

PLANT FOSSIL REMAINS FROM THE RHAETIAN OF SHEMSHAK FORMATION, NARGES-CHAL AREA, ALBORZ, NE IRAN

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Abstract. The Shemshak Formation is well-exposed in Narges-Chal area, East Alborz. It contains abundant well-preserved plant megafossils belonging to twenty two taxa of various orders viz., Equisetales, Marattiales, Filicales, Pteridospermales, Bennettiales, Ginkgoales, and Coniferales. Based on the occurrence of *Equisetites conicus*, *Scytophyllum persicum*, *Otozamites ashtarensis*, *Pterophyllum bavieri*, *Pterophyllum tietzei*, *Zamites persica*, *Nilssoniopteris musafolia* and *Baiera muensteriana* a Rhaetian age is suggested for this assemblage.

Riassunto. La Formazione di Shemshak affiora estesamente nell'area di Narges-Chal, nell'Alborz orientale. Contiene abbondanti e ben conservati macroresti di piante che appartengono a 22 taxa di ordini diversi come Equisetales, Marattiales, Filicales, Pteridospermales, Bennettiales, Ginkgoales e Coniferales. Sulla base della presenza di *Equisetites conicus*, *Scytophyllum persicum*, *Otozamites ashtarensis*, *Pterophyllum bavieri*, *Pterophyllum tietzei*, *Zamites persica*, *Nilssoniopteris musafolia* e *Baiera muensteriana* viene proposta una età Retica per questa associazione.

Introduction

Upper Triassic- Jurassic plants have been found at many localities in Iran. They are usually associated with coal seams which have been widely mined. Göppert (1861) and Stur (1886) described without figures nine species from Tash (West Alborz), three from Rudbar and five from Sapuhin (Central Alborz) respectively. Schenk (1887) described with figures twenty-seven species from Hiv near Qazvin and Tash (West Alborz). Krasser (1891) added to Stur's list of species from Sapuhin making the total into twenty two. Zeiller (1905) described without figures fifteen species from Fashand, Bidargardan and Lalun (C. Alborz). Boureau et al. (1950) described with figures eight species from Shem-

shak and Rudbar. Lorenz (1964) figured eight species with brief descriptions from Gajereh (10 km to Shemshak). Kilpper (1964, 1968, 1971, 1975) described with figures twenty-six species of Pteridophyta, four species of Bennettiales, four species of Peltaspermales and thirteen species of Ginkgophyta from Central Alborz. Barnard (1965, 1967) described and figured a total of thirty-three species from Dorud, Shemshak and Ashtar (C. Alborz). Kimyai (1972) described with figures nine species from Garmabdar (C. Alborz). Poliansky & Safrosov (1972) reported without figures fourteen species from Kerman Basin (C. Iran). Sadovnikov (1976) reported several species from Tazareh and Karmozd (C. Alborz). Barnard & Miller (1976) described with figures twenty-two species from Khatumbargah, Vasekgah and Imam Manak (C. Alborz). Fakhr (1977) discussed with figures more than one hundred and twenty species from Hiv, Abiek (W. Alborz), Ask, Zirab, Shemshak, Djam (C. Alborz), Ferizi (E. Alborz). Corsin & Stampfli (1977) described with figures thirty-eight species from Azadshahr, Ghosnavi, Farsian, and Nodeh (C.-E. Alborz). Vassiliev (1984) reported with figures more than eighty species from Andvar, Arust, Sangrud (Alborz) Parvadeh, and Mazinu (C. Iran). Boersma & van Konijnenburg-van Cittert (1991) described with figures twelve species from Aghdarband (E. Alborz). Vaez-Javadi & Ghavidel-Syooki (2002) and Vaez-Javadi & Pour-Latifi (2002, 2004) described with figures seventeen species from Jajarm, three species from Dizbad-Balla and eight species from Golmakan (E. Alborz) respectively. Vaez-Javadi & Mirzaei-Ataabadi (2006) described with figures thirty-nine species from Dasht-e-Khak, Hashooni mine and Pabdana (C. Iran). Schweitzer alone or with co-authors (1978, 1995, 1996, 1997, 1998, 2000, 2003) described with figures numerous species of various or-

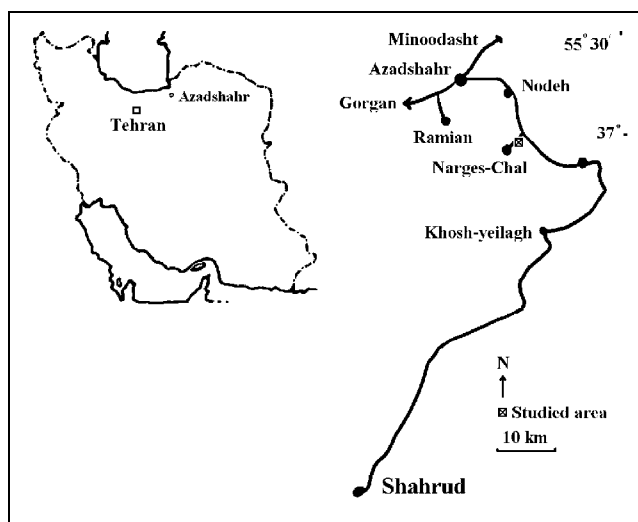


Fig. 1 - Location map of the studied area.

ders from Alborz Range and Kerman Basin. The material for this study is the plant megafossil remains of the Shemshak Formation in Narges-Chal area.

Stratigraphy

Narges-Chal village is located at east Alborz Range, 36° 59' North; 55° 14' East, 20 km south of the Azadshahr town. There is a coal mine close to the village. The Shemshak Formation in Narges-Chal area consists mainly of grey-dark shales, siltstones and sandstones intercalating with coal seams. This formation is strongly covered by forest in this area, so it can not be possible to have a complete geological column of it. However, the specimens were gathered from two parts which are superposed, but it was not possible to measure the distance between these two parts. The log is shown in Fig. 2.

Systematic paleontology

There are abundant well-preserved plant megafossils belonging to twenty-two species allocated to sixteen genera of various orders viz., Equisetales, Marattiales, Filicales, Pteridospermales, Bennettitales, Ginkgoales and Coniferales. The flora from this locality is here described for the first time. All the studied specimens were stored in the Laboratory of Paleobotany, University of Shiraz, Iran. The ages of the described specimens is arranged in the Tab. 1.

Division Sphenophyta

Class Sphenopsida

Order Equisetales

Family Equisetaceae

Genus *Equisetites* Sternberg, 1833

Equisetites conicus Sternberg, 1833

Pl. 1, figs 2, 5; Fig. 3C, 4D

1833 *Equisetites conicus* Sternberg; parts 5, 6; p. 44, pl. 16 fig. 8

1959 *Equisetites conicus* - Kräusel, p. 12.

1997 *Equisetites conicus* - Schweitzer et al.; p. 121, pl. 2, figs. 4-7; text-fig. 4.

Description. A small part of stem, 6 cm long and 22 mm wide; internodes invisible; leaves elongate triangular, verticillate, 21 mm long and 1 mm wide, acute to obtuse apices forming a sheath. The sinus is acuminate as well. Scars from small side branches are present between the leaves near the base of the sheath. There are 3-4 furrows per cm on the cast.

Sample number. FJSH-NC 1.

Division Pterophyta

Class Eusporangiopsida

Order Marattiales

Family Marattiaceae

Genus *Marattiopsis* Schimper, 1869

Marattiopsis intermedia (Muenster, 1836) Kilpper, 1964

Pl. 5, fig. 1; Fig. 3B

1836 *Taeniopteris intermedia* Muenster; p. 510.

1964 *Marattia intermedia* (Muenster) Kilpper; p. 22, pl. 3, figs. 6-13; pl. 4, figs. 1-11; text-figs. 2-4.

1977 *Marattia muensteri* Corsin & Stampfli; p. 519, pl. 5, figs. 1,2.

1997 *Marattia intermedia* - Schweitzer et al.; pp. 153- 155, pl. 11, figs. 1-4; pl. 12, figs. 1-9; text-fig. 21.

Description. Leaf complete, parallel sided, 9 cm long and 15-18 mm wide, tapering gradually towards the apex; midvein visible, 1 mm wide with two longitudinal striae; lateral veins simple or forked once near the midvein, 12-14 per cm. Synangia arranged at the end of lateral veins; 2.4-2.7 mm long and 11-12 per cm.

Sample number. FJSH-NC 2.

Class Leptosporangiopsida

Order Filicales

Family Dipteridaceae

Genus *Dictyophyllum* Lindley & Hutton, 1834

Dictyophyllum cf. *nathorsti* Zeiller, 1903

Pl. 2, fig. 2; Fig. 5C

1903 *Dictyophyllum nathorsti* Zeiller; p. 109, pl. 23, fig. 1; pl. 24, fig. 1; pl. 25, figs. 1-6; pl. 26, figs. 1-3; pl. 27, fig.1; pl. 28, fig. 3.

1950 *Dictyophyllum nathorsti* - Boureau et al.; pp. 220-221, pl. 7, fig. 38.

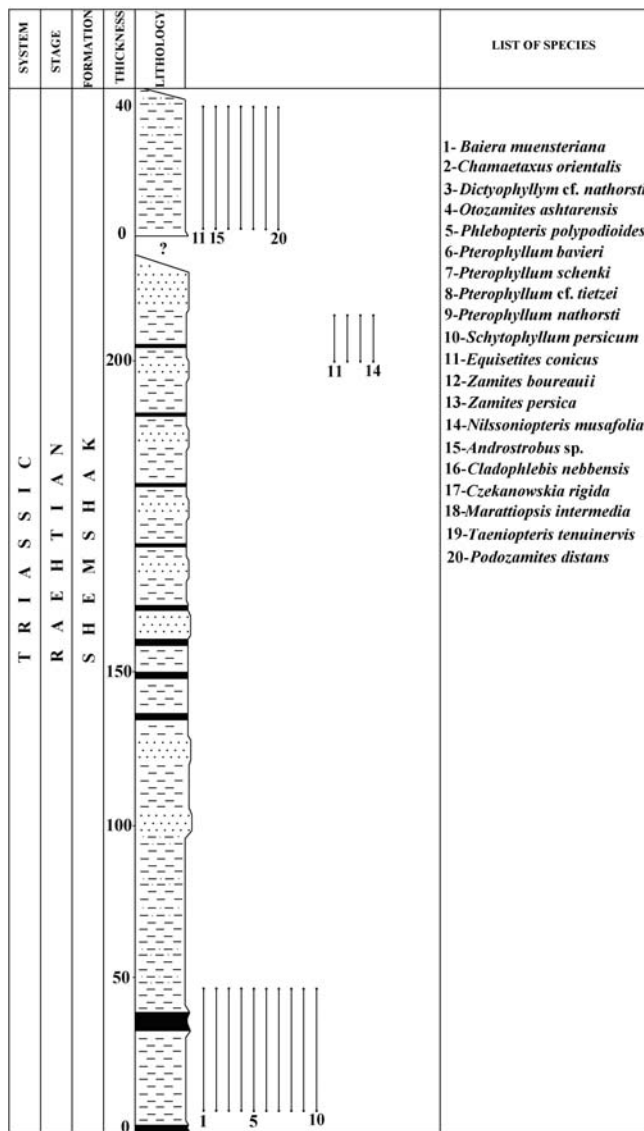


Fig. 2 - Stratigraphic column of the Shemshak Formation in Narges-Chal.

