The Fossil Flora of the Early Jurassic

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After a significant decline in vegetation during the Raibl crisis in the Upper Triassic (Carnian), the flora began to flourish once again as the Lower Jurassic approached. However, the family of flowering plants, which is prevalent today, was clearly absent during this time, with no identifiable ancestors or evolutionary lines. It was only after the emergence of birds as seed propagators in the Upper Jurassic that angiosperms began to appear and flourish globally in the Lower Cretaceous period. During the Lower Jurassic, conifers such as *Podozamites, Swedenborgia,* and *Hirmeriella* were prevalent, although today, they are only found in limited regions of East Asia, represented by species like the golden larch (*Pseudolarix*), umbrella fir (*Sciadopitys*), *Taiwania*, and the Ginkgos. Cycads, including the two-seeded *Nilssonia* and *Ctenis,* as well as the multi-seeded *Macrotaeniopteris,* were also abundant. Surprisingly, nearly extinct ferns, such as ancestors of the Matoniaceae *(Phlebopteris, Laccopteris)* and Dipteridaceae (*Thaumatopteris, Chlathropteris, Dicytophyllum, Sagenopteris, Otozamites*), played an important role. Other fern species, *Thinnfeldia* and *Phialopteris*, were also common, with *Thinnfeldia* belonging to the Schizeacea group due to its distinct tropo- and sporophylls. Additionally, Marattiales precursors (*Marattiopsis)* were abundant, whereas tree ferns (*Cyatheites*) were less prevalent. Horsetails were represented by *Equisetites* and *Schizoneura*, and unusual clubmosses such as *Bernettia, Bavarostrobus,* and *Lepacyclotes* also played substantial roles, although their descendants remain elusive. Overall, the Lower Jurassic period boasted a rich habitat, even in the midst of a subtropical climate.

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A flora community in the Lower Jurassic of Southern Germany. The conifers ***Swedenborgia liaso-keuperianus*** (1), ***Podozamites distans*** (2) and ***Hirmeriella muensteri (***3) were common. Other gymnosperms such as ***Ginkgoites dichotoma*** (4), and the cycad ***Nilssonia acuminata (***5) enriched the landscape. Large numbers of fern families were present in different variations such as ***Thinnfeldia rhomboidales*** (6), ***Phlebopteris angustifolia*** (7) or ***Dictyophyllum acutilobum*** (8).

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Geology

The rich Triassic-Jurassic flora found in Upper Bavaria fascinated palaeobotanists in the early 19th century, including Count Georg Graf zu Münster (1836), Count Kaspar Maria Sternberg (1838), Carl Friedrich Wilhelm Braun (1843), and especially August Schenk (1867). Subsequent research revealed similar floras in regions as far-reaching as Sweden (Nathorst, 1878, 1879), Hungary (Stur, 1874), and Siberia (Heer, 1876), extending all the way to China.

Over the years, various sandpits in Upper Bavaria have yielded plant-rich clay lenses, sometimes through brief explorations, providing valuable insights into ancient ecosystems. Locations such as Strullendorf, Veitlahm, and Fantasie have been particularly fruitful, with new discoveries being added (Pechgraben, Höferänger, Unterschreez).

Most of these sedimentary layers hold no fossils, while others contained coastal deposits with marine animal remains. However, in select clay lenses, exquisitely detailed fossilised plants have been uncovered (Krumbeck, 1939). These sedimentary layers, termed the Rheto-Liassic layers (Schenk, 1867), can reach several tens of metres in thickness and consist of coloured clay sands with 1 to 1.5 m thick lenses, which were classified as "*Pflanzensandstein*" (plant sandstone) (Weber, 1968). Unfortunately, these fossil-rich layers are prone to disintegration, dissolving into unsightly, crumbly lumps upon exposure to humidity or when brought to the surface, presenting challenges for preservation.

Despite these obstacles, the plant horizons found in different localities offer valuable insights from different epochs, distinct from the Ladinian-age (Ilsfeld, Dolomites) or Carnian (Lienz Dolomites, Bergamo) period. The Raibl catastrophe in the Carnian (Early Julian) period (Wachtler, 2021) led to a significant reduction in vegetation within a short geological time frame. This event likely caused considerable changes in the region's vegetation. However, the vegetation quickly recovered, leading to the emergence of the Late Carnian flora of Lunz (Lower Austria) that exhibits similarities with the Lower Jurassic of Bayreuth, as well as the Scalby flora (Middle Jurassic, Bathonian) of Yorkshire (England), the Upper Jurassic (Tithonian) flora of Solnhofen, and even the Lower Cretaceous flora of Duingen (Germany).

In the Lower Jurassic period, it is challenging to draw conclusions about slightly different eras based solely on the presence or absence of certain plant species. Instead, the plants belong to distinct biocenoses with varying proportions of conifers, cycads, ferns and lycopods. Some similarities can even be found with floras from more distant


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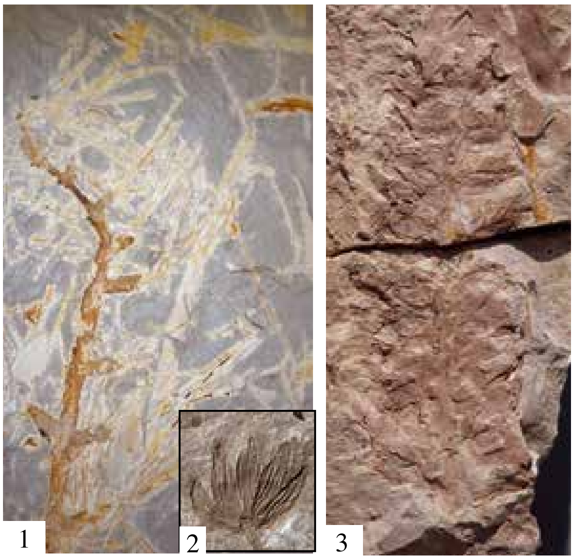
Conifers: *Hirmeriella muensteri.* 1. Branch with male cones (BT 001220.00); 2. Female cone; Coll. Hauptmann Urwelt-Museum Oberfranken

Podozamites distans. 3. Destroyed female cone with seed scale (PECH 102, Coll. thomaseum); 4. Male cones (PECH 713); Ex-Coll. Silberhorn, Dolomythos Museum, Innichen

localities, such as Sweden, particularly around Skåne (Nathorst, 1878, 1879), and Hungary, specifically Pécs, formerly known as Fünfkirchen (Stur, 1874).
Before delving into the history of research on this topic, it is important to briefly discuss the plant societies in the Lower Jurassic of Central Europe, with a focus on the northern Bavarian region. The quarries in the region boast a diverse array of well-preserved plant fossils, which have been intensively collected for decades. Despite the increase in the number of findings in recent decades, research and related publications have lagged behind. Following the pioneering work of Schenk (1865–1867) and Hans Salfeld (1906), who attempted a comprehensive description of fossil plants in southern Germany, progress in this field has been relatively stagnant.
The plant-rich lenses can reach several hundred metres, often tapering at their ends or beginning again slightly offset in height, as is clearly visible in the sand pits at Pechgraben. Particularly, the Küfner sand pit at the southwestern end showcases a lentil that has been divided into two or three parts due to changes in flooding conditions, attracting the attention of several collectors (Hauptmann, Silberhorn, Friess, Fuchs, Gerasch, and Wachtler). In the top layer, immediately adjacent to the predominantly fossil-free, coarse-grained sandstones, layers rich in *Swedenborgia liaso-keuperianus* are typically found. These layers are characterised by their five to six-pointed cone scales, as well as exceptionally well-preserved needles and twigs of these conifers.
Moving downward, there are layers with varying plant societies. The conifer *Podozamites distans* are common throughout. The abundance of *Podozamites* leaves is likely due to a seasonal decline, similar to what we find today in some conifers, even in temperate climates *(Pseudolarix, Metasequoia, Ginkgo)*. Another conifer, *Hirmeriella muensteri,* is rarely found in these layers, while it is common in the sand pits near Schnabelwaid.
Ferns, dominated by *Thinnfeldia rhomboidales*, exhibit varying foliage shapes. In certain locations, their sporophylls, which differ greatly from the leaves, are common. This suggests a relationship to the Schizeaecea family. A climbing fern from this family, *Phialopteris heterophylla,* is rare. Other common ferns include *Marattiopsis intermedia* with its typical sori, *Dictyophyllum acutilobum* with its mesh vein, and *Phlebopteris angustifolia*. *Otozamites brevifolius* is scarce, while *Clathropteris muensteriana* and *Thaumatopteris brauniana* are rare or mostly absent. *Sagenopteris nilssoniana, Ginkgoites dichotoma,* and the fern *Thaumatopteris brauniana* are found more abundantly in Forkendorf and Unternschreez.



