The Kimmeridgian Flora of Segelhorst, Northern Germany (Niedersachsen)

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The Kimmeridgian Flora of Segelhorst, Northern Germany (Niedersachsen)

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Abstract

A medium size fern dominated flora from the northern part of Germany is described. Two new combinations are made; *Cladophlebis geinitzii* (DUNKER) nov. comb. and *Ginkgoites regnellii* (TRALAU) comb. nov.. This flora is comparable with Kimmeridgian floras of France and to a lesser degree with that of Scotland. A comparison with the Berriasian flora's of NW Europe is also made. The climatic implications of these comparisons are discussed.

Key words: Upper Jurassic, Europe, Macroflora,

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1 Introduction

We describe and illustrate here a Flora from the Kimmeridgian of northern Germany, which shows a botanical affinity with some floras of the same age as well as with the flora of the younger Wealden series from Germany, Belgium, France and England. The flora is dominated by ferns; other plants form a minor element. The age is given as Kimmeridgian and a pollen analytical investigation has corroborated this age. We were given this collection by the collector, Mr. Kurt Wiedenroth, from Garbsen near Hannover.

2 Material and methods

The material was collected in a big sandstone quarry named Riesenberg near Segelhorst not far from Hannover. The age was mentioned as Kimmeridgian (Corroborated by a palynological analysis by Dr. C. Heunisch from the Geological survey in Hannover).

The material is preserved as heavily coalified impressions in a medium to fine sandstone. Locally the coal is replaced by iron. In one case only (U24510) some shaley material was present; here the fossils, although easily identified as *Sphenopteris fittonii* and *Cladophlebis dunkeri*, and thus the same as in the sandstone, were rather different in preservation; they were thicker, pointing to leaves with some substance. It was impossible to prepare cuticle preparations, which is a serious drawback in the making of identifications.

The material was therefore only studied by handlenses and dissecting microscope. Photographs were made with a Samsung WB 1000 camera. The material is stored in the collection of the Laboratory of Palaeobotany and Palynology of the Utrecht University under the numbers U24450-U24553.

3 Systematics

3.1 Equisetophyta

Equisetites **sp.?**

Description: Material used: U 24458, U24477. Some imprints of longitudinally striped or grooved axes give the strong impression of material of Equisetites. However, since no nodal structures are found, a definitive assignment to this genus is impossible.
Distribution: Material of Equisetites has been found in the late Jurassic of Sweden (Tralau 1966), Germany (Wilde & Schultka 1996), Belgium (Seward 1900), Portugal (Heer1881), England (Seward 1913), and Scotland (Seward 1911, van der Burgh & Konijnenburg-van Cittert 1984),

3.2 Filicophyta

Sphenopteris fittonii **SEWARD (Pl. 1, fig. 1-4, P. 2, fig. 1-2)**

Description: Material used: c. 20 specimens. Frond tripinnate, rachis thin, straight. At the upper side a ridge in the middle, up till 2 mm. wide. The insertion of the pinnae is alternate, the angle with the rachis is ca 60°. The shape of the greatest entire specimen is triangular, with a greatest length of 120 mm and a greatest width (at the base) of 100 mm (U24492). However, some fragments point to a much larger and more elongate shaped frond, with a length-width relation of 2-3 to 1 (U24454, U24534).
The organization of the pinna is anadrome, the lowermost acroscopic pinnule is enlarged, ca 1.5-2 x larger than the following pinnules (U24450, U24453, Pl. 1, fig 1, 4). The lower pinnules in the frond are lobed (U24454, Pl. 2, fig.1), the pinnules in the middle of the leaf more dentate, the upper ones entire (U24453, Pl. 1, fig.4). The base of the pinnules is constricted, the shape is elongate, up to 3 mm long and up to 1mm wide. The venation is an acroscopic dichotomous division of a single basal vein ((U24451, U24452, Pl. 1, fig.2, 3).
Apart from this material some also ultimate anadrome pinnae with differently shaped pinnules were found. They are constricted at the base, only spreading in the distant half of the pinnule, and slightly reduced in size (Pl.2, fig. 2). Although they are strongly suggestive of fertile material, no spores could be isolated: U24455, U24558, U24480. In some cases the venation of the pinnules could be studied. This is about the same as in the above described "sterile" pinnules and could be followed up to the apex of the pinnules, ending at the apex and not at the margin.
In some cases material in the "sterile" pinnae was suggestive of a transition to this "fertile" material: no. U24458, U24465, U24479, U24507, U24514.
Discussion: Among the ferns known from the end of the Jurassic and beginning of the Cretaceous this species is closely comparable with *Sphenopteris fittonii*, described and depicted by Seward 1894. The character-pair anadrome-katadrome is not mentioned

in the older literature, also not by Seward. However, in his plate VI fig. 2 and especially on his plate VII, fig. 1, the anadrome nature of this species is depicted.
In other respects no differences are found and, therefore, our material has been assigned to this species. Seward (1894) mentioned and depicted also a small specimen with more divided pinnules and truncate lobes (his no. 2327a, page 110-111). Our material has no likeness with it and we doubt whether this material is conspecific with the other material of *S. fittonii* described by Seward.
Sphenopteris cordai (DUNKER) SCHENK 1871 has some likeness to our material; however, the venation as shown in his fig. 2a is different from that of our material. Another also anadrome fern showing affinity is *Sphenopteris* sp. described by Konijnenburg-van Cittert & van der Burgh (1989). However, this fern is not pinnate and also the shape and venation of the pinnules is different. *Sphenopteris compacta*, (SAPORTA) BARALE from the French Kimmeridgian, redescribed by Barale (1981) shows some anadrome characters, but the pinnules are much smaller than those of our material. Also the *Sphenopteris lithographica* BARALE (1981) from the French Kimmeridgian is different, especially in the shape of the pinnules which are nearly connate.
The basal parts of the pinnae bear larger pinnules, which are often lobed and show their venation more or less clearly. The most occurring material is from more apical frond parts with smaller pinnae. The least occurring are the "fertile" pinnae with their reduced truncate pinnules. Taken together we get here a picture of a type of fern with leaf dimorphism, adjusted to the circumstances at the habitat. If we add the observation that the leaf was rather thick, the conclusion must be that we here have a type of fern, occurring under (partly) dry circumstances.
Distribution: Germany (Pott et al. 2014), Belgium (Seward 1900), France (Carpentier 1927), England (Seward 1894), Spain (Diéguez & Melindez 2001), .N. China (Wu, Sheng 2000-2001). Halle (1913) mentions some material from the southern hemisphere.

***Sphenopteris* sp. 1 (Pl. 4, fig. 1)**

Description: Material used: No U24458, U24503. The sterile material consists of two pinnae, the most complete is straight, and bears 12 pairs of pinnules. The other pinna is slightly curved, with 7 pinnules and the base of another pinnule. The pinnules are inserted with an angle of 35 °, the lower ones are slightly lobed and between 3 and 5 mm in length. The venation consists of an acroscopic, dichotomously one or two times divided single vein, the tips do not reach the margin.
Discussion: This material is not known from the literature. Based on the shape of the pinnules and their venation they are assigned to the genus *Sphenopteris*.

***Sphenopteris* sp. (2 Pl. 4, fig. 2)**

Description: Material used: U 24458, U24459. Two pinnae of 13 and 15 mm in length respectively, both bear more or less transversely extending elliptic pinnules, 3-

5 mm long and contracted at the base. They look like fertile pinnules, but due to their much-coalified preservation no further observations could be made.
Discussion: In the literature no material could be found that could be matched with ours. Therefore it is described as *Sphenopteris* sp.