1967 *Dictyophyllum nathorsti* - Barnard; pp. 547-551, pl. 46, fig. 6; text-figs. 4 H, 2 A-C.

1976 *Dictyophyllum nathorsti* - Sadovnikov; p. 81, pl. 2, fig. 9.

1977 *Dictyophyllum nathorsti* - Fakhr; pp. 69-70, pl. 17, figs. 1-4, text-fig. 6A-D

1977 *Dictyophyllum nathorsti* - Corsin & Stampfli; pp. 523-524, pl. 6, figs. 7-9.

Description. Pinna incomplete, 8 x 1-3 cm in size, lanceolate as a whole, width gradually increasing towards the middle region; pinnules subopposite, triangular to slightly falcate, 7-11 long, 6-8 mm wide at the base, tapering to obtuse apices; separated by an angular acutely pointed sinus in one third to two thirds of the length of pinnule; midrib strongly marked, arising from the pinna rachis at angles of 50°- 55°, curving toward the apex, lateral veins forming an irregular polygonal meshes; smaller veins forming finer meshes, enclosing free vein endings.

Discussion. Since there is not a complete frond and pinnae it is difficult to make an exact decision on this specimen. Therefore, cf. was used to describe this specimen. This specimen shows some characters of *Dictyophyllum exile* (Brauns) Nathorst as well, but in general the pinnae in this material are wider than in *D. exile*.

Sample number. FJSH-NC 3.

Family Matoniaceae

Genus *Phlebopteris* Brongniart, 1828

Phlebopteris polypodioides Brongniart, 1828

Pl. 1, fig. 6; Fig. 5A

1828 *Phlebopteris polypodioides* Brongniart; p. 57.

1975 *Phlebopteris polypodioides* - Kilpper; pp. 26-27, pl. 5, figs. 4-7, text-figs. 5,6.

1977 *Phlebopteris* cf. *polypodioides* - Fakhr; p. 64, pl. 14, figs. 1-4; pl. 15, figs. 1,2; pl. 16, fig. 3; text-fig. 5B,C.

1977 *Phlebopteris polypodioides* - Corsin & Stampfli; pp. 522-523, pl. 9, fig. 4-6; pl. 10, fig. 12.

1978 *Phlebopteris polypodioides* - Schweitzer; pp. 49-54, pl. 6, fig. 4; pl. 7, figs. 4-6; pl. 8, figs. 1-7; text-figs. 32, 34,36,37.

1984 *Phlebopteris polypodioides* - Vassiliev; pl. 6, fig. 1, pl. 1, fig. 3b.

Description. Frond sympodial with pinnae; rachis 2 mm thick with longitudinal striae; pinnules linear, 5 cm in length and 4-6 mm in width, expanded to decurrent bases; midrib clear, going towards the end of pinnule; lateral veins running out at an angle of 40°, forking almost at once into forward and backward branches. Branches from adjacent lateral join and form primary arches which are wider than their height and have no included veins. The primary arches give off 2 or 3 outer veins which run transversely to the enrolled margins. The lateral veins are at intervals of 0.3-0.5 mm. The outer branch veins have a marginal density of 26-28 per cm.

Discussion. This species differs from *Phlebopteris muensteri* Brongniart and *P. affinis* Schenk in having different pattern of meshes.

Sample number. FJSH-NC 4.

Filicales incerte sedis

Genus *Cladophlebis* Brongniart, 1849

Cladophlebis nebbensis (Brongniart, 1828)

Nathorst, 1875

Pl. 1, fig. 4, Fig. 5G

1828 *Pecopteris nebbensis* Brongniart; p. 57.

1875 *Cladophlebis nebbensis* (Brongniart) Nathorst; p. 379.

List of species	Age	Place	Author
<i>Equisetites conicus</i> <i>Marattiopsis intermedia</i>	Norian- Rhaetian Rhaetian-Dogger	Apun valley (Zirab), Darbid-Khun Farsian, Zirab, Sangrud, Tazareh, Kelardasht, Ferizi, Eshkeli, Darbid-khun	11, 18 4, 6, 18
<i>Dictyophyllum nathorsti</i>	Rhaetian-L.Liassic	Shemshak, Ashtar, Tazareh, Abiek, Shahrud	2,3,4,5,13
<i>Phlebopteris polypodioides</i>	U.Rhaetian-Toarcian	Gheshlagh, Parvadeh, Karmozd, Abiek, Alborz	4,5,8,15, 23
<i>Cladophlebis nebbensis</i>	Norian-Liassic	Lalun, Gheshlagh, Karmozd, Andvar mine, Pak mine (Zirab), Parvadeh, Zirab, Djam, Dorud, Hiv, Darbid-Khun	4,5,6,13, 18, 23 14,21,23
<i>Taeniopteris tenuinervis</i> <i>Scytophyllum persicum</i>	Rhaetian Rhaetian	Hiv, Parvadeh, Jajarm Hiv, Lalun, Fashand, Tazareh, Parvadeh, Aghusbin, Kaman, Ask, Shirkola near Qazvin, Ekrasar, Galandrud, Gheshlagh, Darbid- Khun	8,13,14,20,23,24
<i>Czekanowskia rigida</i> <i>Nilssoniopteris musafolia</i> <i>Pterophyllum bavieri</i>	Liassic-Dogger Rhaetian Rhaetian	Zirab, Tazareh, Golmakan Dorud, Hiv Hiv, Shemshak, Garmabdar, Ask, NE Shahrud, Parvadeh,	5,7,13,16,22 1,20 2,4,5,9,12,14,20,23
<i>Pterophyllum nathorsti</i>	Rhaetian	Kalat, Fashand, Bidargardan, Aghusbin, Fashand, Gajereh, Ashtar, Asiabgardan, Apun near Zirab	2,12,20
<i>Pterophyllum schenki</i>	Rhaetian-L. Liassic	Abiek, Ask, NE Shahrud, Emarat Anticlinal, Tiri-Bazar (Babol valley)	4,5,13,20
<i>Pterophyllum tietzei</i>	Rhaetian- L. Liassic	Hiv, Dorud, Garmabdar, Gheshlagh, Abiek, Parvadeh	1,4,5,9,14,20,23
<i>Otozamites ashtarensis</i> <i>Zamites persica</i>	Rhaetian Rhaetian	Ashtar, Hiv, Nodeh, Tazareh Shemshak, Ashtar, Abiek, Tazareh, Zirab	2,4,5,13,23 2,3,20
<i>Zamites boureauii</i> <i>Baiera muensteriana</i>	Rhaetian Rhaetian	Abiek Tash near Shahrud, Fashand, Gheshlagh, Kiasar, Sapuhin, Shemshak, Garmabdar, Sangrud, Kaman near Ask, Gajereh, Zirab, Parvadeh, Qazvin, Apun near Zirab, Karmozd, Babnizu, Darbid- Khun	5 2,5,7,9,10, 12,13,14,16,23,24
<i>Chamaetaxus orientalis</i> <i>Podozamites distans</i>	U. Liassic Rhaetian-L. Dogger	Zirab Lalun, Rudbar, Farsian, Gajereh, Qazvin, Tazareh, Sangrud, Zirab, Damavand, Eshkeli, Babnizu	17 2,4,5,17

Tab. 1- Stratigraphic range and palaeogeographic distribution of the megafossils from this locality in Iran.

1- Barnard (1965), 2-Barnard (1967), 3- Boureau et al. (1950), 4- Corsin & Stampfli (1977), 5- Fakhr (1977), 6- Kilpper (1964), 7- Kilpper (1971), 8- Kilpper (1975), 9- Kimyai (1972), 10-Krasser (1891), 11- Kräusel (1959), 12- Lorenz (1964), 13- Sadovnikov (1976), 14- Schenk (1887), 15- Schweitzer (1978), 16- Schweitzer & Kirchner (1995), 17- Schweitzer & Kirchner (1996), 18- Schweitzer et al. (1997), 19- Schweitzer & Kirchner (1998) 20- Schweitzer & Kirchner (2003) 21- Vaez-Javadi & Ghavidel-Syooki (2002a), 22- Vaez-Javadi & Pour-Latifi (2004), 23- Vassiliev (1984), 24- Zeiller (1905).

- 1964 *Cladophlebis nebbensis* - Kilpper; pp. 59-60, pl. 11, figs. 7,-9,10,12; pl. 12, figs. 1-3; pl. 13, fig. 1; pl. 14, fig. 5?, text-fig. 35.
 1976 *Cladophlebis nebbensis* - Sadovnikov; p. 130, pl. 10, figs. 1,2.
 1977 *Cladophlebis nebbensis* - Fakhr; p. 43, pl. 3, figs. 2,3; text-fig. 4 A-C.
 1977 *Cladophlebis nebbensis* - Corsin & Stampfli; pp. 521-522, pl. 4, figs. 3-5.
 1984 *Cladophlebis nebbensis* - Vassiliev; pl. 9, fig. 2.
 1997 *Cladophlebis nebbensis* - Schweitzer et al.; pp. 172-175; pl. 19, figs. 1-5; text-figs. 24 B, 26.

Description. This specimen is an incomplete pinna, rachis 1 mm thick; pinnules subopposite-alternate, rounded to obtuse apices, expanded acroscopic bases, set closely, 21 mm long and 5-6 mm wide; veins forked once, rather rarely three times, 12-14 per cm in the margins of pinnule.

Sample number. FJSH-NC 5.

Genus *Taeniopteris* Brongniart, 1828

Taeniopteris tenuinervis Brauns, 1862

Pl. 3, fig. 2; Fig. 5D

- 1862 *Taeniopteris tenuinervis* Brauns, p. 50, pl. 13, figs. 1-3.
 1887 *Taeniopteris tenuinervis* - Schenk; pl. 25, figs. 3-4.