Swedenborgia liaso-keuperianus. 1. Twig. Coll. Hauptmann, Urwelt-Museum Oberfranken (BT 005972.01); 2. Seed scale (PECH 716); 3. Female cone (PECH 170; Coll. Wachtler, Dolomythos-Museum, Innichen

Ginkgos: 3. *Ginkgoites hauptmannii*; 4. *Ginkgoites dichotoma*; Coll. Hauptmann, Urwelt-Museum Oberfranken

The cycad *Nilssonia acuminata,* known inall parts, is a common sight in the area, followed by *Nilssonia polymorpha* in slightly smaller numbers. Less frequently seen are *Pseudoctenis prossii* and *Macrotaeniopteris gigantea* or *Taeniopteris tenuinvervis.*
Of particular interest is the low-growing lycopod *Bernettia inopinata.* The various names for the megasporophylls (*Chlamydolepis lautneri*, when found without megaspores), their leaves *Desmiophyllum gothanii,* and the microsporophylls named *Piroconites kuespertii* are all part of the same species. Another previously unrecognised lycopod, *Bavarostrobus friessii,* is also quite common. It tends to form layered carpets, although usually only decayed mega- and microsporophylls are found. Horsetails such as *Schizoneura silberhornii* and *Equisetites muensteri* are considered rare.
A significant discovery was made at the western end of the Küfner sandpit, where a rich deposit of shark capsules (*Palaeoxyris muensteri*) was found towards the wedge of a long and thick clay lens. These capsules, numbering in the hundreds, were mostly located at the lowest base between the massive sandstone banks in direct contact with fine muddy layers, alongside *Thinnfeldia* ferns or *Podozamites* trunks. Today, only about 30% of sharks, like most cat sharks and all bullhead sharks, lay eggs. It is believed that these elongated, grooved shark capsules were deposited in sheltered shallow waters to protect the young from predators. Rare findings in this area include freshwater mussels (*Anodonta liasokeuperina)* (Brown, 1860) and crayfish (*Franconiolimulus pochankei)* (Bicknell et al. 2021). Even less frequently, insect wings (*Bavariophlebia schmeissneri*) have been found (Nel & Petrulevičius, 2005).
These may have been freshwater canals close to the sea with low currents. On one hand, this allowed for a perfect conservation of the plants and formed an ideal retreat for spawning sharks.

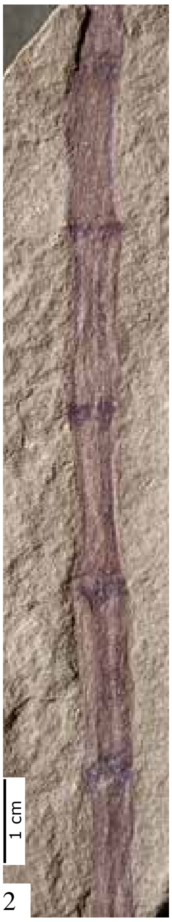
Cycads: 1. *Nilssonia acuminata.* Frond (PECH 726, Ex-Coll. Friess, Coll. Wachtler, Dolomythos-Museum); 2. *Nilssonia polymorpha.* Frond (BOCK 27, Ex-Coll. Silberhorn, Coll. Wachtler, Dolomythos-Museum); 3. *Nilssonia,* female cone (PECH 534); 4. Male cycad cone (PECH 520); Coll. Wachtler, Dolomythos-Museum, Innichen

By examining specimens from numerous quarries, researchers were able to identify a limited number of plant genera and species. Despite the challenges posed by quickly refilled quarries due to unprofitable mining opportunities, the connection between these plants and their fertile organs allowed for meaningful classifications to be established. The resulting flora from the Lower Jurassic period offers deep insights into the ancient living world.

Conifers

Three conifer genera are primarily found in different lenses with varying frequencies. These are *Podozamites distans*, *Swedenborgia liaso-keuperianus* and *Hirmeriella muensteri*. While these genera do have modern representatives, these do not belong to the larger conifer groups seen today, such as pines, firs, spruces, or araucaria. Instead, they form monotypic genera that occur only in certain relic areas of East Asia. *Podozamites distans* is the most common of the three, characterised by its short and long shoots. It shows a relationship with the gold larch (*Pseudolarix*), which can still be found in some isolated areas of eastern and central China. Fossilised leaf carpets suggest that *Podozamites distans* may have shed its leaves seasonally. *Swedenborgia liaso-keuperianus* is another common species, which stood out as a defining element due to its five- to six-pointed seed scales. Its needle-shaped leaf tufts are less frequently preserved. It is believed to be an ancestor of the only remaining species, *Sciadopitys verticillata,* the umbrella fir, which is found on certain islands in Japan. The last conifer, small-needled *Hirmeriella muensteri*, is easily distinguishable from the other coniferous genera due to its small rounded pollen cones that occur in mass. Comparisons can be made with *Taiwania cryptomerioides*, which is currently limited to relic zones in East Asia, spanning from China to Japan and Vietnam.

Swedenborgia has been documented as far back as the Middle Triassic, with spe-



Horsetails: 1. *Schizoneura silberhornii (*Coll. Hauptmann, Urwelt-Museum Oberfranken)*;* 2. *Equisetites muensteri* (PECH 731, Coll. Wachtler, Dolomythos-Museum, Innichen

