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INSECT BORINGS IN OLIGOCENE WOOD, KLIWA SANDSTONES, OUTER CARPATHIANS, POLAND

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Abstract: Two types of insect borings in silicified wood (Taxodiaceae or Cupressaceae) from Lower Oligocene turbiditic sands (Menilite Beds) in the Polish Outer Carpathians are reported. The first type is quite similar to those of larvae of the extant beetle genus *Anobium* and can be ascribed to the ichnogenus ?*Anobichnium* Linck, 1949. The second type resembles that of larvae of the living wasp genus *Sirex*. The studied trace fossils were produced by insects that fed on dead wood on land. The bored wood was moved into the shallow sea, buried in sand and then transported to the deep-sea environment by mass transport. Silification of the specimens probably started in marine conditions.

Abstrakt: Opisano dwa typy drążeń owadów w skrzemionkowanym drewnie (Taxodiaceae lub Cupressaceae) z dolnooligoceńskich piaskowców kliwskich (warstwy menilitowe) jednostki skolskiej zewnętrznych Karpat fliszowych. Pierwszy typ podobny jest do drążeń larw współczesnego chrząszcza *Anobium* i może być zaliczony do ichnorodzaju ?*Anobichnium* Linck, 1949. Drążenie drugiego typu podobne jest do drążeń larwy współczesnej błonkówki z rodzaju *Sirex*. Larwy owadów tworzyły drążenia w warunkach lądowych, prawdopodobnie w obumarłym drzewie. Nawiercone drewno zostało przetransportowane i pogrzebane w piaszczystych osadach płytkomorskich, a następnie przeniesione w głąb morza w spływie piaszczystym. Sylifikacja tych drewien rozpoczęła się prawdopodobnie w środowisku morskim.

Key words: borings, insects, wood, Oligocene, Carpathians.

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INTRODUCTION

Borings in wood are rare in flysch deposits. The finding of two pieces of bored fossil wood (by J. R.) in deep-marine flysch deposits of the Outer Carpathians in Poland, provides an opportunity for detailed description of such material. Dimensions and shape of the borings suggest that they were produced by insects.

Most of the borings that have been described so far in wood have been produced by bivalves of the families Teredinidae and Pholadidae. These borings are known under the ichnogenus name of *Teredolites* (e.g., Bromley *et al.*, 1984; Kelly & Bromley, 1984; Kelly, 1988).

Fossil borings formed by insects in wood are little known, although they have been described since the first half of 19th century. The literature on this topic is voluminous but scattered and the trace fossils, almost invariably, have been compared directly to the work of modern insect taxa instead of receiving trace fossil names. This literature has been collected partially by Kolbe (1888), Vialov (1975), and Boucot (1990). A wider review of plant-arthropod interactions is presented by Chaloner *et al.* (1991), Scott (1992), and Scott *et al.* (1992).

The application of nomenclature to trace fossils is inadvisable, especially in application to the older, Palaeozoic and Mesozoic forms. However, the younger Tertiary forms are not greatly changed (cf. Radwański, 1977), owing to the slow evolution of insects since this time. The most commonly described forms are those compared with borings of beetles of the genus *Anobium* (Tab. 1).

REMARKS ON INSECTS FEEDING IN WOOD

There are about 40.000 species of wood-eating insects known (Haack & Slansky, 1987). These mostly belong to larvae and adults of beetles (Coleoptera) of the families Anobiidae, Bostrychidae, Buprestidae, Cerambycidae, Lytidae, Platypodidae, and Scolytidae; termites; wasps and bees (Hymenoptera) of the families Siricidae and Xylohidridae, and moths (Lepidoptera) of the families Cossidae and Sessidae (Haack & Slansky, 1987).

