *P. braunianum*. This species is reported from Rhaetian strata of Tazareh by Sadovnikov (1976).

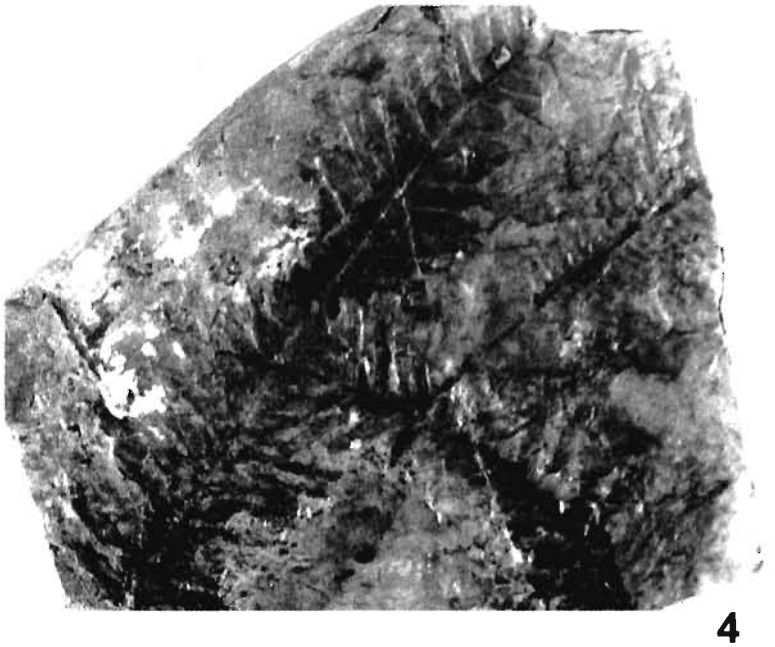
PLATE 2

1. *Taeniopteris tenuinervis* Brauns 1862.
2. *Clathropteris meniscioides* (Brongniart 1825) Brongniart 1828.
3. *Pterophyllum obovatum* Fakhr 1977.
4. *Pseudoctenis ensiformis* Halle 1913.

1

2

3



4

PLATE 2

PTEROPHYLLUM CONTIGUUM Schenk 1883

(Pl. 4·3; Fig. 3·2; Fig. 4C)

1903 *Pterophyllum contiguum* Zeiller; p. 191, pl. 48, figs 1-4, 6.
1905 *Pterophyllum contiguum* Zeiller; p. 194.
1965 *Pterophyllum contiguum* Vu Khuc *et al.*; p. 42, pl. 13, figs 1-3.
1977 *Pterophyllum contiguum* Fakhr; p. 119, pl. 40, fig. 8; fig. 13E.

Description—Incomplete frond 4 cm in length and 3 cm in breadth, pinnate, lanceolate, tapering towards apex; rachis 0·2-0·4 mm broad; pinnae attached at angles of 40°-50° to the rachis laterally by the entire base, opposite, closely placed, 12-18 mm long, 1·5-3 mm broad, margins parallel, apex obtuse to round; veins parallel, fine, simple or rarely once forked, 6-7 per pinna.

Comparison & Remarks—*Pterophyllum braunianum* Goeppert 1843 resembles this species. It differs in having larger pinnae with more narrow apex than *P. contiguum*. In *P. braunianum*, pinnae are never set closely, and they are expanded at the base. *Pterophyllum bavieri* Zeiller 1903 is distinguished by its much more linear pinnae (long is 12-25 times than width). *Pterophyllum aequale* (Brong.) Nathorst differs from *P. contiguum* by its usually broader pinnae (4-5 mm) and greater number of veins in each pinnae (10-12). Fakhr (1977) reported this species from Rhaeto-Liassic strata of Shemshak area (Iran).

PTEROPHYLLUM OBOVATUM Fakhr 1977

(Pl. 2·3; Fig. 3·1; Fig. 4D)

1977 *Pterophyllum obovatum* Fakhr; p. 115, pl. 40, figs 1, 2; fig. 13H-J.

