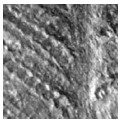
The Pennsylvanian *Pecopteris ticleanui* sp. nov. from Secu, Reşiţa Basin, Romania

MIHAI EMILIAN POPA & JOSEF PŠENIČKA



The new species *Pecopteris ticleanui* sp. nov. is described and figured from Secu, Reșița Basin, South Carpathians, Romania, from the Pennsylvanian deposits of the Reșița Formation. The studied material included both mature and immature frond fragments. The species is rare in both the Reșița Basin and generally in the South Carpathians. *Pecopteris ticleanui* sp. nov. is an Asturian-Stephanian species, suggesting the same age for the Secu facies of the Reșița Formation. The new species belongs to a rich pecopterid assemblage which contains more than 20 pecopterid taxa. • Key words: *Pecopteris ticleanui,* Marattiales, palaeobotany, Pennsylvanian, Reșița Basin, Romania.

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Marattialeans plants, most often represented by sterile pinnules called pecopterids, are known from Bashkirian macrofloras, but their global radiation occurred during the late Moscovian and Kasimovian times (DiMichele & Phillips 2002). They became widespread in the Carboniferous world and their remains are found in almost every Carboniferous locality.

One of these localities is Secu, situated in the Reșița Basin. This basin which includes both Palaeozoic and Mesozoic continental formations, represents the largest sedimentary basin of the Getic Nappe (for summary see Bucur 1991, 1997; Popa 2009). Both Pennsylvanian and Lower Jurassic coal measures in the basin were mined for their significant coal reserves. Secu (Caraș-Severin County), located in the north-eastern part of the basin, is a former coal mine locality for Pennsylvanian anthracite, it has a large colliery tip situated along the Râul Alb (White River) valley. It represents the most important Pennsylvanian plant bearing locality of the Reșița Basin, due to both the high diversity and the degree of preservation of its fossil plants (for summary see Popa 2001, 2005, 2009), as well as for its invertebrates (Popa 2005, Jarzembowski 2008).

The Pennsylvanian continental deposits of the Reșița Basin are represented by the Reșița Formation which ranges stratigraphicaly from the uppermost Baskirian (Duckmantian) to the lower Gzhelian (Stephanian C).

The Reșița Basin was studied from a paleobotanical point of view by several authors such as Stur (1870), Hantken (1878), Mateescu (1957), Humml (1963), Maxim & Petrescu (1970), Bițoianu (1973, 1974, 1987, 1988), Preda *et al.* (1984), Negrea (1987), Dragastan *et al.* (1997), and Popa (2001, 2009). They described a rich palaeoflora including pecopterid taxa. We have separated specimens from old collections, originally classified under different names, and new findings, using them both for defining the new species *Pecopteris ticleanui* sp. nov.

Material

The material was collected from the sterile dumps of the former Secu mine (Fig. 1), being represented by compressions and impressions of various sizes and degrees of preservation. The hand specimens are preserved as a dark gray claystone. Three main collections were surveyed and studied, the M.E. Popa Collection (specimens P140/C2/58 and P140/C2/230), the I. Preda Collection (specimens PR 186) and the Paleobotany Collection of the Reșița Museum, temporarily housed in the "Porțile de Fier" Museum, Drobeta Turnu-Severin (Mehedinți County) (specimens No. 23 and No. 129). The first two collections are housed within the Department of Geology and Paleontology at the University of Bucharest.

Geology and stratigraphy

The Carboniferous system of the Reșița Basin was described in a series of relatively recent papers by Năstăseanu *et al.* (1973), Năstăseanu (1987), Bucur (1991), and Stănoiu *et al*. (1996). The Carboniferous deposits of the Reșița Basin represent relics having a much wider distribution during pre-Alpine phases, now occurring in limited areas due to tectonic and erosional factors. Many authors refered to standard l units such as formations and members, but the formal definition was given by Bucur (1991).

Bucur (1991) distinguished the following three members within the Reșița Formation: the Doman Member (Bolsovian–Asturian), the Lupacu Bătrân Member (Asturian–Stephanian B), and the Lupac Member (Stephanian C). The continental sequence in Secu, occurring in the north-eastern part of the Reșița Basin, complicated the separation of the three distinct members due to the marginal position of this area with respect to the main basin and to depositional factors, such as the lateral migration of the depositional centre of the Reșița Formation during the Middle and Upper Pennsylvanian time interval (Stănoiu *et al.* 1996). Therefore, the range of this formation is only Asturian–Stephanian B (Popa 2005) including a series of stratigraphical gaps (Năstăseanu *et al.* 1973, Dragastan *et al.* 1997), for example the Cantabrian–Barruelian, and the uppermost Stephanian C (Popa 2005). Nevertheless, to date the stratigraphical gaps have not been well documented.

