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Occurrence of *Aninopteris* (Matoniaceae) from the Middle Jurassic of East central Iran

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ABSTRACT

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Aninopteris Givulescu and Popa 1998, a matoniacean fern originally known from the Lower Jurassic deposits of Romania, has been recently reported from the Middle Jurassic coal bearing deposits of Mazino mine, south of Tabas region, east central Iran. This is the second record of this genus, excepting its original occurrence from the Anina region of Romania. Besides the younger age, the Iranian material differs from the type material in having a higher number of sporangia, and less branched secondary veins. Thus, *Aninopteris formosa* var. *persica* var. nov. is proposed for the studied material.

Key-words—Filicales, Matoniaceae, Middle Jurassic, Hojedk (Mazino) Formation, East central Iran.

सारांश

पूर्वी मध्य ईरान के मध्य जुरैसिक से प्राप्त *एनीनोप्टेरिस* (मैटोनिएसी)

माज़िद मीरजई अटाबडी, मोहम्मद अली ज़फरियान एवं ज़फर मोहम्मद अलीजादेह

नीनोप्टेरिस गिवुलेस्क्यू एवं पोपा 1998 जो कि मूलरूप से रोमानिआ के निम्न जुरैसिक से ज्ञात एक मैटोनिएसियन पर्णांग है, को हाल ही में पूर्वी मध्य ईरान के दक्षिणी तबास क्षेत्र की मेज़ीनो खान के मध्य जुरैसिक कोयलाधारक निक्षेपों से अंकित किया गया है। रोमानिआ के एनीना क्षेत्र से इसकी मौलिक प्राप्ति के अलावा यह इस प्रजाति का दूसरा अभिलेख है। तरूण आयु के अतिरिक्त ईरान की सामग्री स्पोरेन्जिया में अधिक होने तथा द्वितीय शिराओं में कम शाखाएँ होने में यह प्ररूप सामग्री से भिन्न है। इस प्रकार *एनीनोप्टेरिस फोरमोसा* तुलना *परसिका* तुलना नवप्रजाति अध्ययन हेतु प्रस्तावित करती है।

संकेत-शब्द- फिलिकेल्स, मैटोनिएसी, मध्य जुरेसिक, होज़ेक (मेज़ीनो) शैलसमूह, मध्य ईरान।

INTRODUCTION

ANINOPTERIS Givulescu and Popa 1998 is a fern genus belonging to Family Matoniaceae. This genus is known only from the Lower Jurassic (Sinemurian) continental sequences of Romania. In this paper a new variety of *Aninopteris* is described from the Mazino coalmine in Tabas region, where it occurs in the Middle Jurassic Hojedk (Mazino) Formation and this is the second reported occurrence in the world. The fossil material from the central Iran is represented by a number of complete fronds and fragments. Even before the discovery and identification of the genus *Aninopteris*, material belonging to this taxon was recorded in Iran in the 1970's, as an unknown, undescribed pinnule from the Ferizi area, northeast part of the country (Fakhr, Personal communication, 2001).

Geological setting

The Mazino coalmine is located 100 Km south of Tabas (Fig. 1), at 56°19' N latitude and 33°12' E longitude. Hojedk (Mazino) Formation is a non-marine Middle Jurassic sequence, well developed and widely distributed in central Iran. It extends from north of Kerman in southeast central Iran (Kerman coal subzone) to south of Tabas in eastern central Iran (Mazino coal subzone, Fig. 1). They represent two separated coal generating basins which occasionally joined, forming a wide spread basin in which rich coal bearing strata of central Iran were deposited (Repin, 1983).