Cladophlebis dunkeri (SCHIMPER) SEWARD (Pl. 3, fig. 1, 2)

Description: Material used: no. U 24450, U24451, U24452, U 24456, U 24457, U24473, U24490, U24496, U24500, U24502, U24522.
Frond at least tripinnate. Rachis thin, straight, up till 3 mm wide. The shape is elongate, the secondary pinnules can be rather long (up to 100 mm).
The pinnae are inserted at an angle of ca 60-70°, the penultimate pinnae are alternating, the ultimate pinnae nearly opposite. The organization is katadrome; however, the first acroscopic pinnules tend to be enlarged in comparison to the other pinnules of a pinna.
The often bulging pinnules are entire, the shape is rounded, the length is 1-2 mm, the width ca 1-1.5 mm (Pl. 3, fig. 1), the laminae are connected along the rachis of the ultimate pinnae. At the apex of a pinna, the pinnules become fused to a short, crenulate apical pinnule (Pl. 3, fig. 1, 2). The venation consists of a short primary vein with once divided secondaries.
Discussion: This fern is also known from the Wealden Formation, both from Great Britain and Germany. The material agrees beautifully with the description and figures by Dunker 1846 and Schenk 1871. Therefore our material is assigned to this species. *Pecopteris dunkeri* was renamed *Cladophlebis dunkeri* by Seward (1894). According to Radforth and Woods (1950) material referred to this species contained Schizaeaceous spores (cited in Watson 1969). Based on the description and figures in van Amerom et al. 1976, there is a fair possibility, that their *Cladophlebis (Gleichenites* ?) sp. can also be attributed to this species, especially as their figure 13B gives a representation of a katadrome fern with the first basiscopic pinnule being shorter than the first acroscopic pinnule.
The often bulging pinnules point to a rather thick and coriaceous lamina, which can be interpreted as an adaption to rather dry circumstances.
Distribution: Germany (Schenk 1871, Michael 1936, Benda 1962), Netherlands (van Amerom et al. 1976), Belgium (Seward 1900), France (?) (Carpentier 1927), England (Seward 1894, Watson 1969)

Cladophlebis geinitzii (DUNKER) nov. comb. (Pl. 4, fig. 3, 4)
Basionym: *Pecopteris geinitzii* DUNKER 1846

Description: material used: U 24460, U24477, U24489. This material consists of a fragmented at least bipinnate frond; length of the remains c. 90 mm, width c. 70 mm, and a fragment of a frond with a number of ultimate pinnae. The main rachis is straight and thin, ca 1 mm thick. The secondary pinnae are inserted at an angle of c. 60 °, their length is up to 50 mm. The organization is katadrome. The pinnules are in

between a pecopterid and a sphenopterid shape, they are inserted at an angle of about 60 ° and their shape is falcate, with a length of 2-3 mm. Their margin is entire or crenulate.

Discussion: This material is comparable with descriptions and figures of *Pecopteris geinitzii* by Dunker 1846 (p. 6, 7, Pl. 8:3), and Schenk 1871 (p.13, pl 8: 2). Therefore, our material is assigned to this species. Seward (1894) renamed *Pecopteris geinitzii* as a species in his provisional genus *Nathorstia*: *N. valdensis*. However, *Nathorstia* is now recognized as genus for certain fertile Matoniaceae. As *Pecopteris* is in Mesozoic deposits replaced by *Cladophlebis* for ferns of which the systematic position is not clear, but with a more or less broad attachment of the pinnules, we propose the new combination *Cladophlebis geinitzii*.

Distribution: Germany (Dunker 1846, Schenk 1871, Michael 1936, England (Seward 1894)

***Ruffordia goeppertii* (DUNKER) SEWARD (Plate 5, fig. 1, 2)**

Description: Material used: U24460, U24461. The frond is tripinnate, triangular, with a broad base (60-70 mm) and the same length. The pinnae are slightly curved; the rachis is thin, ca 1 mm wide. The secondary pinnae are alternatingly inserted. The pinnules are lobed, the lobes are narrow and elongated. The base is contracted, sphenopterid. The lamina is thin, the venation is easy visible, bifurcating. The pinnules are up to 10 mm long and up to 3 mm wide.

Discussion: This material is comparable with that described and depicted by Dunker 1846 (p. 4, pl. 9: 1-3.), Schenk 1871 (p. 7, 8, pl. 4: 2-7) and Seward 1894 (p. 81-86, pl 4, 5, 6: 1). Therefore it is ascribed to this species. Seward named the specimens with wider pinnules var. *latifolia*. However, he pointed out, that there are transitions to the forms with narrower pinnules. This view is also adopted by Watson 1969. Furthermore there is a strong likeness to *Sphenopteris jugleri* ETTINGSHAUSEN (Ettingshausen 1852), which was already unified with the present species by Schenk (1871).

Distribution: Sweden(Tralau 1966), Germany (Dunker 1846, Schenk 1871, Michael 1936, Pott et al. 2014), Netherlands (van Amerom et al. 1976), Belgium (Seward 1900), Austria (Ettingshausen 1852), England (Seward 1894, 1913, Watson 1969), Spain (Diéguez & Meléndez 2000), but also In N. China (Wu, Zheng, 2001-2002) and Brazil (Mohr et al. 2015)

3.3 Coniferophyta

***Podozamites* sp. (Pl. 7, fig. 2)**

Description: Material: U24460, U24465 (with three leaves attached to an axis), U24517 (with one dispersed leaf). The elongate leaves have short petioles (2 mm) and are lanceolate in shape and relatively short, c. 25-30 mm or more long and 5-9 mm wide; the venation is strictly parallel. As no cuticle could be obtained a further characterization of the leaf is impossible.

Discussion: Superficially this plant fossil is comparable with material described by Barale (1981) for France as leaf incertae sedis. However, he describes the venation as at least partly ending at the margin of the leaves. Therefore, he could not assign them to *Podozamites* as Saporta (1875) did. Our material is strictly parallel-veined and therefore can be assigned to the genus *Podozamites.*
Distribution: *Podozamites* is known from many deposits all over the world, ranging from Early Jurassic to Early Cretaceous in age.

***Pagiophyllum* sp. (Pl. 6, fig. 1)**

Description: Material used: U24467. Some short branches are present with not very well preserved, sessile, thick leaves. The attachment of the leaves is nearly transverse to the stem. The length of the leaves varies from 4 mm to 7 mm. and they are apparently implanted very close to each other.
Discussion: Material with this arrangement of needle-like leaves is known from several places in the upper Jurassic of Europe and placed in the genus *Pagiophyllum.* Due to the condition of the material no further identification could be made
Distribution: *Pagiophyllum* is known from Belgium (Seward 1900), France (Carpentier 1927, Barale 1981), Portugal (Heer 1881), England (Seward 1894)

***Brachyphyllum obesum* HEER (Pl. 6, fig. 2-4, Pl. 7, fig.3)**

Description: Material used: U24458, U24460, U24463, U24465, U24466, U24484, U24504. Short, often branched com/impressions are present on a number of specimens from this locality. Most leaves appear to be short and scale-like, they are spirally arranged, certainly not oppositely attached (Pl. 7, fig. 3). They must have been thick, maybe more or less woody. In some cases they are longer and stand out as small triangular, free leaves (Pl. 6, fig. 2,3). When in the right position, the leaves can show a keel on the ventral side (Pl. 6, fig. 2). In two cases (U24458, U24504) the remains of a cuticle were visible, showing longitudinal lines of 'ringed' stomata. The rings consisted of 7 apparently thickened cells (Pl. 6, fig. 4).
Discussion: The stouter branches within our material show triangular, keeled leaves. With respect to the smaller branches, the most agreement is with *Brachyphyllum obesum* Heer, especially the material depicted by Seward (1895) on his plate 20 figs. 3 and 4, where both specimens show some longer triangular leaves, next to short scale like leaves. This is what we also find in our Segelhorst material. So we identify our material as belonging to this species. With respect to the cuticle-fragments, the botanical affinity is most likely with the Araucariaceae
Distribution: *Brachyphyllum* is found in Upper Jurassic and Lower Cretaceous deposits all over Europe: Germany (Schenk 1871, Michael 1936) , Netherlands (van .Amerom 1976), France (Saporta 1884, Carpentier 1927), Portugal (Heer 1881), England (Seward 1894), Scotland (Seward 1911, Konijnenburg-van Cittert. & van der Burgh 1989)

Pinites **sp. (Pl. 7, fig. 1)**

Description: Material used: no. U24464, U24479. Needle-like leaf that is c.1mm broad and up to 40 mm long (longest measured is 38 mm, Pl. 7, fig. 1). A mid-vein is present, no other details could be observed.
Discussion: This material looks like the needle of the genus *Pinus*, however, no sustaining evidence could be obtained from our material. *Pinites solmsii* with needle-like leaves is described from the Wealden deposits in England.
Distribution: England (Seward 1895), France (as *Tritaenia* sp.?)(Carpentier 1927).