The sediments of the Reșița Formation are typical for the continental environment of intramontane basins being dominated by alluvial, fluvial, lacustrine and swamp facies, in a succession which starts with alluvial sediments and ends with lacustrine sediments. The basal Doman Member is dominated by conglomerates, breccias and coarse sandstone, and it lacks fossils (Năstăseanu *et al.* 1973). The coals are confined to the Lupacu Batrân Member and the Lupac Member (Năstăseanu *et al.* 1973), occurring as two coal seams in Secu.

Systematics

Class Filicopsida
Order Marattiales Engler & Prantl, 1902
Family Asterothecaceae Engler & Gilg, 1919

Genus *Pecopteris* Brongniart, 1828

***Pecopteris ticleanui* sp. nov.**
Figure 2

1970 *Pecopteris longifolia* Maxim & Petrescu, p. 286, fig. 3.

Holotype. – The specimen No. 129 was selected; from the collection of the Reșița Museum housed in Drobeta Turnu-Severin.

Paratype. – The specimen No. 23 was selected; from the collection of the Reșița Museum housed in Drobeta Turnu-Severin.

Type locality. – Secu mine sterile dump, along the Rîul Alb valley, the Reșița Basin, Romania.

Type horizon. – The Reșița Formation, within the fine sandstone sequences associated with coal seams.

Etymology. – After Professor Nicolae Țicleanu, a prominent Romanian paleobotanist and coal geologist.

Diagnosis. – Ultimate rachis longitudinally striated, 1 mm wide; free pinnules inserted on ultimate rachis oppositely to sub-oppositely, at angles varying between 50°–80°, with bases entire, without constrictions; pinnules 20–35 mm long, 3–4 mm wide, ratio L/W 1/5–1/6; pinnule margin straight, sometime slightly undulate; pinnule apex rounded; midvein strong, straight, reaching the apex; lateral veins divided once, close to the midvein, into two arms which are decurrent against each other; lateral veins inserted at angles of 70°–90°; density of lateral veins 17–20 veins per 10 mm.

Description. – The fronds are usually found strongly fragmented, in both mature and immature developmental stages. The rachis is thin, 1 mm wide, finely striated longitudinally (Fig. 2A, D, E), the pinnules are inserted on its adaxial (upper) surface (Fig. 2A, E). The pinnules are inserted obliquely to the rachis, oppositely to sub-oppositely, at angles varying between 50°–80°, with their bases entire, without constrictions (Fig. 2A, C, E). The pinnules are elongated, linear, with a constant width between 3–4 mm, and lengths between 20–35 mm (Fig. 2A, C, E, F). The margins are usually straight, but sometimes they can be slightly undulated, most probably as a result of taphonomy, without clear teeth. The apex is rounded, the pinnule width decreasing abruptly towards the apex (Fig. 2A, E, F). The midvein is straight, strong and clearly marked, almost reaching the apex. The lateral veins are inserted at angles between 70°–90° to the midvein, they are usually divided only once, very early and next to the midvein, forming two arches which reach the pinnule margins perpendicularly (Fig. 2B, F). The lateral veins are always very prominent. The density of the lateral veins reaching the margin is about 17–20 veins per 1 cm. The immature pinnules are often falcate, narrower, with indistinguishable venation (Fig. 2D). They appear to be more or less tubular, with transversal striations caused by secondary veins which produce undulations on the external surface.