Significant palaeogeographical changes subsequently occurred as a result of the Early Kimmerian tectonic movements during the Late Middle-Late Triassic (Carnian-Norian), and thus it played a major role in the Jurassic events in these areas. After these tectonic activities, the action of faults in the north and in the south formed a new basin. The strong subsidence associated with these events caused the deposition of a thick sequence of terrigenous sediments. This sedimentation continued until the Middle Kimmerian (Bajocian-Bathonian) movements (Berberian & King, 1981). The detritic sediments in this basin vary in thickness from a few meters to more than 3000 m. These sediments are known as the Shemshak Group which includes the Nayband, Abhaji, Badamu and Hojedk formations of central Iran (Aghanabati, 1977).

In Mazino coalmine the outcropping strata are Badamu and Hojedk formations. The Badamu Formation is 8.5 m thick and it includes marls, oolitic limestone, limestone, sandstones, and microbreccia. The Hojedk Formation, which is informally known as the Mazino Formation (Repin, 1983), is 32 m thick and it is a succession of shales, coaly shales and sandstones (Fig. 2). Coal bearing sequences (or horizons in coal mining terminology) are found towards the base of this formation, deposited in a delta plain, while the upper horizons lack coal and they are deposited in a meandered river system (Lasemi & Kheradmand, 1999).

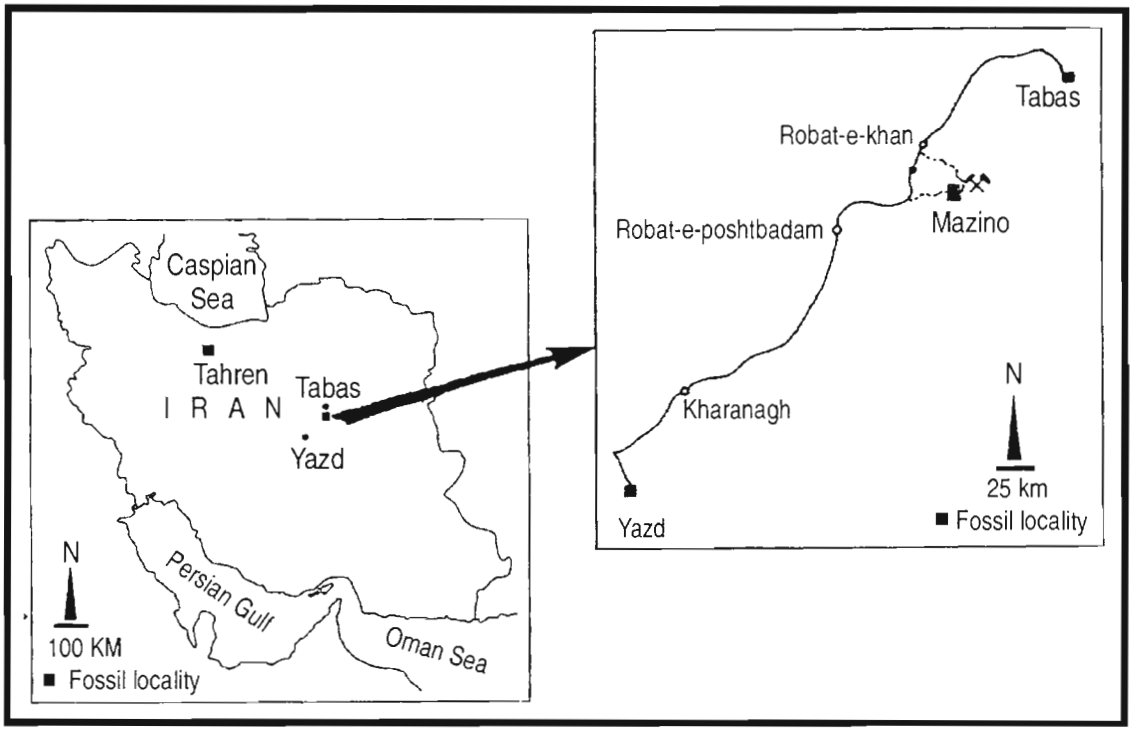


Fig. 1—Location map of the fossil locality and Mazino coalmine, south of Tabas, east central Iran.

