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MIOCENE BRACKET FUNGI (BASIDIOMYCETES, APHYLLOPHORALES) FROM THE NETHERLANDS

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For the first time, bracket fungi (Basidiomycetes, Aphyllophorales) are recorded from Miocene deposits in the province of Noord Brabant (The Netherlands). The extremely good preservation allows the specimens to be tentatively referred to the well-known extant European genus *Ganoderma* Karsten, 1881, thus extending the range of this genus down into the Miocene. The present record appears to be the first documentation of fossil basidiocarps of the polyporoid Ganodermataceae from Europe. The described material reveals two types of fossilisation (carbonization and partial petrification).

Key words — Fungi, Basidiomycetes, Ganodermataceae, Miocene, The Netherlands.

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CONTENTS

INTRODUCTION

In a sand pit near the 'De Hoogdonk' brickyard at Liessel (province of Noord Brabant), Miocene-Pleistocene sediments are excavated to a maximum depth of *c.* 40 metres. Due to the underwater quarrying it is not possible to collect *in situ* but on the basis of extensive collections made from 1986 onwards a preliminary stratigraphic column has been worked out (Collins & Fraaye, 1991). At a depth of *c.* 25 metres occur glauconitic sands and sandy clays rich in fossils, marine as well as terrestrial. These deposits are assigned to the Breda Formation (van Staalduinen *et al.*, 1979) of Miocene age.

Interfingering marine and terrestrial strata have yielded varying amounts of marine macrofossils and of fossil wood, cones and seeds. Amongst plant remains pieces of amber are occasionally found, as are leaf imprints. A fragmentary petrified fungus was encountered while screening the large collection of fossil wood remains at the Geo Centrum Brabant (Ammonietenhoeve, Boxtel). In view of the great rarity of fruiting structures of fleshy polypore fungi in the fossil record (see *e.g.* Andrews & Lenz, 1947; Stewart & Rothwell, 1993) a description of the Liessel bracket fungi, comprising a single near-complete carbonized specimen and two smaller incomplete petrified specimens, appeared warranted.

SYSTEMATIC DESCRIPTION

Order Aphyllophorales Rea, 1922
Family Ganodermataceae Donk, 1948
Genus *Ganoderma* Karsten, 1881

Ganoderma adspersum (Schulzer, 1878) Donk, 1969
(= *Ganoderma europaeum* Steyaert, 1961)
Pls 1, 2; Text-figs 1-6

Material — The available material is deposited in the collections of the Geo Centrum Brabant/Ammonietenhoeve, Boxtel, under registration numbers MAB Fu.0001 to 0003.
Description — The two larger specimens have become detached from their hosts. The basidiocarp is hoof shaped, clear concentric growth rings are in part preserved on the upper surface. The largest and most complete specimen (MAB Fu.0001) measures 14 x 11 cm in top view, and the thickness of the hymenial tube layer varies between 1.5 and 2.5 cm (Pl. 1, Figs 1-3). The maximum thickness of the bracket tissue amounts to 3.0 cm. Specimen MAB Fu.0001 is carbonized whereas the two others are petrified. The second largest specimen (MAB Fu.0002) measures 9.5 x 4.0 cm and preserves unidentifiable remains of the host along the wide and thick zone of attachment (Pl. 2, Fig. 1). About 4 cm from this zone the bracket tissue and hymenial tube layer are broken almost vertically.

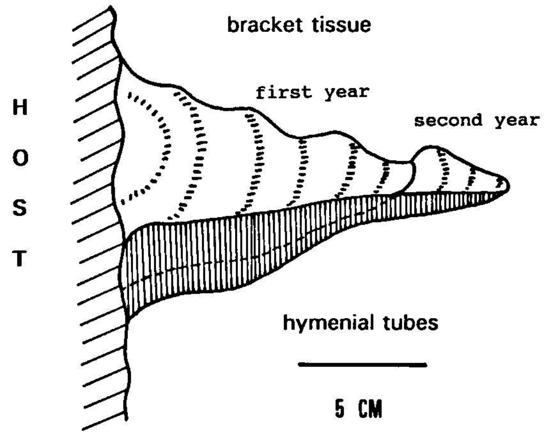

Fig. 1. Schematic vertical section of *Ganoderma adspersum* (Schulzer, 1878) Donk, 1969 on a host (modified from Ingold & Hudson, 1993).