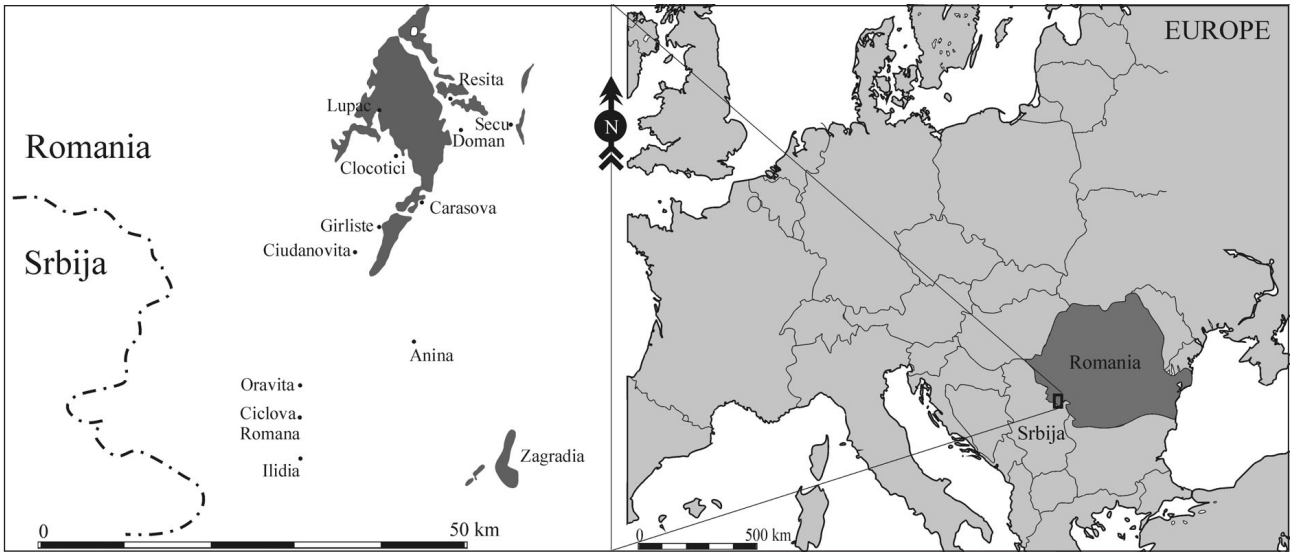


Figure 1. Locality map, showing the general position of the Secu locality in the Reşiţa Basin. The grey shades represent the Pennsylvanian deposits in the Reşiţa Basin.

Discussion. – *Pecopteris ticleanui* sp. nov. was described earlier from Romanian localities under different names such as *Pecopteris longifolia* Brongniart (Maxim & Petrescu 1970, Bițoianu 1973) or probably (non figured) *Diplazites longifolius* (Brongniart) Stur (Stur 1870, Hantken 1878) or *Desmopteris longifolia* Stur (Popa 2005) from Romanian localities. For example Stur (1870) cited *Diplazites longifolius* from an occurrence near to Secu, as well as Hantken (1878), citing *Diplazites longifolius* (Brongniart) Stur from an occurrence near to Clocotici, and from Caraşova, both of them in the Reşiţa Basin. Maxim and Petrescu (1970) described and illustrated *Pecopteris longifolia* Brongniart from Secu, based on material similar in character to *Desmopteris longifolia* Stur, unfortunately without a detailed description of the venation. Bițoianu (1973, 1974) cited *Pecopteris longifolia* Brongniart from Lupac, including *P. longifolia* var. *typica* Corsin, but never illustrated it. Popa (2005) considered the citations of Bițoianu (1973, 1974) as synonyms for *Desmopteris longifolia*, although due to the lack of descriptions and illustrations, these citations may also be in fact synonyms for *Pecopteris ticleanui* sp. nov.

Comparison of Pecopteris ticleanui sp. nov. with other pecopterids. – *Pecopteris ticleanui* sp. nov. shows similarities with the following species: *Pecopteris platoni* Grand'Eury, *P. major* (Doubinger) Vetter, *P.* (*Diplazites*) *unita* Brongniart, *Pecopteris microphylla* Corsin and *P. longifolia* var. *stricta* Corsin (Fig. 3).

The type of venation seen in *Pecopteris ticleanui* sp. nov., especially the character of the lateral veins, can be closely compared with the venation pattern occurring in *Pecopteris* (*Diplazites*) *unita*. The lateral veins of the *unita*-type pecopterids are undivided, or rarely once divided, and the veins are decurrent against each other or against the midvein. The other pecopterids have a quite different venation pattern in the dividing lateral veins. These species have divided lateral veins in which the arms of lateral veins are more or less parallel with each other. The *unita*-type pecopterid plant was described for the first time by Göppert (1836) under the name *Diplazites emarginatus* Göppert. In the same year Brongniart (1836) described the same plant under the name *Pecopteris unita* Brongniart. Brongniart (1836) also described another species with the *unita*-type venation, under the name *Pecopteris longifolia* Brongniart. Later Zeiller (1888) and Pšenička (2005) stated that the venation of *Pecopteris* (*Diplazites*) *unita* corresponded to the venation of Brongniart's *Pecopteris longifolia* Brongniart. Nevertheless, the pinnules of *Pecopteris longifolia* are elongated and narrower than those of *Pecopteris* (*Diplazites*) *unita*. *Pecopteris longifolia* was later discussed and emended by Corsin (1951). He figured more than one natural species and placed his specimens under the name *Pecopteris longifolia*. Some specimens (Corsin, 1951, pl. 122, fig. 2, pl. 123, figs 1, 2) appear to be pinnules from the distal end of a young pinna of *Pecopteris unita* as in Brongniart's (1836, pl. 116, fig. 2) specimens of *Pecopteris longifolia*. Corsin (1951) also mentioned that *Pecopteris longifolia* has *Acitheca*-type fertile organs. Nevertheless, he did not give further details of the fertile organs and his specimens figured in Corsin (1951, pl. 127, figs 1–3) look similar to *unita*-type (*Ptychocarpus*) reproductive organs. Based on our new, detailed observations of Brongniart's (1836) (*Pecopteris unita*, *Pecopteris longifolia*), Göppert's (1836) (*Diplazites emarginatus*), and Corsin's (1951) (*Pecopteris longifolia*) material, we assume that all of them belong to the same natural species,