Description—Leaf obovate-lanceolate as a whole, pinnate, 7 cm in length, up to 2 cm in width; rachis up to 1 mm wide; pinnae attached laterally to the rachis, opposite to alternate, 5-11 mm long, 2-2·5 mm broad; set closely at 80°-85° angles with the whole base, margin parallel, apex rounded; veins parallel, fine, simple or forked only once at its base, 7-8 veins per pinna.

Comparison & Remarks—*Pterophyllum nathorsti* Schenk comes closer to this species. *P. nathorsti* has always fewer veins per pinna (5-7) than *P. obovatum* (7-8). Moreover, the leaf of *P. nathorsti* is a linear-lanceolate in shape while *P. obovatum* has an obovate-lanceolate contour. *Pterophyllum rajmahalense* Morris 1863 differs in having oblanceolate frond and in vein concentration (15-25 per pinna: Bose & Banerji, 1981). This species is reported from Rhaeto-Liassic strata of Shemshak area (Iran) by Fakhr (1977).

Order—CYCADALES

Genus—NILSSONIA Brongniart 1825

NILSSONIA AEQUALIS Brongniart 1825

(Pl. 4·1; Fig. 3·3)

1825 *Nilssonia ?aequalis* Brongniart; p. 219, pl. 12, fig. 6.

Description—An incomplete leaf, 8 cm in length; rachis is covered at places, 2 mm wide, with longitudinal striations on the exposed part. Pinnae attached laterally with entire base at angles of 50°-60°, margin parallel, both the acroscopic and basiscopic margins curved upward and downward; apex rounded; 2·5-3 cm long, 5-8 mm wide, veins strong, simple, parallel, 10-12 per pinna.

Comparison—Our specimen resembles *Pterophyllum aequale* (Bron.) Nathorst 1878. *N. aequalis* in comparison with *P. aequale* has no forked veins but it has more linear pinnae (2-6 cm long, 2·5-5 mm wide) than present specimen and more veins per pinna (18-28). Fakhr (1977, p.125) described *P. aequale* with pinnae attached to the rachis at angles of 70°-90° and pinnae with truncate apices. Our specimen as a whole resembles *Pterophyllum* cf. *subaequale* Hartz described by Boersma & van Konijnenburg-van Cittert (1991, p. 227) from Aghdarband, Iran. But, venetion is not visible in the present specimen. *Nilssonia aequalis* has thicker and simple veins in comparison with the species of *Pterophyllum*.

NILSSONIA COMPTA (Phillips 1829) Goeppert 1844

(Pl. 4·2; Fig. 4F)

1829 *Cycadites comptus* Phillips; p. 148, pl. 7, fig. 20.
1844 *Nilssonia compta* (Phillips) Goeppert; p. 139.
1864 *Pterophyllum comptum* Leckenby; p. 77, pl. 9, fig. 1.
1875 *Pterophyllum comptum* Phillips; p. 227, pl. 7, fig. 20.
1900 *Nilssonia compta* Seward; p. 223, pl. 4, figs 5, 39, 40.
1905 *Nilssonia compta* Ward; p. 94-95, pl. 17, figs 11-14.
1942 *Nilssonia compta* Harris; p. 578, fig. 5.
1960 *Nilssonia compta* Farshad; p. 95, fig. 81.
1964 *Nilssonia compta* Benda; p. 115, pl. 11, figs 1, 2; fig. 20.
1964 *Nilssonia compta* Harris; p. 50-54, text-figs 22, 23.
1977 *Nilssonia compta* Fakhr; p. 92, pl. 27, figs 6, 7.