Wood eaters are monophagous or polyphagous. Mono-

Table 1

Published records of wood borings related to the *Anobiidae*

References	Country	Age	Facies	Wood	Producer of trace fossil
Brues, 1936	U.S.A.	Upper Miocene	no data	*Pinus*	?Anobiidae
Freess, 1991	Germany	Middle Oligocene	shallow-marine siliciclastics	Pinaceae	*Anobium*-type
Gellehorn, 1894	Germany	Miocene	brown-coal formation	*Taxodium*	*Anobium*
Jurasky, 1932	Romania	Lower Jurassic	coal formation	no data	Anobiidae
Kolbe, 1888	Germany	Miocene	brown-coal formation	*Pinus silvestris, Cupressus, Taxites*	Anobiidae
Kušta, 1880	Czech Republic	Permian	sandstones	*Araucarites*	*Anobium*
Linck, 1949	Germany	Triassic (Keuper)	sandstones	?*Dadoxylon*	*Anobichnium simile*
Schönfeld, 1965	Germany	Miocene	brown-coal formation	Colostraceae	*Anobium*
Selmaier, 1984	Germany	Upper Miocene Oligocene	molasse	*Laurinoxylon seemannianum* deciduous	*Anobichnium simile*

phagy is most common. Insects may be wood-specific in respect to the taxonomy of wood, preservation (live, dead or decaying wood), and to the anatomical part of the tree. Some insects are adapted to feeding (see Haack & Slansky, 1987) on the nutritionally-rich inner bark (phloem and cambium), and others on harder and more nutrient-deficient xylem (sap wood and heartwood).

The insects are anatomically well-adapted to their nutritional environment. This is commonly expressed by their shape, and in consequence, by the shape of the borings, *i.e.* cylindrical shape in case of xylem feeders, and flattened shape in the case of phloemfeeders. The borers' legs are usually reduced and the mouth parts are strongly developed (Haack & Slansky, 1987).

Some insects, e.g. siricids and anobiids, are xylomycetophages, *i.e.* they feed on fungi farmed in their galleries. Monophagous insects are usually phloem eaters and the first colonisers of a tree, whereas the polyphagous insects are usually xylem eaters and are later colonisers (Haack & Slansky, 1987).

GEOLOGICAL SETTING

The Outer Carpathians comprise a few imbricated nappes consisting of Tithonian to Miocene flysch deposits, which attain a few thousands of meters in thickness in most of the nappes. It is believed that sediments of each nappe originated in separate deep-sea basins. The Skole nappe occupies the northern position in the eastern part of the Polish Outer Carpathians (Książkiewicz, 1977; Fig. 1A).

The pieces of fossil wood described here were found in the area to the south of Pawłokoma near Dynów (Fig. 1B) on the eastern side of the Bartkówka syncline (Rajchel, 1989). They were collected as loose pieces in weathered material derived from the Oligocene (Rupelian) Menilite Beds. Pieces of similar silicified wood have been found previously in different parts of the Skole nappe only in sediments of the same age (Brzyski, 1979; Kotlarczyk, 1979), but they lack borings. The weathered material bearing the described specimens comes from the so-called "cherty-marly complex" and the Kliwa Sandstone that form the lower part of the Menilite Beds. Local field conditions indicate that the specimens derive from the Kliwa Sandstone, which consists of thick-bedded, quartz, medium- and coarse-grained, clayey-siliceous, highly porous sandstones. This unit originated through dense turbidite currents (grain flows) of sandy material supplied from a coastline on the northern margin of the Skole Basin (see Książkiewicz, 1962). The material accumulated in the inner and medial parts of a deep-sea fan *via* distributary channels (Kotlarczyk, 1988).

DESCRIPTIONS OF TRACE FOSSILS

Despite the many illustrations and descriptions in the literature, very few ichnotaxa are available for insect borings in planty substrates. Kolbe (1888), Walker (1938), Amerom (1966), Madziara-Borusewicz (1970), Amerom and Boersma (1971), and Jarzembowski (1989) provided trace fossil names for some insect leaf mines. Owing to their restricted substrate, however, these trace fossils are flattened and do not closely resemble borings in wood.