The hymenial tube layer has a maximum thickness of 1.2 cm (Pl. 2, Fig. 2); it is sharply and regularly bounded from the bracket tissue. There are 3-4 hymenial tubes per millimetre (Pl. 2, Fig. 3; Text-fig. 2). The bracket tissue reaches a total thickness of 2.9 cm.

Microscopical studies of parts of the broken surface of specimen MAB Fu.0002 revealed well-preserved cellular structures (Text-figs 2-6).

DISCUSSION

European studies of fossil fungi are generally limited in number and are scattered in the literature.

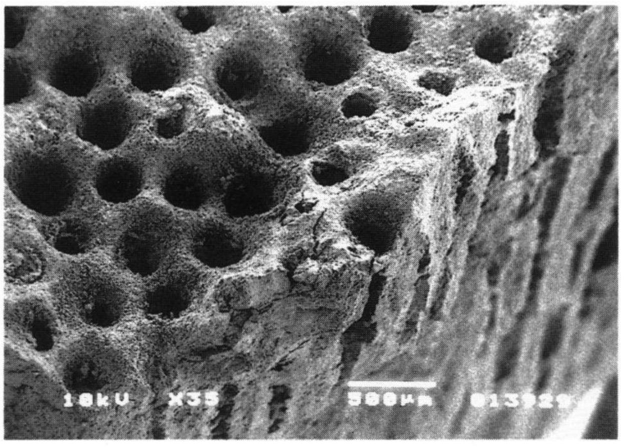

Fig. 2. *Ganoderma adspersum* from the Miocene of Liessel. SEM photomicrograph of pore surface and lateral view of hymenial tubes of specimen MAB Fu.0002. Scale bar equals 500 μm.

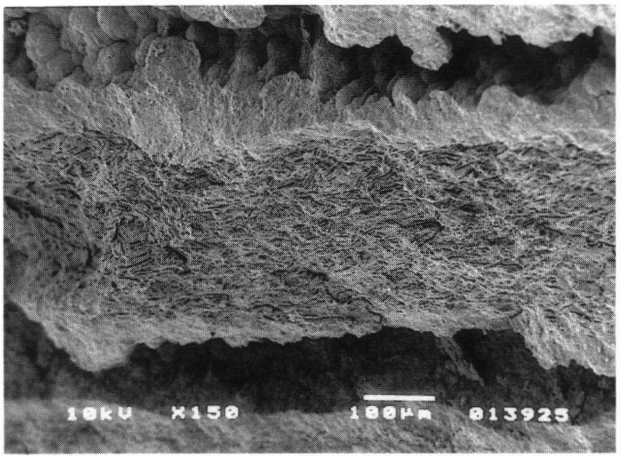

Fig. 3. *Ganoderma adspersum* from the Miocene of Liessel. SEM photomicrograph of two hymenial tubes of specimen MAB Fu.0002. Scale bar equals 100 μm.

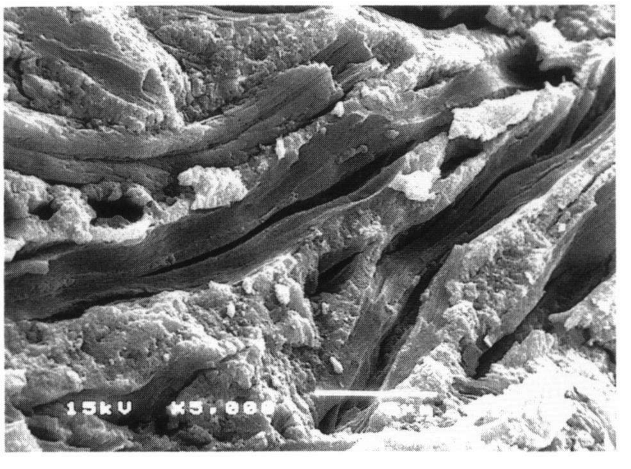

Fig. 4. *Ganoderma adspersum* from the Miocene of Liessel. SEM photomicrograph of interhymenial tube tissue of specimen MAB Fu.0002 (detail of Fig. 3). Scale bar equals 5 μm.

