Geo.Alp, Vol. 5, S. 69–81, 2008

CONSIDERATIONS ON *PHYLLADELPHIA STRIGATA* BRONN FROM THE HISTORICAL RAIBL FLORA (CARNIAN, LOWER UPPER TRIASSIC, ITALY)

Evelyn Kustatscher[1] and Johanna H.A. van Konijnenburg-van Cittert[2]

With 1 figure, 1 table and 3 plates

[1] Naturmuseum Südtirol, Bindergasse 1, 39100 Bozen, Südtirol, Italy; e-mail: Evelyn.Kustatscher@naturmuseum.it;
[2] Laboratory of Palaeobotany and Palynology, Budapestlaan 4, 3584 CD Utrecht, The Netherlands; e-mail: j.h.a.vankonijnenburg@uu.nl and National Natural History Museum 'Naturalis', PO Box 9517, 2300 RA Leiden, The Netherlands; e-mail: Konijnenburg@naturalis.nl

Keywords: Carnian, Upper Triassic, *Phylladelphia strigata*, Raibl, Alps, Italy

Abstract

Raibl is a historical Carnian (Upper Triassic) locality in the Alps, famous for fossil plants and fishes. Although already known from the 19th century, only a few authors described and figured the fossil flora. One of the more peculiar components of this flora is represented by 22 specimens: *Phylladelphia strigata* Bronn is characterized by relatively large, spatulate to tongue-shaped leaves with a pointed apex and broad basal attachment area. Several ribs run parallel to a putative midrib, apically transversally arranged marginal wrinkles are sometimes present.

When established by Bronn, *Phylladelphia* was considered a monocot leaf; afterwards Schenk and Stur compared it with sphenophytes. Up to now the botanical attribution of the genus is unclear, although it resembles slightly the problematic plant (putative angiosperm or ancestor??) *Sanmiguelia lewisii* Brown. Of particular interest is also the bilaterally symmetry of the leaves, indicating that the leaves were probably closed at some point of the life of the plant, perhaps during the juvenile stage.

Zusammenfassung

Raibl ist eine historische Fundstelle (Karnium, Obere Trias), welche besonders wegen ihrer fossilen Fische und Pflanzen berühmt ist. Obwohl diese seit dem 19. Jahrhundert bekannt sind, haben nur wenige Wissenschaftler diese Flora beschrieben und abgebildet. Zu den interessantesten Vertretern dieser Flora gehören 22 Exemplare von *Phylladelphia strigata* Bronn. *Phylladelphia* besitzt lange spatelförmige bis zungenförmige Blätter, einen spitzen Apex und eine breite Blattansatzstelle. Mehrere rippenförmige Verdickungen verlaufen parallel zum vermeintlichen Mittelnerv, am Apex können manchmal senkrechte oder geneigte Hautfalten erhalten sein.

Als Bronn diese Art benannte, betrachtete er sie als Blätter von Monokotyledonen; später stellten Schenk und Stur sie hingegen zu den Schachtelhalmen. Bis heute ist ihre botanische Zugehörigkeit nicht geklärt, auch wenn sie Ähnlichkeiten mit *Sanmiguelia lewisii* Brown hat, einer Pflanze, die möglicherweise zu den ersten (oder zu den Vorgängern der) Angiospermen zählt. Besonders interessant ist außerdem die bilaterale Symmetrie der Blätter, die darauf schließen lassen könnte, dass ihre Blätter im juvenilen Stadium möglicherweise gefaltet waren.

1 Introduction

The Raibl flora is one of the most famous historical floras from the Upper Triassic (Carnian) of the Alps. It has been known from the 19th century onwards, together with the famous floras from Lunz (Austria) and Neue Welt (Switzerland).

The first description of fossil plants from this area has been given in 1858 by H. G. Bronn, professor at the University of Heidelberg. In his paper he did not only describe 5 species and three undefined taxa from the Raibl area (Tab. 1) but also discussed the geology and various animal remains of this area. According to him some taxa from Raibl (*Noeggerathia*, *Voltzia*) were typical for the German Buntsandstein, others for the Keuper (*Taeniopteris*) or for the Lower Jurassic (*Pterophyllum*).

Later Schenk (1866) described newly collected material as well as part of the original specimens of Bronn, proposing a list of 10 species (Table 1). According to Schenk the most abundant taxon was *Voltzia coburgensis*, followed by *Equisetites* sp. and *Pterophyllum* spp. Rare taxa were *Neuropteris* sp. and *Taeniopteris* sp. Schenk emphasised also the bad preservation of the organic material, which did not allow him to see any details of the plant structure.