Based on the ammonite fauna from the underlying limestones of the Badamu Formation (Toarcian-Lower Bajocian), it is concluded that the Hojedk Formation has been deposited during the Middle Bajocian - Lower Bathonian interval (Seyed Emami, 1971; Aghanabati, 1998). Therefore, the specimens of *Aninopteris* found in the lower horizon of the Hojedk (Mazino) Formation in the Mazino coalmine should be Middle to Late Bajocian in age.

Plant fossils, mostly macroflora, of the Hojedk Formation have been described mainly from the Kerman coal basin (Mirzaie Ataabadi, 2002; Poliansky & Safronov, 1973; Sadovnikov, 1976; Schweitzer, 1978; Schweitzer & Kirchner,

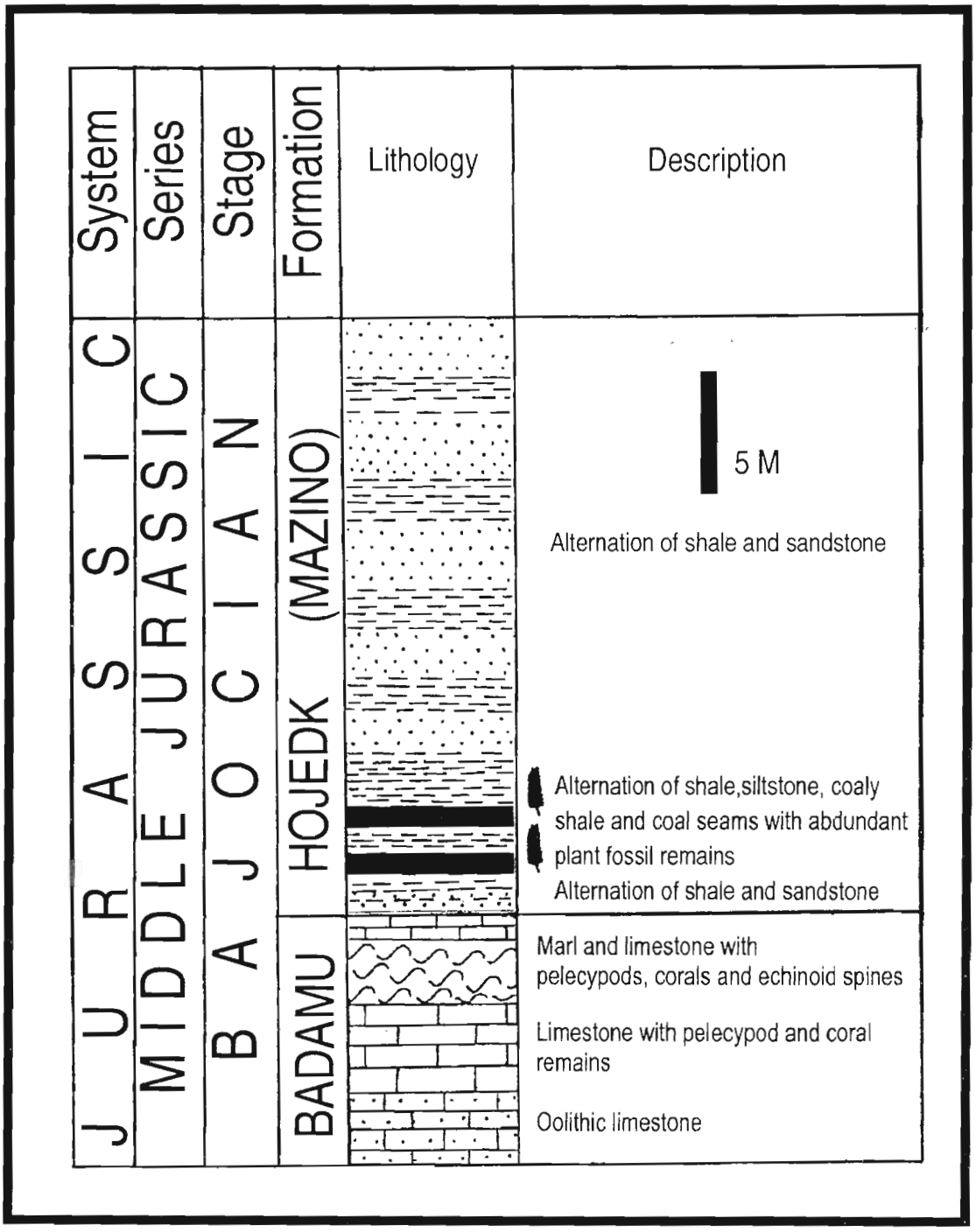


Fig. 2—Stratigraphic log of the Middle Jurassic deposits in Mazino coalmine and the plant bearing strata (after Yusefzadeh, 1995).

1995, 1996, 1998, 2003; Schweitzer *et al.* 1997, 2000; Vassiliev, 1985) and less from the Tabas coal basin (Vassiliev, 1985; Yusefzadeh, 1995).

These studies have shown that the flora is diverse and it includes horsetails and ferns in addition to a variety of seed ferns, cycads, bennettitaleans, conifers and ginkgoaleans, showing close affinity with the Middle Jurassic flora of Trans Caucasus (Delle, 1967), Romania (Popa, 1998) and north Afghanistan (Jacob & Shukla, 1955).