- 1984 *Taeniopteris tenuinervis* - Vassiliev; pl. 6, fig. 1a, pl. 11, fig. 1c, pl. 23, fig. 2a; pl. 37, fig. 1.
 2002 *Taeniopteris tenuinervis* - Vaez-Javadi & Ghavidel-Syooki; p. 64, pl. 2, fig. 1, text-fig. 3: 6.

Description. Leaf linear, margins entire, 9 cm in length (the whole length unknown) and 8 mm in width, midrib clear with a longitudinal striae, base constricted, tapering gradually towards an obtuse apex. Lateral veins are simple or forked once in different levels, 30-32 per cm.

Sample number. FJSH-NC 6.

Taeniopteris sp.

Pl. 1, fig. 3

Description. Leaf with entire margins, 19 mm in length and 5 mm in width, obtuse apex and constricted base; midvein clear and lateral veins obscure.

Sample number. FJSH-NC 7.

Division Pteridospermophyta

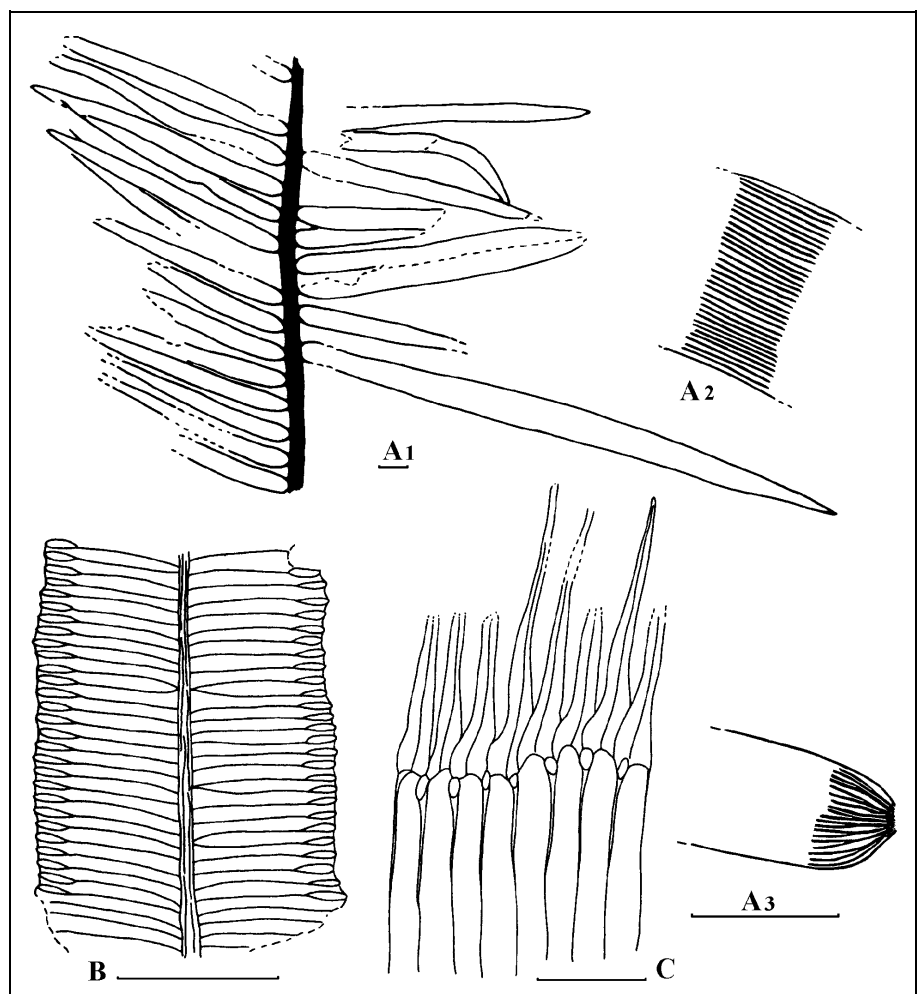
Class Pteridospermopsida

Order Peltaspermales

Family Peltaspermaceae

Genus *Scytophyllum* Bornemann, 1856

Fig. 3 - A 1-3: *Zamites boureauii*, B: *Marattiopsis intermedia*, C: *Equisetites conicus* (bars are 1 cm long).



Scytophyllum persicum (Schenk, 1887) Kilpper, 1975

Pl. 1, fig. 1, Fig. 4A

1887 *Pecopteris persica* Schenk; pp. 3-4, pl. 1, figs. 5,6.1905 *Pecopteris persica* - Zeiller; p. 194.1975 *Scytophyllum persicum* Kilpper; pp. 146-148, pl. 1, fig. 1, text-figs. 4 A-C, 5.1976 *Scytophyllum persicum* - Sadovnikov; p. 89, pl. 3, figs. 1,2.1984 *Scytophyllum persicum* - Vassiliev; pl. 12, fig. 1a.2003 *Scytophyllum persicum* - Schweitzer & Kirchner; pp. 20-22, pl. 2, figs. 1,2; pl. 3, fig. 1-11; text-figs. 2,3.

Description. Frond bipinnate, pinna lanceolate, 11 cm long, the main rachis 3 mm wide; pinnules opposite, margins undulate, rounded apices, attached at angles of 60°-65°, 24-38 mm long and 6-10 mm wide; midvein clear, 1 mm wide, lateral veins simple, 5-6 per cm.

Sample number. FJSH-NC 8.Order **Czekanowskiales**Genus *Czekanowskia* Heer, 1876**Czekanowskia rigida** Heer, 1876

Pl. 8, fig. 1

1876 *Czekanowskia rigida* Heer; p. 70, pl. 5, figs. 8-11; pl. 10, fig. 2b; pl. 20, fig. 3d; pl.21, fig. 6e, 8b.1971 *Czekanowskia rigida* - Kilpper; p. 99, pl. 26, fig. 2.1976 *Czekanowskia rigida* - Sadovnikov; p. 104, pl. 7, fig. 11.1977 *Czekanowskia rigida* - Fakhr; p.140, pl.48, fig. 5.1995 *Czekanowskia* cf. *setacea* - Schweitzer & Kirchner; p. 43, pl. 12, figs. 1,2.2004 *Czekanowskia rigida* - Vaez-Javadi & Pour-Latifi; pp. 101-102, pl. 2, fig. 3.

Description. Short shoot bearing bundle of foliage leaves; foliage leaves, as a whole, wedge-shaped, leaf radius 21 mm, basal angle of 160°; dividing by dichotomies into 8 filiform segments, 17 mm long which forked in 16 lobes, 3-5 mm long, ending in obtuse apices; venation obscure.

Sample number. FJSH-NC 9.Division **Cycadophyta**Order **Bennettitales**Genus *Nilssoniopteris* Nathorst, 1909**Nilssoniopteris musafolia** Barnard, 1965

Pl. 2, fig. 1; Pl. 3, fig. 1; Fig. 6

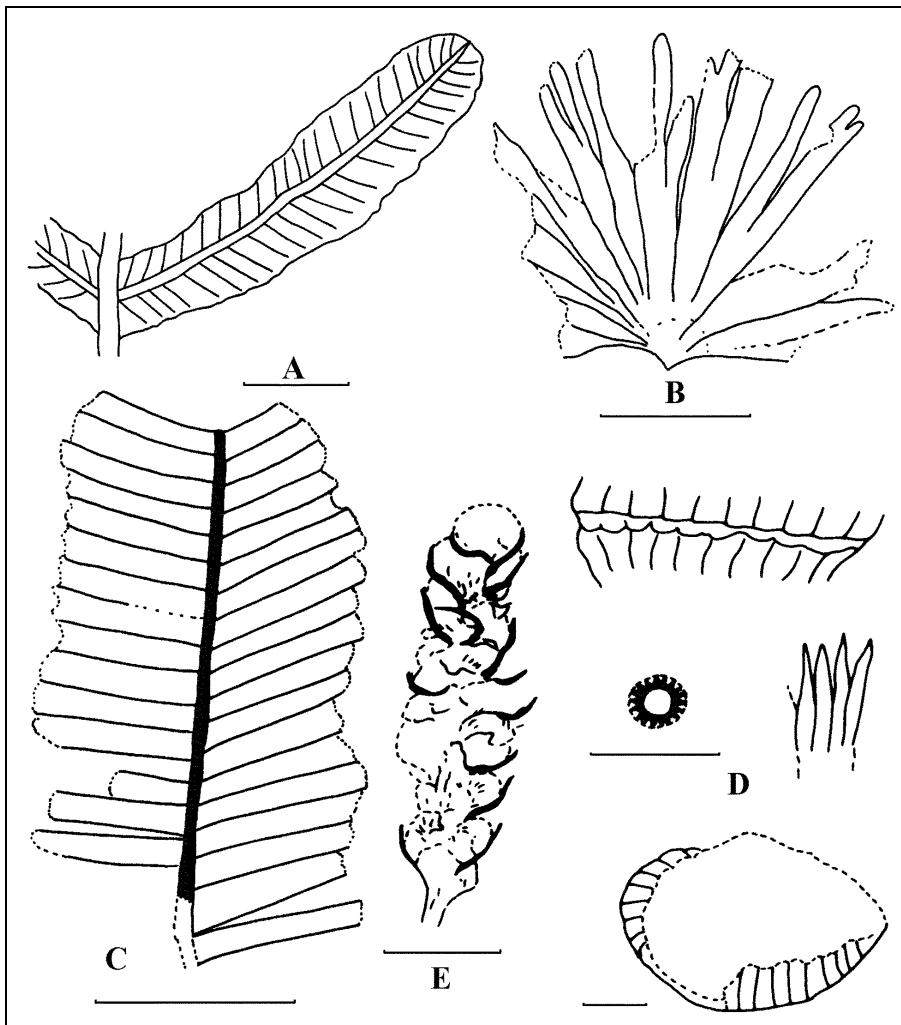


Fig. 4 - A: *Scytophyllum persicum*, B: *Baiera muenstriana*, C: *Pterophyllum bavieri*, D: *Equisetites conicus*, E: ? *Androstrobus* sp. (bars are 1 cm long).

1965 *Nilssoniopteris musafolia* Barnard, pp. 1145-1146, pl. 98, fig. 4; pl. 99, fig. 1; text-figs. 5 D-G.

2003 *Nilssoniopteris musafolia* - Schweitzer & Kirchner, p. 26; pl. 1, fig. 1; text-fig. 1.