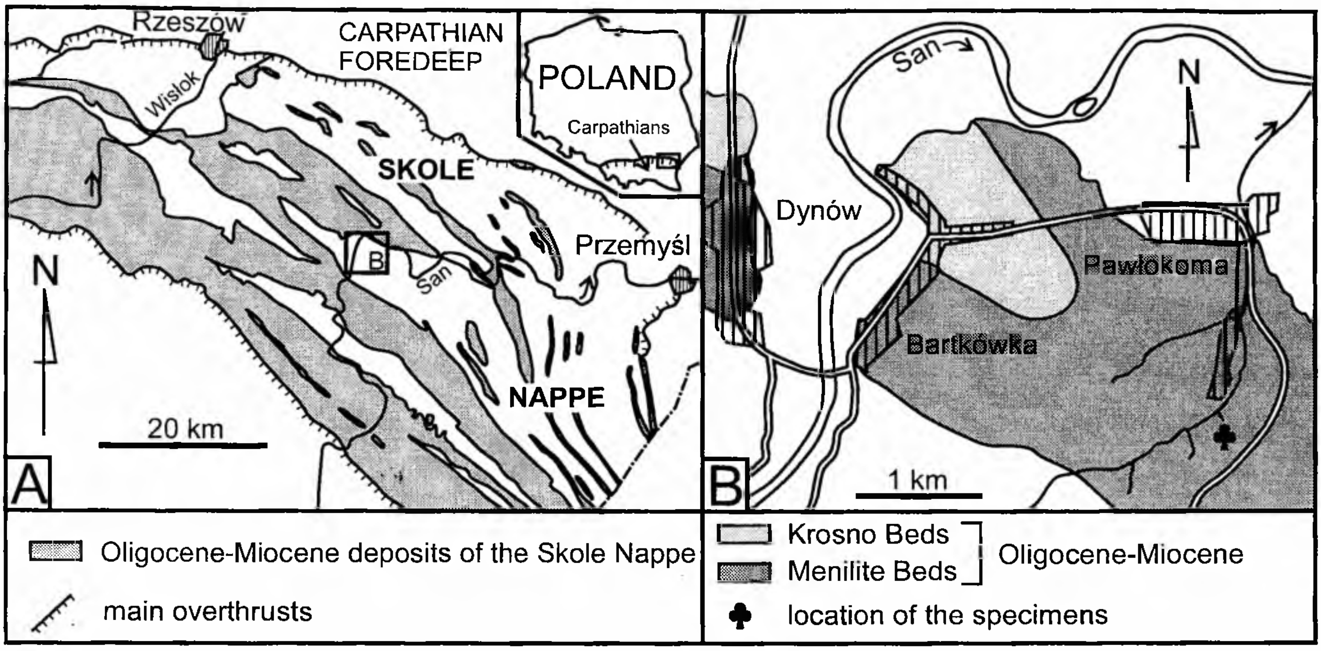

Fig. 1. Locality map

Linck (1949) provided a name for borings in Triassic wood, which resembled the work of *Anobium*; he called these trace fossils *Anobichnium simile* Linck, 1949. Guo (1991) introduced the ichnogenus *Scolytolarvariumichnus* with ichnospecies *S. radiatus* from a Miocene wood, which is very similar to wood borings of recent Scolytidae. For instance, Oligocene/Miocene borings related to beetles of the same family were described by Karpiński (1962) and Radwański (1977).

In the present material, the smaller structures (Form A) are similar to these described by Linck (1949), and probably are referable to his ichnogenus ?*Anobichnium* Linck, 1949. The larger boring (Form B) is different.

Fig. 2. ?*Anobichnium* isp. Specimen A, AGHT 12301; wood in roughly tangential view with borings comparable with those of the extant species of *Anobium*. Detail in the upper left corner. Scale bar = 1 cm

The two specimens described here are housed in the Geological Museum of the University of Mining and Metallurgy in Cracow (numbers AGHT 12301 and AGHT 12302).