Stur (1868) studied in detail the stratigraphy and palaeontology of the "Bituminösen Schiefer" of Raibl. He described several outcrops containing fossil plants, bivalves, ammonoids, brachiopods and fishes. In 1885 he proposed a complete list of 18 different species distinguished so far in this area. In the same paper he also gave some interesting information regarding the specimens deposited at the Geologische Reichsanstalt (Geological Survey) at Vienna. According to him the first fossil plants had been collected by Foetterle in the years 1855-1856 and were sent to the "Museum der k.k. geologischen Reichanstalt" (= Geological Survey) in Vienna. Afterwards the elementary school teacher Joseph Tronegger (on assignment from the director of the "k.k. geologischen Reichanstalt") visited the locality several times for fossil plants and fishes. A list at the Geological Survey records the arrival of one box ("83 Pfund" = c. 42 kg) of "Fisch und Pflanzenabdrücke" (fossil fishes and plants) in 1855, sent by the board of mines. In 1862 six boxes of fossil fishes and plants ("260 Pfund" = 130 kg) were sent including "*Noeggerathia vogesiaca*" and "*Voltzia heterophylla*". In 1863 Joseph Tronegger sent seven boxes ("147 Pfund" = 74 kg) to Vienna, while a second collector, Joseph Dolling, sent four boxes ("108 Pfund" = 54 kg) to the Museum of the Geological Survey. In 1867 Josef Schnitzel collected fossils plants and animals, including "*Pterophyllum bronnii*" and "*Cephalotaxus*". The material collected by Stur for his "Beiträge ..." in 1868 is also recorded in the list. It is also the last recorded collection from the Raibl locality.

After Stur (1885) the flora from Raibl has been neglected for almost 150 years. Only Arber (1907) considered some specimens described as *Pterophyllum giganteum* and *Pterophyllum bronnii* by Schenk (1866), in his "Treatise on the Triassic species of the genera *Zamites* and *Pterophyllum*". Passoni et al. (2003, p. 331-335) transferred *Pterophyllum bronnii* Schenk to *Sphenozamites* after the study of a Carnian Flora from northern Italy. In 2001 Dobruskina, Jurkovsek and Kolar Jurkovsek published a list of fossil plants from Raibl (Tab. 1) as well as a comparison between the classifications of the various researchers. They also figured several specimens with their original determination as written on the labels.

Even so, almost 150 years after the first detailed descriptions of Bronn, Schenk and Stur this important Carnian flora needs a modern taxonomic study, which was started in 2005 with a Synthesys project (AT-TAF-2999: "Taxonomic revision of the Carnian (Upper Triassic) conifers from the historical Raibl flora from Northern Italy"). First the specimens attributed to the species *Pterophyllum sandbergeri* Schenk have been studied and transferred to the genus *Ptilozamites* (see Kustatscher & van Konijnenburg-van Cittert, 2007).

In the present paper the focus is on another species of the Raibl flora, indicated so far as *Phylladelphia strigata* Bronn, *Calamites raibelianus* Schenk, *Equisetites strigatus* (Bronn) Stur or *Equisetum strigatum* (Bronn) Stur. This taxon will be described and its possible botanical affinities discussed.

2 Geographical and geological setting

The fossil locality of Raibl (today called Cave del Predil) is a historic locality, famous not only for fossil plants (e.g. Schenk, 1866-67; Stur, 1868), but also for bivalves (e.g. Allasinaz, 1966) and fishes (e.g. Bronn, 1858; Kner, 1866). It is situated near the

Bronn 1858	Schenk 1866	Stur 1868	Stur 1885	Arber, 1907	Dobruskina et al, 2001
	Equisetites sp.				*Equisetites* sp.
Monocotyledon fragment	*Calamites arenaceus* Schenk	*Equisetites arenaceus* Schenk	*Equisetum arenaceum* Jaeger		
		Aneimia ? sp.			
		Chiropteris sp.			
		Clathropteris sp.	*Clathropteris* sp.		
Taeniopteris marantaceae Presl.	*?Taeniopteris angustifolia* Schenk	*Danaeopsis* cf. *marantaceae* Presl.	*Danaeopsis* cf. *marantaceae* Presl.		
	?Neuropteris ruetimeyeri Heer	*Neuropteris* cf. *ruetimeyeri* Heer	*Speirocarpus* cf. *ruetimeyeri* (Heer) Stur		
			Rhacopteris raiblensis Stur		
			Sagenopteris sp.		
		Cycadites suessii Stur	*Cycadites suessii* Stur		
Filices, gen. indet.	*Cyatheites pachyrhachis* Schenk	*Dioonites pachyrrhachis* Schenk	*Dioonites pachyrrhachis* Schenk		*Dioonites pachyrhachis* Schenk
Noeggerathia vogesiaca (Schim. & Moug.) Bronn	*Pterophyllum bronnii* Schenk	*Pterophyllum bronnii* Schenk	*Pterophyllum bronnii* Schenk	*Pterophyllum bronnii* Schenk	*Pterophyllum bronnii* Schenk
					Pterophyllum filicoides (Schloth.) Thomas
	Pterophyllum giganteum Schenk	*Pterophyllum giganteum* Schenk	*Pterophyllum giganteum* Schenk	*Zamites grandis* Arber	
		Pterophyllum cf. *jaegeri* Brongniart	*Pterophyllum longifolium* Jaeger		*Pterophyllum longifolium* Brongniart
Pterophyllum minus Brongniart	*Pterophyllum sandbergeri* Schenk	*Pterophyllum sandbergeri* Schenk	*Pterophyllum sandbergeri* Schenk		
					Pterophyllum ? sp.
			Cephalotaxites raiblenisis Stur		*Cephalotaxites raiblenisis* Stur
					Desmiophyllum sp.
					Podozamites ? sp.
					Yuccites ? sp.
					Voltzia heterophylla (Brong.) Schimp. & Moug.
Voltzia heterophylla (Brong.) Schimp. & Moug. p.p.	*Voltzia coburghensis* von Schauroth p.p.	*Voltzia foetterlei* Stur	*Voltzia foetterlei* Stur		*Voltzia foetterlei* Stur
Voltzia heterophylla (Brong.) Schimp. & Moug. p.p.	*Voltzia coburghensis* von Schauroth p.p.	*Voltzia ? haueri* Stur	*Voltzia haueri* Stur		*Voltzia haueri* Stur
					Voltzia pachyphylla Schimper
Voltzia heterophylla (Brong.) Schimp. & Moug.	*Voltzia coburghensis* von Schauroth	*Voltzia raiblensis* Stur	*Voltzia raiblensis* Stur		*Voltzia raiblensis* Stur
		Voltzia sp.			*Voltzia* sp.
Plantarum genus indeterminatum					
		Carpolithes sp.	*Carpolithes* sp.		
Phylladelphia strigata Bronn	*Calamites raibelianus* Schenk	*Equisetites strigatus* (Bronn) Stur	*Equisetum strigatum* (Bronn) Stur		*Equisetites strigatus* (Bronn) Stur

