

FRICIA NOBILIS FROM THE TURONIAN OF THE CZECH REPUBLIC REINTERPRETED AS AN OVULIFEROUS CONE OF A CUPRESSOID CONIFER

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Abstract. *Fricia nobilis* VELENOVSKÝ from the Bílá Hora Formation (Turonian) of the Bohemian Cretaceous Basin is reinterpreted as an ovuliferous cone of a conifer from the family Cupressaceae. A number of arguments are presented to show that its presumed cycadalean affinity can be ruled out. The most important argument is the presence of seeds in the cone. The seeds of *Seletya* type with a campylotropous locule found *in situ* argue for the systematic position of *Fricia* within the Cupressaceae s. l. The differences between the genera *Fricia* and other conifers, particularly *Geinitzia* are discussed. The diagnosis of *Fricia* is emended and a lectotype and an epitype are selected.

■ *Fricia*, *Geinitzia*, *Seletya*, Cupressaceae, Turonian, Bohemian Cretaceous Basin

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Introduction

The genus *Fricia* was erected by Velenovský (1885) to celebrate Professor Antonín Frič, one of the most influential people in the National Museum in the late 19th and early 20th century. The fossil was described by Velenovský (1885) as a male cone of a cycad. This interpretation by Velenovský (1885) was frequently accepted (Berry 1916, Domin 1938), although sometimes with hesitation (Seward 1917, Němejc 1968). Although, the morphology of *Fricia* does resemble male cones of some recent cycad genera such as *Zamia*, the typical Mesozoic genus *Androstrobus* SCHIMPER 1870 is quite dissimilar to *Fricia*. Velenovský (1885) associated *Fricia* with the Cenomanian cycad foliage *Nilssonia bohémica* (Velenovský 1885, J. Kvaček and Knobloch 1997), however his association was not supported by any real characters.

A detailed study of the *Fricia* material, particularly the specimen from Praha – Prosek, which was for a long time inaccessible for study, shed new light on the nature of the genus *Fricia*. The discovery of seeds *in situ*¹ in that specimen clearly argued for a definite rejection of the interpretation of *Fricia* as a cycad pollen cone.

Material and Methods

Material

Six specimens of *Fricia* ovuliferous cones are housed in the old Museum collection. The specimens are preserved as partly limonitized casts. They come from the Bílá Hora

Formation, which was formed from classical sandy marlstones (opuka in Czech). This type of rock has been excavated since medieval times as an important building stone building for the city of Prague. The Bílá Hora Formation as defined by Čech et al. (1980) is formed by shallow-water marine marlstones. A high percentage of sponge spicules is characteristic for most of the Bílá Hora Formation sediments. The marine fauna is characterised by *Inoceramus labiatus* (SCHLOTHEIM), *I. hercynicus* PETRASCHEK, *I. inaequalis* SCHLÜTER, *I. cuvieri* SOWERBY, *Mammites nodosoides* (SCHLOTHEIM), *Lewesiceras peramplum* (MANTELL) etc. (Čech et al. 1980).

In the 19th century numerous quarries on the slopes between the village of Bílá Hora and Strahov Gate in Prague city town wall were exploited for the sandy marlstones for use as building stone. All of them are now closed being replaced by large Strahov stadiums and also housing developments as a part of the expanding city. Fossils were quite rare in the quarries as mentioned by Frič (1878, 1879). In all these quarries however, the stone was excavated manually, and thus the fossils were collected by quarry miners or local people. A. Frič often went there and on a regular basis bought fossils from these people. This is the way most of the fossils were accumulated. In the Museum collection they are generally labeled as Bílá Hora, but due to amateur sampling usually nothing was known about their precise location within the Bílá Hora Formation. This is also the case with *Fricia nobilis*.

¹ Revision of the National Museum's Turonian fossil plants began with a complete rearrangement of the Mesozoic and Cenozoic collections. This was motivated by the transfer of the entire palaeontological collection from the old building to new depositories in Praha – Horní Počernice. This largely happened between 2007–2011.

Some profiles in the Bílá Hora area are however still accessible e.g. near to the Landronka farm house sediments of the Bílá Hora Formation crop out at a height of about 5 m. The closest working quarry in the area nowadays is located in Přední Kopanina. The profile there was designated as a neostratotype of the Bílá Hora Formation (Čech et al. 1980).