artificially named *Pecopteris unita*, and represented by material from different positions on a frond and at different developmental stages. If we compare *Pecopteris ticleanui* sp. nov. with *Pecopteris unita,* thus *Pecopteris unita* differs in its thin penultimate rachis which is 0.5 mm wide, pinnules which are decurrent towards the ultimate rachis, 4–6 mm long, 2–3 mm wide, ratio L/W 1/2, united in its basal part and undivided lateral veins (or very rarely divided once).

Corsins's (1951) *Pecopteris longifolia* var. *stricta* can be compared with *Pecopteris ticleanui* sp. nov. due to its long pinnules and their ratio L/W 1/6. But *Pecopteris longifolia* var. *stricta* has distinct lobed pinnule margins in its basal part and the midvein is clearly marked upto 1/5 length of the pinnule, characters which are quite different to those seen in *Pecopteris ticleanui* sp. nov.

Pecopteris ticleanui sp. nov. shows great similarity with *Pecopteris platoni,* which was described by Grand'Eury (1890) from the Gard Basin Massive Central (France). Both species have a 1 mm wide ultimate rachis which is longitudinally striated, suggesting that the rachises were covered with hairs. Both species have more or less free pinnules with rounded tips. Significant similarities between the two species can be found in the type of venation. Both species have distinct midveins and lateral veins which are divided once close to the midvein. The two arms of the lateral veins are decurrent against each other. Differences between the two occur in the size of pinnules and in the position of pinnules on the ultimate rachis. *Pecopteris ticleanui* sp. nov. has 20–35 mm long, 3–4 mm wide pinnules, with a L/W ratio of 1/6–1/8 and the pinnules are inserted oppositely to sub-oppositely on the ultimate rachis. *Pecopteris platoni* has 10–15 mm long, 2–2.5 mm wide pinnules, with a L/W ratio of 1/5–1/6 and pinnules are situated alternately on the ultimate rachis. *Pecopteris platoni* also has slightly convergent pinnule margins, while *Pecopteris ticleanui* sp. nov. has more or less parallel pinnule margins. The relationship between the two species could be evidenced by a comparison of reproductive organs, but the reproductive organs of *Pecopteris ticleanui* sp. nov. are still unknown, while the reproductive organ of *Pecopteris platoni* were previously described.