Description—Leaf incomplete, 13·5 cm in length, rachis 2-3 mm broad; pinnae rectangular to trapezoid in shape, laterally attached at right angles, 20-25 mm in length, 8-10 mm in width; pinnae are unequal in size; apex truncate with rounded angles,

PLATE 3 →

1. *Podozamites latissimus* Stanislavski 1971.
2. *Dictyophyllum exile* (Brauns 1862) Nathorst 1878.
3. *Nilssonia polymorpha* Schenk 1867.
4. *Podozamites angustifolius* (Eichwald 1865) Schimper 1870.
5. *Pterophyllum braunianum* (Braun 1843) Goeppert 1843

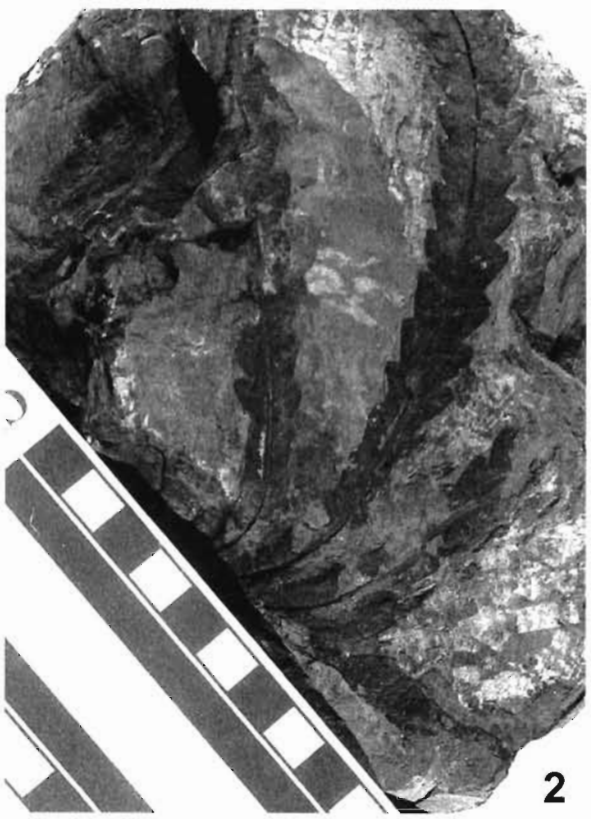


PLATE 3

pinnae decrease in size towards the apex, so leaf margins slightly convergent. Veins parallel, rough, simple, 12-14 per pinna.

Comparison & Remarks—Pterophyllum portali Zeiller 1903 and *Pterophyllum inconstans* (Braun) Goeppert 1844 resemble to the present specimen. *P. portali* differs by its larger pinnae, with rounded apex, and stronger veins. *P. (An.) inconstans* is distinguished by numerous veins (15-28) per segment which forked once or twice. *Pterophyllum muensteri* (Presl) Goeppert has fine veins which forked once or twice. *Nilssonia princeps* Oldham & Morris 1863 differs in having large apical segment, rectangular pinnules and distant bases of pinnules. This species is reported from Rhaeto-Lias strata of Abiek (Iran) by Fakhr (1977).

NILSSONIA POLYMORPHA Schenk 1867

(Pl. 3·3; Fig. 3·9)

1867 *Nilssonia polymorpha* Schenk; p. 127, pl. 29, figs 1-9; pl. 30, fig. 1.
1869 *Nilssonia polymorpha* Schimper; p. 489, pl. 65, fig. 9.
1876 *Nilssonia polymorpha* Nathorst; p. 40, pl. 8, figs. 2-15; pls 8, 9.
1878 *Nilssonia polymorpha* Nathorst; p. 17, pl. 2, figs 6-7.
1879 *Nilssonia polymorpha* Nathorst; p. 72, pl. 15, figs 3-5.
1887 *Nilssonia polymorpha* Schenk; p. 7, pl. 1, fig. 3; pl. 5, fig. 22.
1909 *Nilssonia polymorpha* Nathorst; p. 10, pl. 5, figs 9-13; pl. 6, figs 9-13; pl. 7, fig. 20; pl. 8, figs 12-18.
1940 cf. *Nilssonia polymorpha* Ôishi; p. 210, pl. 26, fig. 6.
2000 *Nilssonia* cf. *polymorpha* Schweitzer *et al.*; p. 20, pl. 3, figs 3-5.