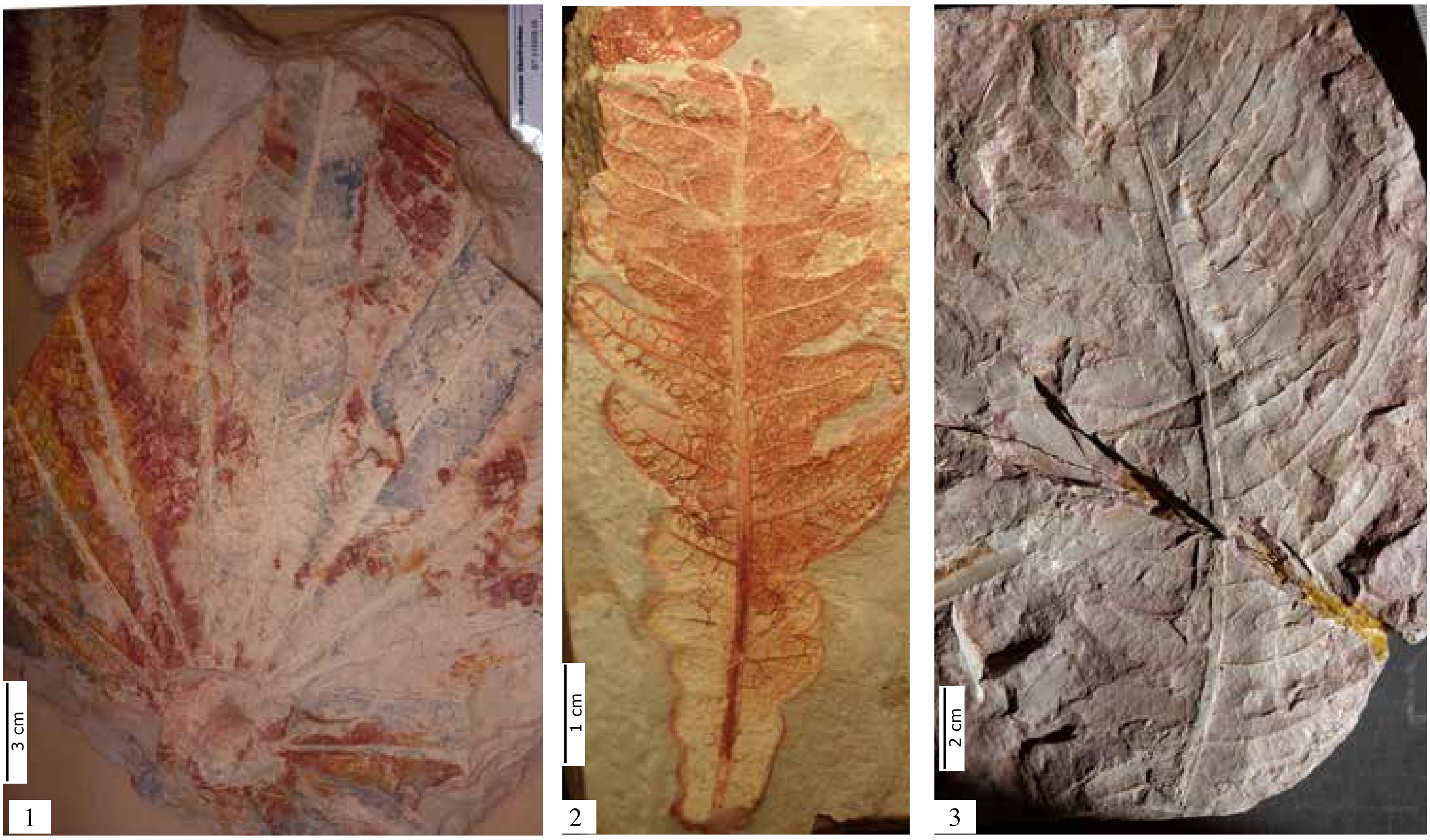
Ancestors of today‘s Matoniaceae: *Phlebopteris angustifolia* (BOCK 01, Unternschreez, Ex-Coll. Silberhorn, Coll.Wachtler, Dolomythos-Museum) cies like *Swedenborgia nissleri* (Wachtler, 2016), probably with *Aethophyllum* even from the Lower Triassic. On the other hand, *Podozamites* date back to the Middle-Upper Triassic, with both genera reaching a large catchment area that extends to regions like Sweden, China, Siberia and Kyrgyzstan.

Ginkgo

The only extant species of this genus, *Ginkgo biloba,* is limited to a few relic areas of China, but the Ginkgo once dominated large parts of the northern hemisphere since the Early Permian period. Initially resembling conifers with their needle-like leaves for millions of years, it was only in the last hundred million years that the typical fan-like plants, reminiscent of broad-leaved foliage, developed. Throughout the history of research, innumerable names have accumulated, leading to more confusion than clarity. Classifications and distinctions, such as *Psygmophyllum* from the Urals of Russia, *Baiera, Sphenobaiera, Karkenia* and *Ginkgophyllum*, can be complex and challenging to understand even for those deeply interested in the subject. It is assumed from their different leaf shapes that during the Hettangian period, there were two Ginkgo species: *Ginkgoites (Baiera) dichotoma* and *Ginkgoites (Baiera) hauptmannii.* The fleshy seeds and pollen cones of *Ginkgo biloba* were similar to today's and have remained unchanged for nearly 300 million years (Wachtler, 2021).

Cycads

Fossil cycads played an important role in the Early Jurassic of Central Europe. However, there have been few attempts to link the abundant fronds with the fructifications to establish relationships with modern palm ferns. The most prevalent species was *Nilssonia acuminata*, which recent findings suggest can be compared to today's *Encephalartos*-cycads. Other species, such as *Nilssonia polymorpha*, also point in a similar direction. *Pseudoctenis prossii* and *Ctenis inconstans* have been found sporadically with unknown fertile organs.



Ferns Dipteridaceae: 1. *Clathropteris muensteriana* (BT 0155508.00, Coll Hauptmann) 2-3. *Dictyophyllum acutilobum,* Urweltmuseum Oberfranken, Bayreuth); 3. Ex. Coll. Silberhorn, Coll. Wachtler, Dolomythos

They also seem to point in the direction of the two-seeded palmfern progenitors. Species like *Macrotaeniopteris gigantea* and *Taeniopteris tenuinervis,* with their multiple seeded fronds, suggest a connection to the Cycas palm fern. Various leaf shapes found in the fossil record are more likely to be attributed to the ferns.

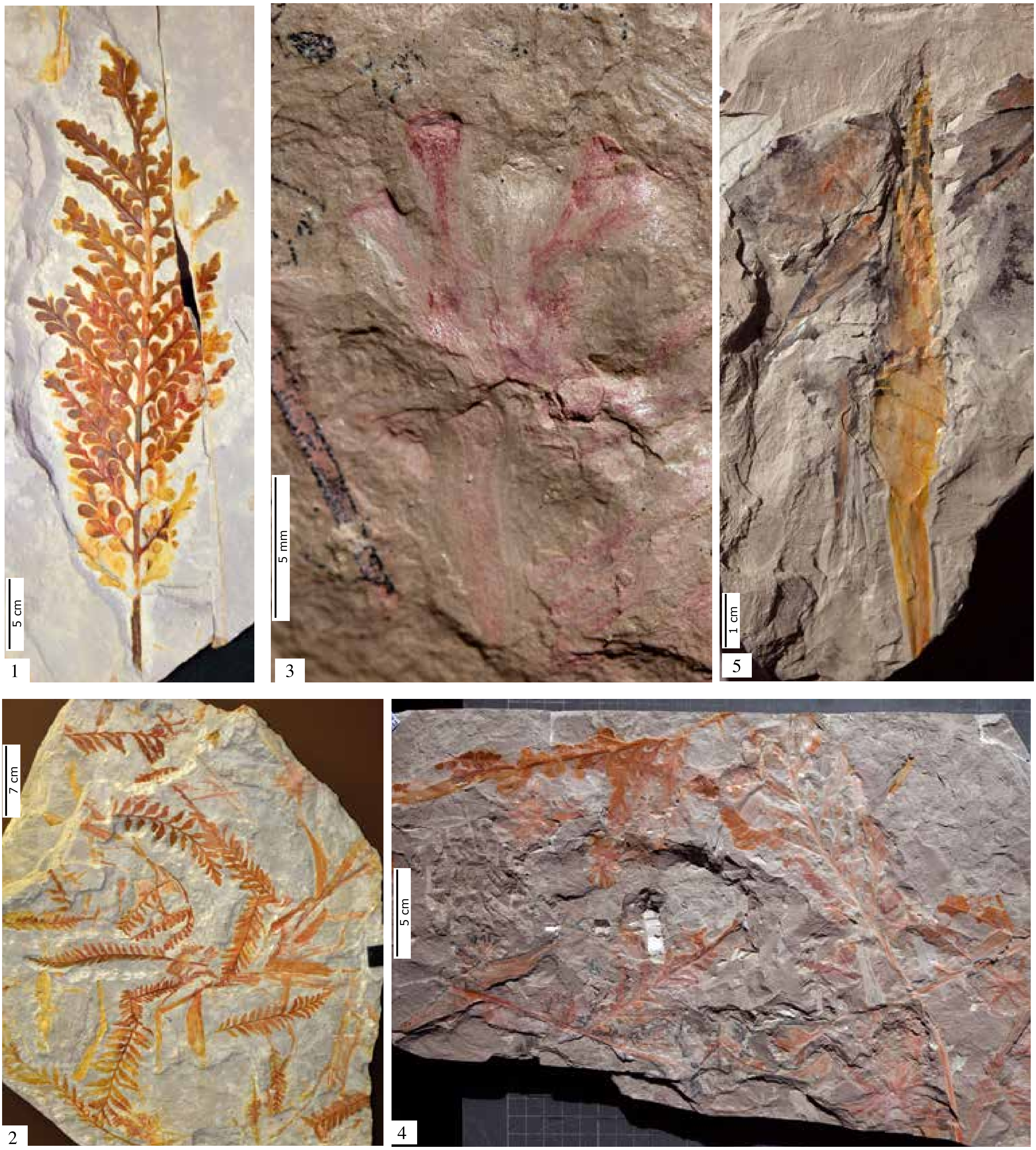
Horsetails

Interestingly, horsetails belong to the less common plant families in the Early Jurassic (Hettangian) of Upper Bavaria, trailing behind the ubiquitous ferns, conifers, cycads, and lycopods. Despite their rarity, enough specimens were discovered to identify two genera: *Equisetites muensteri* and *Schizoneura silberhornii.* These genera can be distinguished by their leaf type, stem furrows, and sporophyll cones, although the latter were rarely found. In contrast to the Triassic, where monopodial hollow trunks up to 20 cm thick were recovered, the horsetails in the Early Jurassic were smaller, with a size of around 10 cm. The sporophyll cones of *Equisetites muensteri* closely resembled those from the Triassic period.