Table 1: List of the various plants and their synonyms from Raibl as indicated in literature (Bronn, 1858; Schenk, 1866; Stur, 1868, 1885; Arber, 1907; Dobruskina et al, 2001)

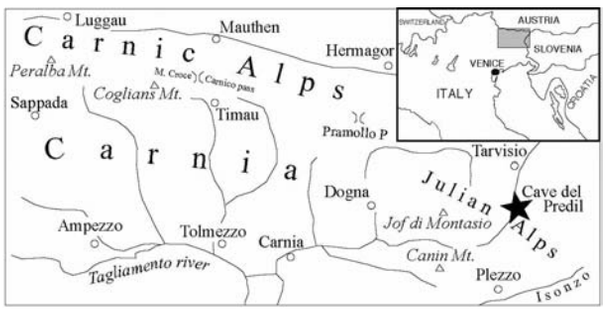

Fig. 1. Location of the Raibl / Cave del Predil area (star) (mod. after Roghi et al., 2006).

north-eastern border between Italy and Slovenia in the Julian Alps (Fig. 1). During the time this area was called Raibl and was part of the Austro-Hungarian Kingdom, it was an important mining area, mainly for zinc sulphide, lead and iron metals, and therefore investigated closely by Austrian geologists (see also Bronn, 1858; Roghi, 2004).

Schenk (1866-1867, p. 10) described plant specimens deriving from the "Schwarze Schiefer" (Black shales), Stur (1885, p. 100) called the layers "Bituminöse Schiefer" (bituminous shales). Today these strata rich in fossil fishes, crustaceans, plants and ammonites are part of the Predil Limestone (see also Roghi, 2004 and references). The Predil Limestone consists of alternations of thin-bedded dark limestones, dolomites and marly slates, deposited in anoxic marine conditions and is of lower Julian age (from Roghi, 2004, p. 3).

3 The material

So far only 22 specimens are known. Most of them (18 specimens) are stored in the Geological Survey of Vienna ("GBA" prefix), three in the Museum of Natural History of Vienna ("NHM" prefix) and one in the National Natural History Museum "Naturalis" in Leiden ("Leiden"). In most cases only one part is preserved; only two specimens at the Museum of Natural History of Vienna (NHM1866/0040/464 and NHM 1866/0040/466) and four at the Geological Survey of Vienna (GBA 2007/072/0013A/B, GBA 2007/072/0039 and GBA 2007/072/0051) are part and counter part of the same fossil. Another set of part and counterpart of the same fossil are stored in different collections, respectively at the Museum of Natural History of Vienna (NHM1866/0040/465) and at the Geological Survey of Vienna (GBA1986/2/101).

The original material described by Bronn and Schenk, stored at the Botanical Garden of Würzburg, disappeared probably during World War II.

4 History of *Phylladelphia strigata* in literature

In 1858 Bronn described *Phylladelphia strigata* and figured two specimens, which he considered short and wide monocot leaves. These leaves show a midrib or thickening in the central part of the leaf, while laterally several (5-6) costae (or ribs) run parallel to the midrib. Partly these parallel costae (or ribs) are connected by small wrinkles, while secondary veins are missing. According to Bronn the specimens resembled *Convallaria polygonatum* (today a junior synonym of *Polygonatum odoratum* (Mill.) Druce).

Afterwards, Schenk (1866) described and discussed new material from Raibl. Because of the similarity with the German horsetail *Equisetites platyodon* Schenk assigned the specimens described by Bronn to the new (and invalid) species *Calamites raibelianus* Schenk.

Stur (1868) described well-preserved specimens similar to those collected by Bronn (1858) and Schenk (1866). He agreed with Schenk concerning the botanical attribution of the specimens to the genus *Equisetites*, but with the nomenclatorial correct epithet *strigatus* (changing its generic name into *Equisetum* in 1885). Mostly he considered the various "leaves" to be fused basally into a leaf sheath.