Form A: ?*Anobichnium* isp.
(Figs. 2–3)

A piece of fossil wood (number AGHT 12301) *c.* 18x10x10 cm in size containing about 25 small borings, mostly visible in cross-section (Figs. 2, 3). The borings are short and smooth, cylindrical cavities, straight to curved, having a circular to elliptical cross-section, with approximately constant diameter, usually 1.4–3.0 mm. The longest observed tube is 10 mm long; probably none was longer than 20 mm. The shortest tubes, 2–3 mm long, are likely incomplete. Changes of diameter of the borings are not continuous: they change in step-like mode (Fig. 4). Most of the tubes fall within a few size classes, *i.e.*, 1.5, 2, and 3 mm in diameter respectively. Some of the borings have a hemispherical termination. The apertures of a few are located in small, shallow and elliptical depressions that are filled by silica. No pellets, commonly found in fossil borings of Ano-

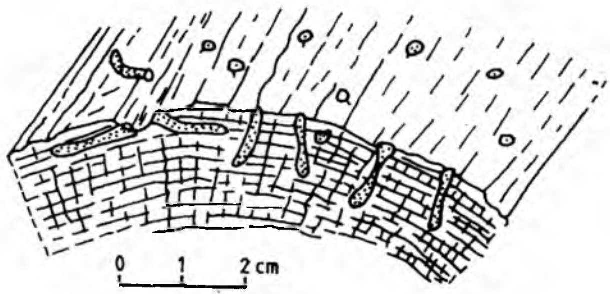

Fig. 3. Interpretative drawing of specimen A in silicified wood, AGHT 12301

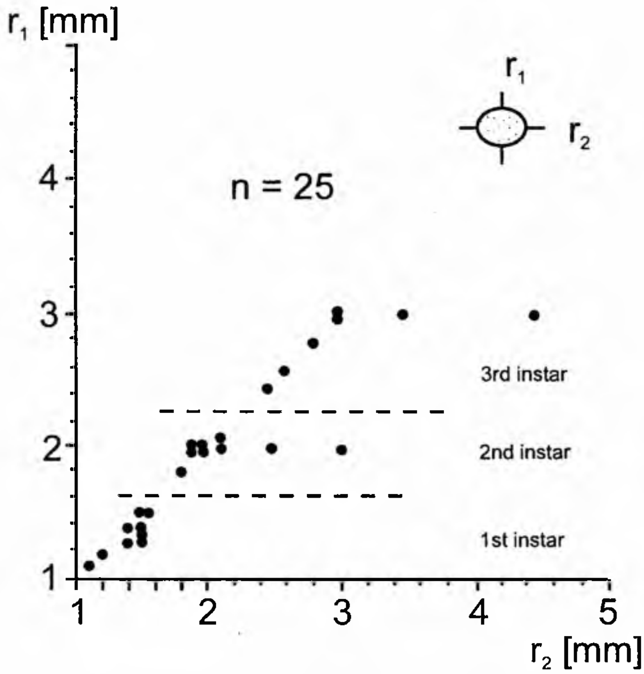

Fig. 4. Diameters (r_1 and r_2) of 25 borings in specimen A

biidae (see Selmeier, 1984), were found. Most of the borings run tangential to tree-trunk surface. Walls of the borings are covered by a thin dark film. The fill is a siliceous, homogeneous opaline-like material.

Form B: boring of ?*Sirex* sp.
(Fig. 5)

The piece of fossil wood (AGHT 12302) contains a slightly curved, smooth boring, 6 cm long, circular to elliptical in cross-section, 4.7×4.2 and 4.9×4.6 mm in diameter at either end, and filled with dark siliceous, opaline-like material (Fig. 5). The boring seems to run probably subparallel with the tree-trunk surface.

INTERPRETATION

The wood of both described specimens belongs to coniferous trees, either of the family Taxodiaceae, or the Cupressaceae (Rejmanówna, 1991, *personal communication*). The specimens are probably fragments of sapwood.