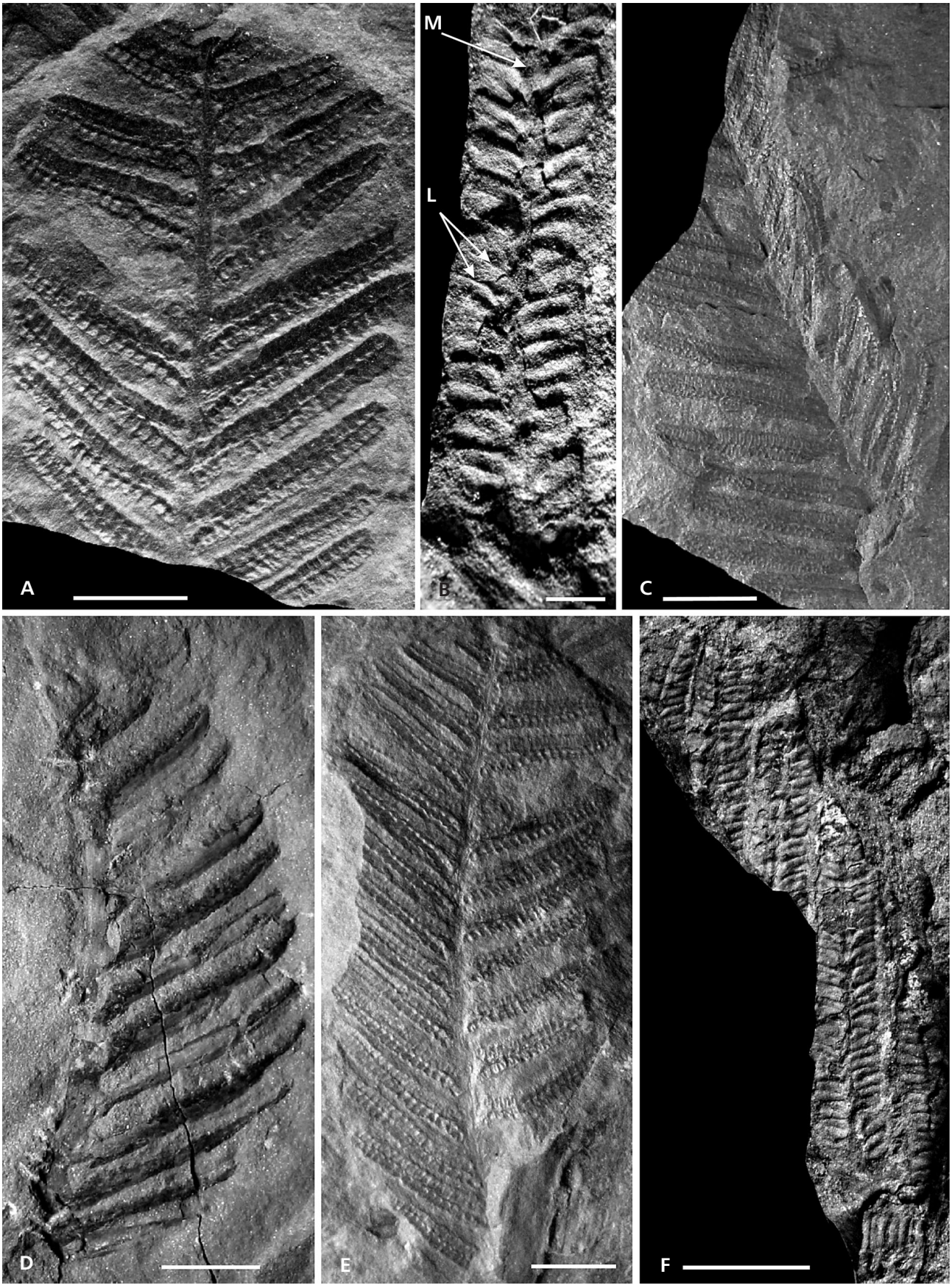
Some similarities also occur between *Pecopteris ticleanui* sp. nov. and *Pecopteris major* (Doubinger) Vetter. *Pecopteris major* was originally described by Doubinger (1956) as *Pecopteris cyathea* var. *major,* but later, Vetter (1968) emended this species and established the new name as *Pecopteris major*, typical for Stephanian deposits. The main similarities between *Pecopteris ticleanui* sp. nov. and *P. major* lie in the general character of the ultimate pinnae; both have relatively long (*Pecopteris ticleanui* sp. nov. = 20–35 mm, *P. major* = 12–20 mm) pinnules, the pinnules are inserted on the ultimate rachis oppositely to sub-oppositely, and the pinnule margins are straight. Nevertheless, *Pecopteris ticleanui* sp. nov. has a rounded pinnule tip, while *P. major* has a bluntly tapering pinnule tip. The significant difference between the two species is in the venation. *Pecopteris ticleanui* sp. nov. has lateral veins which divide once close to the midvein, and the two arms of the lateral veins decurret against each other, while *Pecopteris major* has lateral veins which divide once more or less parallely and are decurrent.

Another pecopterid species similar to *Pecopteris ticleanui* sp. nov. is *Pecopteris microphylla* Corsin (1951). The venation of both species is similar, having lateral veins which divide once, close to the midvein, into two arms which are decurrent against each other, and the pinnule margin is straight with a rounded tip. Nevertheless, the lateral veins of *Pecopteris ticleanui* sp. nov. are inserted on the midvein at angles varying between 70–90°, while in *Pecopteris microphylla* the lateral veins are inserted on the midvein at angles around 60°. The main difference regards the width of the pinnules, *Pecopteris ticleanui* sp. nov. has pinnules 3–4 mm in width, while *Pecopteris microphylla* has pinnules 1 mm in width.