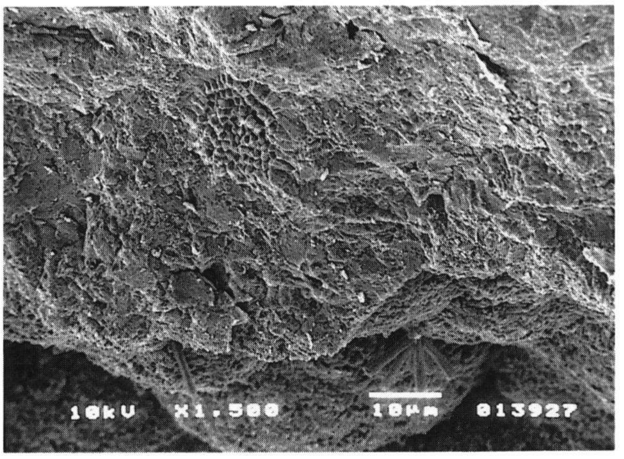

Fig. 5. *Ganoderma adspersum* from the Miocene of Liessel. SEM photomicrograph showing globular structure within hymenial tube tissue of specimen MAB Fu.0002. Scale bar equals 10 μm.

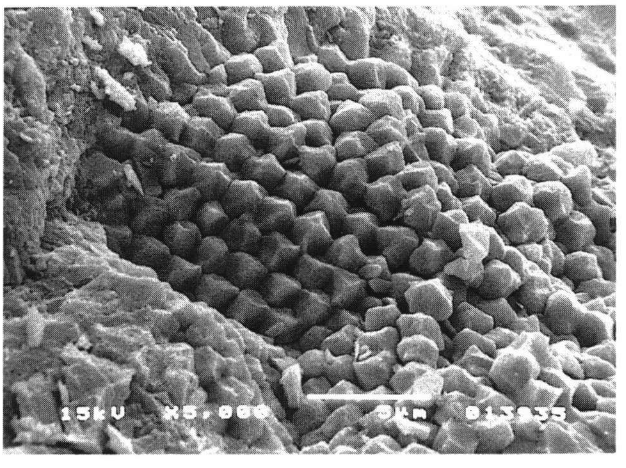

Fig. 6. *Ganoderma adspersum* from the Miocene of Liessel. SEM photomicrograph showing angular elements of globular structure of Fig. 5 of specimen MAB Fu.0002. Scale bar equals 5 μm.

Zablonka (1931) described three species of Pyromycetes from Miocene salt deposits of Wieliczka (Poland) and Neuy-Stolz (1958) recorded many microscopic fungal remains from the German Neogene lignite deposits.

On molecular clock evidence the holobasidiomycetes diverged from the ascomycetes 390 Ma ago (Berbee & Taylor, 1993). In the detailed overview of fossil fungi presented by Stewart & Rothwell (1993) the oldest basidiomycete fungi are reported from the Upper Carboniferous; the only Cainozoic polypore genera that they list are *Geasterites* Cockerell, 1908 and *Fomes* Fries, 1847, the latter of probable Pleistocene age. The oldest known fruiting structure of a holobasidiomycete polypore bracket fungus, *Phelinites digiustoi* Singer & Archangelsky, 1958, was recorded from the Middle Jurassic petrified forests of Patagonia, Argentina (Berbee & Taylor, 1993). Amongst modern West European representatives in forest biotopes comparable to the Liessel occurrence, the following genera of bracket fungi may be considered: *Fomes*, *Fomitopsis* Karsten, 1881, *Ganoderma* Karsten, 1881, *Inonotus* Karsten, 1880, *Perenniporia* Murrill, 1942 and *Phellinus* Quél., 1886. Species of *Fomes* and *Inonotus* have considerably thicker, console-shaped basidiocarps, and assignment of the Liessel fossils to the genus *Phellinus* is rejected on account of overall habitus and of setae being absent. Of the remaining genera, species of *Ganoderma* are the largest and have the most persistent texture. The absence of a stem and of distinct annual rings, the pore density and overall habitus of the basidiocarp in the Liessel specimens compare well with features shown by *Ganoderma adspersum* (Schulzer, 1878) Donk, 1969 (Text-fig. 1). This species differs from its most closely related congener *G. applanatum* (Persoon, 1799) Pat. in lacking a stratified hymenial tube layer, and in showing lower pore density and a thicker bracket tissue.