Tritaenia **sp. (Pl. 6, fig. 5)**

Description: Material used: U24460. A rather long (98 mm) lanceolate leaf with one thick mid-vein is encountered in our material. The width is 5 mm at the base; it is rather thick and of a coniferous nature.
Discussion: This leaf is compared with *Tritaenia scotica* and *T. linkii* from respectively Kimmeridgian deposits in Scotland and Callovian deposits in Germany. As no cuticle could be prepared the assignment is only provisionally.
Distribution: *Tritaenia* is known from Upper Jurassic and lower Cretaceous deposits of the northern part of the world, e.g. Germany (Dunker 1846, Schenk 1871, Michael 1936, Wilde 1991), Scotland (van der Burgh 1987, Konijnenburg-van Cittert & van der Burgh 1989), Greenland (Bose & Manum 1990)

3.4 Ginkgophyta

Ginkgoites brauniana **(DUNKER) WATSON et al. 1999 (Pl. 8, fig. 8)**

Description: Material used: U24468. The leaf is deeply incised, almost to the base. The lobes are incised again and the resulting lobes can also be incised. The ultimate lobes tend to be broadest just beneath the tips, which are rounded. The venation could not be observed. The shape of the leaf is rather wide c. 27 mm, by a length of c.26 mm.
Discussion: This leaf is comparable with material from the German Bückeburg (Wealden) Formation, described as *Ginkgo* or *Baiera brauniana*. From these Ginkgophytes no reproductive structures are known. Watson et al. (1999) made clear that it is impossible to distinguish between *Ginkgo* and *Baiera* on the shape of the leaves alone, especially when the venation is not clear. Therefore, they used the old genus *Ginkgoites* of Seward for Ginkgophytes of which the systematic position is not clear. In this we follow them and assign our material to *Ginkgoites brauniana.*
Distribution: *Ginkgoites* (*Baiera*) *brauniana* is known from Northern Germany (Dunker 1846, Schenk 1871), England (Watson), Scotland (Konijnenburg-van Cittert & van der Burgh 1989)

Ginkgoites regnellii **(TRALAU) comb. nov. (Plate 8 : fig. 4, 6)**
Basionym: *Baiera regnellii* TRALAU 1966

Description: Material used U24470, U24471, U24484. Four specimens with deeply divided lamina show a differentiation in the division of the lobes. The first and second divisions are symmetrical, but the third division only occurs in the outer lobes, resulting in only three lobes in half a leaf (Pl. 8, fig. 4). The tips of the lobes are rounded (Pl. 8, fig. 4), the number of veins in the middle of the lobes varies between 3 and 6. The leaves have a long, sometimes slightly curved petiole (pl. 8, fig. 7).
Discussion: This peculiar division is known from a species described by Tralau (1966) as *Baiera regnellii* from the Kimmeridgian of southern Sweden. Our material shows fewer veins per lobe, but the shape and the tips of the lobes and leaf are very much alike, therefore, we assign our material to this species. Following Watson et al. (1999) (see above) we rename the species as *Ginkgoites regnellii*.
Distribution This species is only known from the Kimmeridgian deposits of S. Sweden.

***Ginkgoites* sp. (Plate 8, fig. 3, 7)**

Description: Material used: U24464 (2 impressions), U24471, U24472, U24478, U24486. The impressions of this species show more or less clear venation. Specimen U24486 bears a very narrow nearly complete leaf with clear venation (Pl. 8, fig 7). The length of the fragment is 21 mm, its width 5 mm. The impression on specimen U24472 is less complete. The lamina of the leaf is rather narrow, deeply incised, almost to the base. The two resulting lobes are less deeply incised. The maximum width of the leaf is 18 mm; the total length (with petiole) is c. 47 mm. The leaf on specimen U24464 was also incomplete, the petiole and the tip of the lamina are lacking. The venation however, is very clear (Pl. 8, fig. 3). From the base of the lamina 4 veins extend towards the tip; they bifurcate at least 2 times, one bifurcation is positioned near the base of the leaf just below the central incision, the other at the base of the division of the lobes. The maximum width of the lamina is 12 mm, the length only 15 mm. A second impression on specimen U24464 shows repeated incisions, but no clear venation. Its length is 20 mm, its width 13 mm..
Discussion: The leaves are more or less comparable with those described as *G. pluripartitus* as described by Pott et all (2014). However, the venation is different as the veins bifurcate quite at the base of the leaf. Moreover the tips of the lobes are narrower; in this respect they are more comparable with *G. brauniana* (see above). Based on the rather narrow shape of the leaves they are considered as specifically different. At present no species is known in the literature to which they can be assigned.
Distribution: *Ginkgoites* spp comparable with the above described material are known from Sweden (Tralau 1966), Scotland (Seward 1911, van der Burgh 1987), Germany (Dunker 1846, Schenk 1871, Michael 1936, Benda 1962), Austria (Ettingshausen 1852), and France (Carpentier 1927)

Sphenobaiera **sp. (Pl. 8, fig. 2, 5)**

Description: Material used: U24467, U24469. Leaf once divided, with strong veins, which divide at the base. The fragment on U24467 is incomplete, 30 mm. long and 7 mm wide. The base is not complete, it ends in a point, no traces of petiole are visible, but also not of an attachment scar. U24469 contains a shorter fragment, also without petiole, the division of the veins could not be observed, at the base a abscission scar is present.
Discussion: This type of leaf without petiole is known from *Sphenobaiera*. Therefore, these leaves are assigned to this genus; however, a specific assignment is impossible.
Distribution: *Sphenobaiera* is known from upper Jurassic deposits in Franconia (Germany)

Pseudotorellia sp. **(Pl. 8, fig. 1)**

Description: Material used: U24467. A linear to lanceolate leaf without a petiole and a more or less rounded apex. The weak venation of the leaf is predominantly parallel. This venation has apparently originated from dichotomies of the three veins that are present at the base. The leaf is only 40 mm. long and at the utmost 5 mm wide. At the only 2 mm wide base are remains of an attachment scar visible (Pl. 8, fig. 1). In the same specimen is a second fragmentary impression, only 23 mm long and up to 5 mm wide. The base is also very narrow, 2 mm wide.
Discussion: Several Ginkgophytes with linear to lanceolate leaves are present in the Mesozoic from Europe. From these only *Pseudotorellia* survives into the Cretaceous. Most of the species of this genus do not show much variation in the shape and length of the leaves. An exception is formed by *Pseudotorellia heterophylla* which is described as 12 to 30 mm long; it is the most variable in length of all known species of this genus. However, due to the absence of cuticle preparations we refrain from assigning it to any described species.
Distribution: the genus is known from the English Wealden (Watson 1969).

3.5 Cycadophyta

Pterophyllum **sp. 1 cf** ***Pterophyllum fontarianum*** **WATSON et SINCOCK (Pl. 9, fig. 1-3, Pl. 10, fig. 2)**

Description: Material used for description: specimen U24460 (2 impressions), U24468, U24473, U24474, U24481, U24526, U24530, U24533. Leaves pinnate, length unknown, (the longest fragment 23.5 cm long), consisting of an up till 5 mm wide axis, bearing long linear leaflets up till 100 mm long. Their apex is tapering to a blunt tip. Most of them are attached with an angle of 90° to the axis, but the angle diminishes slightly to the tip of the leaf (Pl. 10, fig. 2). They are attached to the upper side of the axis (Pl. 9, fig. 2), The distances along the axis are variable, sometimes they stand next to each other with the bases touching, but they can also be placed at a distance of up to two leaf bases (Pl. 9, fig. 1, 3). The leaflets themselves have a wide

base (Pl. 9, fig. 3); the first 5 mm of the leaflet is more or less contracted and after that it widens again to form a linear leaflet unto the apical part (Pl. 9, fig. 1, Pl. 10, fig. 2). The veins are strong and easy visible; their number is between 5 and 7; no anastomoses are observed (Pl. 9, fig. 2).