Any relationship between the aforementioned species based on a comparison of the reproductive organs cannot be discussed because the reproductive organs of *Pecopteris ticleanui* sp. nov. are still unknown whilst the reproductive organs of *Pecopteris* cf. *platoni, Pecopteris unita* and *Pecopteris longifolia* were previously described by Laveine (1969).

Comparison of Pecopteris ticleanui sp. nov. with Desmopteris longifolia. – The genus *Desmopteris* Stur was described by Stur (1883). Earlier, Stur (1870) described *Diplazites longifolius* from localities near to Secu (Romania). Pinnules of *Pecopteris ticleanui* sp. nov. can be compared with *Desmopteris longifolia* or *D. alethopteroides.* Both species are very similar in pinnule shape and venation. *Desmopteris* has been described and discussed by Crookall (1929), Tenchov (1977), Laveine (1989a, b), and by Cleal & Thomas (1994).

Figure 2. Morphology of *Pecopteris ticleanui* sp.nov. from Secu, Reșița Basin, South Carpathians. • A – paratype, specimen No. 23; fragment of ultimate pinna, showing the pinnule shapes and insertions; scale bar: 10 mm. • B – specimen P140/C2/58; detail of pinnule showing the midvein (M), lateral veins (L) and pinnule margin; detail in Fig. F; scale bar: 1 mm. • C – specimen PR 186; fragment of ultimate pinna showing pinnule shape and insertions; scale bar: 10 mm. • D – specimen P140/C2/230; fragment of ultimate pinna showing an immature frond fragment with tubular-like pinnules inserted onto the rachis; scale bar: 10 mm. • E – holotype, specimen No. 129; fragment of ultimate pinna showing pinnule shapes and insertions; scale bar: 10 mm. • F – specimen P140/C2/58; fragment of ultimate pinna showing the pinnules and venation, secondary veins and pinnule margin; scale bar: 5 mm.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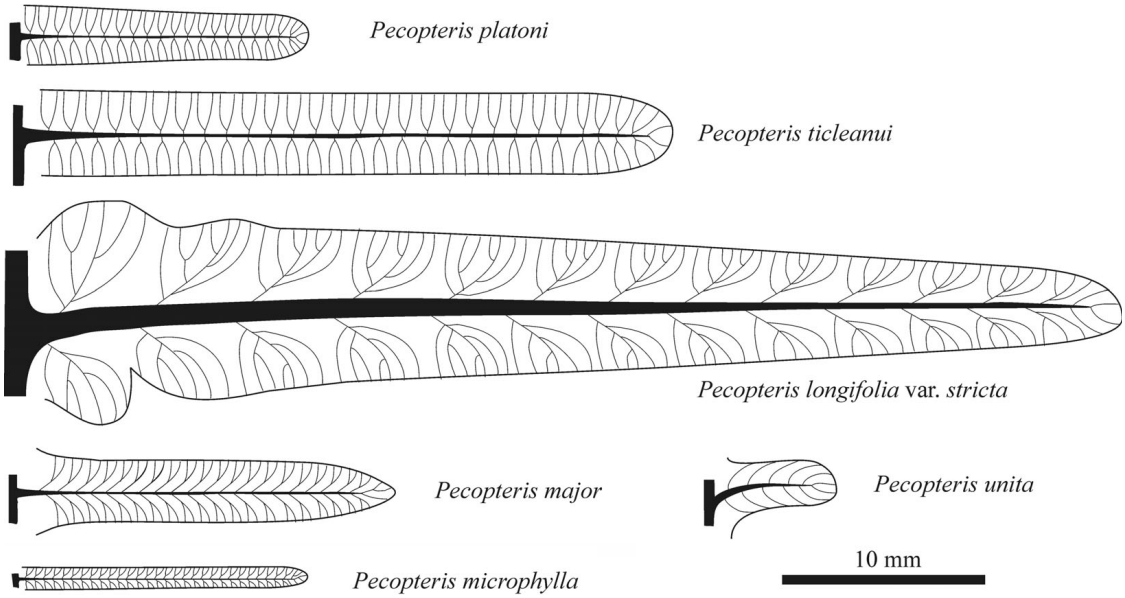

Figure 3. Morphological comparison of pinnules of *Pecopteris ticleanui* sp.nov. with similar Marattialean species.