MATERIAL—The specimens were collected from two localities in coalmining areas of Mazino region: (1) close to the exploration well No. 149, (2) Fajr mine. The described fossils are preserved as compressions in dark grey and light brown mudstones and almost all hand specimens contain *Pagiophyllum* foliage. Other genera associated with *Aninopteris* are *Dictyophyllum* (abundant), *Marattiopsis*, *Cladophlebis* and *Ctenis* (less abundant). Except the foliar fragments taken into consideration for this study, the samples also contain small pinnule fragments of *Aninopteris*, some of them in great numbers. The notation of samples is as follows: Samples ENHM-PC A1 belong to the Djafarian collection, curated at the Palaeobotanical collection of the Esfahan Natural History Museum (ENHM). The other specimens from this collection (EUGM-PC A2) are curated in the Palaeobotanical collection of Esfahan University Geology Museum (EUGM). Samples HMNH-PC A 1-2 belonging to Mohammadalizadeh collection are curated in the Palaeobotanical collection of the Hamedan Museum of Natural History (HMNH).

SYSTEMATICS

Class—FILICOPSIDA Pichi-Sermolli, 1958

Order—FILICALES Engler and Prantl, 1902

Family—MATONIACEAE Presl, 1847

Genus—ANINOPTERIS Givulescu and Popa, 1998

Species—ANINOPTERIS FORMOSA Givulescu and Popa, 1998

ANINOPTERIS FORMOSA var. **PERSICA** var. nov.

(Figs 3-4; Pl. 1-2)

Diagnosis & Description—Frond fragments 50 to 170 mm long, pinnule margins parallel, tapering in distal half of pinnules. Pinnules parallel, attached with rachis, long (up to