Description—Incomplete leaf 5·6 cm in length and 1·6 cm in width, rachis about 1 mm thick. The segments cover the rachis proximally. The segments attached at right angles to the rachis, with the upper margin nearly straight or slightly concave and the lower margin with a gentle broad curve towards the outer margin. The outer upper margin is obtusely pointed. The veins are parallel, unbranched, and vein concentration 11-21 per segment or 11-12 per cm.

Comparison & Remarks—Nilssonia schaumbergensis (Dunker) Nathorst 1881, *N. sarakhs* Barnard & Miller 1976 and *N. serratus* (Prynada) Schweitzer *et al.* 2000 are somewhat similar to *N. polymorpha*. *N. schaumbergensis* can be distinguished by its narrower frond (less than 1 cm broad) and more veins concentrations (30 per cm). *N. sarakhs* has 20 veins per cm and it is reported from Dogger strata of Iran (Barnard & Miller, 1976, p.72). *N. serratus* distinguished by its more triangular-falcate shape of the pinnae and more veins in each pinna (11-34). Moreover, the margins of pinnae are dentate (Schweitzèr *et al.*, 2000, p. 48-50). Schenk (1887) and Schweitzer *et al.* (2000) reported this species from Rhaetian of Alborz.

Genus—PSEUDOCTENIS Seward 1911

PSEUDOCTENIS ENSIFORMIS Halle 1913

(Pl. 2·4; Fig. 4B)

1913 *Pseudoctenis ensiformis* Halle; p. 51, pl. 6, fig. 8.
1976 *Pseudoctenis ensiformis* f. *minor* Sadovnikov; p. 100.

Description—Leaf 8·5 cm in length, 3-3·3 cm in width, pinnate; rachis rather slender, 1-2 mm broad; pinnae inserted laterally with the whole of the base at angles of 70°-80°, bases expanded with both the edges of the pinna continuing on the rachis sometimes to the next pinna, thus forming a rounded sinus between two adjacent pinnae. Pinna ensiform with somewhat obtuse to rounded apices, 20-28 mm in length, 4-5 mm in width; veins parallel, strong, simple or rarely once forked, 5-7 veins per pinna.

Comparison—P. ensiformis described by Halle (1913, p. 51) is a large leaf (12-14 cm in width). Although our specimen bears morphologically similar pinnae but smaller in size. Fakhr (1977, p. 89, pl. 39, figs 1-3) also described somewhat similar species as *Pseudoctenis ?abiekensis* from Iran. *P.? abiekensis* differs from *P. ensiformis* by its obtuse to acute apices of pinnae. Furthermore, the density of veins is more in the present than Halle's specimen.

Order—CONIFERALES

Genus—PODOZAMITES Braun 1843

PODOZAMITES ANGUSTIFOLIUS (Eichwald 1865) Schimper 1870

(Pl. 3·4; Fig. 3·13)

1865 *Zamites angustifolius* Eichwald; p. 39, pl. 2, fig. 7.
1870 *Podozamites angustifolius* (Eichwald) Schimper; p. 160.
1941 *? Zamia angustifolia* Furon; p. 250.
1958 *Podozamites angustifolius* Vakhrameev; p. 122, pl. 31, figs· 3-5; pl. 32, fig. 5.
1967 *Podozamites angustifolius* Takhtajan; pl. 11, figs 10, 11.
1977 *Podozamites angustifolius* Fakhr; p. 142, pl. 45, fig. 10; fig. 20A.

Description—Shoot incomplete, 7 cm in length, 8 cm in width; leaves lanceolate-linear in shape, typically 5 cm long, 5 mm wide, spirally attached at angles of 70°-80° to the rachis; margins entire, parallel, gradually tapering to apex; base strongly contracted; veins simple or forked once at the base of leaf, parallel, 6-8 in number in the middle part of the leaf, converging towards the apex.