Discussion: The typical base of the leaflets points rather to *Pterophyllum* which shows the contraction and the wide attachment. Therefore or material is with some reserve assigned to this genus. There is a strong likeness to the material of *Pterophyllum fontarianum* WATSON et SINCOCK (Watson & Sincock 1992), but in absence of any cuticle no definitive identification could be made.

Several fragments from this type of leaf are found at the locality, but it is impossible to reconstruct the length of the entire leaf from them.

Distribution: Cycadophyte material with similar morphology is described under several names in Late Jurassic and Early Cretaceous floras. It is known from Germany (Dunker 1846, Schenk 1867, 1871, Michael 1936, Daber 1960, Benda 1962, Pott et al. 2014), Belgium (Seward 1900) France (Carpentier 1927, Barale 1981), Austria (Ettingshausen 1852), England (Seward 1895, Watson 1969, Scotland (Seward 1911, Burgh 1987, Konijnenburg-van Cittert & van der Burgh 1989).

***Pterophyllum* sp. 2 (Pl. 10, fig. 3)**

Description: Material used for description: U24475. A pinnate leaf was found, only fragmentary and very damagedly preserved. The leaflets are attached with a broad base and are short, only c. 20 mm long. The whole fragment is 70 mm long. Nearly from the base the leaflets taper to blunt tips. They show c. 5 parallel veins.

Discussion: This material can also be assigned to the genus *Pterophyllum*. The difference with the foregoing species is clearly visible in the attachment and shape of the leaflets. A closer identification is by lack of a cuticle not possible

Distribution: see the foregoing species

***Pseudoctenis* sp. (Pl. 10, fig. 1)**

Description: Material used for description: U24470. A pinnate fragment with elongate, linear, up to 90 mm long and 5 mm wide pinnae; they show a lateral, wide and decurrent attachment to the rachis. The veins are parallel, anastomoses between the veins were not observed. Leaflets at the tip of the pinnate leaf attached at an angle of 40-30 °.

Discussion: This leaf-fragment differs from those assigned to *Pterophyllum* by the shape and place of the attachment to the rachis and the angle of the leaflets to the rachis at the tip of the leaf. These characters are known from the leaves of *Pseudoctenis*, as defined by Harris (1964), so our material has been assigned to this genus. As no cuticle is preserved, it is not possible to identify our material at species level.

Distribution: This genus is known from Germany (Benda 1962), France (Carpentier 1927), Austria (Ettingshausen 1852?), England (Seward 1913), Scotland (Seward

1911, van der Burgh & van Konijnenburg-van Cittert 1984, van der Burgh 1987, van Konijnenburg-van Cittert & van der Burgh 1989).

4 General Discussion

The amount of described floras from the Kimmeridgian of Europe is small. From the continental floras the floras from France, described by Barale (1981) are the most extensive and are also the best comparable with our flora. They are dominated by Filicophyta (15 species, *Sphenopteris* and *Cladophlebis* being co-dominant). Other elements within this flora are Pteridospermophyta (1 species), Coniferophyta (2 species), Ginkgophyta (1 species) and Cycadophyta (1 species). Our flora is also dominated by Filicophyta (6 species, *Sphenopteris* and *Cladophlebis* being codominant), and contains further Sphenophyta (1 species), Coniferophyta (5 species), Ginkgophyta (5 species) and Cycadophyta (3 species). Another Upper Jurassic flora from the neighboring regions is from Southern Germany: (Sphenophyta (1 species), Filicophyta (2 species), Pteridospermophyta (3 species), Coniferophyta (18 species), Ginkgophyta (2 species) and Cycadophyta (3 species) (Saporta apud Barale 1981, Salfeld 1907, Barale & Doludenko 1993, Schweigert 2016 (pers. comm.). As this material is deposited in fully marine deposits and abrasive working of the wash of waves has to be considered, probably resulting in the reduction of Filicophyta (ferns) and other less robust materials, no comparison is made.

The French floras and our flora have the rather small pinnules in most of the ferns in common. This and the rather thick and coriaceous nature of the other elements point to rather dry circumstances. With respect to the Ginkgophyta the near absence of them in the French floras and the scanty presence in our flora is in accordance with this probably dry climate. Our flora is deposited in a sandy delta pointing to a strong and voluminous river. Therefore, as a whole the climate must have been sufficiently humid to allow for these water-masses to assemble. Although our flora is dominated by ferns, it is typical from the preservation of the thick flat or bulging pinnules that the original plant material was rather thick and coriaceous, pointing to an at least seasonally dry climate. The presence of several Ginkgophyta genera and species, although in small numbers, points to at least locally more humid and possibly slightly cooler circumstances. A comparison with the recent mediterranean climate is, therefore, possible.

The Kimmeridgian flora of Scotland is quite different. Although also in this flora ferns are dominant (13 species), the Sphenophyta are present (1 species), Pteridospermophyta are well represented (3 species), Coniferophyta and Cycadophyta are also well represented (6 species and 7 species resp.). The Ginkgophyta are rare (2 species), but on the other hand *Czekanowskia* and *Phoenicopsis* (known as rather cold elements), are well represented. Also physiologically this flora was different, while in the ferns as well as in the Pteridosperms species with large thin-textured leaves were regularly present. This flora was possibly a little bit colder than those on the

continent, deduced from the presence of *Czekanowskia*, but the climate was not desiccating.
The comparison with Lower Cretaceous, especially Berriasian, floras of Germany, Northern France and England is not hampered by the lack of sufficient material. Interesting is in this respect the presence of the two leading fern species of our flora in these younger flora's. Also Pteridospermophyta, Coniferophyta and Cycadophyta from our Jurassic flora are comparable at least on generic-level. The same can be remarked with respect to de Ginkgophyta, but here the absence of *Ginkgoites* together with the marked abundance of ferns has to be mentioned with respect to the English floras. The overall impression of these Lower Cretaceous floras is their relative richness in species and genera of especially Cycadophyta and Coniferophyta, as well as the quantitative greater presence of *Ginkgoites* in comparison with the continental Kimmeridgian flora's, giving the impression of a qua humidity ameliorated climate.

5 Acknowledgements

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Plates

Plate 1. Fig. 2: bar 5 mm, figs 1,3,4: bars 10 mm

***Sphenopteris fittonii* SEWARD**

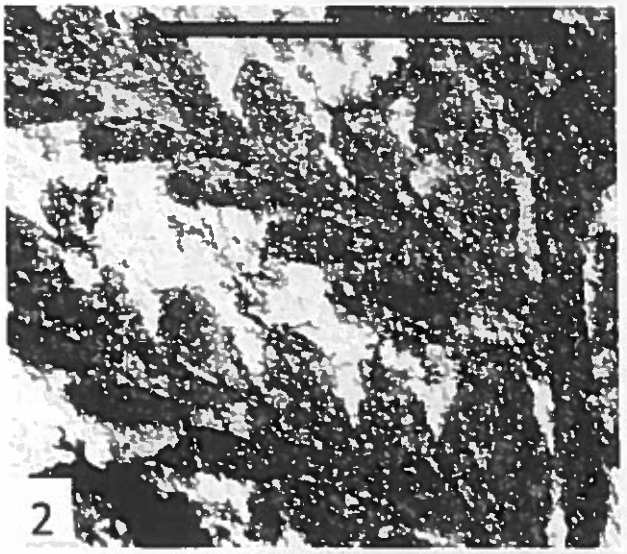
Fig.1: U24450; sterile part of a frond

fig. 2: U24451; tip of sterile frond-part with venation in the pinnules,

Fig. 3: U24452; sterile pinnules of basal part of a frond with venation;