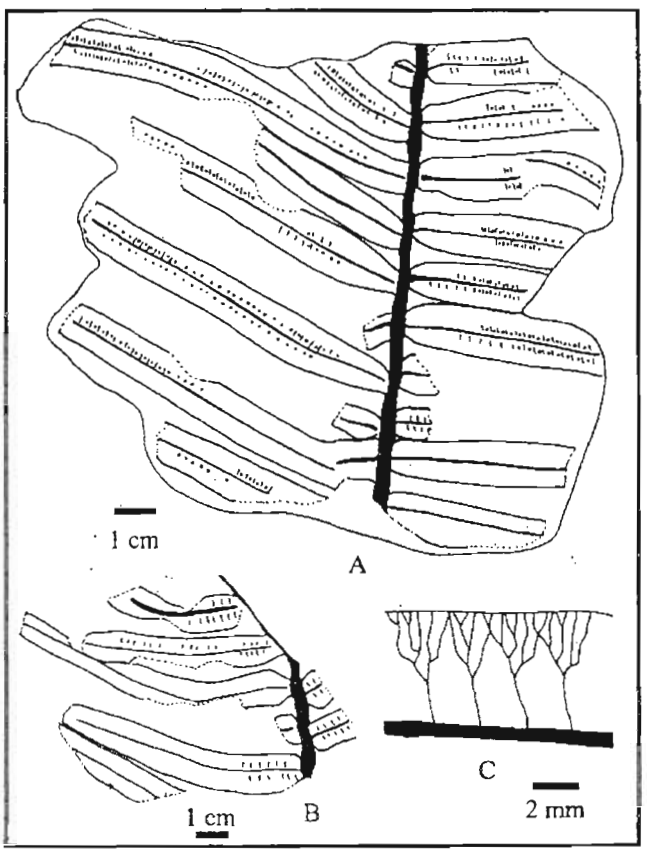


Fig. 3—*Aninopteris formosa* var. *persica* var. nov. A: EUGM-PC A1, B: HMNH-PC A2, Fertile fronds and C: ENHM-PC A1, sterile pinnule venation.