Comparison & Remarks—Podozamites schenki Heer 1876 and *Podozamites gramineus* Heer 1876 are two comparable species to *P. angustifolius*. *P. gramineus* can be distinguished from this species by its more linear leaves (up

1

2

3

4

5

PLATE 4

1 *Nilssonia aequalis* Brongniart 1824.
2. *Nilssonia compta* (Phillips 1829) Goeppert 1844.
3 *Pterophyllum contiguum* Schenk 1883.
4. *Podozamites lanceolatus* (Lindley & Hutton 1837) Braun 1843.
5 *Otozamites furoni* Boureau *et al.* 1950.

to 10 cm long) and fewer number of veins (4-5 per leaf). *P. schenki* has shorter and narrower leaves (2·5-4 cm in length and 1·5-2·5 mm in width: Fakhr, 1977, p.143) than *P. angustifolius*. Fakhr (1977) reported it from Rhaeto-Liassic strata of Shemshak area, Iran.

PODOZAMITES LANCEOLATUS (Lindley & Hutton 1837) Braun 1843

(Pl. 4·4; Fig. 3·8)

1837 *Zamites lanceolata* Lindley & Hutton; p. XCIC.
1843 *Podozamites lanceolatus* (L. & H.) Braun; p. 36.
1950 *Podozamites lanceolatus* Boureau *et al.*, p. 227, pl. 7, fig. 36.
1956 *Podozamites lanceolatus* Sze; pl. 52, fig. 1; pl. 53, fig. 1.
1963 *Podozamites lanceolatus* Jongmans; p. 2525.
1976 *Podozamites lanceolatus* Sadovnikov; p. 110, pl. 6, fig. 6.
1977 *Podozamites lanceolatus* Corsin & Stampfli; p. 536, pl. 5, fig. 6.
1977 *Podozamites lanceolatus* Fakhr; p. 141, pl. 48, figs 3, 4, 7-9.
1984 *Podozamites lanceolatus* Vassiliev; pl. 41, fig. 2, pl. 42, fig. 1.

Description—Incomplete specimen bearing lanceolate leaves, rachis 3 mm in width; leaves large, 50 mm in length, 12 mm in width, base strongly contracted; optimum width below the middle, at about 5 mm from the base; veins simple or dichotomous only at the base of the leaf, parallel, 27-29 per leaf at the broadest part, converging towards the apex.

Comparison & Remarks—Podozamites distans (Presl) Braun 1843 resembles *P. lanceolatus*. It can be distinguished by lesser concentration of veins (13-22 per leaf : Schweitzer & Kirchner, 1996, p. 89). Boureau *et al.* (1950) reported this species from lower Lias of Haoz-e-Hadj Mehdi (Khorassan) and Shemshak. Sadovnikov (1976), Corsin & Stampfli (1977), Fakhr (1977) and Vassiliev (1984) reported it from Karmozd; Farsian; Shemshak, Abiek, Ferizi, Alasht and Sangrud (Iran) respectively.

PODOZAMITES LATISSIMUS Stanislavski 1971

(Pl. 3·1; 3·10)

1971 *Podozamites latissimus* Stanislavski; in Boersma *et al.*, 1991, p. 226.
1976 *Podozamites latissimus* Sadovnikov; p. 110, pl. 6, fig. 6.

Description—Shoot 9 cm long, 6 cm wide; leaf-blade lanceolate, typically 5-6 cm long, 8-10 mm wide, arranging in a simple helix at variable distance at an angle of 30°; margins entire; base strongly contracted without any distinct petiole, optimum width in the middle, about 2-2·5 cm from the base; apex slightly obtuse; veins simple or forked once at the base of leaf, parallel, 13-14 per leaf at the broadest part, converging towards the apex.

Comparison & Remarks—Podozamites paucinervis Boersma & van Konijnenburg-van Cittert JHA, 1991 is comparable to the present species in shape. It can be distinguished by its fewer veins per leaf (10-11) and its optimum width is about 10 mm (Boersma & van Konijnenburg-van Cittert JHA, 1991). *Podozamites distans* (Presl) Braun differs from this species in having more concentration of veins (13-22 per cm: Schweitzer & Kirchner, 1996). It is reported from the Rhaetian flora of Donets Basin by Stanislavski (1971). Sadovnikov (1976) reported this species from Upper Triassic strata of Tazareh, Iran.