Fig. 4: U24453; upper part of a frond

Plate 1



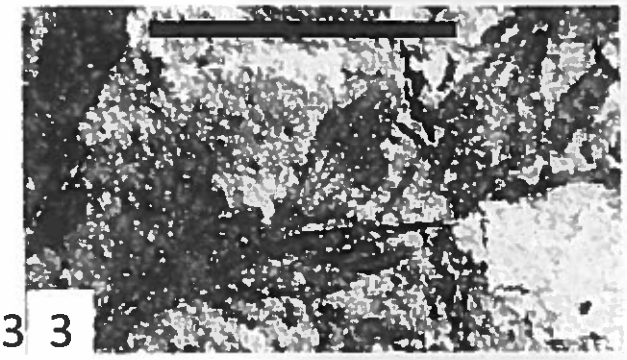


Plate 2. Bars 10 mm

Sphenopteris fittonii **SEWARD**

Fig. 1: U24454; basal part of a frond,

Fig. 2: U24455; „fertile" part of a frond

Plate 2

1

2

Plate 3. Bars 10 mm

***Cladophlebis dunkeri* (SCHIMPER) SEWARD,**

Fig. 1: U24456; part of a frond with bulging pinnules

Fig. 2: U24457; basal part of a frond

Plate 3

1

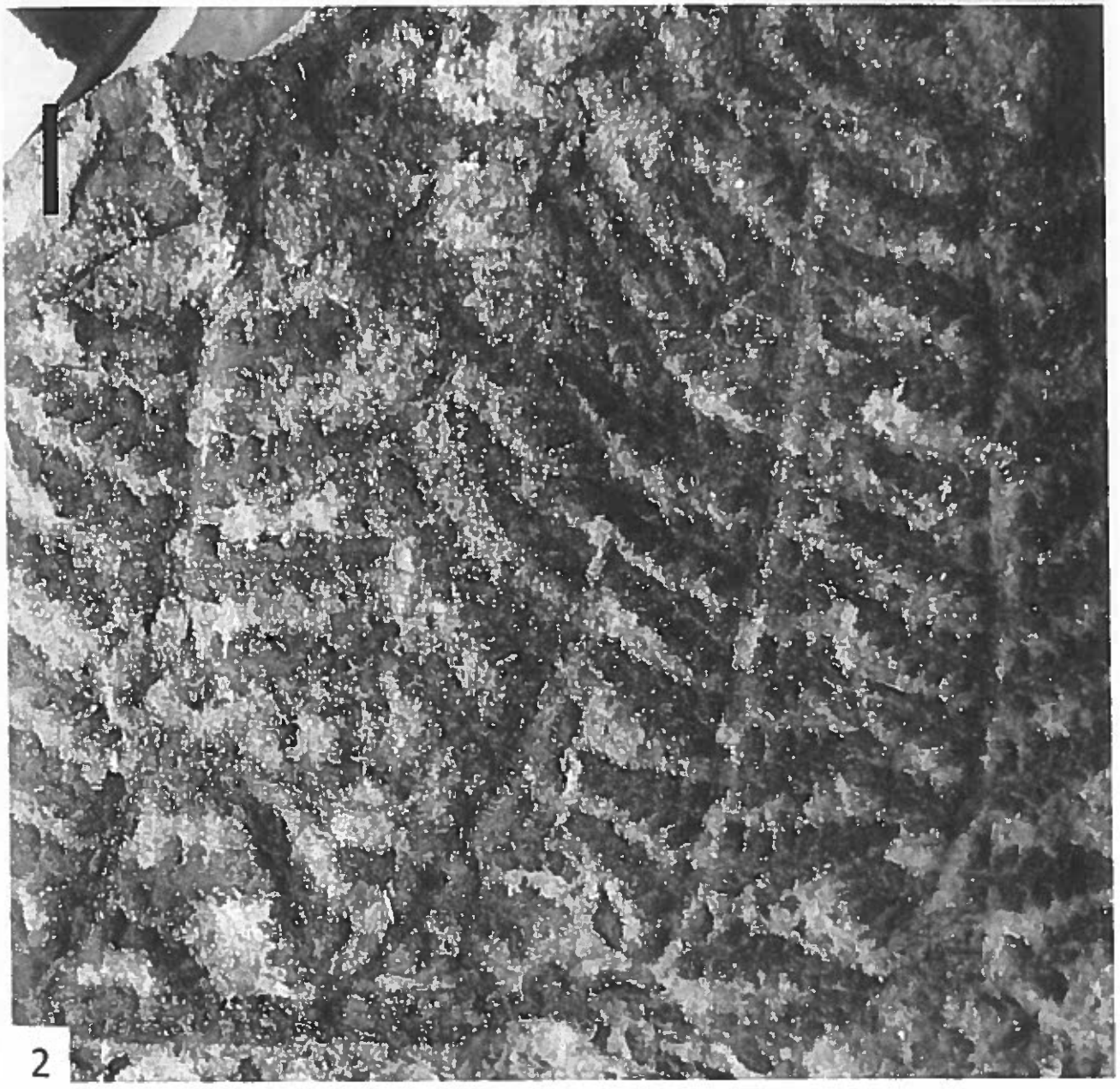


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Plate 4.Bars 10 mm

Sphenopteris **sp. 1**

Fig. 1: U24458; ultimate pinna with pinnules

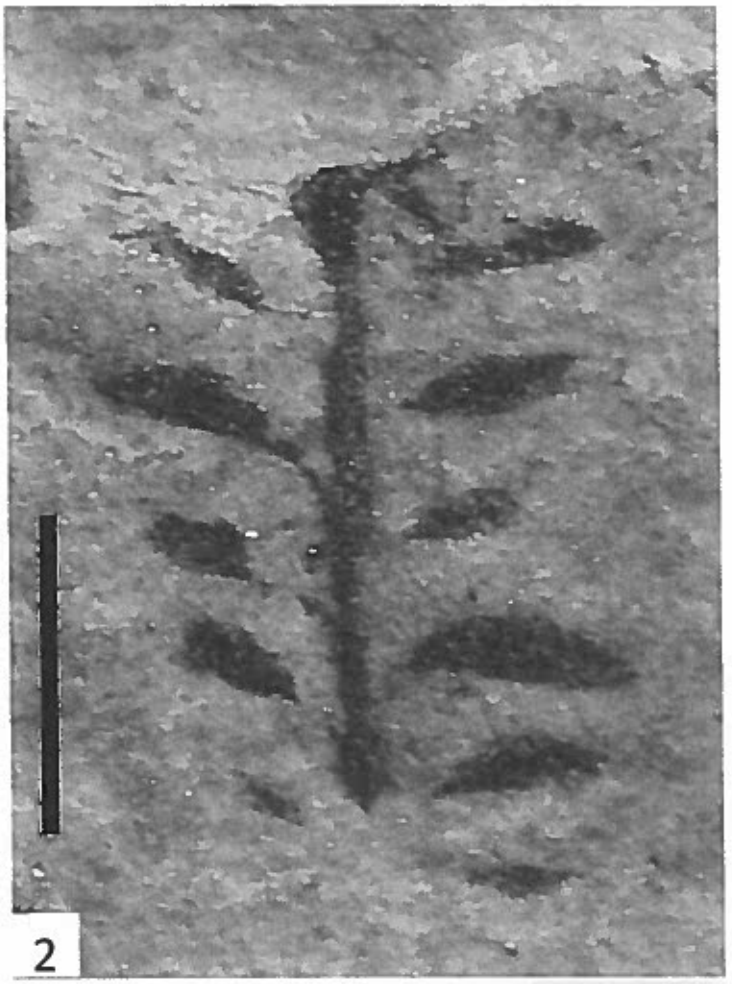
Sphenopteris **sp. 2**

Fig. 2: U24459; ultimate pinna with pinnules