Description. Frond entire; pinna 21 cm long (the whole length unknown), 65-70 mm wide, tapering gradually towards the apex, middle region of pinna parallel sided; midrib clear, 5 mm wide in the middle part of pinna, decreasing in width from base to the apex, 2-3 mm wide near the apex; secondary veins curving out from the midrib, transversing lamina at angles of 80°-90°, simple or forking once, 21-23 per cm.

Sample number. FJSH-NC 10a, FJSH-NC 10b.

Genus *Pterophyllum* Brongniart, 1828

***Pterophyllum bavieri* Zeiller, 1903**

Pl. 5, figs 2, 3, 6; Fig. 4C

1887 *Pterophyllum braunianum* - Schenk; p. 6, pl. 7, figs. 38-40.

1903 *Pterophyllum bavieri* (Schenk) Zeiller; p. 198, pl. 49, figs. 1-3.

1964 *Pterophyllum bavieri* - Lorenz; p. 23, pl. 3, fig. B.

1967 *Pterophyllum bavieri* - Barnard; pp. 559-561, pl. 47, figs. 2,3,7, text-fig. 3E.

1972 *Pterophyllum bavieri* - Kimyai; p. 14-15, fig. 9.

1977 *Pterophyllum bavieri* - Corsin & Stampfli; p.531, pl. 5, fig. 8; pl. 6, fig. 1.

1977 *Pterophyllum bavieri* - Fakhr; pp. 124-125, pl. 38, figs. 3-6; text-fig. 13A,B.

1984 *Pterophyllum bavieri* - Vassiliev; pl. 23, fig. 1.

2003 *Pterophyllum bavieri* - Schweitzer & Kirchner; pp. 62-67, pl. 13, figs. 1-8, text-figs. 21a,b; 22 a-f.

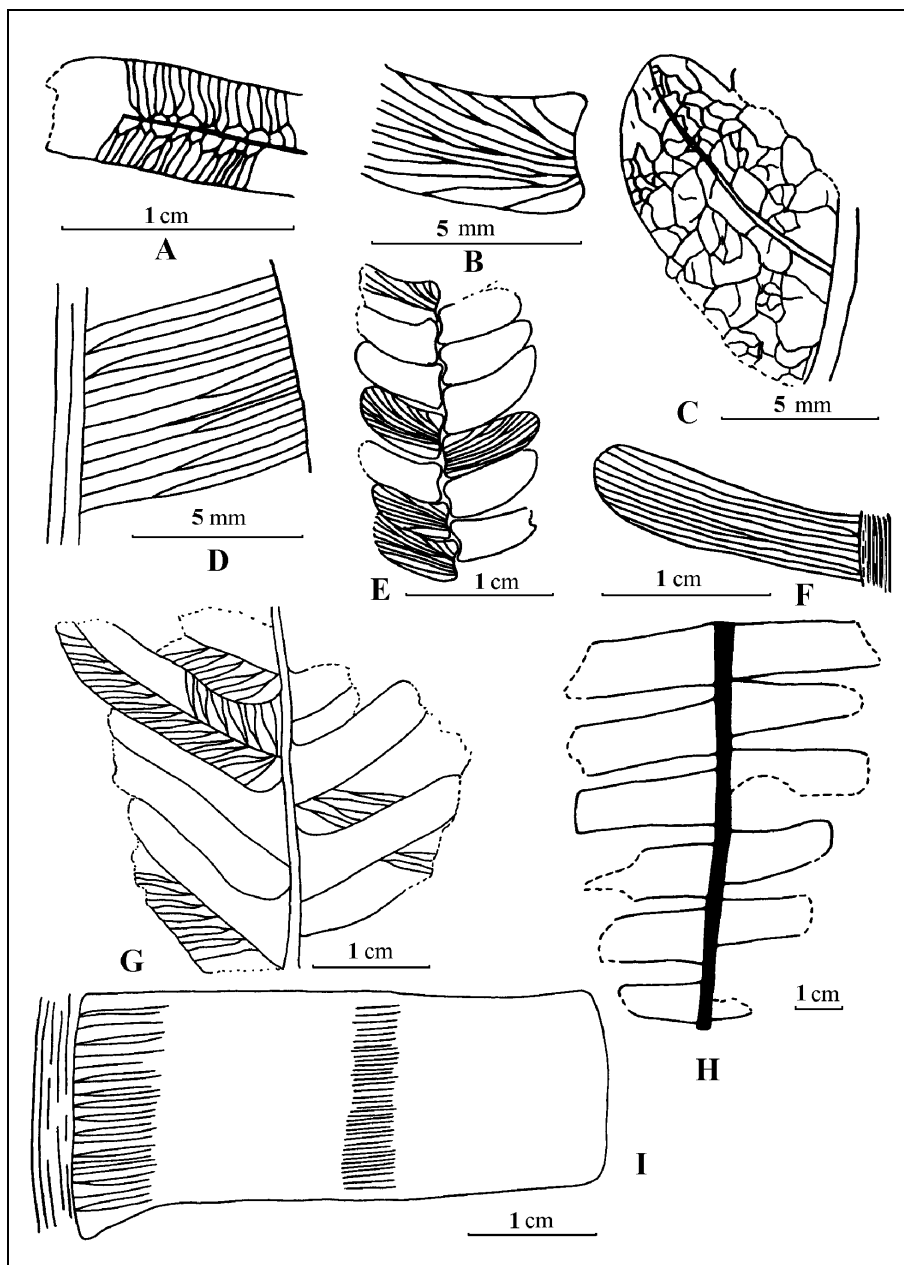


Fig. 5 - A: *Plebopteris polypodioides*, B, E: *Otozamites ashtarensis*, C: *Dictyophyllum* cf. *nathorsti*, D: *Taeniopteris tenuinervis*, F: *Pterophyllum nathorsti*, G: *Cladophlebis nebbensis*, H, I: *Pterophyllum tietzei*.

Description. Leaf once pinnate, outline linear-lanceolate, width 8-15 mm (full length unknown but exceeds 3 cm); rachis clear, pinnules opposite to subopposite, attached at angles of 70°-85° to the rachis. Pinnae linear, straight, truncate apices, parallel sided, 7 x 1-1.25 mm in size, constant length from six to seven times longer than broad, set closely and attached by the full width of their bases; veins obscure.

Comparison. The margins of adjacent pinnae are in contact in *Pterophyllum bavieri* Zeiller but in *P. angustum* (Braun) Gothan and *P. braunianum* (Braun) Goepfert adjacent pinnules are usually separated by a sinus. In addition, *P. bavieri* has thinner and smaller pinnules.

Sample number. FJSH-NC 11.

***Pterophyllum nathorsti* Schenk, 1883**

Pl. 4, figs 2, 5; Fig. 5F

1883 *Pterophyllum nathorsti* Schenk (in Richthofen) part 4; p. 261, pl. 53 figs. 5, 7.

1964 *Pterophyllum nathorsti* - Lorenz, p. 23, pl. 4, fig. H.

1967 *Pterophyllum nathorsti* - Barnard; pp.561-563, pl. 48, fig. 5; text-fig. 3F.

2003 *Pterophyllum nathorsti* - Schweitzer & Kirchner; pp. 68-71, pl. 14, figs.2-7, text-fig. 23 a, b, 24.

Description. Leaf once pinnate, linear, 7 cm long, 3 cm wide, rachis nearly 2 mm wide, with fine longitudinal striations; pinnules set closely, opposite, attached to the rachis at angles of about 65°-75° with the whole base, rounded apices, 16-18 mm long and 3-4 mm wide; veins parallel, rough, simple or forked once just at the base of pinnules, 7-8 per pinnules.

Comparison. *Pterophyllum contiguum* Schenk resembles *P. nathorsti* Schenk but it differs in having fine and dichotomous veins.

Sample number. FJSH-NC 12.

***Pterophyllum schenki* (Zeiller, 1886) Zeiller, 1903**

Pl. 4, figs 3, 4

1886 *Anomozamites schenki* Zeiller; p. 460; pl. 24, fig. 9.

1903 *Pterophyllum schenki* (Zeiller) Zeiller; p. 181, pl. 43, fig. 7.

1977 *Pterophyllum schenki* - Fakhr; p. 121, pl. 38, figs. 1,2; figs. 14 A-C; 15 A-F.

1977 *Pterophyllum cf. schenki* - Corsin & Stampfli; p. 533, pl. 8, fig. 6.

1984 *Pterophyllum schenki* - Sadovnikov; pl. 30, fig. 8.

2003 *Pterophyllum schenki* - Schweitzer & Kirchner; pp. 71-74, pl. 15, figs. 1-3; text-fig. 25 a-c.

Description. Leaf once pinnate; rachis clear, 1 mm wide; pinnules attached laterally at an angle of 80° to the rachis with the whole base which is occasionally expanded, alternate, separated by a rounded sinus, 2-2.5 cm long and 8-9 mm wide; parallel margins, truncate apices; veins parallel, simple or forked once, 19-21 per pinnules.

Sample number. FJSH-NC 13.

***Pterophyllum tietzei* Schenk, 1887**

Pl. 4, fig. 1; Fig. 5H, I

1887 *Pterophyllum tietzei* Schenk; pl. 6, fig. 27-29; pl. 9, fig. 52.

1965 *Pterophyllum tietzei* - Barnard; pp. 1146-1149, pl. 99, fig.2, text-figs. 6A-D.

1972 *Pterophyllum tietzei* - Kimyai; p. 15, fig. 10.

1977 *Pterophyllum cf. tietzei* - Corsin & Stampfli; p. 533, pl. 9, fig. 8.

1977 *Pterophyllum tietzei* - Fakhr, p. 118, pl. 40, fig. 3, text-fig. 14 D,E.

1984 *Pterophyllum tietzei* - Vassiliev; p. 49, pl. 24, fig. 1.

2003 *Pterophyllum tietzei* - Schweitzer & Kirchner; pp. 75-78, pl. 15, fig. 4; pl. 16, figs. 1,2; text-fig. 26 a,b.

Description. Leaf once pinnate (largest incomplete specimen 95 mm long and 65 mm wide); rachis with longitudinal striations, 4-5 mm wide; pinnules attached laterally at about a right angle to the rachis with the whole base which is occasionally expanded, alternate, separated by a wedge shaped sinus, 2-3 mm wide; entire margins, truncate apices; veins parallel, fine, simple or forked once, 24-26 per cm basally and 32 per cm in the middle part of pinnules.