5 Description

PLANTAE INCERTAE SEDIS
Order indet.
Family indet.
Genus *Phylladelphia* Bronn 1858
Phylladelphia strigata Bronn 1858
Plates 1-3

Synonymy:
1858 *Phylladelphia strigata* Bronn 1858, p. 49-51, pl. 7, figs 2-3.

1866 *Calamites raiblianus* Schenk, p. 14-15, 19, pl. 1, fig. 1.
?1866 *Equisetites* sp., Schenk, p. 19.
1868 *Equisetites strigatus* (Bronn) Stur, p. 101.
1885 *Equisetum strigatum* (Bronn) Stur, p. 102.
1994 *Phylladelphia strigata* Bronn 1858, Dobruskina, p. 299.
2000 *Phylladelphia strigata* Bronn 1858, Dalla Vecchia, p. 22.
2001 *Equisetites strigatus* Brongniart 1858, Dobruskina et al., pl. 10, figs 3-11.

Description:
Most specimens are represented by leaf-like structures or fragments of those. Most leaves are incomplete; two specimens at the Geological Survey of Vienna seem to represent however complete or almost complete "leaves" (GBA 2007/ 072/0039 and its counterpart GBA 2007/072/0051, Pl. 1, Fig. 4; GBA 2007/072/0013A/B, Pl. 1, Figs. 5-6). They are spatulate to tongue-shaped with a pointed apex and broad basal attachment area. The entire leaves are up to 96 mm long, with a maximum width of 44 mm and basally only 18-25 mm wide. The width of the basal part of the leaf (c. 3 cm) is more or less the same, then the leaf blade expands slowly for another 3 cm and the distal 3 cm are contracted again, ending in an acute apex.

In the central part, a furrow (or ridge in the counterparts) is visible, crossing the whole leaf and becoming more distinct in the basal half of the leaf; this might represent a midrib. It works almost as a symmetry axis. Laterally to this feature several (4-5) ribs (costae) (at a distance of 1-2 mm) run parallel to it, up to the apical margin. In the distal half, where the leaf is broader, 2-3 additional ribs appear, crossing the entire lamina, from one margin to the other. Basally the leaf appears to be thicker, and the attachment area is almost straight (e.g. GBA 2007/072/0013A/B, Pl. 1, Figs. 5-6; GBA 1986/2/145, GBA 1986/2/111, Pl. 1, Fig. 7).

Usually the specimens are only partly preserved, either the basal or the apical part. In the apical fragments the ribs, although visible, seem less prominent (NHM 1866 XL 464, Pl. 3, Fig. 2; GBA 2007/072/0088, Pl. 1, Fig. 8). Sometimes the leaf fragments show only the wide costae-like structure with this central furrow (e.g. GBA 1986/2/101, Pl. 2, Fig. 2; Leiden THDP 4628, Pl. 2, Fig. 5). In apical fragments the margin shows sometimes marginal wrinkles of up to 5 mm long (NHM 1866 XL 464, Pl. 3, Fig. 2), while in the central part also the first few ribs near the symmetry axis are connected by very small, up to 1 mm long wrinkles (GBA 1986/2/101, Pl. 2, Fig. 2). In basal fragments the ribs are much more prominent. The specimen figured by Schenk (1866, pl. 1, fig. 1) was almost certainly a basal one (with its straight attachment area).

In a few cases the leaves or leaf fragments cover each other partly (GBA 1986/2/120, Pl. 2, Fig. 1; GBA 2007/072/0044, Pl. 3, Fig. 3). In this case the leaves seem slightly more rhomboidal than in the isolated specimens. Finding several leaves together suggests that the leaves arose originally from one common axis. This is also confirmed by a specimen from the Geological Survey labelled "*Annulariopsis waagenii* F. Kr. n. sp." consisting of two leaf bases arched almost as arranged around a now missing axis (GBA 2007/072/0017).

Perhaps a young, "closed" leaf can be distinguished in the flora. It is 39 mm long and 16 mm wide, with a long and pointed apex and several costae at a distance of 1–1.5 mm (GBA 2007/ 072/0019, Pl. 2, Fig. 4)

Annotation:
Schenk (1866) placed this species in *Calamites*, because of the similarities with the German horsetail *Equisetites platyodon*; Stur (1868) transferred it to *Equisetites*. In the collection of the Geological Survey there are several fragments (e.g. 2007/072/0020, 2007/072/0027) labelled *Equisetites strigatus* Bronn that do not belong to *Phylladelphia strigata* but are stem fragments belonging to *Equisetites* and showing vascular bundles.

The labels of the various *Phylladelphia* specimens as well as the numbers on the labels give us some information on the period the specimens have been collected. It is interesting that the specimens stored at the Museum of Natural History of Vienna (acquired in 1866 shown by the labels 1866 XV 464-466) indicate *Phylladelphia strigata* Bronn on their labels (Pl. 1, Fig. 1). Also the specimen in the National Natural History Museum "Naturalis" in Leiden was recorded as *Phylladelphia strigata* Bronn. On the other hand, the specimens stored today at the Geological Survey of Vienna are labelled as "*Equisetites strigatus* Bronn sp." from the "k.k. geologischen Reichsanstalt" (Pl. 1, Fig. 2). These specimens at least correspond to older material classified by Stur as *Equisetites strigatus* (Bronn) Stur, probably before 1885, since by then

Stur transferred the material to the living genus *Equisetum* and not to the fossil genus *Equisetites*. The labels indicating "Sammlungen der Reichsstelle für Bodenforschung" (Pl. 1, Fig. 3), written after 1939 (the "Reichsstelle für Bodenforschung" has been instituted in 1939 and cancelled in 1945), and also showing "*Equisetites strigatus* Bronn sp." are probably just a re-writing of old, historical labels since the way of writing is the same as the one labelled "k.k. geologischen Reichanstalt". Additionally no re-sampling after 1868 has been recorded in the official list of the Geological Survey at Vienna.