Some authors consider *Desmopteris alethopteroides* (Ettingshausen) Stur a synonym of *D. longifolia* (Presl) Stur, while other authors consider it to be different (Libertín *et al.* 2009). Libertín *et al*. (2009) considered *Desmopteris alethopteroides* as having a herbaceous habit in Central Bohemia, the Czech Republic. Opluštil *et al.* (2009) cited *D. longifolia* from the Czech localities [for example Antonín Uxa Mine, Obránců Míru Mine (both in the Pilsen Basin) and from Svinná locality and Ovčín open cast mine in the Radnice Basin], where this species is a common element of peat-forming assemblages. Both *D. longifolia* and *D. alethopteroides* are similar to the Romanian *Pecopteris ticleanui* sp. nov. material in shape and venation, but *Desmopteris* is always reported as having pinnules with a fine, dentate margin, a character which is not consistent with the Secu material. The dimensions of the newly collected material are generally smaller than those cited in the literature. In the case of *Desmopteris longifolia*, Crookall (1929) mentioned lengths between 40–90 mm, Remy & Remy (1959) mentioned lengths up to 70 mm, Cleal & Thomas (1994), almost 40 mm, while the Romanian material is 20–35 mm long. In Crookall's view (Crookall, 1929), as well as generally in Laveine (1989a, b), the base of the pinnules is slightly rounded and irregularly constricted (as mentioned by Brousmiche 1983), while in the Romanian material the base is entire. Also, with a density of the secondary venation of 17–20 veins per 10 mm, the Secu material is different than that described by Cleal & Thomas (1994), with a density lower than 15 veins per 10 mm. The density illustrated by Remy & Remy (1959) is about 11 veins per 10 mm, even lower than that cited by Cleal & Thomas (1994). Laveine (1989a, b) illustrated material with less conspicuous secondary veins than the Secu material.

The association of pecopterid ferns from Secu

Pecopterids are particularly rich in Secu, more diverse and frequent than in Lupac or anywhere else in the Reșița Basin as a result of better collecting conditions in Secu (the sterile dumps are more visibly outcropped), but also due to sedimentological factors as Secu has a more external, marginal position when compared to Lupac. We have attempted to redescribe pecopterids from Secu based on published and new material. Nevertheless, the taxa recorded by previous authors are difficult or impossible to review as many papers include only taxa lists (Stur 1870, Hantken 1878, Humml 1963, Bițoianu 1974), and rare illustrations (Bițoianu 1973, 1987, 1988; Negrea 1987; Dragastan *et al.* 1997) or even rarer descriptions (Mateescu 1957, Maxim & Petrescu 1970, Popa 2001). Moreover, most of the material collected and published by the previous authors has been lost, except for that of I. Maxim, H. Humml, I. Preda and M.E. Popa. It is possible to recognize 27 pecopterid taxa.

In Secu it is possible to find the following pecopterid taxa: *Acitheca ambigua* (C. Presl *in* Sternberg) Němejc, *A. polymorpha* (Brongniart) Schimper, *Lobatopteris miltoni* (Artis) Wagner, *Pecopteris affinis* Sternberg, *P. arborescens* (Schlotheim) Schlotheim *ex* Brongniart, *P. bredovii* Germmar, *P. candolleana* Brongniart, *P. cyathea* (Schlotheim) Stur, *P. densifolia* (Göppert) Weiss, *P. hemitelioides* Brongniart, *P.* (*Polymorphopteris*) *integra* (Andrae) Schimper, *P. jongmansii* Wagner, *P. lepidorachis* Brongniart, *P. monyi* Zeiller, *P. oreopteroides* Brongniart, *P. palaeacea* Zeiller, *P. pectinata* Corsin, *P. permica* Němejc, *P. platoni* Grand'Eury, *P. pseudobucklandii* Andrae,

P. pseudooreopteridia Potonié, *P. raconensis* Němejc, *P. rarinervosa* Corsin, *P.* (*Danaeites*) *saraefolia* Bertrand, *P. unita* Brongniart, *P. villosa* Brongniart and *P.* (*Polymorphopteris*) *subelegans* (Potonié) Wagner.