Ferns

Ferns played a dominant role in the Lower Jurassic of the Northern Hemisphere. Ancestors of the Matoniaceae (*Phlebopteris angustifolia, Laccopteris goepperti)* were common, although today, they are restricted to a few tropical and subtropical relict zones in Asia, Australia, and Polynesia. The Dipteridaceae (*Thaumatopteris schenkii, Clathropteris muensteriana, Dictyophyllum acutilobum* and *Sagenopteris nilssoniana*) were also prevalent, coexisting with other fern families such as *Otozamites brevifolius* or *Acrostichites princeps* in the same landscapes. A Marattiales precursor, *Marattiopsis intermedia,* was widespread, while tree ferns (*Cyatheites asterocarpoides*) were less frequently found. *Thinnfeldia rhomboidales,* another dominant fern, was found in the landscapes alongside other ferns. While it was commonly associated with seed ferns, the lack of convincing

Ferns Dipteridaceae: 4. *Sagenopteris nilssoniana* (BT 0155511.00, Forkendorf, Coll. Hauptmann) 5-6. *Otozamites brevifolius,* Urweltmuseum Oberfranken, Bayreuth; 6. Coll. Friess, Dolomythos-Museum); **Ferns Marattiales:** 7. *Marattiopsis intermedia,* (PECH 83, Coll. Wachtler, Dolomythos)

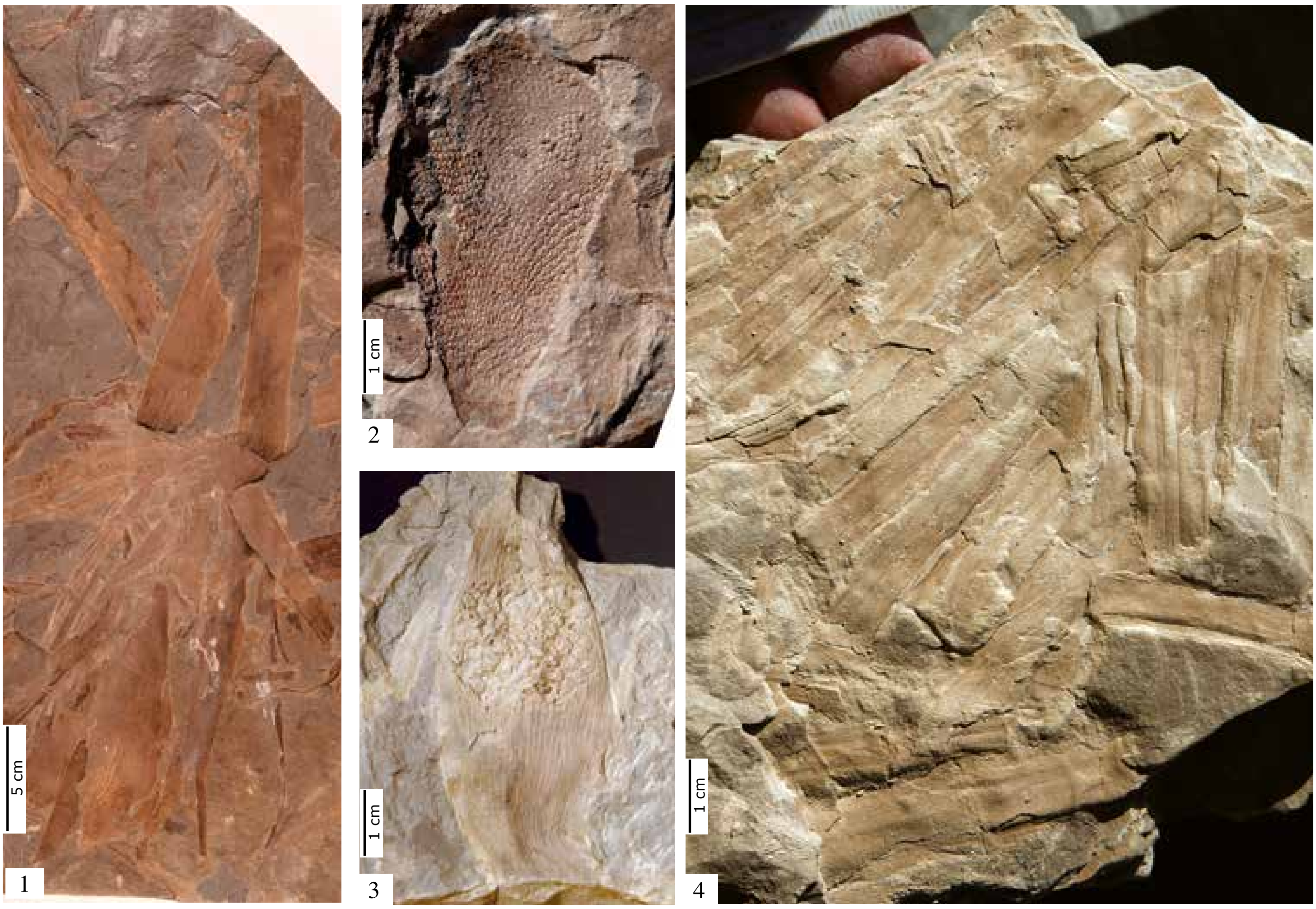


Ferns Schizaeaceae: *Thinnfeldia rhomboidales,* 1. Single frond; 2. On the basis of this large-format plate it is possible to recognize the variability of fronds. Coll. Lutz Kaecke, Hannover, Paläontologisches Museum Nierstein; 3. Sporophyll (PECH 682) 4-5. Fronds with fertile parts and *Palaeoxyris*-shark capsules, (PECH 675, PECH 688) Coll. Wachtler, Dolomythos-Museum, Innichen evidence for seeds suggests that it should probably be categorised within the large group of Schizaeaceae, similar to modern *Schizaea* or *Anemia,* due to its distinct tropophyll and sporophyll fronds. This family also encompasses the rare *Phialopteris heterophylla.*