Locality: Raibl/Cave del Predil (Julian Alps, Italy).

Storage: Museum of Natural History and Geological Survey (both Vienna), National Natural History Museum "Naturalis", Leiden.

Type-material:
Since the original material figured by Bronn (1858) seems to have disappeared we had to define a neotype: GBA 2007/072/0013A/B, it is the most complete single leaf fragment of *Phylladelphia strigata* showing also the ribs (Pl. 1, Figs. 5-6) and is stored at the Geological Survey (Vienna).

6 Discussion

The botanical affinity of *Phylladelphia strigata* Bronn is completely unclear; there are very few Triassic plants with similar characteristics. Bronn (1858) thought that the specimens belonged to a monocot plant with two or three leaves attached at the same level to the axis. Later, Schenk (1866) and Stur (1868, 1885) considered *Phylladelphia* to be a sphenophyte (attributing it respectively to the genera *Calamites*, *Equisetites*, *Equisetum*), with "leaves" fused basally into a leaf sheath. The specimens are quite probably leaves, frequently found isolated, which might have been attached to an undefined structure or axis, even if the attachment is still not clear. The ribs are not comparable with vascular bundles of *Equisetites*/*Equisetum*; they are much too broad and thick. They resemble more some structural strengthening (fibrous bundles?) sometimes found in thick leaves.

So far, no similar material has ever been found in European Triassic (or even Jurassic) floras. Spatulate to tongue-shaped leaves with parallel veins are often considered typical for angiosperms and especially monocots *Phylladelphia strigata* is remotely similar to the problematic Triassic plant (putative angiosperm or ancestor??) *Sanmiguelia lewisii* Brown 1956 first described from Colorado (USA). When in 1956 Brown found these leaves with parallel veins, he compared them with monocots and especially palms. The broadly oval or elliptic leaves have a restricted basis, their maximum width in the middle part of the leaf and an acute or acuminate apex (Tidwell *et al*., 1977). The leaves are sessile and spirally inserted on the axis. Particular, and similar to our material, is the presence of ribs (or costae), attributed to fibrous bundles. Veins are also visible, about 11/cm in the larger leaves.

Because of the macromorphological features of these leaves (leaf shape and size, ribs, veins and leaf distribution along the stem) Tidwell *et al*. (1977) compared *Sanmiguelia* to the monocot genus *Veratrum* (Green or False Hellebore). However, they did not consider *Sanmiguelia* a monocot, because some important characteristics of the monocots were still missing: a visible second order of venation, cross veins, or apical fusion of the vascular bundles. Tidwell *et al*. (1977) compared *Sanmiguelia* also to other plant groups, and stated that it has no cycadophyte leaf features and is easily distinguishable both from the conifer *Pelourdea* (ribs missing) and the horsetail *Schizoneura* (leaves in groups of three and arranged in whorls). Cornet (1989) described afterwards from the late Carnian of Texas leaves plus inflorescences, carpels and solitary male flower-like units attributed by him to *Sanmiguelia*. He described also secondary veins and concluded that *Sanmiguelia* might be a semi-aquatic herbaceous monocot resembling the extant genus *Veratrum* (Liliaceae). The botanical attribution of the species to the monocots (or even angiosperms) is however still under debate (Taylor & Taylor, 1993).

Our specimens resemble *Sanmiguelia* in the presence of ribs (costae); the preservation does however not allow to distinguish a clear venation pattern (the most distinct one is figured in Pl. 2, Fig. 5) and no reproductive organ can be attributed to *Phylladelphia strigata*. They differ from the leaves of *Sanmiguelia* however in being considerably smaller and having a different shape. Moreover, in *Sanmiguelia* the longitudinal ribs are parallel to the margin, arising near the leaf base and merging at

the apex. They show, therefore, a higher concentration at the apex and base than in the central part of the leaf (Tidwell *et al.*, 1977). In *Phylladelphia* the longitudinal ribs (costae) are parallel to the symmetry axis (or mid vein) and independent from the leaf margin. Additionally, *Phylladelphia strigata* does not show any clear secondary vein structure. The wrinkles, observed in some specimens, originate probably from desiccation of the leaf or are caused by the thickness of the leaf substance, and are not due to transversal secondary veins, evidenced also by their appearance and disappearance independently from the margin.

Another slightly comparable Triassic taxon is the conifer genus *Pelourdea*. *Pelourdea*-like leaves are well known from the Carnian flora of Raibl (labeled often as *Noeggerathia vogesiacus*) but are easily distinguishable from *Phylladelphia* because of the different shape (spatulate to tongue-shaped against lanceolate for *Pelourdea*) and size (96 mm x max. 44 mm against at least 260 x 30 mm) of the leaves and the absence of ribs (costae). In *Pelourdea* no costae have been found but veins with a frequency of up to 12/cm (in the middle part of the leaf).