In the 19th and early 20th century quarries mining sandy marlstones from the Bílá Hora Formation were also active in north east of Prague in Prosek (Prosík). The stone was mined in an area between streets Na Prosecké vyhlídce, Na Vyhlídce, Na Pokraji and Na Prosecké cestě (now Litoměřická). Fossils were even rarer there, but the best preserved specimen of *Fricia* was found in that area.

Methods

The specimens were photographed under low angle incident light using a Canon EOS 6D camera with a Canon 100 macro lens. The material was studied and photographed under Olympus SZX 12 binocular microscope equipped with an Olympus DP72 digital camera. Detailed photographs were taken by digital microscope Keyence VHX-2000. Photographs were processed and the plate assembled using Adobe Photoshop 7.01.

Systematic palaeontology

Order Pinales

Family Cupressaceae

Genus *Fricia* VELENOVSKÝ 1885

Type: *Fricia nobilis* VELENOVSKÝ 1885 p. 8, pl. 3, figs 1–3, 6, 11.

Emended diagnosis. Isolated ovoid ovuliferous cones, cone scales helically arranged, massive, cylindrical with centrally placed vascular bundle and polygonal smooth fasete (escutateon). Each cone scale bearing seeds of *Seletya* type in irregular rows.

Discussion. *Fricia* VELENOVSKÝ is defined as an ovuliferous cone with unknown foliage. In that way it differs from the genus *Geinitzia* ENDLICHER 1847 which is based on sterile foliage. The genus *Geinitzia* was previously understood in two ways, either as a form genus based on sterile foliage (Harris 1979) or a natural genus based on foliage and ovuliferous cone (as emended by Kunzmann 1999). Because the conservation of *Geinitzia* as a natural genus with the new type (*G. formosa*) was not successful (Zijkstra et al. 2010, Herendeen 2011), *Geinitzia* is in this paper understood as a morphogenus based on its type *G. reichenbachii* and which has as the holotype a sterile twig (Kunzmann 2010). However, differences exist between the ovuliferous cones of *Fricia nobilis* and *Geintzia formosa* in the morphological characters. The ovuliferous cones of *Fricia nobilis* differ from those of *Geinitzia formosa* in having a more conical and massive cone axis, and cone scales bearing more seeds, in at least two irregular rows. *Fricia* has flat cone scale fasetes (escutateons) while *Geinitzia formosa* has ornamented fasetes. Both cones however contain *Seletya* type seeds. The occurrence of *Seletya* type

seeds in ovuliferous cones was a major argument used by Kunzmann (1999) when establishing the family Geinitziaceae. However, the Geinitziaceae is in need of revision and should be reconsidered with respect to more recent studies based on molecular data (Gadek et al. 2000, Kusumi et al. 2000, Farjon 2005) in which the Taxodiaceae and Cupressaceae were united in the Cupressaceae s.l. The Geinitziaceae can be distinguished from other Cupressaceae by the following characters: seed morphology (campylotropous/ curved locule), arrangement of vascular bundles and resin ducts in the cone scale complex (Kunzmann 1999). From this point of view the Geinitziaceae are a distinguishable group of conifers, most likely within the Cupressaceae s.l., its status however will be the topic of a forthcoming publication.

Another similar ovuliferous cone *Cupressospermum* MAI, differs from *Fricia* in the lower number of seeds born in a zigzag row and particularly in having seed morphology more similar to *Kozykorpeshia* than *Seletya* (Kunzmann 1999).

From other cupressoid ovuliferous cones e.g. *Cunninghamites lignitum* (Bosma et al 2012) *Fricia* differs in the type of seed (*Seletya*) and in shape of the cone scale. *Fricia* has very conical massive cone scales whereas *Cunninghamites* has more flat peltate cone scales. In the shape of its cone scales, *Fricia* resembles the recent genus *Cupressus*, however *Fricia* does not exhibit a decussate arrangement of cone scales. The genus *Conago* MILLER et HICKEY 2010 (type *Conago tonsifera* MILLER et HICKEY 2010 from the Early Cretaceous Wintrop Formation in Washington) is presented as a morphogenus of cones of unknown systematic affinity. *Fricia* differs from *Conago* in having a clear systematic position. In morphology it particularly differs in having *Seletya* type seed and massive conical ovuliferous cone scales.

Fricia also differs from cycadoid male cones of *Androstrobus* SCHIMPER 1870 in the absence of pollen sacs and from the ovuliferous cones *Microzamia* CORDA in REUSS (see Kvaček 1997), it differs in the high number of curved seeds per cone scale.