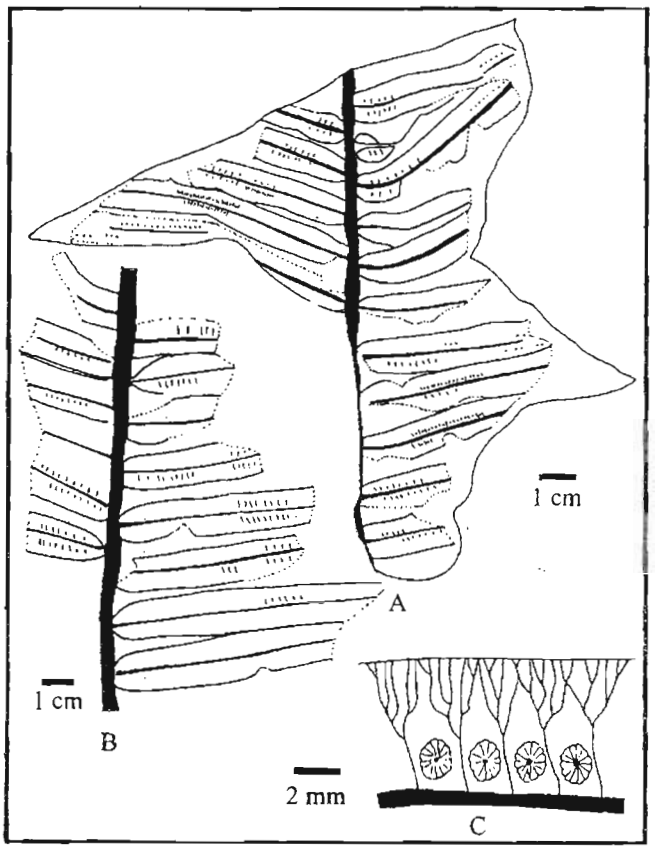
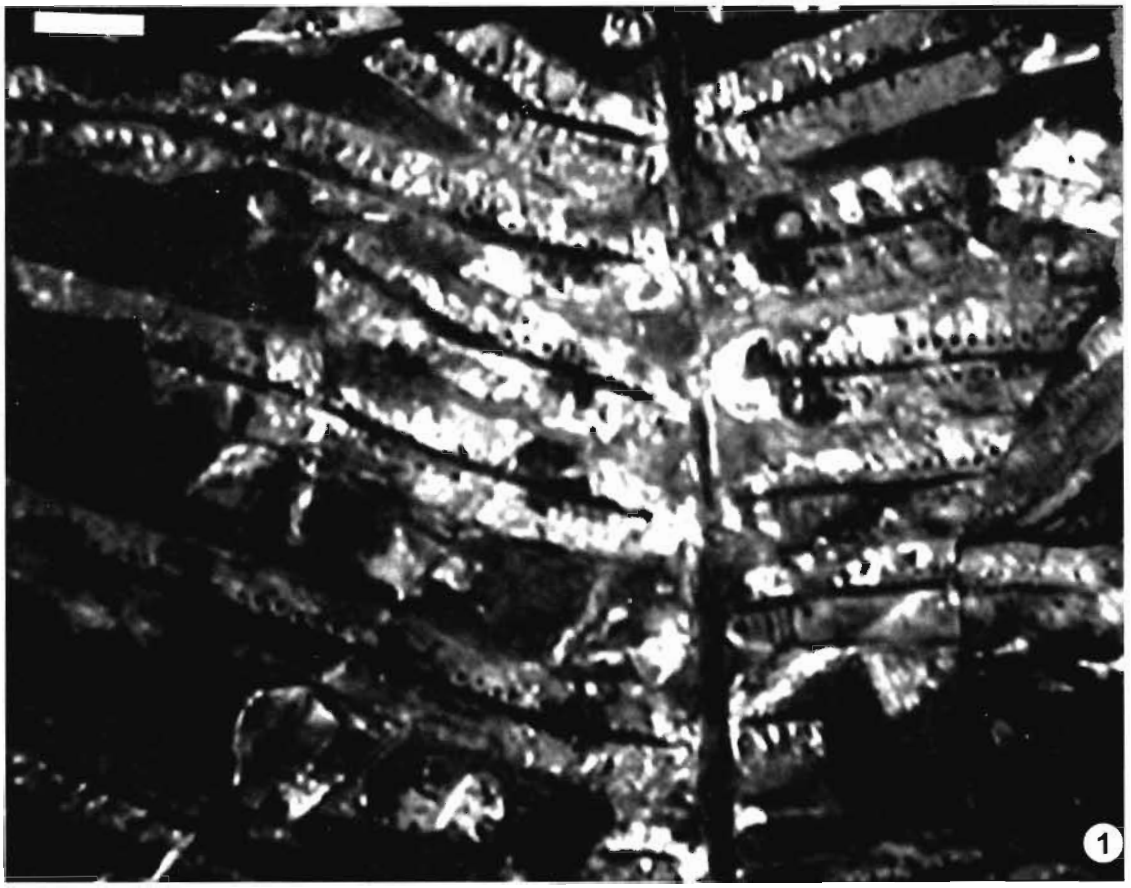


Fig. 4—*Aninopteris formosa* var. *persica* var. nov. A: ENHM-PC A1, B: HMNH-PC A1, Fertile fronds and C: ENHM-PC A1, Fertile pinnule showing position of sori.



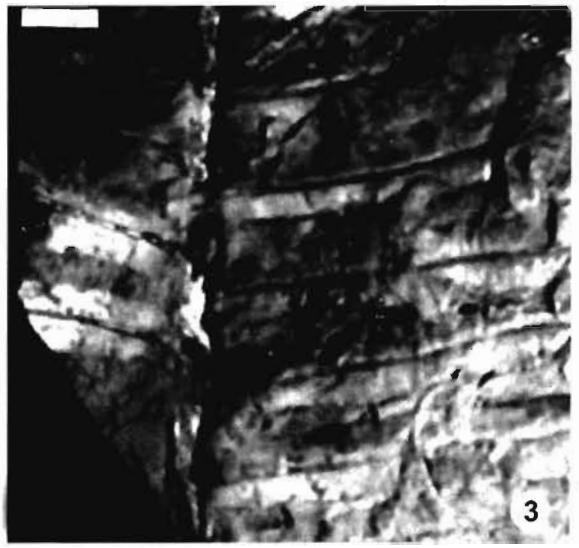


PLATE 1

Aninopteris formosa var. *persica* var. nov.