CONCLUSION

There are several index species such as *Dictyophyllum exile, Nilssonia polymorpha, Podozamites latissimus* and *Equisetites arenaceus* (only in Iran) which suggest the Rhaetian age for the basal part of Shemshak Formation. Furthermore, abundance of fern genera of Dipteridaceae such as *Clathropteris* and *Dictyophyllum* and greater frequency of large stem of Equisetales indicate the prevalence of a warm and humid climate in this area. The former groups are identified usually as thermophilic and the later one as flourishing in humid places.

Acknowledgements—*The authors are indebted to Drs Fakhr and Mc Louglin for their useful comments.*

REFERENCES

Afshar-Harb A 1979. The stratigraphy, tectonics and petroleum geology of the Kopet Dagh Region, Northern Iran; Doctoral Imperial College of Science and Technology, Univ. London, 316 p.

Antevs E 1919. Die liassische Flora des Hörsandsteins. Kungl. Sven. Ven. Akad. Handl. 59 (8) : 3-69.

Ash SR 1969. Ferns from the Chinle Formation (upper Triassic) in the Fort Wingate area, New Mexico. Geol. Surv. Prof. Pap., Washington 613(D).

Assereto R, Barnard PDW & Fantini Sestini N 1968. Jurassic stratigraphic of central Alburz (Iran). Riv. Ital. Paleont. Strat. Milano 74 (1) : 3-24.

Barnard PDW & Miller JC 1976. Flora of the Shemshak Formation (Elburz, Iran)—Part 3. Middle Jurassic (Dogger) plants from Katumbargah, Vasek Gah and Imam Manak. Palaeontographica B 155 : 31-117.

Benda L 1964. Die Jura-Flora aus der Saighan-Serie Nord-Afghanistans. Beih. Geol. Jb. 70 : 99-152.

Boersma M & van Konijnenburg-van Cittert JHA 1991. Late Triassic plant megafossils from Aghdarband (NE Iran), and its pre-Triassic frame. Abh. Geol. B.A. 38 : 223-252.

Bose MN & Banerji J 1984. The fossil floras of Kachchh. I- Mesozoic megafossils. Palaeobotanist 33 : 1-189.

Bose MN & Banerji J 1981. Cycadophytic leaves from Jurassic-Lower Cretaceous rocks of India. Palaeobotanist 28-29 : 218-300.

Boureau E, Furon R & Rosset LF 1950. Contribution a l'étude les flores Jurassiques d'Asie. Mém. Mus. Hist. Nat. Paris, n.s. 30 : 207-242.

Boureau E 1964. Traité de paléobotanique, III. Sphenophyta – Noeggerathiophyta. Paris, 544 p.

Bragin Y, Jahanbakht F, Golubev S & Sadovnikov GN 1976. Stratigraphy of the Triassic-Jurassic coal-bearing deposits of Alborz. Nat. Iran Steel Corp. V/O "Technoexport", USSR. Unpublished paper, Tehran, 51 p.

Braun CFW 1843. Beiträge zur Urgeschichte der Pflanzen in Munster. G. : Beiträge zur Petrefacten-Kunde, Bayreuth 6 : 42.

Brauns D 1862. Der Sandstein bei Seinstedt unweit des Fulsteins und die in ihm vorkommenden Pflanzenreste. Palaeontographica B 9 : 47-62.

Brongniart A 1825. Observations sur végétaux fossiles renformes dans les Grés de Hoer en Scanie. Ann. Sci. Nat. Paris. I (4) : 200-219.

Corsin P & Stampfli G 1977. La formation de Shemshak dans l'Elburz oriental (Iran) flora, stratigraphie, paleogeographie. Geobios 10 : 509-571.

Eichwald E 1865. Lethaea Rossica ou paleontologie de la Russie. II, Periode moyenne, Stuttgart (partie fossiles végétaux: 1-71).