Cladophlebis geinitzii **(DUNKER) nov. comb.,**

Fig. 3: U24460; part of a frond with remains of penultimate and ultimate pinnae

Plate 4



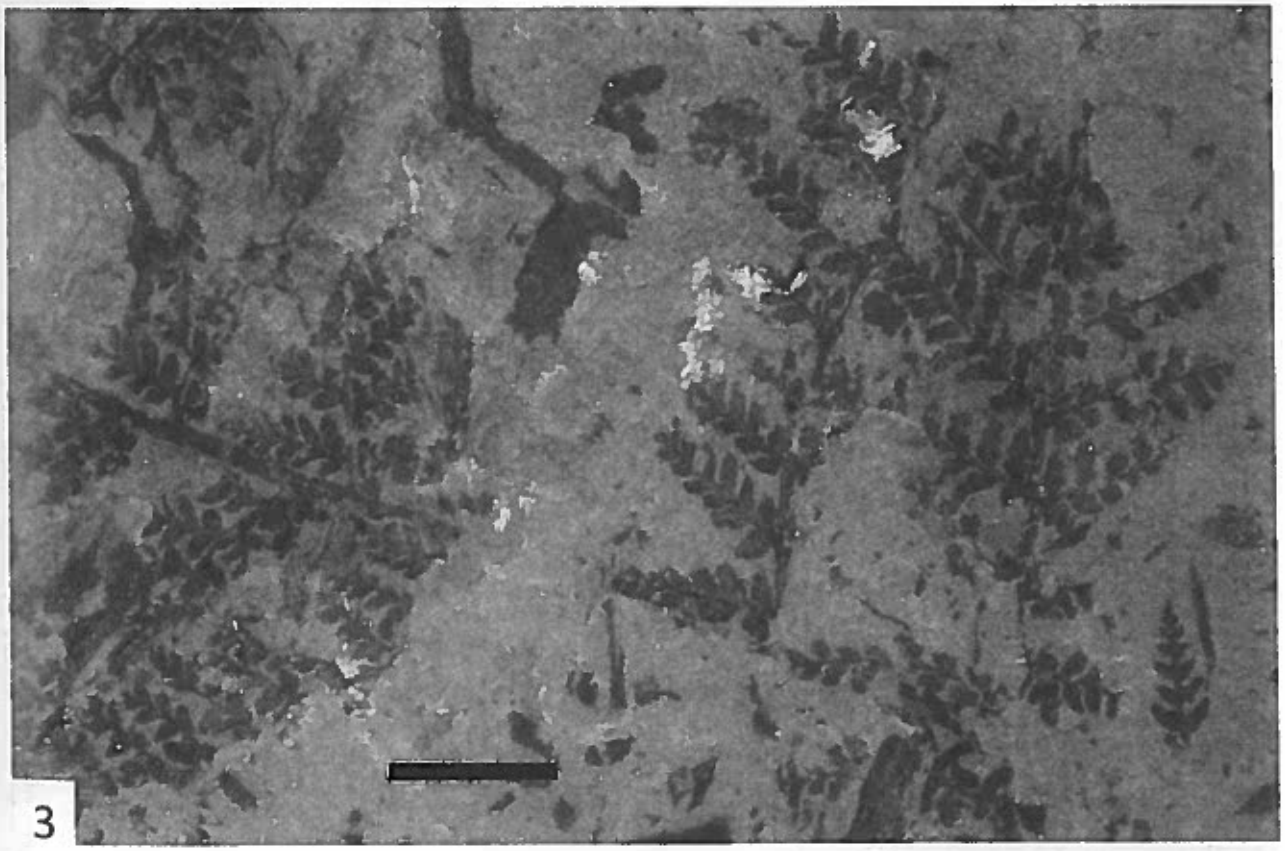


Plate 5. Bars 10 mm

***Ruffordia goeppertii* (DUNKER) SEWARD**

Fig. 1: U24460; frond with narrow pinnules

Fig. 2: U24461; frond with wide pinnules

Plate 5

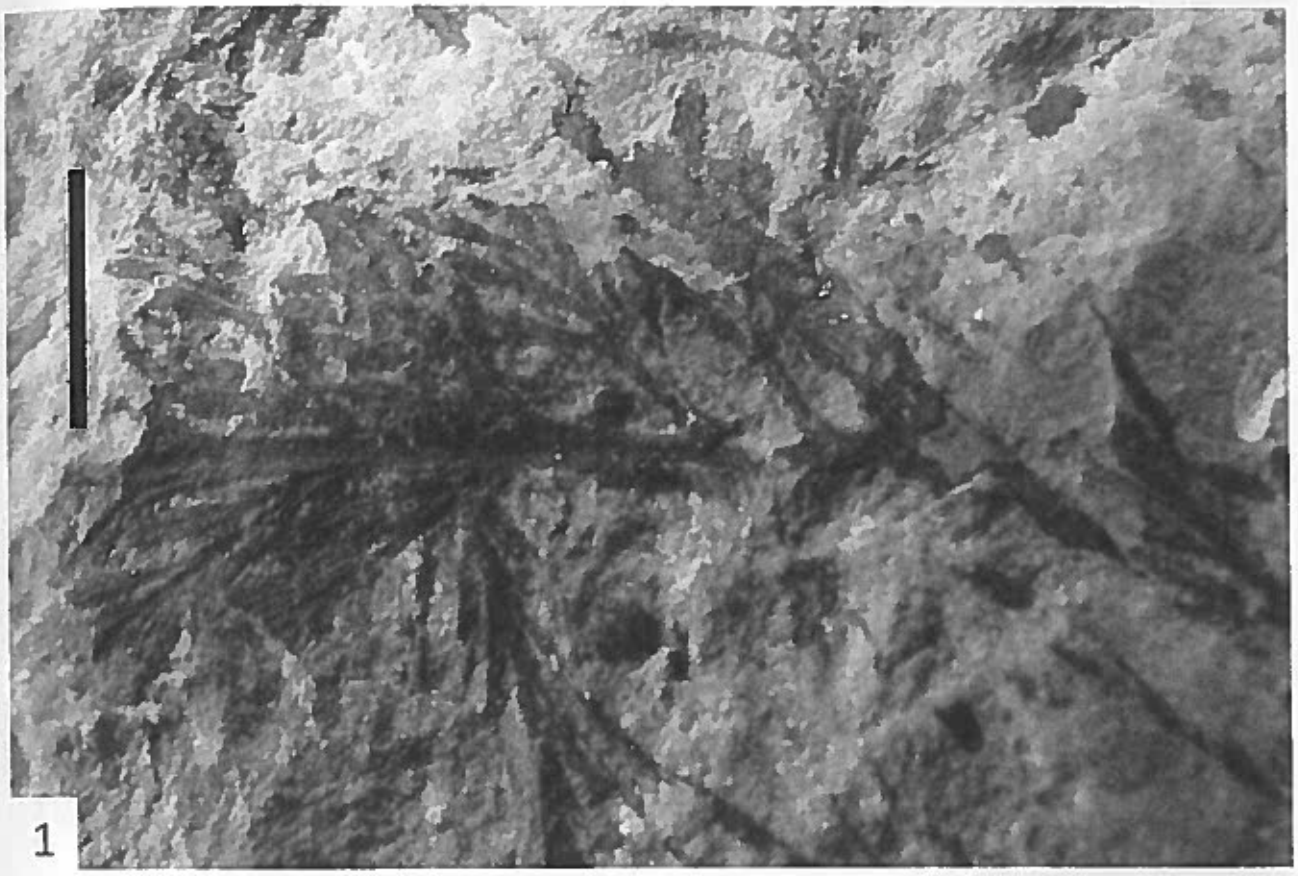


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Plate 6. Bars 10 mm

***Pagiophyllum* sp.**

Fig. 1: U24467; branch with transverse orientated leaves

***Brachyphyllum obesum* HEER,**

Fig. 2: U24458; branch with triangular leaves

Fig. 3: U24463; branch with triangular leaves

Fig. 4: Cuticle of branch from Fig.2, stomata; magnification: 80 x