Discussion. *Pterophyllum schenki* Zeiller and *Pterophyllum kalawchiensis* Barnard resemble this species. *P. kalawchiensis* Barnard differs in having more contiguous pinnules which may overlap each other and smooth rachis (Barnard 1967). *P. schenki* Zeiller differs in having smaller pinnules (18-25 x 7-9 mm) and transverse wrinkles.

Sample number. FJSH-NC 14.

Genus *Otozamites* Braun, 1842

***Otozamites ashtarensis* Barnard, 1967**

Pl. 5, figs 4, 5, 7; Fig. 5B, E

1967 *Otozamites ashtarensis* Barnard; p. 566, pl. 47, Fig. 8, pl. 48, fig. 1; text-figs. A,C,D.

1976 *Otozamites ashtarensis* - Sadovnikov; p. 94, pl. 4, fig. 6.

1977 *Otozamites ashtarensis* - Fakhr; p. 103, pl. 32, fig. 6; text-fig. 11E.

1977 *Otozamites cf. ashtarensis* - Corsin & Stampfli; p.535, pl. 8, fig. 2.

1984 *Otozamites ashtarensis* - Vassiliev; pl. 16, fig. 2.

Description. Leaf small in size, once pinnate, outline lanceolate, up to 54 mm long (full length unknown) and 14-16 mm wide; pinnules ovate to slightly falcate, 5-8 mm long, 2-3 mm wide, rounded apices, entire margins, base slightly auriculate to auriculate, alternate to subopposite and cover proximal face of the rachis at angles of 45°-55°; veins divergent, arising from a point at the base of the pinnules, dichotomous twice. The density of veins in the middle part of the pinnules is 7-8 (maximum 9).

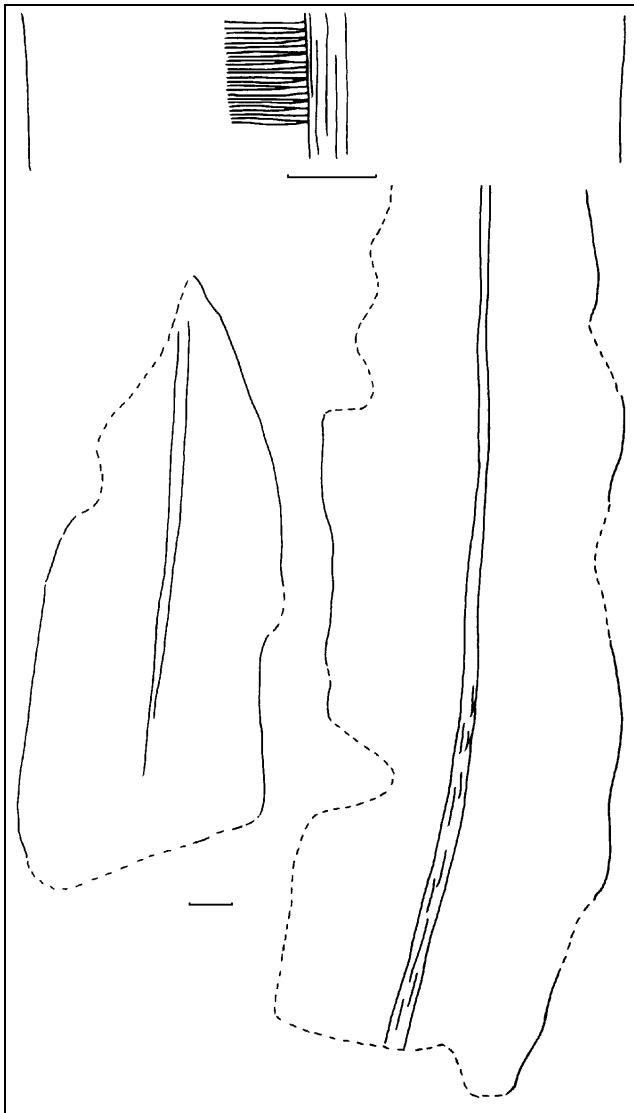


Fig. 6 - *Nilssoniopteris musafolia* (Bars are 1 cm long).

Comparison. *Ptilophyllum cutchense* Morris resembles this species, but it differs in having rather parallel veins instead of a radius pattern.

Sample number. FJSH-NC 15.

Otozamites sp.

Pl. 8, fig. 4

Description. Frond pinnate, up to 8 cm long, pinnules 55 mm long (the whole length unknown) and 11 mm width, auriculate bases with expanded acroscopic auricle; veins obscure.

Discussion. Since the veins pattern is obscure it can not be identified precisely. Likewise, the pattern of auricles resembles *Dictyozamites asseretoi* Barnard as well.

Sample number. FJSH-NC 16.

Genus *Zamites* Brongniart, 1828

Zamites boureaui Fakhr, 1977

Pl. 6, fig. 1; Pl. 7, fig. 2; Fig. 3A

1977 *Zamites boureaui* Fakhr; p. 109, pl. 31, fig. 12A.

Description. Frond simplipinnate, rachis clear, 5-5.5 mm thick with longitudinal striae; pinnules linear-lanceolate, 20 cm long and 12 mm broad (the length is about twenty times than the width), parallel margins, constricted bases, acute to obtuse apices; veins simple or forked twice near the base, running in a slightly radial pattern in which some veins ending to the margins and the others running towards the apex; 24-26 per pinnules.

Comparison. *Zamites persica* Boureau resembles this species but it differs in their proportion of length to the width of pinnules in which this proportion in *Zamites persica* Boureau is eight to ten times while it is up to twenty times in *Zamites boureaui* Fakhr.

Sample number. FJSH-NC 17.

Zamites persica Boureau, 1950

Pl. 5, fig. 1

1950 *Zamites persica* Boureau in Boureau et al; p. 226, pl. 8, fig. 41, 42.

1967 *Zamites persica* - Barnard; p. 563, pl. 48, figs. 2,3; pl. 49, fig. 10.

2003 *Zamites persica* - Schweitzer & Kirchner; p. 90, pl. 22, figs. 2-4; pl. 23, fig. 1; text-fig. 32 a,b.

Description. Frond once pinnate, 11 cm long; rachis 2- 2.5 mm wide with two longitudinal ridges on adaxial surface; pinnules opposite to alternate, attached at angles of 50°- 60°; covered parts of the margins of rachis. These angles reduce towards the apex of frond to an angle of 20°. Pinnules lanceolate-linear, entire margins, constricted bases, 3-4 cm long and 2/5-3 mm wide; the proportion of length to width is eight to ten times. Veins simple or forked, originally divergent in which some veins running out to the end of pinnules and some other ending to the margins. The concentration of veins is 10-12 per pinnules.

Sample number. FJSH-NC 18.

Order *Cycadales*

Genus *Androstrobus* Schimper, 1872

? *Androstrobus* sp.

Pl. 8, fig. 3; Fig. 4E

Description. Cone 38 mm long, 9-10 mm broad, shape cylindrical in middle region, apex rounded, base tapered and then rounded; stalk absent; outer edges of

microsporophylls short and acute, overlapping the scales above. Microsporophylls arrange spirally around the axis of cone.

Sample number. FJSH-NC 19.

Division Ginkgophyta

Order Ginkgoales

Genus *Baiera* Braun, 1843 emend. Florin, 1936

Baiera muensteriana (Presl, 1838) Heer, 1876

Pl. 7, figs 5-7; Fig. 4B

1838 *Sphaerococcites münsteriana* Presl in Sternberg; p. 105, pl. 27, fig. 3.

1876 *Baiera muensteriana* (Presl) Heer; p. 51.

1887 *Ginkgo münsteriana* - Schenk; p. 8, pl. 8, fig. 44.

1891 *Ginkgo muensteriana* - Krasser; p. 430.

1905 *Baiera muensteriana* - Zeiller; p. 194.

1964 *Baiera muensteriana* - Lorenz; p. 22, pl. 4, fig. E.

1967 *Baiera muensteriana* - Barnard; pp. 568-571, pl. 48, fig. 4; pl. 49, fig. 2; text-fig. 5 D,E.

1971 *Baiera* cf. *muensteriana* - Kilpper; pp. 94-95, pl. 26, figs. 5, 6; text-figs. 7,8.

1972 *Baiera muensteriana* - Kimyai; p. 17, fig. 13.

1976 *Baiera muensteriana* - Sadovnikov; p. 106, pl. 5, fig. 9.

1977 *Baiera muensteriana* - Fakhr; p. 128, pl. 45, figs. 5, 6; pl. 47, fig. 4; text-fig. 19A.

1984 *Baiera muensteriana* - Vassiliev; pl. 40, figs. 2, 4; pl. 42, fig. 1b.

1995 *Baiera muensteriana* - Schweitzer & Kirchner; pp. 20-24, pl. 5, figs. 1-9; text-figs. 11 a-I, 12.

Description. Leaf radius 21 mm and basal angle is 160°. Eight primary segments in 17 mm long which forked into 16 lobes, 3-5 mm long, rounded to obtuse apices. Venation obscure.

Sample number. FJSH-NC 20.

Division Coniferophyta

Order Coniferales

Genus *Chamaetaxus* Schweitzer & Kirchner, 1996

Chamaetaxus orientalis Schweitzer & Kirchner, 1996

Pl. 7, fig. 3

1996 *Chamaetaxus orientalis* Schweitzer & Kirchner; p. 126, pl. 15, figs. 1-9; text-fig. 25 a-d.

Description. Leaves spirally arranged around rachis, tending secondarily to be in a surface. Leaves are ellipsoid in shape, 4-5 mm long, 1 mm or less wide, decurrent bases, rounded-obtuse apices. The free part of leaves are far from the rachis. There is one vein in each leaf.

Discussion. *Elatides thomasii* Harris resembles this species but *Chamaetaxus orientalis* differs in having leaves tending secondarily to be in a surface and ellipsoid shape with rounded-obtuse apices.

Sample number. FJSH-NC 21.

Genus *Podozamites* Braun, 1843

Podozamites distans (Presl, 1838) Braun, 1843

Pl. 7, fig. 4; Pl. 8, fig. 2

1838 *Zamites distans* Presl in Sternberg; p. 196, pl. 4, fig. 1.

1843 *Podozamites distans* (Presl) Braun; pp. 33,36.

1967 *Podozamites distans* - Barnard; pp.572-573, text-fig. 5A.

1977 *Podozamites distans* - Corsin & Stampfli; p. 536, pl. 1, fig. 2.

1977 *Podozamites distans* - Fakhr; p. 141, pl. XLVIII, figs. 1,2.

1996 *Podozamites distans* - Schweitzer & Kirchner; pp. 88-91, pl. 1, figs. 1-5, text-fig. 2 a-f.