An interesting feature for *Phylladelphia* is the bilaterally symmetry of each leaf, together with the furrow (?midvein) running along the entire leaf indicating that the leaves were probably closed at some point of the life of the plant (in the juvenile stage? See Pl. 2, Fig. 4). This feature has not been observed so far in any Triassic plant.

A concrete attribution of *Phylladelphia* to any botanical group is not possible, until better preserved specimens are collected or fertile structures can be attributed to these leaves.

Acknowledgements

We wish to thank Alexander Luckeneder and Andreas Kroh (Naturhistorisches Museum Wien) for the help during the study of the Raibl flora. Irene Zorn and Barbara Meller (Austrian Geological Survey) not only made the Raibl flora available but helped also in the understanding of the history of the Raibl specimens and with the research of the old bibliography. Menno Booi took the picture of the specimen at National History Museum "Naturalis" in Leiden (NL). The manuscript was greatly improved by the constructive remarks and considerations from Barbara Meller (Austrian Geological Survey).

The project "Taxonomic revision of the Carnian (Upper Triassic) conifers from the historical Raibl flora from Northern Italy " (AT-TAF-2999) received funding through SYNTHESYS, which is made available by the European Community - Research Infrastructure Action under the FP6 „Structuring the European Research Area" Programme.

References

Allasinaz, A. (1966): Il Trias in Lombardia XVIII. La fauna a Lamellibranchi dello Julico (Carnico medio). Rivista Italiana di Paleontologia e Stratigrafia, 72: 609–752.

Arber, E.A.N. (1907): On Triassic species of the genera *Zamites* and *Pterophyllum* types of fronds belonging to the Cycadophyta. The Transactions of the Linnean Society of London 7(7): 109–127.

Bronn, H.G. (1858): Beiträge zur Triasischen Fauna und Flora der bituminösen Schiefer von Raibl, nebst Anhang über die Kurr'sche Sippe *Chiropteris* aus dem Lettenkohlen-Sandsteine. 63 pp., E. Schweitzerbart'sche Verlagshandlung und Druckerei, Stuttgart.

Brown, R.W. (1956): Palmlike plants from the Dolores Formation (Triassic) in southwestern Colorado. U.S. Geol. Surv. Prof. Paper, 274: 205–209.

Cornet, B. (1989): The reproductive morphology and biology of *Sanmiguella lewisii*, and its bearing on angiosperm evolution in the Late Triassic. Evolutionary trends in Plants, 3(1): 25–51.

Dalla Vecchia, F.M. (2000): Macrovegetali terrestri nel Mesozoico Italiano: un'ulteriore evidenza di frequenti emersioni. Natura Nascosta, 20: 18–35.

Dobruskina, I.A. (1994): Triassic Floras of Eurasia. 422 pp., Springer Verlag, Wien.

Dobruskina, I.A., Jurkovsek, B., Kolar Jurkovsek, T. (2001): Upper Triassic Flora from „Raibl beds" of Julian Alps (Italy) in Karavanke Mts. (Slovenia). Geologija, 44(2): 263-290.

Kner, R. (1866): Die Fische der bituminosen Schiefer von Raibl in Kärnthen. Sitzungsbericht der Akademie der Wissenschaften Wien, 53: 152–197.

Kustatscher, E., Van Konijnenburg-Van Cittert, J.H.A. (2007): Taxonomical and palaeogeographic considerations on the seedfern genus *Ptilozamites*. Neues Jahrbuch der Geologie und Paläontologie, 243(1): 71–100.

Passoni, L., Van Konijnenburg-Van Cittert, J.H.A. (2003): New taxa of fossil Carnian plants from Mount Pora (Bergamasc Alps, Northern Italy). Review of Paleobotany and Palynology 123: 321–346.

Roghi, G. (2004): Palynological investigations in the Carnian of Cave del Predil area (once Raibl, Julian Alps). Review of Palaebotany and Palynology, 132: 1–35.

Roghi, G., Kustatscher, E. van Konijnenburg-van Cittert, J.H.A. (2006): Late Triassic Plant from Julian Alps (Italy). Bollettino della Società Paleontologica Italiana, 45 (1): 133-140.

Schenk, A. (1866-7): Über die Flora der schwarzen Schiefer von Raibl. Würzburger naturwissenschaftliche Zeitschrift, 6:10-20.

Stur, D. (1868): Beiträge zur Kenntnis der geologischen Verhältnisse der Umgebung von Raibl und Kaltwasser. Jahrbuch der Geologischen Reichsanstalt, 18: 71-122.

Stur, D. (1885): Die obertriadische Flora der Lunzer-Schichten und des bituminösen Schiefers von Raibl. Sitzungsbericht der Kaiserlichen Akademie der Wissenschaften Wien, Mathematisch-Naturwissenschaftliche Klasse, Abt. 1, 88(1): 93-103.

Taylor, T.N., Taylor, E. J., (1993): The Biology and Evolution of plants. 982 pp., Prentice-Hall Inc., Englewood Cliffs, New Jersey (USA).