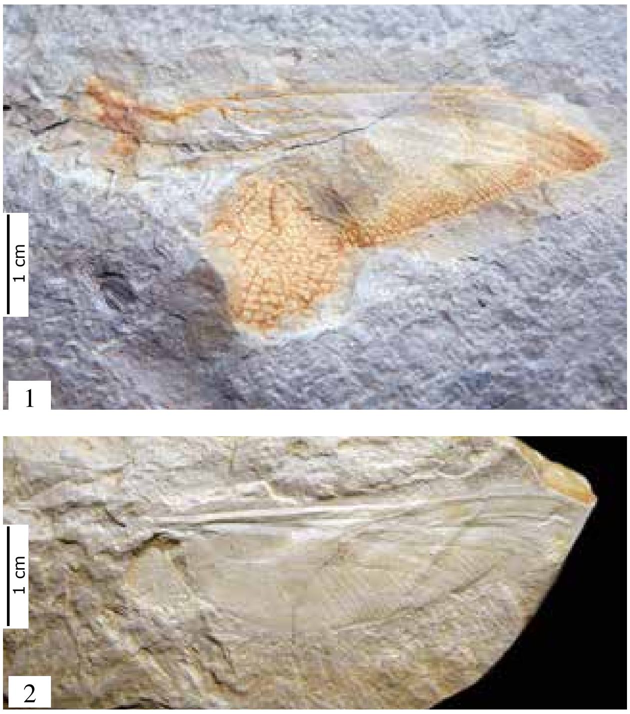
Clubmoss

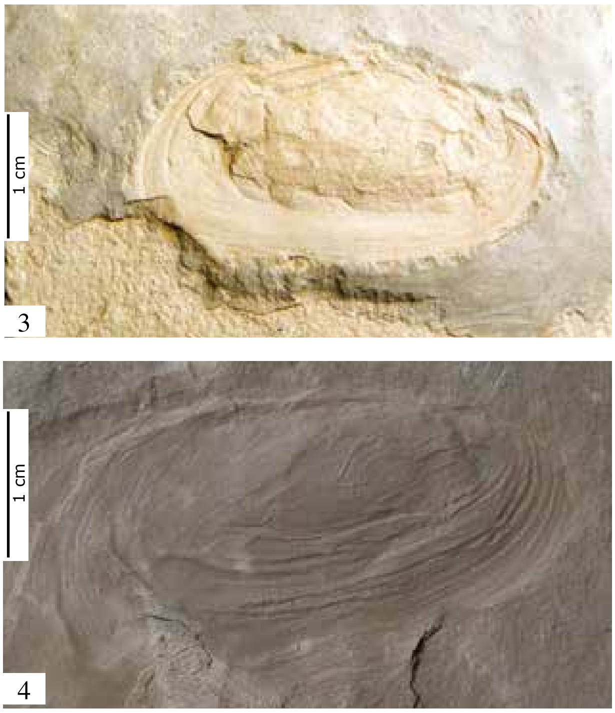
Despite their decline after the Carboniferous period, lycopods played an important role in the Triassic era. While they did not reach the towering heights of their Carboniferous ancestors (*Sigillaria, Lepidodendron)*, Triassic species like *Pleuromeia* and *Lycopia* reached heights of 2 to 3 m, surpassing the stature of modern lycophytes. In addition to isosporous lycopods with spores of the same size (*Lycopia)*, there were also heterosporous with separately sized macro- and microsporophylls (*Sigillcampeia, Pleuromeia, Selaginellites, Isoeites, Lepacyclotes* and *Eocyclotes*).

Two peculiar lycopsids were common in the Lower Jurassic of Northern Bavaria: *Bernettia inopinata* and *Bavarostrobus friessii,* whose affiliation could only be clarified on the basis of a large number of finds. The classification of these species was challenging due to the various descriptions of their individual parts, such as their long lanceolate leaves, described as *Desmiophyllum,* sterile spore leaves (*Chlamydolepis lautneri*), microsporophylls (*Piroconites kuespertii)*, and macrosporophylls (*Bernettia inopinata)*. However, the presence of typical heterosporous fertile parts indicated a probable categorisation as clubmosses, with *Bernettia inopinata* being considered the



Clubmoss: *Bernettia inopinata,* 1. Sporophyll cone with covering foliage and sterile leaves (Botanical garden, Klagenfurt BPB); 2. Microsporophyll (PECH 487, Coll. Wachtler, Dolomythos-Museum, Innichen); 3. Macrosporophyll (Ex. Coll. Hauptmann, Coll. Tischlinger); *Bavarostrobus friessii* 4. Sporophylls (PECH 476, Coll. Wachtler, Dolomythos-Museum_Innichen)





1-2. **Insect parts (***Bavariophlebia schmeissneri),* Sandpit Küfner, Coll. Schmeissner, Coll. Hauptmann, Urweltmuseum, Oberfranken, Bayreuth.

3-4. **Duck mussel** *Anodonta liasokeuperina* (Museum Oberfranken, Bayreuth, Dolomythos Museum, Innichen

1-2. **Rotten fungi** *(Xylomites)* on a *Marattiopsis*-leaf (PECH 350); 2. on *Podozamites* (PECH 703); (Both Coll. Wachtler Dolomythos-Museum; 3. *Desmiophyllum,* Coll. Hauptmann, Urweltmuseum, Oberfranken, Bayreuth; 4. **Eating traces** on leaves of *Sagenopteris nilssoniana* (BOCK 26, Ex-Coll. Silberhorn, Coll. Wachtler) appropriate name for the entire plant. Of particular interest is *Bavarostrobus friessii,* previously known with a related member (*Porastrobus)* only from the Upper Triassic of northern Italy but now discovered in larger numbers, especially at the Pechgraben site. This species belongs to the low-growing lycopods composed of a large number of heterosporous sporophylls. Both lycophytes have no representatives at the present time.

History of research

Count Georg Graf zu Münster, a government director based in Bayreuth with a keen interest in natural sciences, was a pioneer in the study of fossil plants in the Bayreuth area. In his 1836 work "*Über einige neue Pflanzen in der Keuper-Formation bei Bayreuth*" (On Some New Plants in the Keuper Formation Near Bayreuth)

He described various plants but without any illustrations. These included conifers, cycads, and ferns, such as the genus *Phlebopteris* from the precursor group of Matoniaceae. This work coincided with the introduction of the same genus to science by French palaeobotanist Adolphe Brongniart in that year. Münster's comparisons of cycad leaves to *Glossopteris* plants native to the Permian southern hemisphere and the Danaea precursor *Marantoidea*, now categorised as a fern, were notable. However, in his publication, he expressed a desire for the most informative plants to be illustrated by the Czech clergyman Sternberg (1761–1838) or his collaborators Karel Bořivoj Presl (1794–1852) and August Carl Joseph Corda (1809–1849). Their extensive work "*Versuch einer geognostisch-botanischen Darstellung der Flora der Vorwelt"* (Attempt for a Geognostic-Botanical Representation of the Flora of the Prehistoric World) documented a wealth of significant plants from the locality Strullendorf (also Strahlendorf)

Count Georg Graf zu Münster (1776–1844) was considered the greatest collector of fossils of his time, and his area of interest extended as far as the Dolomites. Large parts of his collection went to Bayreuth but also to Cambridge in England (Photo: Urwelt-Museum Oberfranken, Bayreuth).

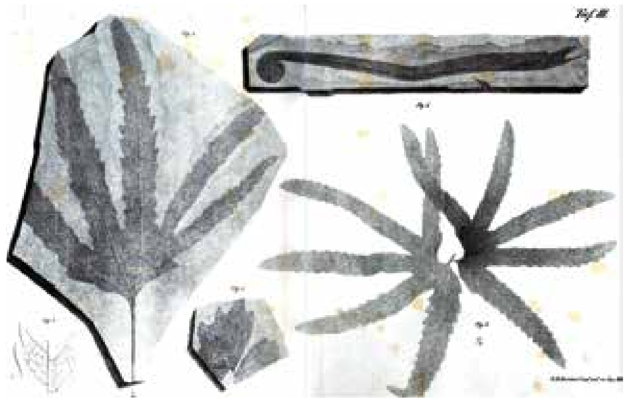
The botanist and pharmacist Carl Friedrich Wilhelm Braun (1800–1864) was the first curator of the "Kreis-Naturalien-Kabinett" of Bayreuth. We owe him the discovery of many plant fossils around Bayreuth (Photo: Urwelt-Museum Oberfranken, Bayreuth).

near Bamberg. This included *Equisetites (muensteri), Sagenopteris (rhoifolia)* and *Zamites (acuminatus),* particularly in the seventh and eighth volumes published in 1838.