Notes on the Carboniferous stratigraphy of the Secu area

Previous authors attempted phytostratigraphic studies of the Carboniferous deposits in the Reșița Basin. The most important are those of Bițoianu (1973, 1974, 1988), and Dragastan *in* Dragastan *et al.* (1997). The stratigraphical range of the pecopterid species from the Secu area are shown in Fig. 4. Based on the flora in the Secu area, Dragastan *et al.* (1997) identified Duckmantian deposits based on the occurence of *Sphenophyllum majus* Bronn or *Paripteris gigantea* (Sternberg) Gothan, Bolsovian deposits were identified based on the occurence of *Alethopteris serlii* (Brongniart) Goeppert and Asturian deposits based on the occurence of *Neuropteris ovata* Hoffman, and in the Lupac area, he recognized also Stephanian B and C sediments. However, Popa (2005) collected in the Secu area only Stephanian plant fossils such as *Alethopteris zeillerii* Ragot, *Nemejcopteris feminaeformis* (Schlotheim) Barthel or Sphenophyllum oblongifolium (Germar) Unger. Pecopterids described from Secu more or less support this suggestion. The Duckmantian and the Bolsovian ages are supported only by the occurrence of *Lobatopteris miltoni.* The Asturian age may be represented by several species such as *Pecopteris* (*Danaeites*) *saraefolia*, *P.* (*Polymorphopteris*) *integra, Acitheca ambigua, P. villosa, P. raconensis* and *P. palaeacea.* The Stephanian B and C may be represented by *Pecopteris pseudobucklandii, P. pseudooreopteridia, P. jongmansii, P. permica* and *P. subelegans.* The remaining pecopterids from the Secu locality have a relatively wide stratigraphical range, from the Asturian to the Permian. Nevertheless, these species are associated together with pecopterids which are characteristic for Stephanian B and C. Based on this fact, the other pecopterids probably represent the Stephanian B and C rather than the Cantabrian or the Barruelian. The Duckmantian and the Bolsovian contain 1 pecopterid taxa, nevertheless the presence of this stratigraphical position is documented by the occurrence of some biostratigraphically important species such as *Sphenophyllum majus, Paripteris gigantea* or *Alethopteris serlii.* The Asturian contains 6 pecopterid taxa accompanied by *Neuropteris ovata* and the Stephanian B and C contain 20 pecopterid taxa associated with *Alethopteris zeillerii, Nemejcopteris feminaeformis* or *Sphenophyllum oblongifolium,* while the absence of large lycopsids in Secu confirm this classification.

The rapid development of pecopterid taxa across the Asturian-Cantabrian boundary was mentioned by Phillips

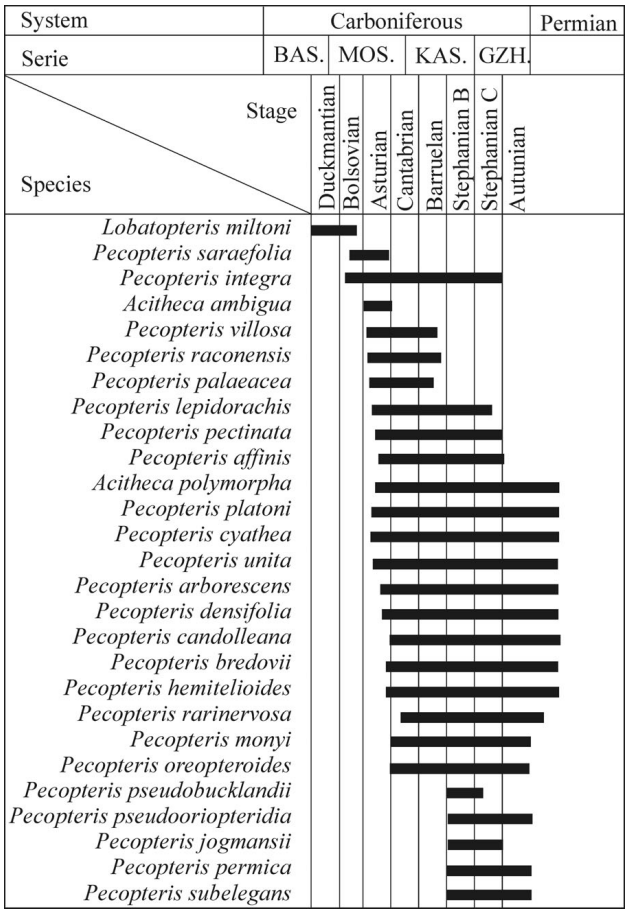

Figure 4. Stratigraphic ranges of the pecopterid species occurring in the Secu area. BAS. – Bashkirian; MOS. – Moscovian; KAS. – Kasimovian; GZH. – Gzhelian.

et al. (1985). This boundary is characterized by a rapid change when the arborescent lycopods almost died-out while species variability of tree-ferns rapidly increased. This effect is also visible in the Secu locality, as the Duckmantian, the Bolsovian and the Asturian intervals are characterized by 7 taxa, while the Stephanian is characterised by 20 taxa. This major change in plant diversification must have been a reaction to a significant, probably global, climate change.

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