1 EUGM-PC A1, Frond showing fertile pinnules, Scale bar 10 mm (Holotype).

2. ENHM-PC A1, Frond bearing pinnules, Scale bar 10 mm (Paratype).

3. HMNH-PC A1, Sterile frond showing attachment of pinnules, Scale bar 10 mm.

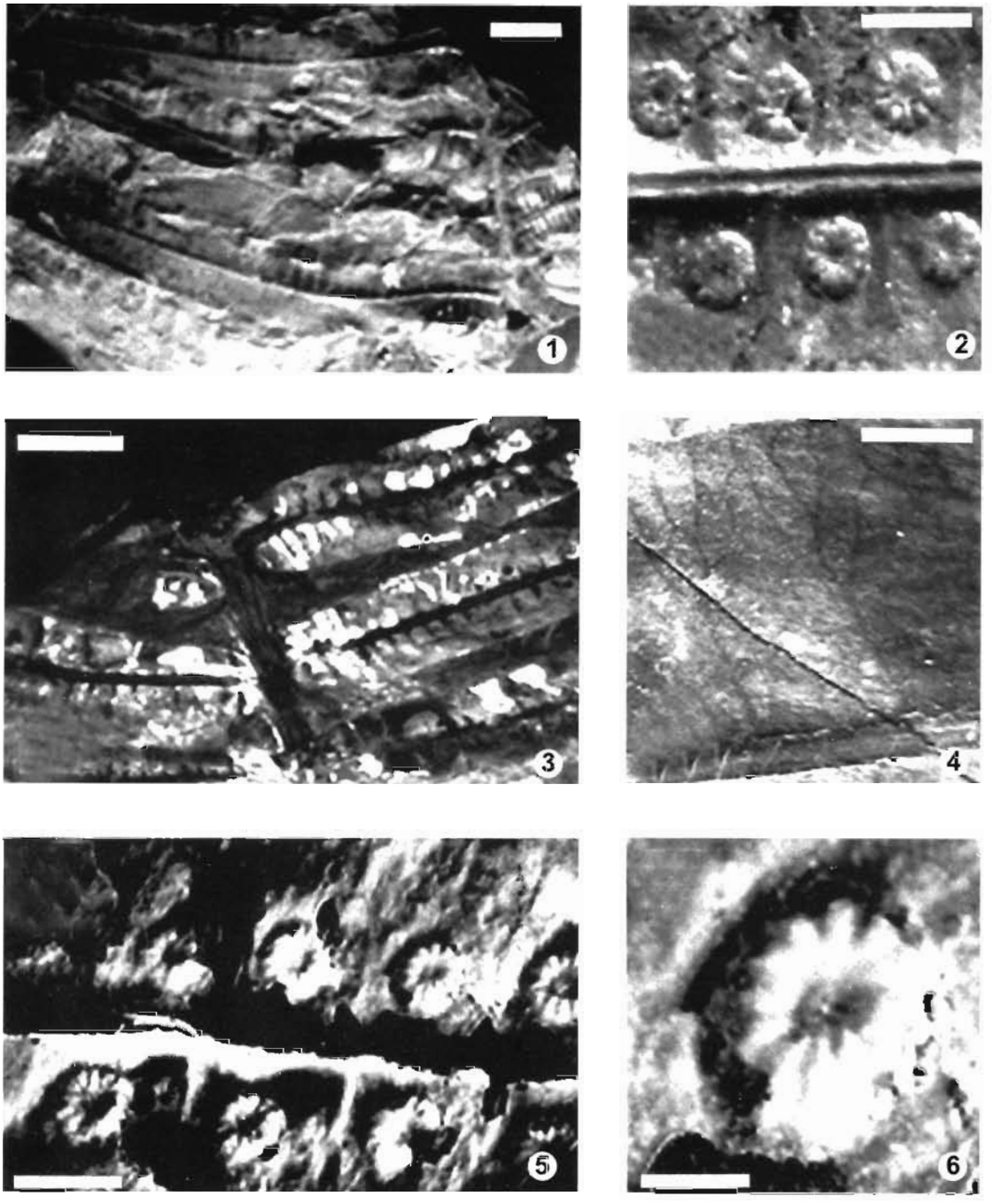


PLATE 2

Aninopteris formosa var. *persica* var. nov.

1. HMNH-PC A2, Frond showing sterile pinnules, Scale bar 10 mm.
2. EUGM-PC A1, Fertile pinnule with sori aligned sub oppositely on both sides of the midrib, Scale bar 2 mm.
3. EUGM-PC A1, Pinnules with roundly constricted bases, Scale bar 10 mm.
4. ENHM-PC A1, Sterile pinnule with midrib and dichotomously branched secondary veins, Scale bar 2 mm.
5. ENHM-PC A1, Fertile pinnule with sori aligned oppositely on both sides of the midrib, Scale bar 2 mm.
6. HMNH-PC A1, Sorus with 12 sporangia, Scale bar 0.5 mm.

200 mm in basal parts), wide (up to 130 mm), separated by a very narrow sinus, lamina margins never overlap in first half-length. Pinnule midrib generally perpendicular to rachis, more prominent on abaxial surface, more sunken on adaxial surface. Midrib inserted at 9 and 18 mm intervals. Secondary veins perpendicular to midrib, opposite or subopposite, at intervals of 1.5-2 mm, branching dichotomously, not more than three times, sometimes interconnect with first dichotomy on second half of pinnule width. Fertile pinnules mainly in central parts of frond. Sori arranged in two rows along both sides of midrib, excepting first quarter or half of total length, always in first half of distance between midrib and margin, flanked by unbranched segments of secondary vein. No visible vein connecting to sori, sori bear 9-12 circular sporangia.

Holotype—Specimen No. EUGM-PC A1

Paratype— Specimen No. ENHM-PC A1

Etymology—From Persia; the ancient name of Iran.