Count Georg Graf zu Münster and His Circle

Münster served as the editor of the publication *"Beiträge zur Petrefactenkunde"* (Contributions about fossils), which was first published in 1843. Collaborating with renowned botanists like Johann Heinrich Göppert and Carl Theodor von Siebold, Braun played a crucial role in exploring the sites around Bayreuth in his *"Beiträge zur Urgeschichte der Pflanzen"* (Contributions to the Prehistory of Plants). After Braun's extensive botanical studies in Carinthia and northern Italy, he took further advantage of palaeobotanical studies in Prague in collaboration with Sternberg. Not only did he organise the northern Bavarian district collections, but he also investigated new sites around Bayreuth from 1835, such as the quarries at Strullendorf, Himmelreich near Eckersdorf, the newly discovered clay lens "Fantasie", and Theta. Moreover, Braun classified many plant fossils from the Lower Jurassic and Liassic (known today as Hettangian).
The descriptions in Sternberg's *"Flora der Vorwelt"* and even more so Braun's *"Beiträge zur Urgeschichte der Pflanzen"* served as crucial starting points for research into the Early Jurassic fossils not only of Upper Franconia but also of other sites of the same age, which ranged from Sweden, Italy to Hungary. These works shed light on the extensive subtropical climate that prevailed in the northern hemisphere during that era from Europe to Central Asia and China, leading to the proliferation of plant communities with similar characteristics.
Unfortunately, this subsequently led to a plethora of plant names, resulting in confusion within the field of palaeobotany. This publication aims to acknowledge the contributions of the first describers, recognising that some terms have become anchored in scientific nomenclature through custom and usage, the omission of which would contribute to further confusion rather than clarity.
Braun was particularly a victim of taxonomy for a variety of reasons. In the case of the fern *Diplodictyum*, it was discovered that

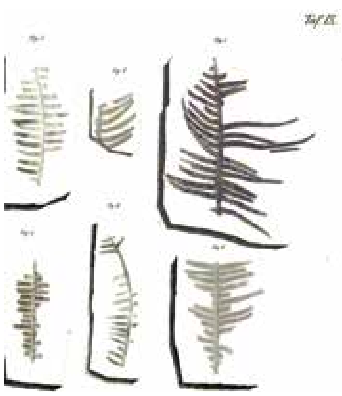
Tables from 1843: „Beiträge zur Petrefactenkunde". Editor Count Georg zu Münster, Author: Carl Friedrich Wilhelm Braun



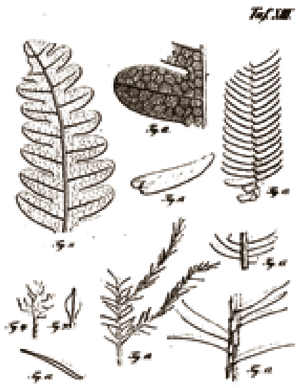
Ferns: Plate III. *Camptopteris münsteriana*

Ferns: Plate X. *Andriania Baruthina*

Ginkgo: Table XII. *Baiera dichotoma*



Ferns: Plate IX. Fig. 1. *Geoteuthis obconica,* 2. *Geoteuthis flexuosa,* 3, 7, 8-10. *Andriania Baruthina, var. abbreviata*. 4. 5. 6. 11. 12. *Andriania Baruthina var. elongata*



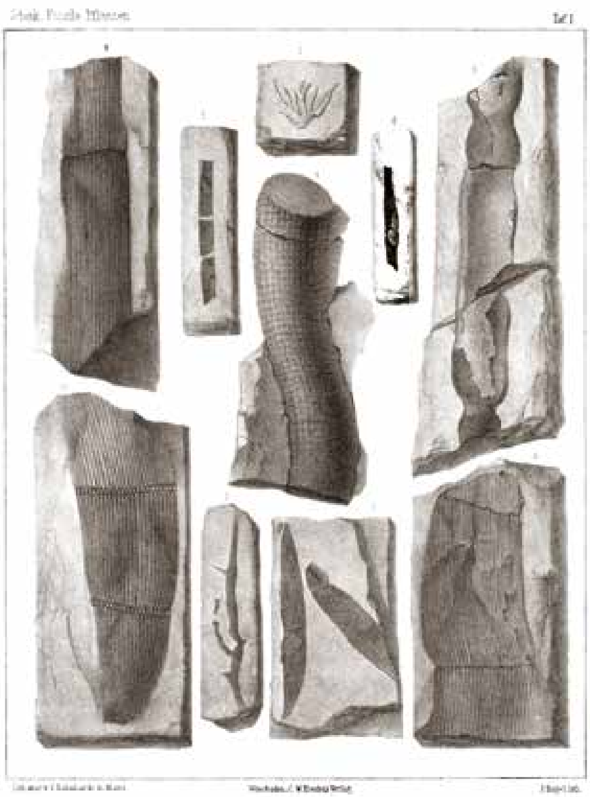
Ferns: Plate XIII. 11-12. *Diplodictyum obtusilobum;* 13-15. *Zamites brevifolius.* Braun; **Conifers:** 16-20. *Cunninghamites sphenolepis*

John Lindley and Willian Hutton had already described a conspecific plant in 1834 as *Dictyophyllum acutilobum*. Additionally, *Andriania baruthina* was found to be an ancestor of the Matonia fern, which was widespread in Europe and formerly described as *Phlebopteris angustiloba* (Presl in Sternberg, 1838; Pacyna, 2021). Furthermore, *Zamites brevifolius* was mistakenly identified as a cycad when it was actually a fern. One of the most enduring names in taxonomy is *Baiera,* which is believed to be the ancestor of the ginkgo plant. Braun had the most doubts here, as Sternberg had previously used the name *Bajera* in 1825 to refer to a horsetail genus, which was later incorporated into the name *Equisetites*. Despite his efforts, Braun was unable to establish a clear connection between *Baiera* and ginkgo plants.

The botanist and palaeontologist August Schenk (1815-1891) wrote the most important publication on the flora of Lower Jurassic Bavaria in the 19th century.

August Schenk's Milestone

The German palaeobotanist Schenk was the next to study the fossil flora of the Early Jurassic in Upper Bavaria from 1865 to 1867 in a mammoth work that was previously



Schenk 1867, Plate 1. The species described as *Calamites* belong to the Triassic genera *Equisetites* or *Schizoneura.*

Schenk 1867, Plate 25. The amount of *Thinnfeldia*-species was less than described (*Thinnfeldia rhomboidales, Thinnfeldia saligna)* considered impossible. He successfully organised both publicly owned collections and privately held collections by Martin Kirchner, Gümbel, Dunker, Schlönbach, and Schlumberger from earlier decades and reinterpreted former publications by Sternberg and Presl, Münster, Braun, Göppert, Constantin Freiherr von Ettingshausen, Andrä and Popp. Schenk meticulously visited and collected plant fossils from various sites and quarries in Bavaria, including Strullendorf, Höfen and Reindorf near Bamberg, Veitlahm near Kulmbach, Jägersburg near Forchheim, Hart and Saaserberg near Bayreuth, Forst, Oberwaiz, and Phantasie near Bayreuth, Centberg near Bamberg, Thurnau and Oberleitersbach near Ebensfelde, Hohengüssbach near Schesslitz, Burkersdorf and Kaltenbrunn near Sesslach, Teufelsgraben near Küps, Atzelsberg near Erlangen, Adelhausen in Baden, Hinterholz near Waidhofen in Upper Austria, and many others. His detailed illustrations on 45 plates showcasing hundreds of plant fossils were unrivalled at the time. Where possible, he combined the fertile parts of the plants with the sterile ones.

Despite subsequent efforts by other scientists to expand the knowledge horizon by exploring sites of the same age in Sweden – mainly the area around Skånes (Nathorst, 1878, 1879), the Northern Italy elaborated by De Zigno (1856-1868) and Hungary, particularly the Early Jurassic site of Pécs, the former Fünfkirchen (Stur, 1874), or by using first photographic images (Salfeld, 1906) – to better document plant diversity, several questions regarding the

Peter Silberhorn in 2007 at the rich Schnabelwaid site (Archive Friess)

The sandpit Küfner at the Pechgraben with the plant fossils rich horizon

Sandpit Küfner, Pechgraben, 2022

Sandpit Küfner, Pechgraben, 2022, recovering large *Podozamites* slabs

relationships between fertile and sterile flora elements remained unanswered.