***Tritaenia* sp.**

Fig. 5: U24460; single leaf

Plate 6


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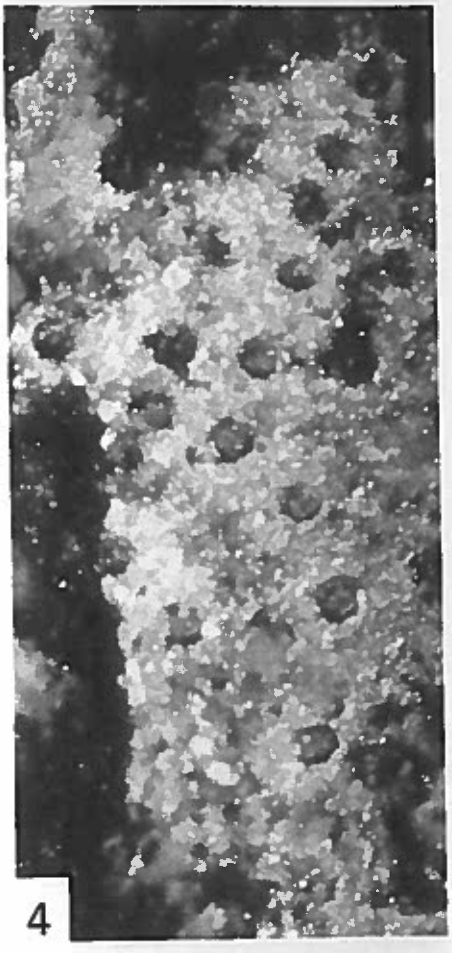
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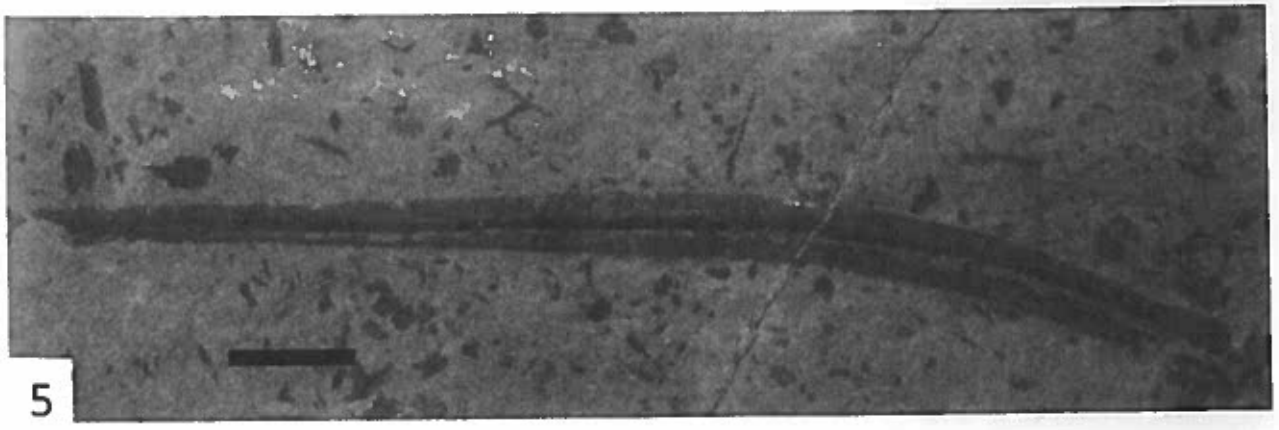
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Plate 7. Bars 10 mm

Pinites **sp.**

Fig. 1: U24464; single needle-like leaf

Podozamites **sp.**

Fig. 2: U24465; branch with three leaves

Brachyphyllum obesum **HEER**

Fig. 3: U24466; branches with scale-like leaves

Plate 7


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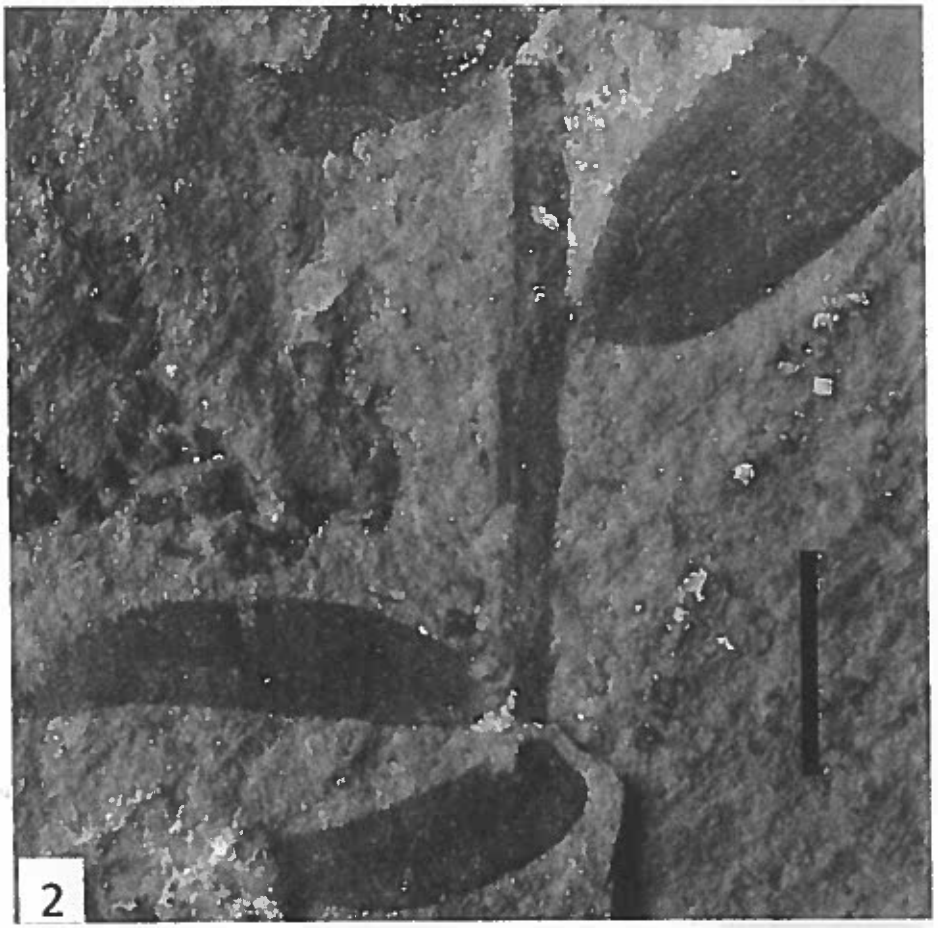
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Plate 8. Bars 10 mm