Nowadays, *G. adspersum* is probably the commonest species of the genus in western Europe (Pegler, 1990). Specific identification, however, is hampered by the wide range of variation displayed by macroscopic characters of the basidiocarps. There is no doubt that *Ganoderma* is the most difficult genus of all polypores (Ryvarden & Gilbertson, 1993). In many fungal studies *G. adspersum* is erroneously referred to as *G. applanatum* (see *e.g.* Jahn, 1979) or as *G. australe* (Fries, 1821) (see Ríos & Eyzaguirre, 1992).

Ganoderma adspersum is a perennial species, which occurs most frequently in subatlantic-submediterranean regions, and which is rare in eastern Europe and absent in northern Europe. It is common in the form of thick, woody brackets, sometimes 50 cm across, rigidly and broadly attached to the trunks of dead and dying trees, especially beech (Ingold & Hudson, 1993). This matches the common occurrence of fossilised beech-nuts associated with the Liessel bracket fungi. Like other *Ganoderma* species, *G. adspersum* causes a disease of forest trees known as 'white rot', to which many trees such as beech, linden, poplar, chestnut, birch, maple, basswood, oak and elm are susceptible. True firs, Douglas fir, spruce and hemlock rarely suffer from this parasitic fungus (Robbins *et al.*, 1965).

A *Ganoderma* basidiocarp may survive for a period of five to ten years. A large specimen is able to liberate 20 million spores per minute, and to maintain this for a five month spore-fall period (Ingold & Hudson, 1993). Unlike most bracket fungi, *G. adspersum* can continue discharging spores in the driest weather conditions, being able to produce metabolic water from the breakdown of cellulose in the wood of the host. Basidiomycetes play a vital role in nature in being able to recycle carbon and minerals fixed in plants. Basidiomycete fungi are the most effective organisms that can degrade lignin, a major component of wood (Leisola, 1990). Members of the so-called white rot fungi, such as *Ganoderma*, have recently been studied for their potential in biotechnological processes like biopulping (Ríos & Eyzaguirre, 1992).

About a dozen additional fossilised fungi have been found at Liessel, which are now in private collections and in the local Natural History Museum 'de Peel' at Asten, and which we hope will become available for future studies. In view of the high diversity in fossil tree taxa at this locality, we expect to find amongst the fungi quite a number of genera. Since the preservation of both wood and fungi at Liessel is excellent, it should prove possible in future to determine host-parasite relationships amongst these fossils.

Future palaeofungal polypore studies should also focus on insect inhabitants of the tube layers. For instance, the tubes of modern *Ganoderma applanatum* often yield larvae of the dipteran *Agathomya wankowiczi* Weidner & Schremmer, 1962, which produce rounded mounds at the pore surface with a central hole through which the adult insect ultimately escapes (Ryvarden & Gilbertson, 1993).

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PLATE 1

Ganoderma adspersum (Schulzer, 1878) Donk, 1969 from the Miocene of Liessel (province of Noord Brabant, The Netherlands).

Figs 1-3. Specimen MAB Fu.0001, different views showing bracket tissue surface, hymenial tubes and hymenial tube layer, respectively, x 1.