Occurrence—Middle Jurassic (Bajocian) deposits of Mazino coalmine, south of Tabas, east central Iran.

Comparison & Discussion—The new *Aninopteris* specimens collected from the Middle Jurassic coal bearing deposits of central Iran differ from the original Romanian material by having a higher number of sporangia (9-12, instead of 6-8), and also by having a less complicated network of interconnected secondary veins (Figs 3-4). In the Iranian material, the secondary veins branch dichotomously more than 3 times, and thus they create a simple net by interconnecting the neighboring branches of secondary veins close to the margin of pinnule. Since *in situ* spores from the Iranian material are not known, therefore, these are presently described as *Aninopteris formosa* var. *persica* var. nov.

Like the Romanian material, *Aninopteris* specimens in Iran are accompanied mainly by *Pagiophyllum* and especially *Dictyophyllum*. This association, together with the depositional environment of plant bearing strata at both localities, indicates that like other matoniaceous ferns such as *Phlebopteris*, *Aninopteris* is also a thermophyllic genus. *Aninopteris* is so far reported only from two localities within the Euro-Sinian floral region (Vakhrameev, 1991). Because of its restriction to the European Province in the Early Jurassic times and Middle Asia Province in the Middle Jurassic times, this genus probably has migrated from the European Province to the Middle Asia Province, sometime at the Early-Middle Jurassic transition. Since the Middle Jurassic flora of central Iran has a great affinity with the Middle Jurassic flora of trans-Caucasus, South Carpathians and Afghanistan (Mirzaie Ataabadi, 2002) it seems that *Aninopteris* may be found in future in above subprovinces including these floras.

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