Fricia nobilis VELENOVSKÝ

Pl. 1, figs 1–6; Pl. 2, figs 1–4

1885 *Fricia nobilis* VELENOVSKÝ, p. 8, pl. 3, figs 1–3, 6, 11.

1917 *Fricia nobilis* VELENOVSKÝ, Seward, p. 505.

1938 *Fricia nobilis* VELENOVSKÝ, Domin, p. 117.

1968 *Fricia nobilis* VELENOVSKÝ, Němejc, p. 253, 256, pl. 29.

Lectotype. NMP F 340 designated here, pl. 1, figs 1, 4, 6.

Epi type. NMP F 1444, designated here, pl. 1, figs 2, 5.

Type locality. Praha – Bílá Hora district.

Type horizon. Bílá Hora Formation, Turonian, Late Cretaceous.

Occurrence. Praha – Bílá Hora, Praha – Prosek, Nové Strašecí.

Material. NMP F 338, F 339, F 3735 – F 3738.

Emended diagnosis. Isolated ovoid ovuliferous cones, cone scales helically arranged on robust main axis. Each cone scale massive, cylindrical having polygonal, usually hexagonal smooth fasetes (escutateons). Seeds

curved, *Seletya* type, numerous, arranged irregularly in two or more irregular rows on the surface of the whole cone scale cylinder.

Description. The lectotype F 340 exhibits ovoid ovuliferous cone 68 x 32 mm. Its axis is 0.9-1.1 mm broad bearing about 60 helically arranged cone scales (pl. 1, fig. 1). The massive axis shows helically arranged circular scars from detached cones-scales showing centrally located limonitized vascular bundle. Each massive cylindrical ovuliferous cone scale is 11-14 mm long and about 3-5 mm broad. It is narrow at the base (4 mm in diameter), widening towards the apex (12–14 mm in diameter). The facete (escutateon) is difficult to observe, because it is usually tightly embedded in the sediment. In one place it had been previously removed by Velenovský. It shows a smooth hexagonal facete (escutateon) (pl. 1, fig. 4). The inner surface of the cone scale shows a number of small pits which are arranged in irregular rows (pl. 1, figs 1, 4). Two seeds *in situ* with limonitized integuments are filled with sediment (pl. 1, fig. 6). The seeds are ovoid (2–3 x 3–3.5 mm). Terminally they show fragmentary micropyle. Further details are not preserved. The epitype F 1444 as the best preserved specimen (pl. 1, fig. 2) and shows an ovoid, cylindrical cone (30 x 60 mm) and massive axis bearing about 50 cone scales. The cone scales are relatively small (4 x 10 mm) bearing number of fragmented curved *Seletya* type seeds. The seeds are small 1.5 x 3.5 mm. Although not usually complete, they show clearly curved campylotropous locules (pl. 1, fig. 5). The largest specimen, 93 mm long, shows an ovuliferous cone (pl. 2, fig. 1) broken longitudinally. Other ovuliferous cones (e.g. F 3738) are broken obliquely or perpendicularly showing a helical arrangement of ovuliferous cone scales (pl. 1, fig. 3, pl. 2, figs 3, 4). The figured specimen F 3738 (pl. 1, fig. 3) from Nové Strašecí displays cone scales which are very narrow basally (3 mm in diameter) and broad apically (15 mm in diameter).

Discussion. *Fricia nobilis* was described by Velenovský (1885) as a cycad male cone. This assumption was based on an interpretation of the pits on the cone scales as scars left after detachment of sporangia. This fact and the weakness of the argument were already questioned by Seward (1917). Having a very well preserved specimen available, designated here as an epitype (F 1444) which shows fragments of seeds it is clear that *Fricia nobilis* is not a cycad cone. The epitype shows (pl. 1, fig. 5) *Seletya* type seeds with campylotropous locules in some place which have nothing in common with the pollen sacs of the Cycadaceae. Also *Fricia nobilis* cone scales internal anatomy includes in particular a vascular bundle which corresponds with coniferous cone scales of *Geinitzia formosa* HEER (Kunzmann 1999). Additionally, the ovuliferous cones *Fricia nobilis* co-occur with sterile twigs of *Geintzia reichenbachii*.