Fakhr MS 1977. Contribution a l'étude de la flore Rhéto-Liasique de la formation de Shemshak de l'Elbourz (Iran). Mém. Sec. Scien., Paris 5 : 1-178.

Farshad F 1960. Mesozoic stratigraphy. Tehran, 212 p., 132 figs (in persian).

Furon R 1941. Geologie du plateau Iranien (Perse-Afghanistan-Beloutchistan). Memoir Museum of Natural History, Paris 7 : 177-411.

Germar EF 1847. Über die in dem Lias bei Halberstadt vorkommenden Versteinerungen. Palaeontographica B 1 : 107-125.

Goeppert HR 1841-1846. Les genres des plantes fossiles comparés avec ceux du monde moderne expliqués par des figures. Bonn.

Gothan W 1914. Die unter-liassische(rhätische) Flora der Umgegend von Nürenburg. Abb. Natur. Ges. Nürenberg 19 : 91-186.

Halle TC 1913. The Mesozoic flora of Graham land. Wiss. Erg. Schw. Südpol-exp. (1901-1903), Stockholm 3 (14) : 1-123.

Harris TM 1926. The Mesozoic flora of Scoresby Sound, East Greenland. Medd. Gronl. Kjob. 68 : 43-148.

Harris TM 1931. The fossil flora of Scoresby Sound, East Greenland. Medd. Gronl. Kjob. 85 : 1-104.

Harris TM 1942. Notes on the Jurassic flora of Yorkshire, 1: *Ptilophyllum caytonense* sp. nov; 2: *Dettolepis credipota* gen. *et* sp. nov., 3: On *Nilssonia compta* and its reference to *Beannia gracilis*. Ann. Mag. Nat. Hist. 11 : 568-587.

Harris TM 1964. The Yorkshire Jurassic flora. II. Caytoniales, Cycadales *et* Pteridosperms. Brit. Mus. (Nat. Hist.), London 191 p.

Jongmans W 1963. Fossilium catalogus, II: Plantae, part 54(27). Junk edit. Gravenhage.

Kelber KP & van Konijnenburg-van Cittert JHA 1998. *Equisetites arenaceus* from the Upper Triassic of Germany with evidence for reproductive strategies. Review of Palaeobotany and Palynology 100 : 1-26.

Kilpper K 1964. Über eine Rät-Lias-Flora aus dem nördlichen Abfall des Alburs-Gebriges in Nord Iran. I. Bryophyta und Pteridophyta. Palaeontographica B 114 : 1-78.

Kon'no E 1968. Some upper Triassic species of Dipteridaceae from Japan and Borneo. Journal of Linnaean Society (Bot.), London 61 (384) : 93-105.

Lindley J & Hutton W 1837. The fossil flora of Great Britain, or figures and descriptions of the vegetable remains found in a fossil strata in this country. London. Vol. III.

Leckenby J 1864. On the sandstones and shales of the Oolithes of Scarborough, with descriptions of some new species of fossil plants. Quaterly Journal of Geological Society of London 20:74-82.

Lundblad AB 1950. Studies in the Rhaeto-Liassic floras of Sweden. Kung. Sven. Veter. Akad. Handl. 4 : 1-82.

Nathorst AG 1876. Bidrag till Sveriges fossila Flora. K. Svenska Veter. Akad. Handl. 14 : 1-82.

Nathorst AG 1878. Bidrig till Sveriges fossila Flora. II. Floran vid Hoganas och Helsingborg. K. Svenska Veter. Akad. Handl. 16 . 1-53.

Nathorst AG 1879. Om floran i Skanes kolforande. I. Floran vid Bjuf. K. Svenska Veter. Akad. Handl. 33: 53-82.

Nathorst AG 1909. Über die Gattung *Nilssonia* Brongn. mit besonderer Berucksichtigung schwedischer Arten. K. Svenska Veter. Akad. Handl. 43 : 1-40.

Ôishi S 1940. The Mesozoic flora of Japan. K. Svenska Veter. Akad. Handl. 5 : 1-480.