Pseudotorellia **sp.**

Fig. 1: U24467; nearly entire leaf

Sphenobaiera **sp.**

Fig. 2: U24467; forked leaf

Fig. 5: U24469; part of a leaf with strong veins

Ginkgoites brauniana **(DUNKER) WATSON et al.**

Fig. 8: U24468; 3x divided leaf

Ginkgoites regnellii **(TRALAU) nov. comb.**

Fig. 4: U24470; part of a leaf

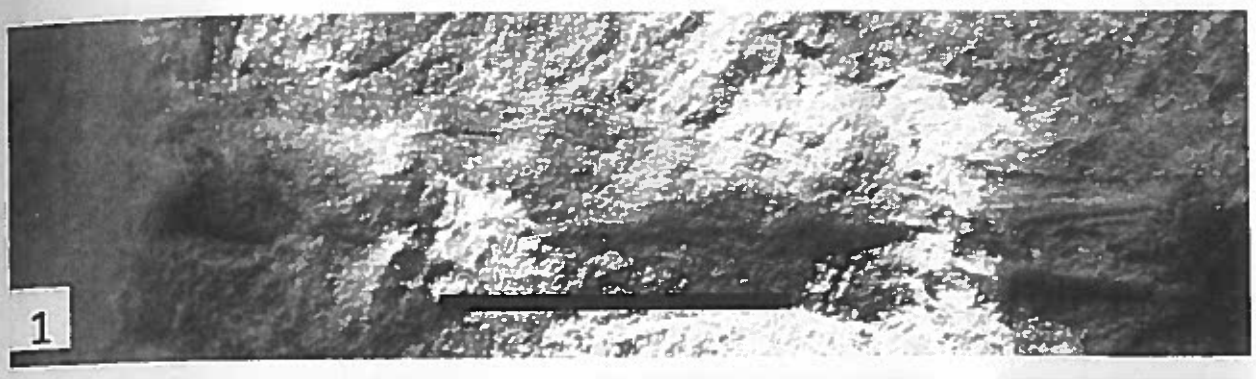
Fig. 6: U24471; nearly complete leaf

Ginkgoites **sp.**

Fig. 3: U24464; wide leaf spread with veins

Fig. 7: U24472; narrow leaf with petiole

Plate 8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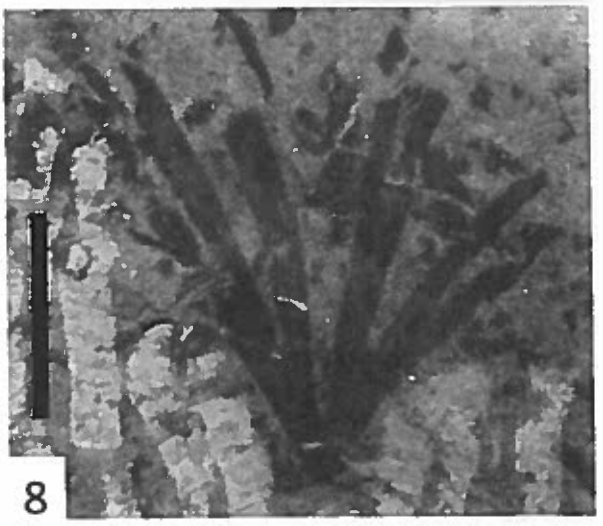
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Plate 9. Bars 10 mm

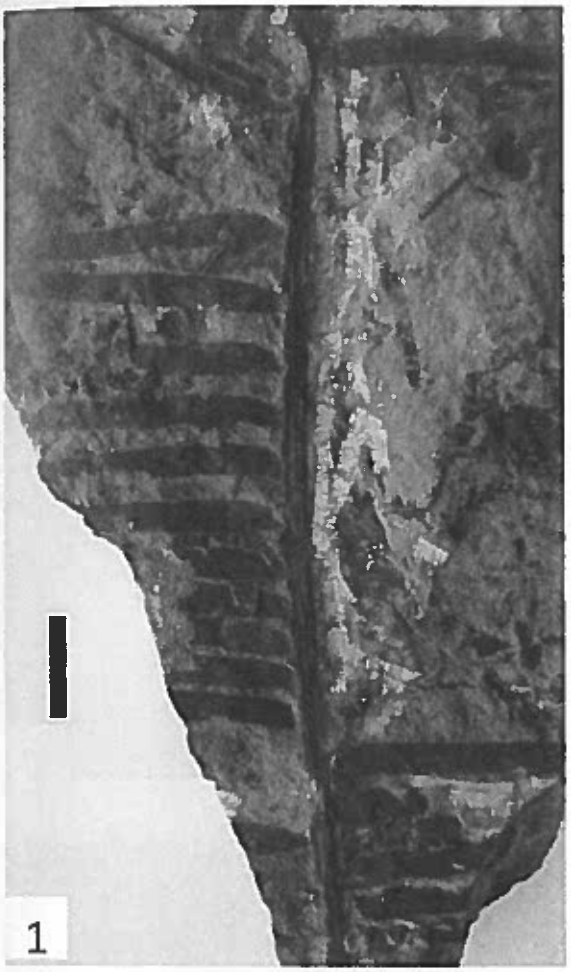
Pterophyllum **sp. 1**

Fig. 1:. U24468; basal part of a leaf seen from the lower side with pinnules contracted near the base

Fig. 2: U24473; Upper side of a leaf with pinnules attached

Fig. 3:. U24460; Distal part of a leaf with pinnules seen from the lower side

Plate 9



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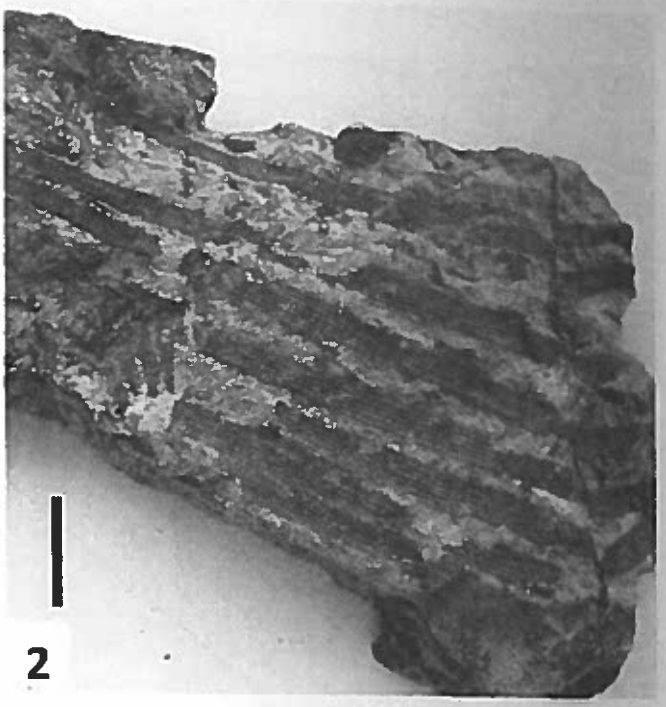

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Plate 10. Bars 10 mm

***Pseudoctenis* sp.**

Fig. 1: U22470; tip of a leaf with pinnules seen from the lower side

***Pterophyllum* sp. 1.**

Fig. 2: U22474; tip of a leaf with pinnules seen from the upper side

***Pterophyllum* sp. 2**

Fig. 3: U22475; fragmented leaf, part of the rachis with adhering pinnules

Plate 10

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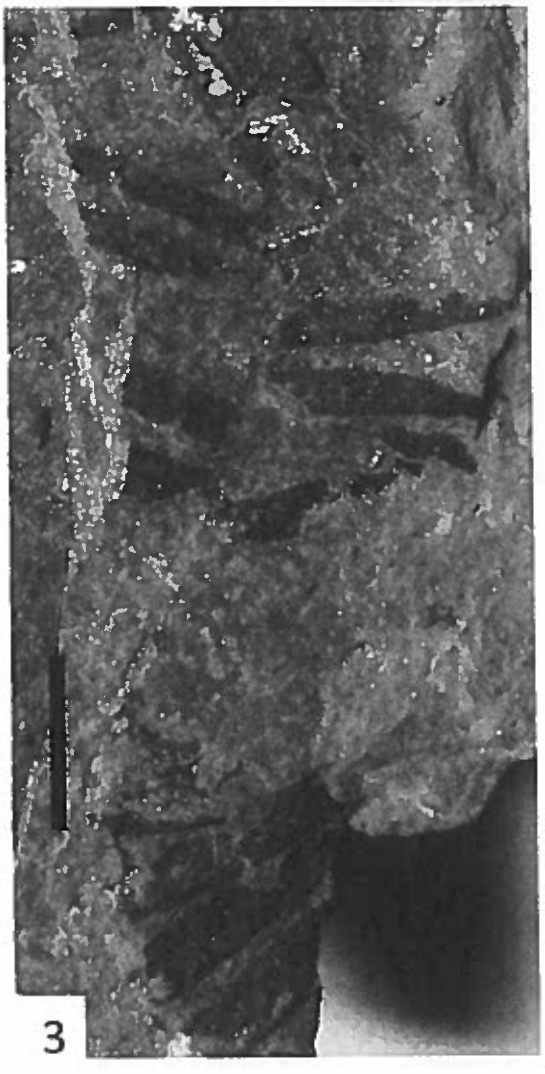

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