Tidwell, W.D., Simper, A.D., Thayn, G.F. (1977): Additional information concerning the controversial Triassic plant: *Sanmiguelia*. Palaeontographica, Abt. B, 163: 143-151.

Manuscript submitted: February 21, 2008
Revised manuscript accepted: March 31, 2008

Plate 1 (scale = 10 mm if not otherwise indicated)

1. Historical label from a specimen at the Museum of Natural History of Vienna (NHM 1866 XL 464).
2. Historical label from a specimen at the Geological Survey of Vienna (GBA 2007/072/0019).
3. Historical label (between 1939 and 1945) from a specimen at the Geological Survey of Vienna (2007/072/0013A).
4. Almost complete leaf of *Phylladelphia strigata* Bronn (GBA 2007/072/0051).
5. Complete leaf of *Phylladelphia strigata* Bronn, neotype (GBA 2007/072/0013A).
6. Complete leaf of *Phylladelphia strigata* Bronn, counterpart of the neotype (GBA 2007/072/0013B)
7. Basal leaf fragment of *Phylladelphia strigata* Bronn (GBA 1986/2/111).
8. Apical leaf fragment of *Phylladelphia strigata* Bronn showing the ribs (GBA 2007/072/0088).

Plate 1

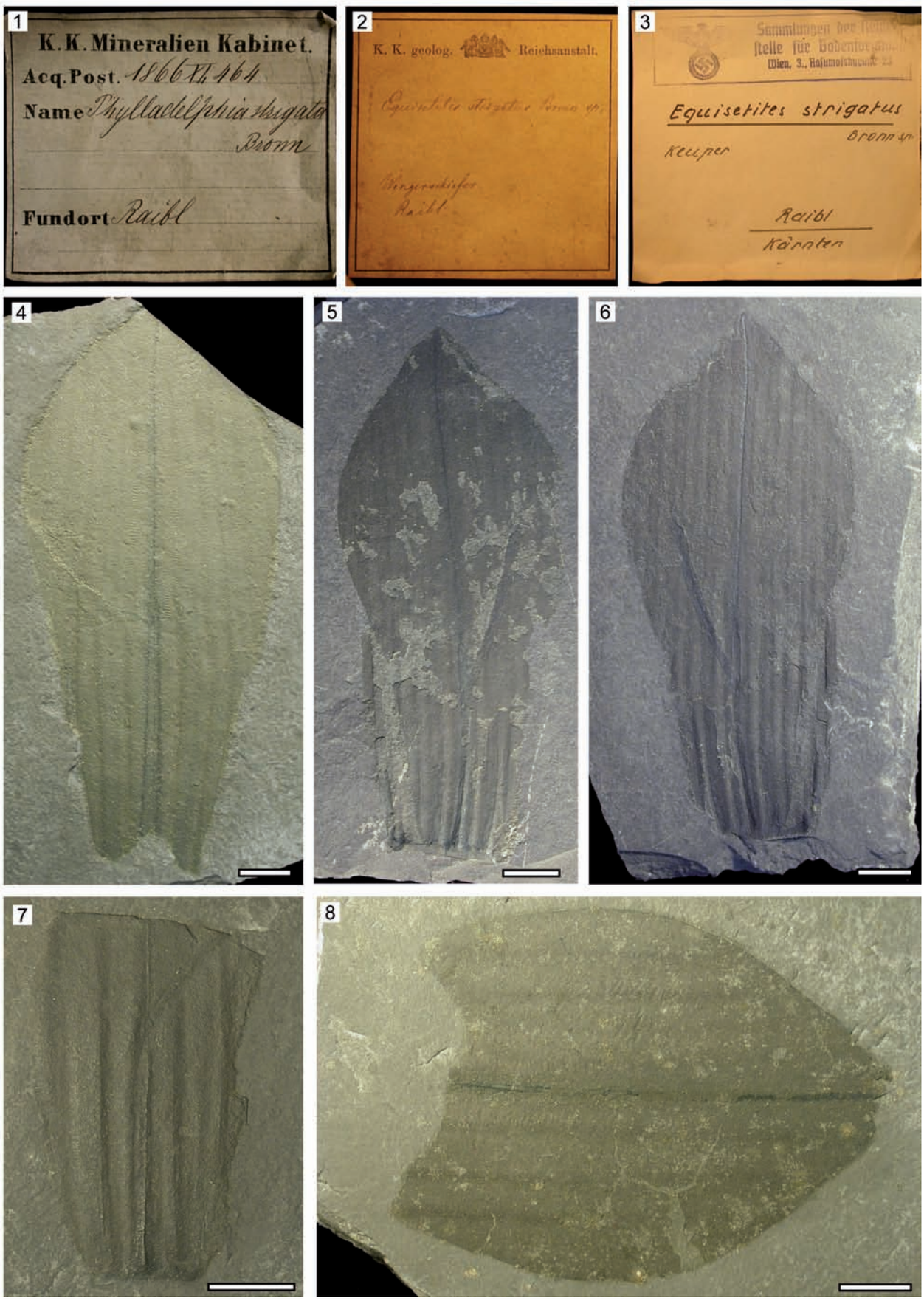
1
K.K. Mineralien Kabinet.
Acq. Post.
Name
Fundort Raibl
2
K. K. geolog. Reichsanstalt.
3
Equisetites strigatus
Keuper
Raibl
Kärnten
4
5
6
7
8