Description. Frond 9 cm long, rachis 6-7 mm thick; leaves elongate-lanceolate in shape, spirally arranged, 30 mm long (the whole length unknown), 9-10 mm wide and constricted bases. The widest part of leaf is in the proximal third of the base. Veins are simple or forked once, 19-21 per cm in the widest part of leaf.

Sample number. FJSH-NC 22.

Age of the plant megafossil assemblage

One plant megafossil assemblage zone can be identified from the Shemshak Formation in Narges-Chal area. On the basis of the occurrence of *Scytophyllum persicum*, *Nilssoniopteris musafolia*, *Otozamites ashtarensis*, *Pterophyllum bavieri*, *Pterophyllum tietzei*, *Zamites persica*, and *Baiera muensteriana* the Rhaetian age assigned for this assemblage. This assemblage is comparable to other reported plant fossil remains from the Rhaetian strata of Iran (Tab. 1).

Conclusion

The Shemshak Formation in Narges-Chal area contains abundant well-preserved plant megafossils belonging to twenty-two species allocated among sixteen genera of various divisions viz., Sphenophyta, Pterophyta, Pteridospermophyta, Cycadophyta, Ginkgophyta and Coniferophyta which is described for the first time in this study. One plant megafossil assemblage zone is identified in this study. This assemblage is considered to belong to the Rhaetian age. An overall comparison of Alborz and Central Iran floras shows a similar palaeoclimate conditions during this period of time. On the basis of the occurrence of Equisetales (*Equisetites*); thermophilic ferns (*Dictyophyllum*) and Bennettitales (*Pterophyllum*, *Otozamites*, *Zamites*) a humid-subtropical climate can be inferred for the Rhaetian in the area.

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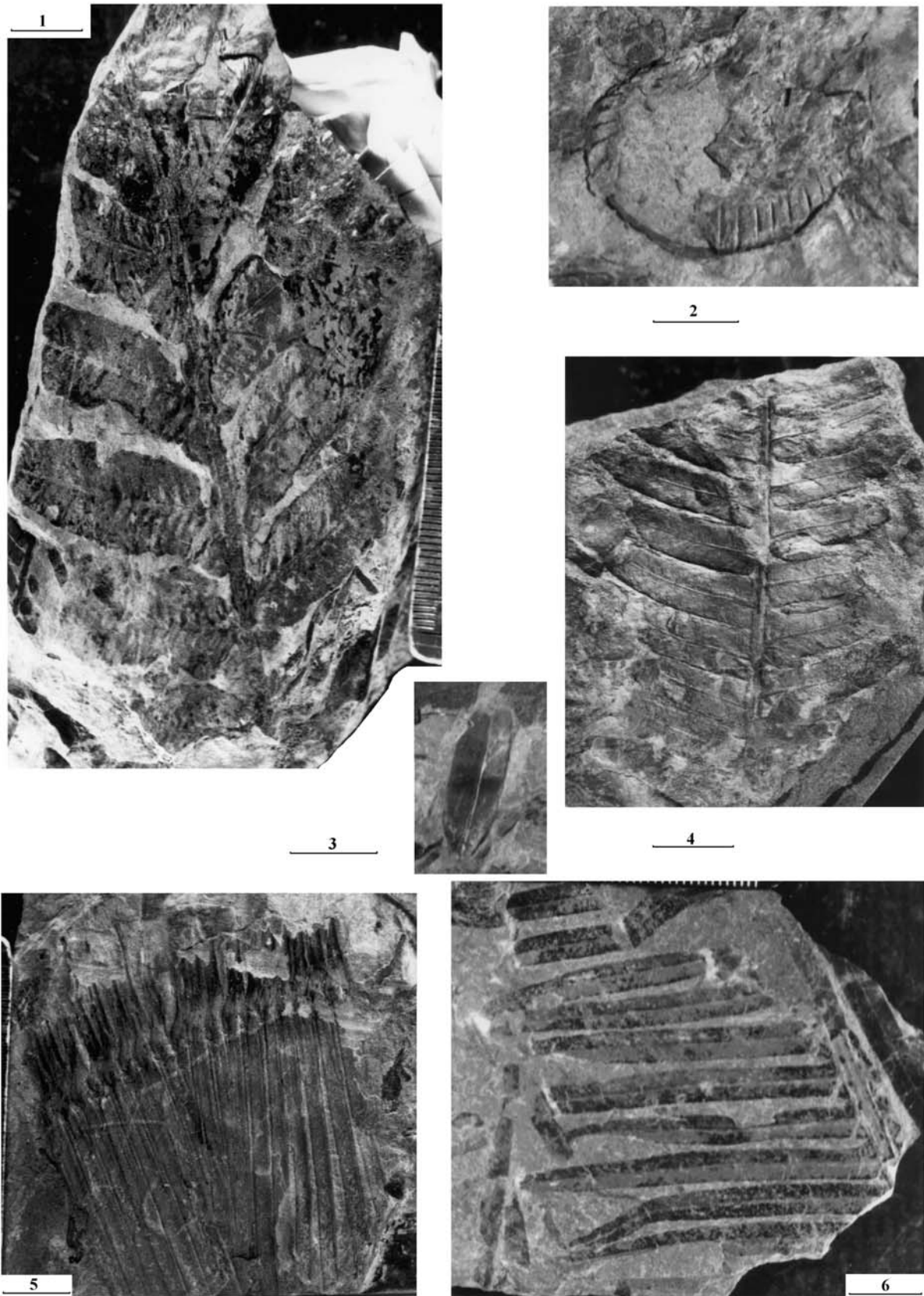


PLATE 1

- Fig. 1 - *Scytophyllum persicum* (Schenk, 1887) Kilpper, 1975 (FJSH-NC 8).
Figs. 2,5 - *Equisetites conicus* Sternberg, 1833 (FJSH-NC 1).
Fig. 3 - *Taeniopteris* sp. (FJSH-NC 7).
Fig. 4 - *Cladophlebis nebbensis* (Brongniart, 1828) Nathorst, 1876 (FJSH-NC 5).
Fig. 6 - *Phlebopteris polypodioides* Brongniart, 1828 (FJSH-NC 4).
Scale bar = 1 cm.

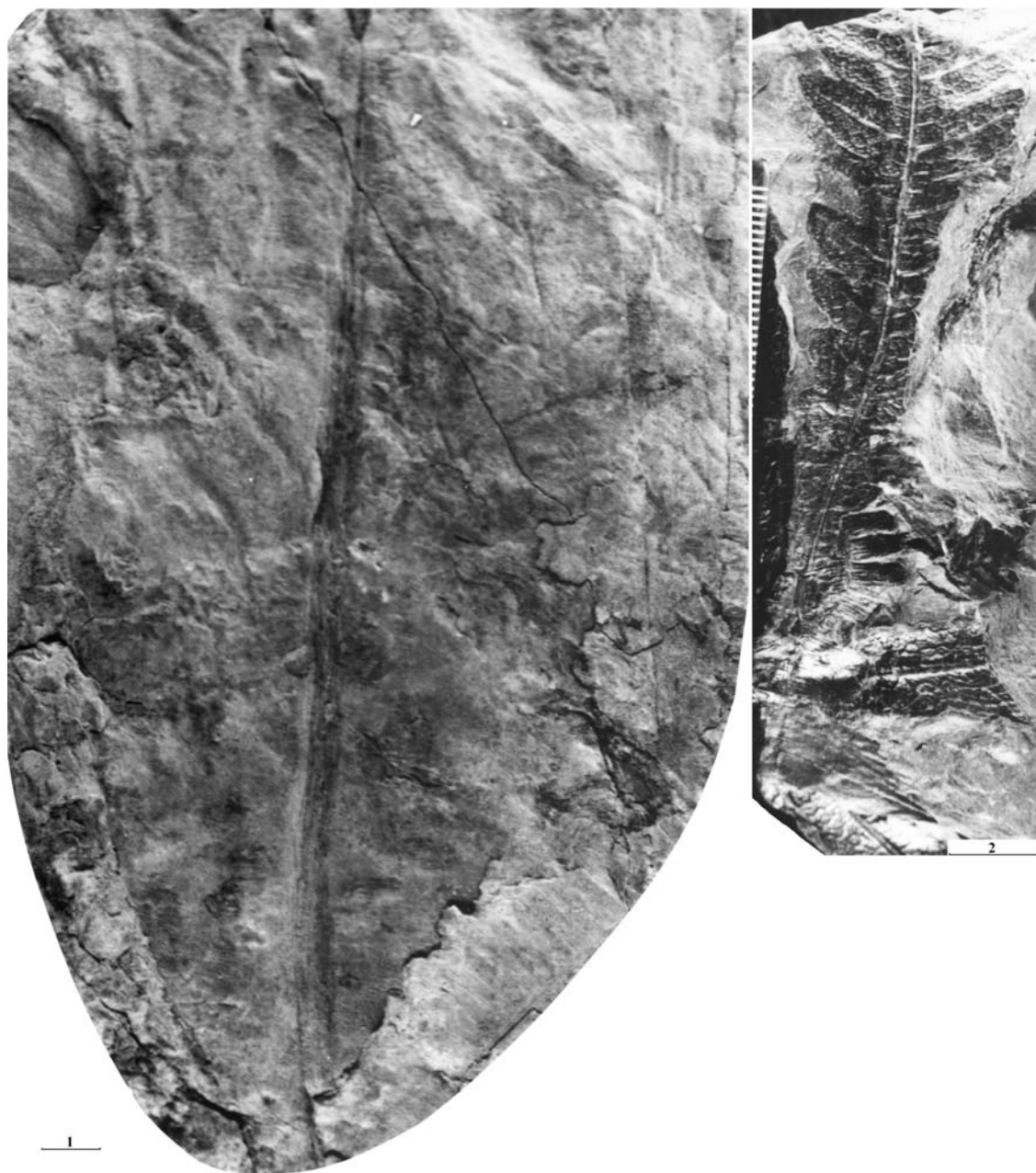


PLATE 2

Fig. 1 - *Nilssoniopteris musafolia* Barnard, 1965 (FJSH-NC 10a).

Fig. 2 - *Dictyophyllum* cf. *nathorsti* Zeiller, 1903 (FJSH-NC 3).

Scale bar = 1 cm.