The genus *Seletya* (with its type *S. krystofovichii*) was designed by Dorofeev (1979) for seeds with a campylotropous locule. A new name *Geinitzia krystofovichii* (DOROFEEV) KNOBLOCH and MAI was introduced by Knobloch and Mai (1986) who recorded such seeds in the Santonian of Quedlinburg. The seeds were also described by Kunzmann and Friis (1999) from the Santonian of Asen. Later these seeds were found *in situ* by Kunzmann (1999) in

ovuliferous cones of *Geinitzia formosa* HEER and *Geinitzia schlotheimii* KUNZMANN (2003) in the Santonian of Germany. This type of seed is characteristic for the whole group of conifers assigned to the Geinitziaceae by Kunzmann (1999).

Ovuliferous cones of *Geinitzia formosa* HEER and *Geinitzia schlotheimii* KUNZMANN differ from *Fricia nobilis* in having seeds arranged in one row per cone scale and in a number of morphological characters of the cone (see discussion of the genus). *Geinitzia formosa* from the Campanian of Grünbach, described by Herman and Kvaček (2010), shows the same type of cone, however seeds *in situ* were not recorded.

As previously mentioned in the discussion of the genus, *Fricia nobilis* resembles in overall shape ovuliferous cones of other Cupressaceae. An ovuliferous cone of similar shape and size is known in *Cunninghamites lignitum* from the Bohemian Cenomanian (Kvaček 1999, Bosma et al. 2012). However *C. lignitum* has peltate cone scales and only a few seeds per cone scale. *Fricia nobilis* is even less similar to other ovuliferous cones of *Quasisequoia crispa* (VELENOVSKÝ) J. KVAČEK and *Ceratostrobis sequoiaphyllus* VELENOVSKÝ (1885) both from the Bohemian Cenomanian (Kvaček 1999). Ovuliferous cones of these conifers are smaller and their surface is covered by the leafy tips of their elaborated escutateons.

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Explanations of the plates

PLATE 1

Fricia nobilis VELENOVSKÝ, Bílá Hora Formation, Turonian

1. Lectotype showing longitudinally broken ovuliferous cone with robust axis and helically arranged cone scales, Praha – Bílá Hora, F 340, scale bar 10 mm.
2. Epitype showing longitudinally broken ovuliferous cone with well preserved seeds, Praha – Prosek, F 1444, scale bar 10 mm.
3. Transversally broken specimen showing helically arranged conical shaped ovuliferous cone scales, Nové Strašecí, F 3738, scale bar 10 mm.
4. Lectotype, detail of conical ovuliferous cone scale showing smooth surface of facete (escutcheon), Praha – Bílá Hora, F 340, scale bar 2 mm.
5. Epitype, detail of seed of *Seletya* type showing campylotropous locule, Praha – Prosek, F 1444, scale bar 0.5 mm.
6. Lectotype, detail of two seeds of *Seletya* type with campylotropous locule, Praha – Bílá Hora, F 340, scale bar 0.5 mm.

PLATE 2

Fricia nobilis VELENOVSKÝ, Bílá Hora Formation, Turonian, Praha – Bílá Hora

1. The largest specimen coming from the type collection, F 338, scale bar 10 mm.
2. Apical part of the ovuliferous cone, F 3735, scale bar 10 mm.
3. Detail of ovuliferous cone scale, F 3737, scale bar 10 mm.
4. Transversely broken specimen, F 3736, scale bar 10 mm.