Phillips J 1829. Illustrations of the geology of Yorkshire; or a description of the strata and organic remains of the Yorkshire Coast, York.

Phillips J 1875. Illustrations of the geology of Yorkshire; or a description of the strata and organic remains. I. The Yorkshire Coast. London. (3ed).

Sadovnikov G 1976. The Mesozoic flora of Alborz and central Iran and its stratigraphic importance. 118p.

Schenk A 1867. Die Fossile Flora der Genzschichten das Keupers und Lias Frankens. Wiesbaden. 186p.

Schenk A 1887. Fossile Pflantzen aus der Albourskette. Biblioth. Bot. Wiesbaden.12p.

Schimper WP 1869-1874. Traité de paléontologie végétale, ou la flore du monde primitif dans ses rapports avec les formations géologiques et la flore du monde actuel, Paris, 3vol.

Schweitzer HJ & Kirchner M 1996. Die Rhäto-Jurassischen Floren des Iran und Afghanistans: 9. Coniferophyta. Palaeontographica B 238 : 77-139.

Schweitzer HJ, van Konijnenburg-van Cittert JHA & van Der Burgh J 1997. The Rhaeto-Jurassic flora of Iran and Afghanistan. 10. Bryophyta, Lycophyta, Sphenophyta, Pterophyta-Eusporangiate and- Protoleptosporangiate. Palaeontographica B 243: 103-192.

Schweitzer HJ, Kirchner M & van Konijnenburg-van Cittert JHA 2000. The Rhaeto-Jurassic flora of Iran and Afghanistan. 12. Cycadophyta II. Nilssoniales. Palaeontographica B 254 : 1-63.

Seward AC 1900. The Jurassic flora. I. The Yorkshire Coast. Catalogue of the Mesozoic plants in the department of geology. British Museum (Nat. His.), London.

Seward AC 1911. Jurassic plants from Chinese Dzungaria, collected by Professor Obrutschew. Mém. Com. Géol. St.-Ptersburg, New Series 75 : 1-61 (in Russia: 1-30, in English:31-61).

Soheili M 1982. Explanation of geological map of Korkhud mountains. Geol. Sur. Iran, Tehran, 110p.

Sze HC 1949. Die Mesozoische Flora aus der Hsiangehi Kohlen Serie in Westhupeh. Palaeontologia Sinica, New Series 2 : 1-17.

Takhtajan AL 1967. Problemota cognitionis florae fosilis deposition um Carboniferarum URSS. Palaeobotanica 6, Acta, series 8 : 212p.

Thomas HH 1911. The Jurassic flora of Kamenka in the district of Isium. Mém. Com. Géol. St.-Petersb. New Series 71 : 1-95 (in Russia: 1-48; in English: 49-95).

Vakhrameev VA 1958. Stratigraphy and fossil flora of Jurassic-Cretaceous of Vilioui depression and the part of flexible margin of Verkhoiansk area. Stratig. Reg. USSR. Akad. Nauk. Geol. Inst. Moscow 3 : 1-136 (in Russian).

Vassiliev Y 1984-85. Mesozoic plant fossils from coal areas in Iran. 2 : 97p. (translated by Mehdian, M.H. into Persian). Atlas. Min. Met. 2 (2).

Vozenin-Serra C & De Franceschi D 1999. Flore du Trias superieur du Vietnam(bassins houillers du Quang-nam et de Hongay). Palaeontographica B 249 (1-6): 1-62.

Vu Kukh *et al.* 1965. Les fossiles caractéristiquea du Trias au Nord Viêt-Nam, Hanoï.

Ward LF 1905. Status of the Mesozoic floras of the United States. U.S. Geol. Surv. Mon., Washington. 48 : 1-616.

Zeiller R 1902-03. Flore fossile des gites de charbon du Tonkin. Étud. Gites Min. Fr. 1-328, Atlas: 56pls.

Zeiller R 1905. Sur les plantes Rhetiennes de la Perse recueilli par M.J. de Morgan. Bull. Soc. Géol. Fr. 4 : 190-197.