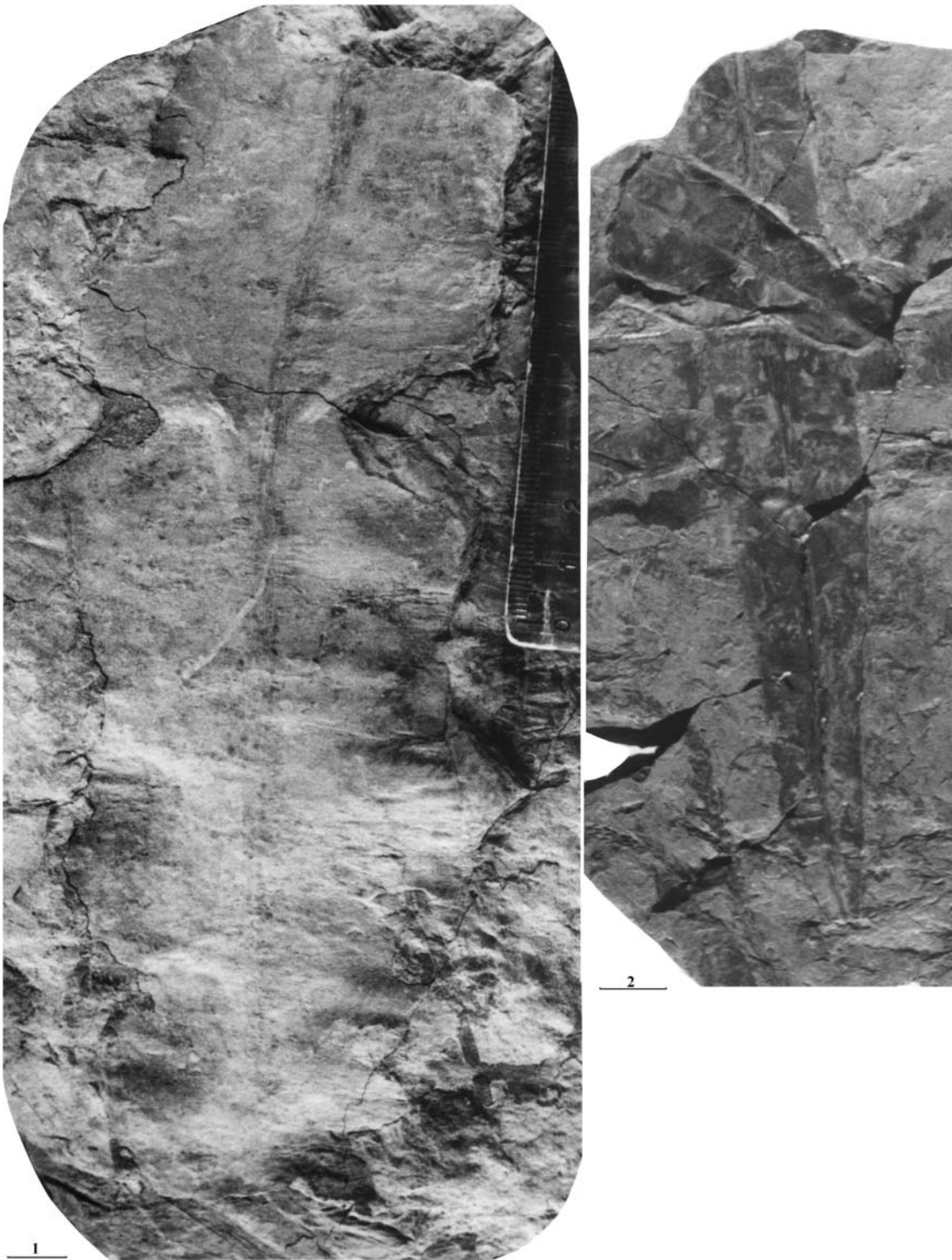


PLATE 3

Fig. 1 - *Nilssoniopteris musafolia* Barnard, 1965 (FJSH-NC 10b).
Fig. 2 - *Taeniopteris tenuinervis* Brauns, 1862 (FJSH-NC 6).
Scale bar = 1 cm.

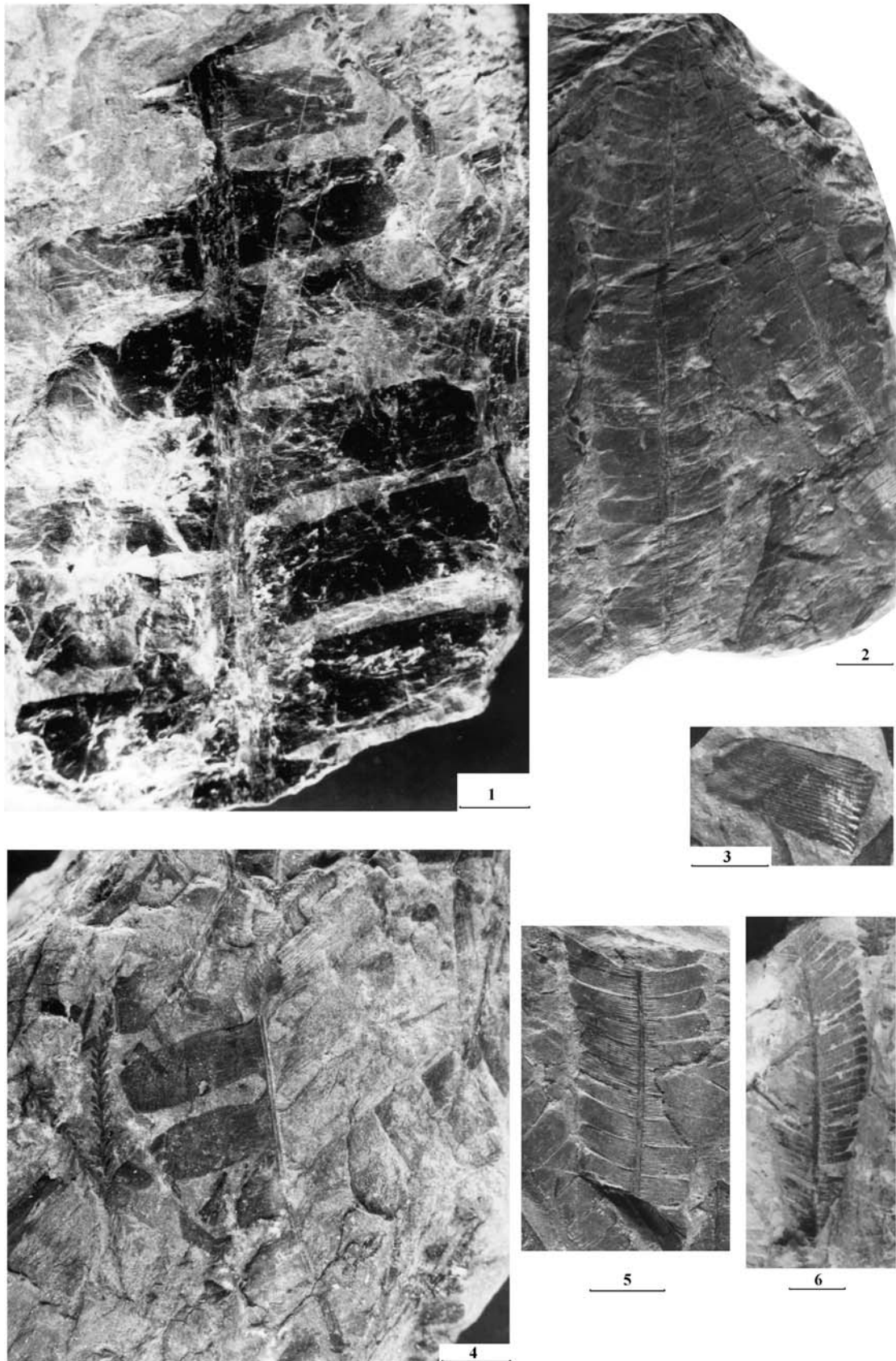


PLATE 4

- Fig. 1 - *Pterophyllum tietzei* Schenk, 1887 (FJSH-NC 14).
 Figs. 2,5 - *Pterophyllum nathorsti* Schenk, 1883 (FJSH-NC 12).
 Figs. 3,4 - *Pterophyllum schenki* (Zeiller, 1886) Zeiller, 1903 (FJSH-NC 13).
 Fig. 6 - *Pterophyllum bavieri* Zeiller, 1903 (FJSH-NC 11).
 Scale bar = 1 cm.