The aim of this publication is to document the numerous discoveries of previously unknown sites, such as the sand pits around Bayreuth that are now mined with heavy equipment, and to honour the contributions of contemporary collectors. Since the 1970s, the Küfner and Dietz sand pits on the Pechgraben in the Bavarian district of Kulmbach, as well as other quarries like Unternschreez and Forkendorf in the Bayreuth district, have yielded exceptionally well-preserved plant fossils from open clay lenses. These discoveries have helped in bridging gaps in the fossil record.

Local Collectors in the 20th Century

The collector couple Sepp and Traute Hauptmann are particularly noteworthy, with both of them exemplifying the fact that specialised studies do not always play a decisive role. Sepp, a Sudeten German born in 1930, completed an apprenticeship as a carpenter, after which he worked in the mineral oil wholesale trade until his company closed and he became unemployed at the age of 54. Traute worked in the fashion industry all her life. Together, they settled in the small northern Bavarian town of Hof. In 1979, shortly before his retirement, Sepp received information from a teacher friend about fossilised plants from the Jurassic period in the area around Bayreuth and the Kulmbach region. In the following years, the couple began to visit the various sites until the collection became so extensive that they started organising special exhibitions for their plant fossils across various locations in Germany from 1989 onwards. Soon, their efforts caught the attention of the international scientific community, including the renowned German palaeobotanist Hans-Joachim Schweitzer (1928–2007), Kirchner, and the Dutch researcher Han van Konijnenburg-van Cittert. The creative power of the collector couple was recognised and honoured with the German Cross of Merit. However, their work was interrupted by the early death of Sepp Hauptmann in 1997 while collecting fossils.
Subsequently, Traute Hauptmann organised and catalogued their diverse collection and gradually handed it over to the Urwelt-Museum Oberfranken in Bayreuth. The processing of the Hauptmann collection is still ongoing, with a special exhibition honouring their passion and dedication.
During this time, numerous collector communities came together. Notable individuals included Stefan Schmeißner from bach, the Stapf family from Nierstein, Jürgen Meyer from the district of Zwickau, and Gerald Friess and Peter Silberhorn from Baden-Württemberg. More recently,

Peter Silberhorn in 2007 at the rich Schnabelwaid site (Archiv. Friess)

Gerald Friess at the discovery of a juvenile fern at Pechgraben (1995, Archive Friess)

Manfred Fuchs working on the left lens in the sandpit Küfner. It was rich in *Podozamites distans, Bernettia inopinata,* and various cycads (spring 2022).

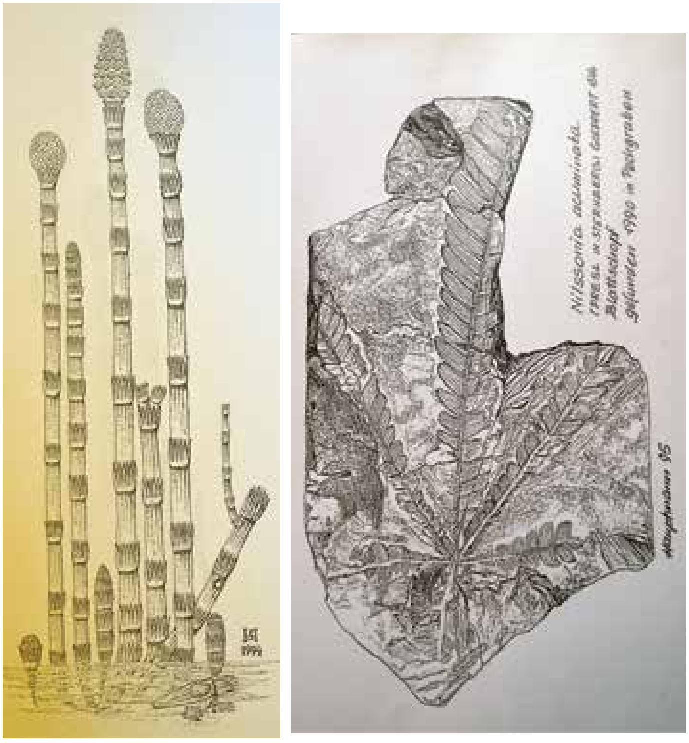
Sepp and Traute Hauptmann prospecting in 1996 (Schnabelwaid, Hauptmann Archive)

Unternschreez, sandpit Pross in 1992 with Sepp Hauptmann (Archive Hauptmann)

Pechgraben, sandpit Küfner, August 1990. On the left the famous lens 2, on the right the lens 4 (Archive Hauptmann)

Plant fossils in the collection in Hof

Irmtraud Hauptmann (6. 5. 1932–25. 9. 2021) in the year 2013 in her apartment, stuffed with fossils



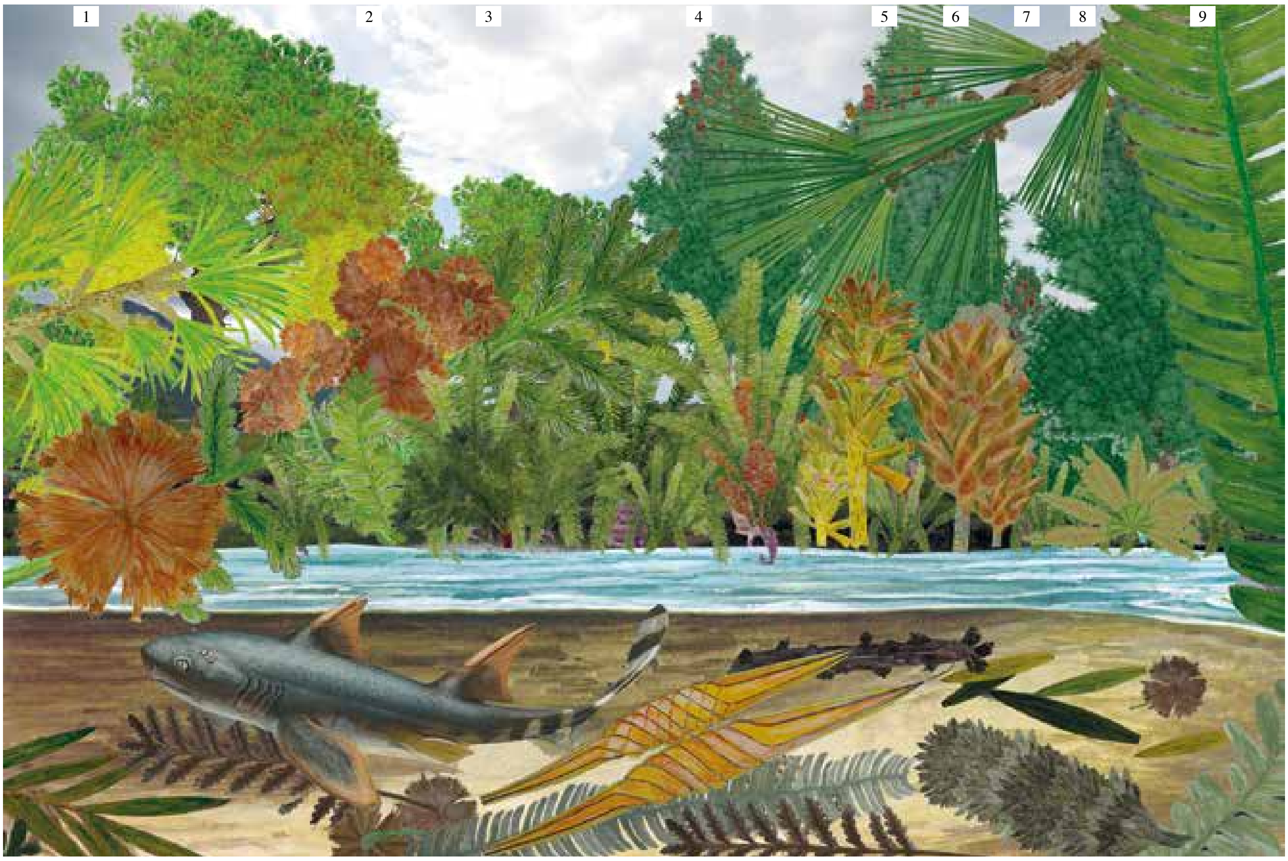
Sepp Hauptmann was a talented draughtsman. In the drawings, *Equisetites muensteri* is depicted with sporophylls and one of its flagship finds, *Nilssonia acuminata.*

The legacy to be processed with the two research assistants Ulrike Albert and Stefan Eggmaier

Thomas Gerasch from Langenaltheim, Manfred Fuchs from Hesse, and Michael Wachtler from South Tyrol have taken to working intensively on the Küfner sand pit in particular, which was slated for filling as part of a renaturation programme. In the past, collectors often focused on material deposited by excavators, but the current focus is on working with large-scale intact layers. This approach has made it possible to identify conifers, ferns, and cycads in their natural context. Furthermore, the discovery of the interesting lycopod *Bernettia inopinata* and the new genus *Bavarostrobus friessii* have added to the excitement of the project.