Plate 2 (scale = 10 mm if not otherwise indicated)

1. Several basal leaf fragments of *Phylladelphia strigata* Bronn partially covering each other (GBA 1986/2/120).
2. Basal leaf fragment of *Phylladelphia strigata* Bronn with marked ribs and distinct midrib (GBA 1986/2/101).
3. Detail of the counterpart of Fig. 2 (GBA 1986/2/101), showing the midrib and the small trasversal wrinkles (NHM 1866 XL 465) (scale = 5 mm).
4. Putative young leaf of *Phylladelphia strigata* Bronn (GBA 2007/072/0019).
5. Specimen with distinct ribs (Leiden THDP 4628).

Plate 2

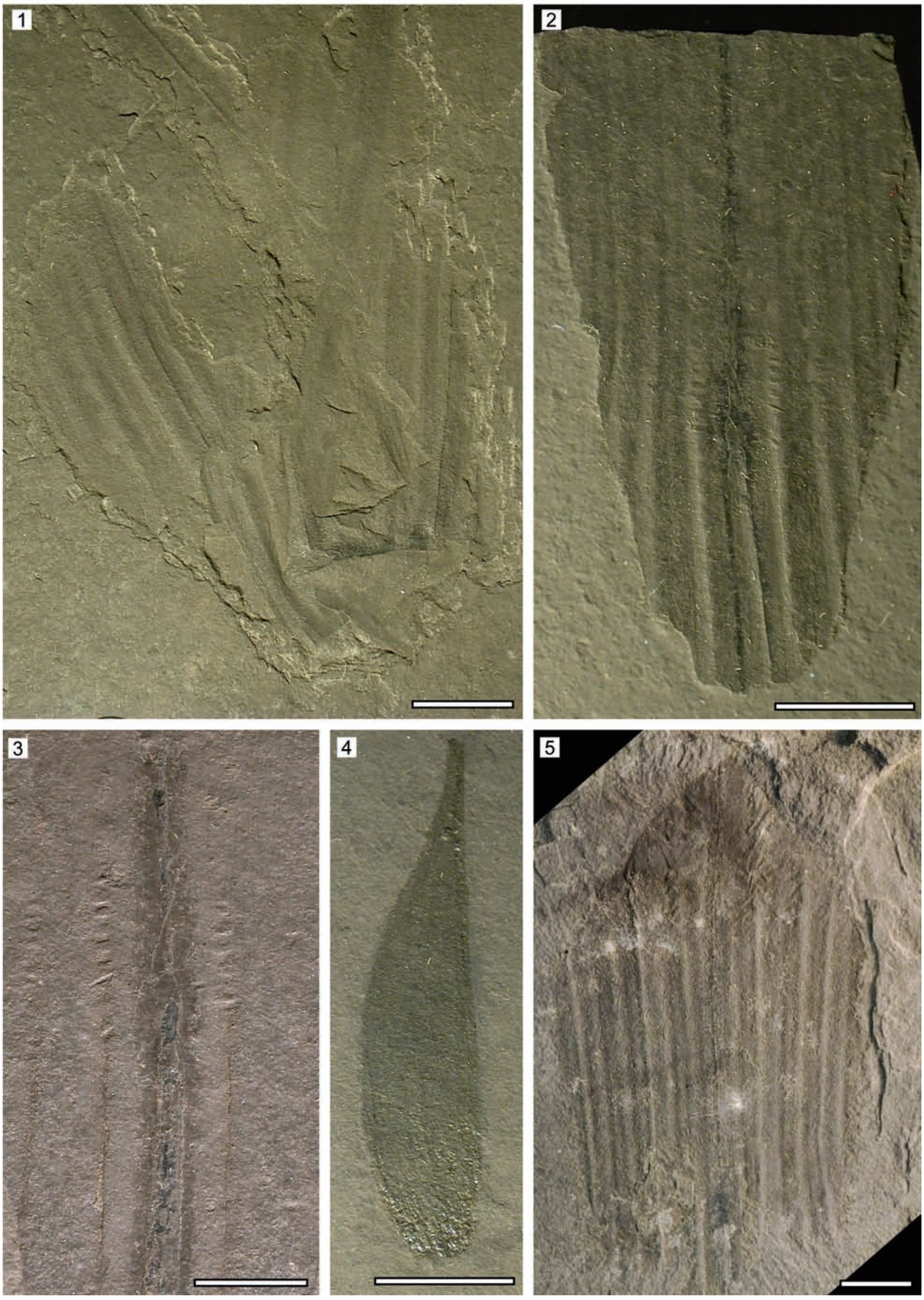

Plate 3

1. Original figure of *Phylladelphia strigata* in Bronn (1858), pl. VII, fig. 2.
2. Fragmentary apical leaf fragment of *Phylladelphia strigata* Bronn with marginal wrinkles (NHM 1866 XL 464)
3. Specimen showing three apical leaf fragments and resembling Bronn's pl. VII, fig. 2 (see Pl. 3, Fig. 1) (GBA 2007-072-0044).

Plate 3