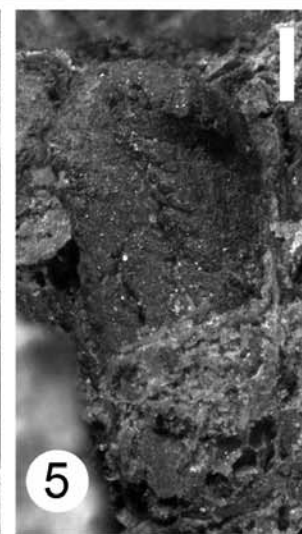
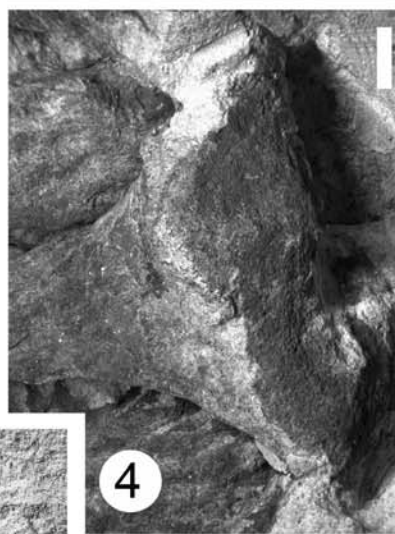
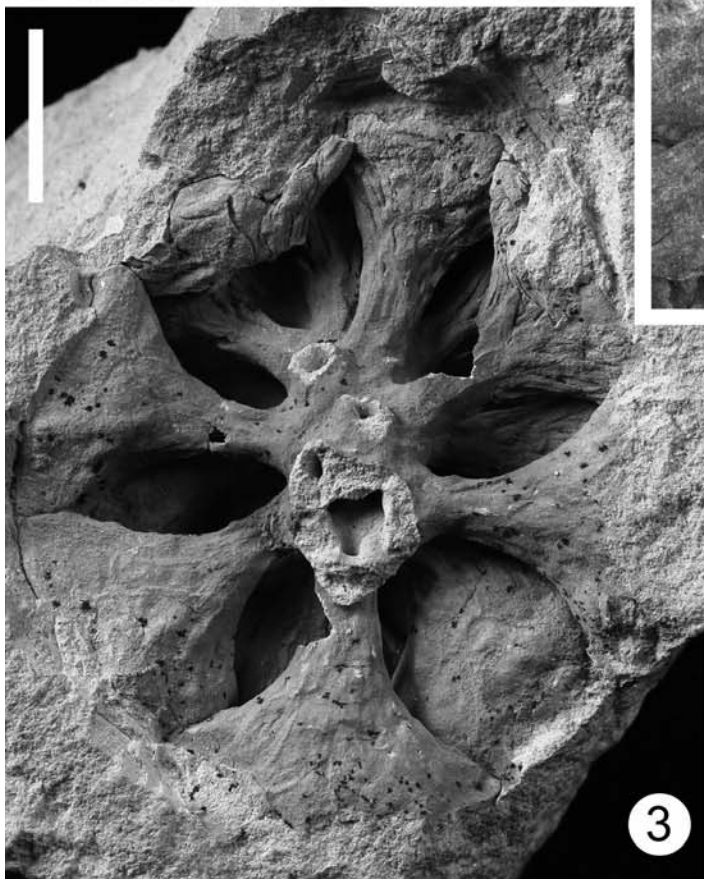
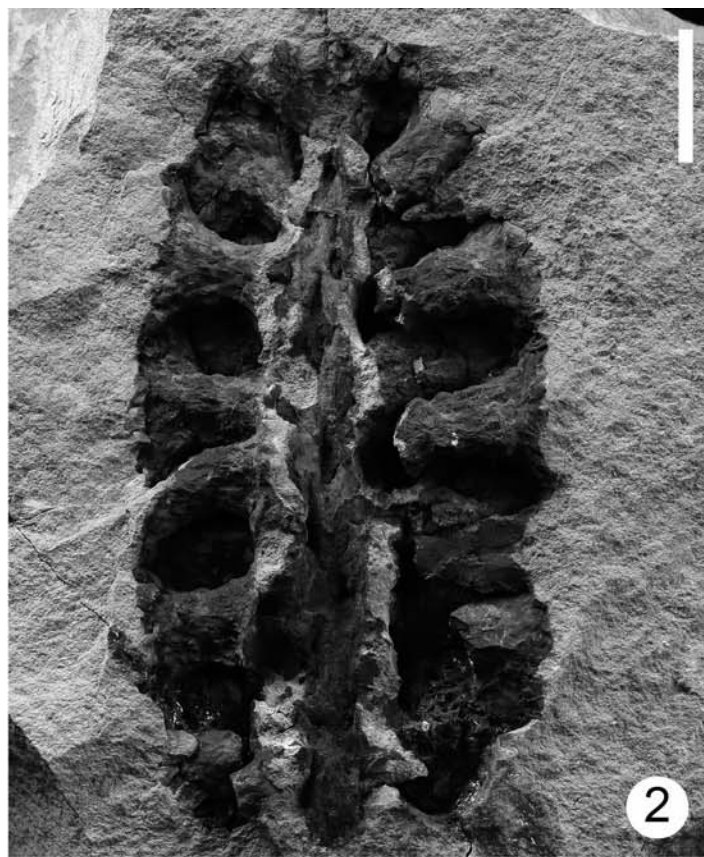


PLATE 2