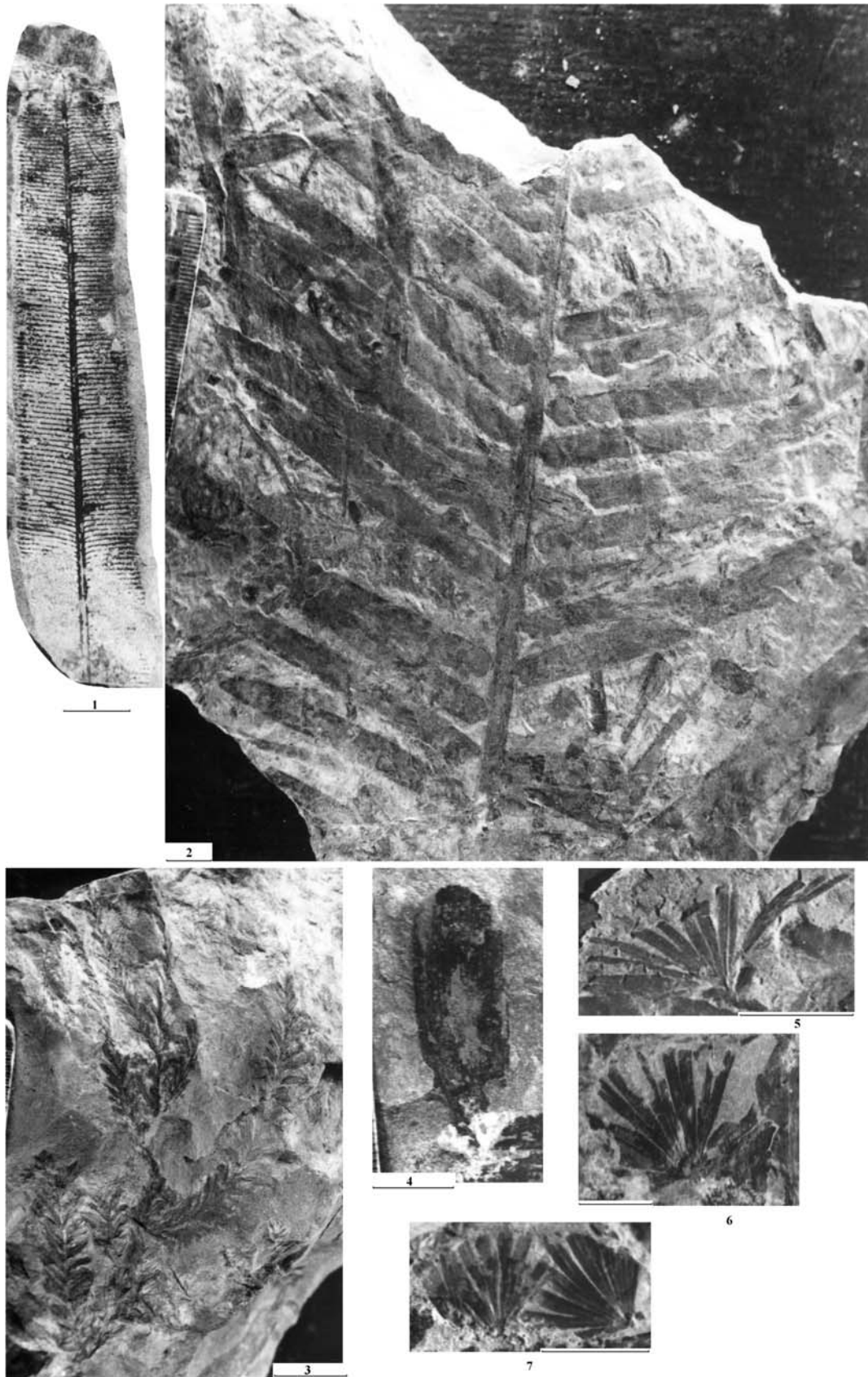


PLATE 5

- Fig. 1 - *Marattiopsis intermedia* (Muenster, 1836) Kilpper, 1964 (FJSH-NC 2).
Fig. 2 - *Zamites boureauii* Fakhr, 1977 (FJSH-NC 17).
Fig. 3 - *Chamaetaxus orientalis* Schweitzer & Kirchner, 1996 (FJSH-NC 21).
Fig. 4 - *Podozamites distans* (Presl, 1838) Braun, 1843 (FJSH-NC 22a).
Figs 5,6,7 - *Baiera muensteriana* (Presl) Heer, 1876 (FJSH-NC 20).
Scale bar = 1 cm.



PLATE 6

Fig. 1 - *Zamites boureaui* Fakhr, 1977.
Scale bar = 1 cm.

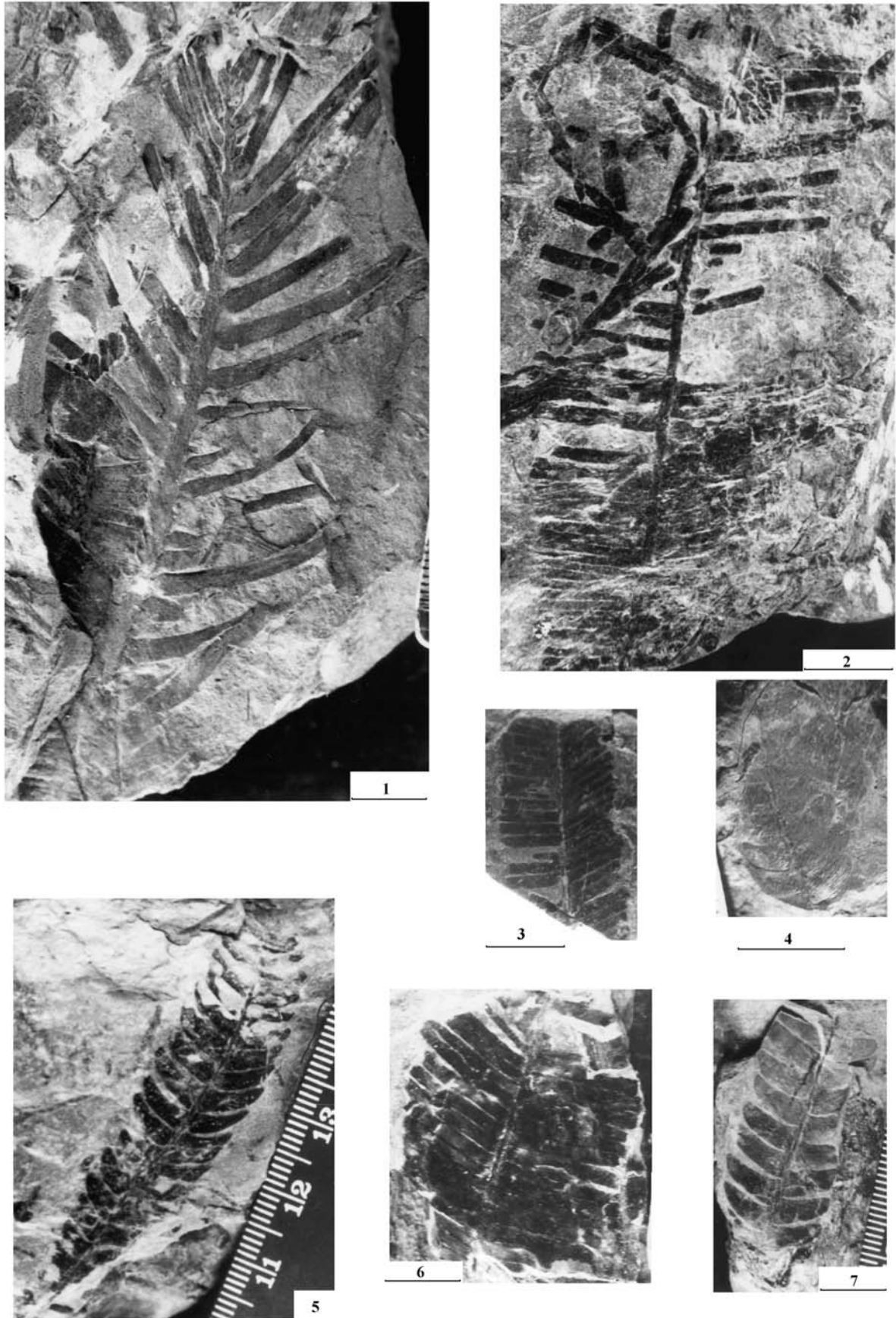


PLATE 7

Fig. 1 - *Zamites persica* Boureau, 1950 (FJSH-NC 18).

Figs. 2,3,6 - *Pterophyllum bavieri* Zeiller, 1903.

Figs. 4,5,7 - *Otozamites ashtarensis* Barnard, 1967 (FJSH-NC 15).

Scale bar = 1 cm.

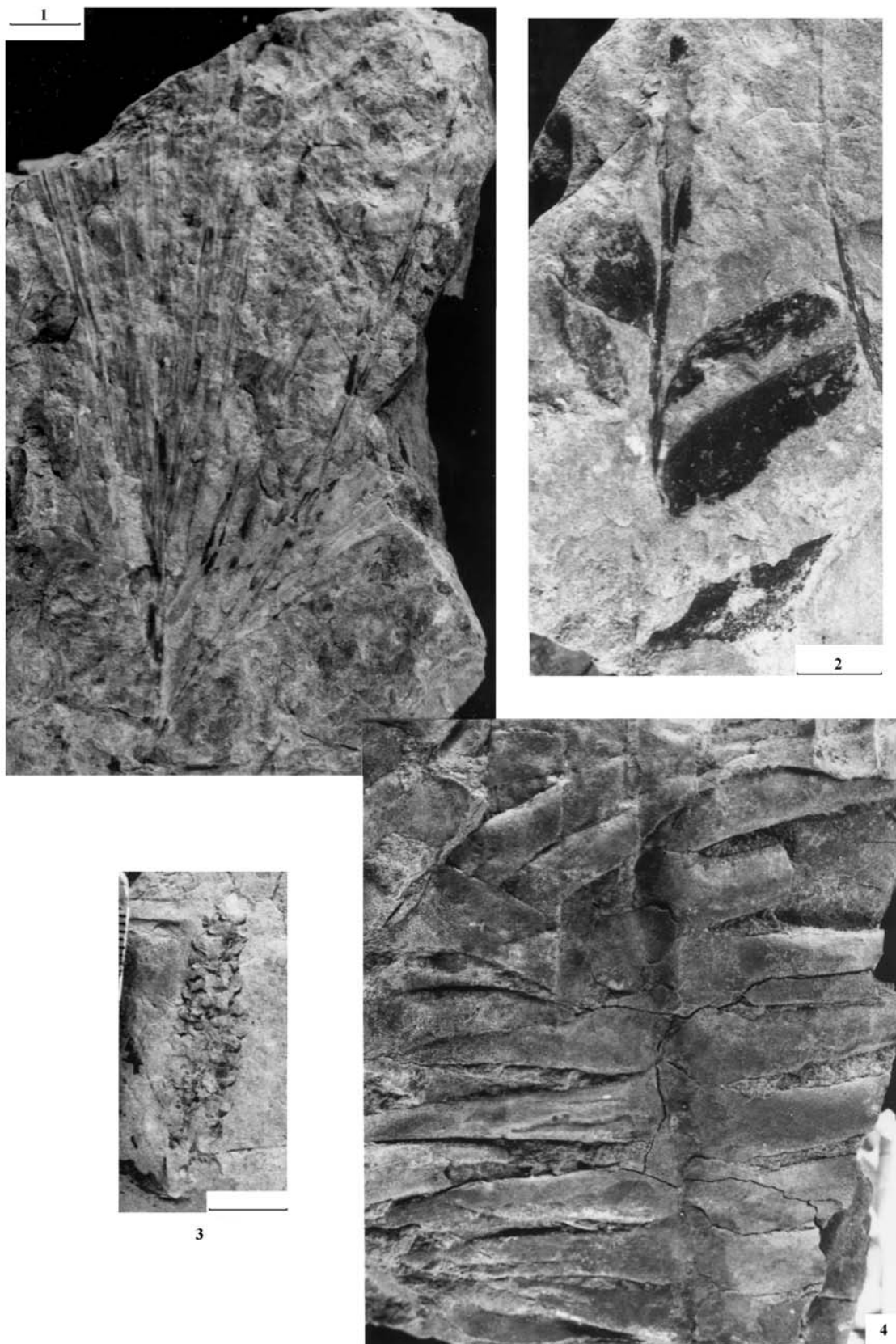


PLATE 8

- Fig. 1 - *Czekanowskia rigida* Heer, 1876 (FJSH-NC 9).
 Fig. 2 - *Podozamites distans* (Presl, 1838) Braun, 1843 (FJSH-NC 22b).
 Fig. 3 - ?*Androstrobus* sp. (FJSH-NC 19).
 Fig. 4 - *Otozamites* sp. (FJSH-NC 16).
 Scale bar = 1 cm.

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