PLATE 1

1

2

3

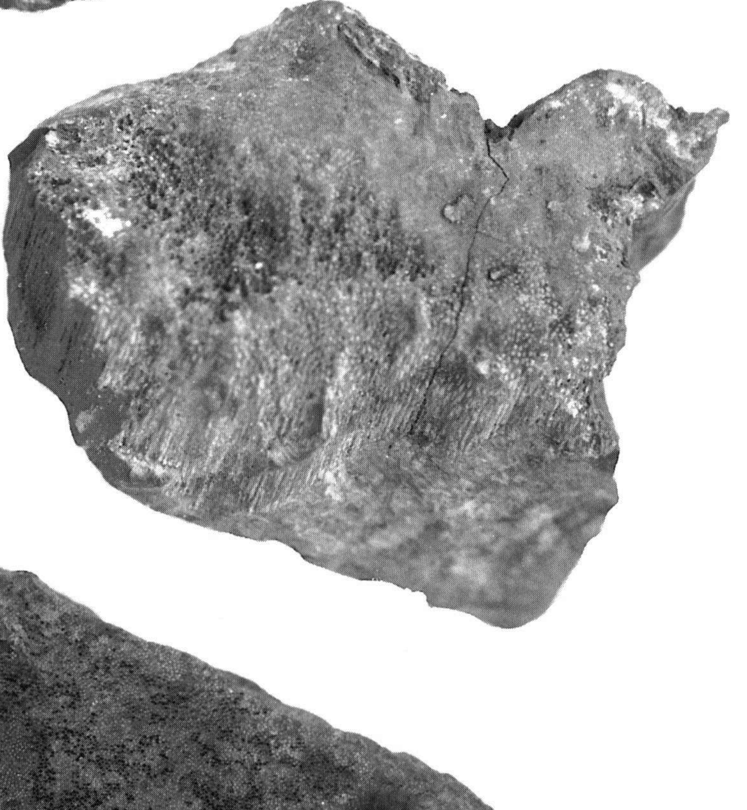
PLATE 2

Ganoderma adspersum (Schulzer, 1878) Donk, 1969 from the Miocene of Liessel (province of Noord Brabant, The Netherlands).

Figs 1-3. Specimen MAB Fu.0002, different views showing bracket tissue and carbonized parts of host, hymenial tubes and pore density of hymenial tube tissue surface, respectively, x 1.

PLATE 2

1



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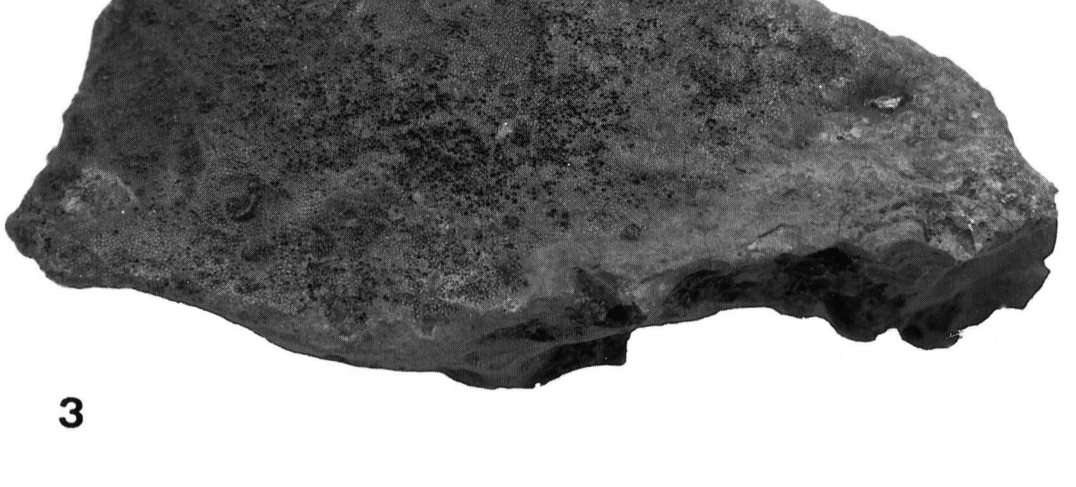

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