Acknowledgements:

Each work is based on many pieces of a puzzle. I would like to thank Dr Joachim M. Rabold, the museum director of the Urwelt-Museum Oberfranken in Bayreuth, as well as Dr Ulrike Albert, the scientific assistant, and Stefan Eggmaier, the taxidermist. I am also indebted to Hartmut Pochanke, the excavator operator of the sand pit. Special thanks are also due to Renè Kindlimann, the fossil shark specialist from Switzerland, and Köbi Siber, who were always on hand with help and advice. I am deeply indebted to Helmut Tischlinger (Stammham) for his unwavering support. I extend my heartfelt thanks to the collectors Gerald Friess (Großbottwar), Peter Silberhorn (Langenbrettach), Manfred Fuchs (Großbieberau), Thomas Gerasch (Langenaltheim), Thomas Perner (Förolach), and Jürgen Meyer (Lichtentanne). Some of them have generously entrusted me with their collections or the most interesting fructifications. I will ensure that they are processed and inventoried in the Dolomythos Museum,



Pechgraben, sandpit Küfner Early Jurassic. A hybodont shark (*Lissodus*) is swimming in the shallow water, which has just laid down its shark capsules (*Palaeoxyris muensteri)*. Conifers grow on the land ***Podozamites distans*** (1) and ***Swedenborgia liaso-keuperianus*** (8). In the shore area are the ferns ***Thinnfeldia rhomboidales*** (2) and ***Marattiopsis intermedia*** (3)***,*** as well ***Dictyophyllum acutilobum*** (7). The cycads were abundant with ***Nilssonia acuminata*** (4). Strange lycopods enriched the landscape: ***Bavarostrobus friessii*** (5) and ***Bernettia inopinata*** (6).

Michael Wachtler in the sandpit Küfner, Pechgraben on one of the richest strata (photo M. Fuchs)

creating well-organised documentation for posterity.

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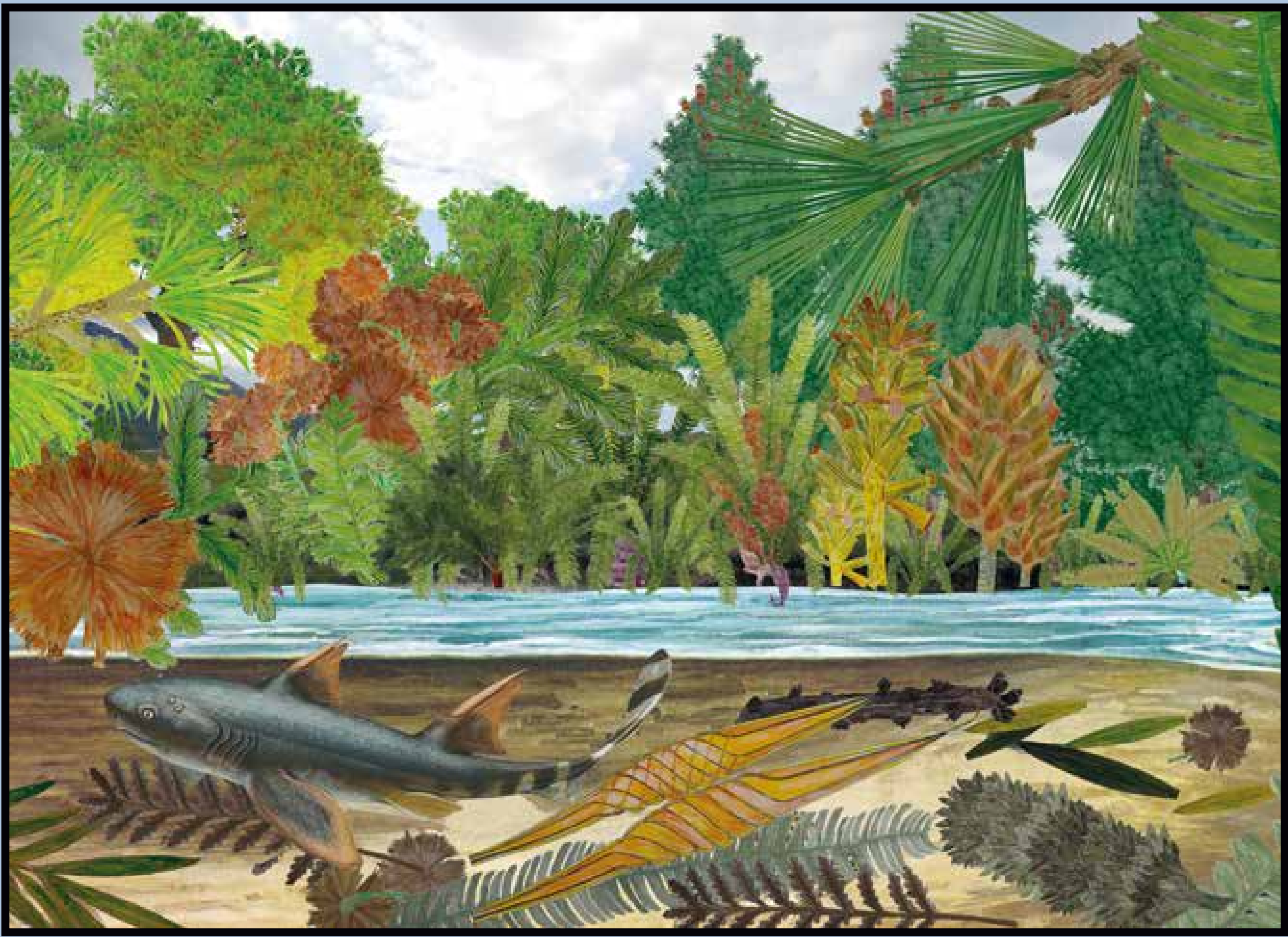

The Fossil Flora of Early Jurassic

A catastrophic decline in vegetation during the Upper Triassic period was followed by a remarkable resurgence of flora in the Lower Jurassic era. However, the family of flowering plants, which is prevalent today, was clearly absent during this time. Even potential ancestors of these plants remain unidentified. During the Lower Jurassic period, conifers such as Podozamites, Swedenborgia, and Hirmeriella dominated, although they are now only found in limited areas in East Asia, represented by species like the golden larch (Pseudolarix), umbrella fir (Sciadopitys), Taiwania, and precursors of ginkgo (Ginkgoites). Cycads, including the two-seeded Nilssonia and Ctenis, as well as the multi-seeded Macrotaeniopteris, were also quite common. Interestingly, ferns that are now rare, such as Matonia (Phlebopteris, Laccopteris) and ancestors of Dipteris (Thaumatopteris, Chlathropteris, Dicytophyllum, Sagenopteris, Otozamites), played an important role during this period. Another notable fern, Thinnfeldia, which can be classified within the large Schizaeales group due to its distinct trophophyll and sporophyll fronds, was abundant. Precursors of Marattiales (Marattiopsis) were numerous. Horsetails were represented by Equisetites and Schizoneura, while strange clubmosses such as Bernettia, Bavarostrobus and Lepacyclotes also had a notable presence, with no clear descendants identified.

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