The shape and size of the borings in specimen A resemble borings produced by larvae of beetles of the family Anobiidae. Members of this family are polyphagous eaters of

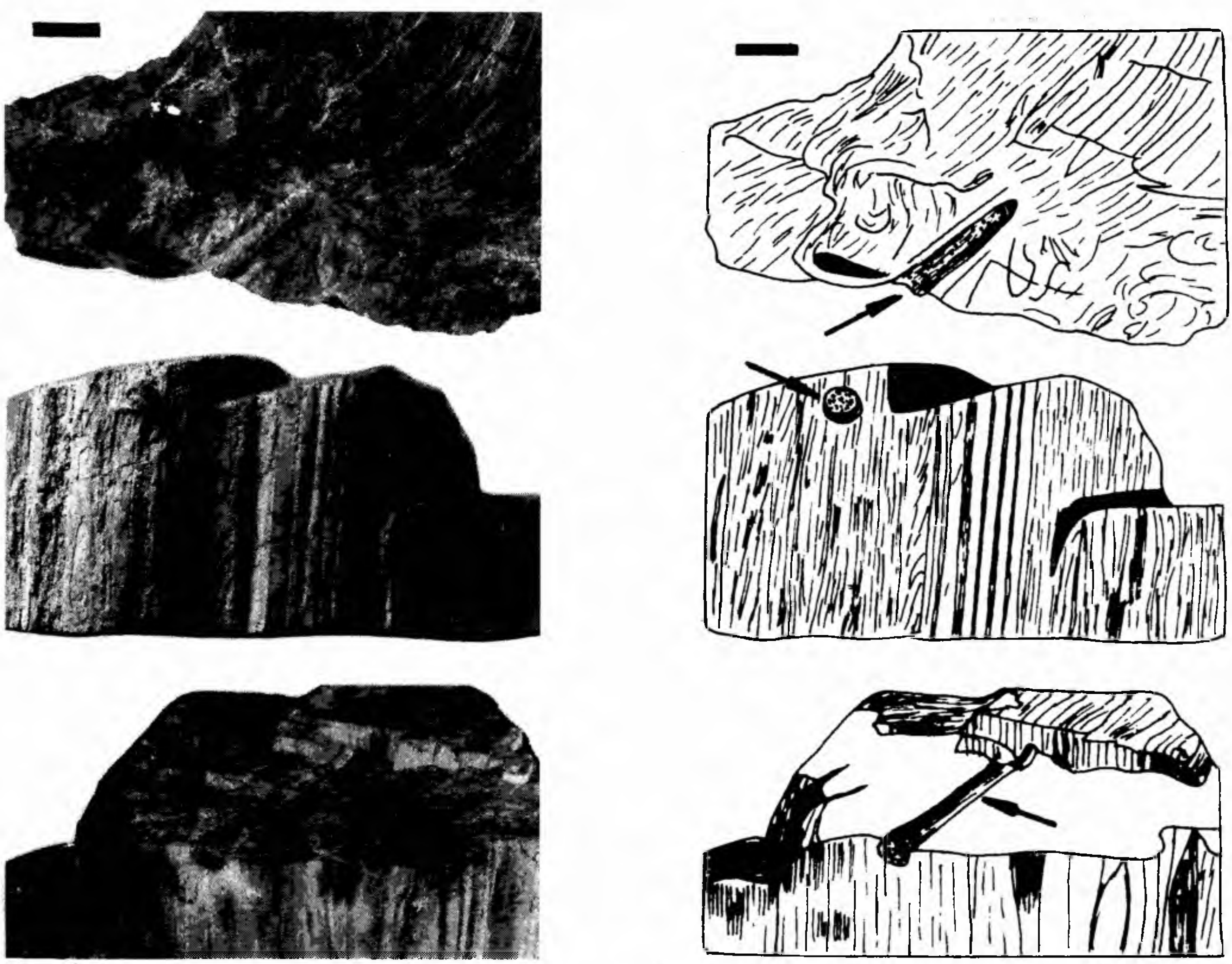

Fig. 5. Specimen B, AGHT 12302, various views. Boring comparable with those of the extant species of ?*Sirex*. Scale bar = 1 cm

dead coniferous wood (Schnaider, 1976), which borings are known since the Permian (Kušta, 1880). They are the most common insect wood-borings in the geological record, reported mainly from the Tertiary (Tab. 1).

All described borings from the specimen A were produced by one species. Thus, steep-like changes of diameter of their tubes (Fig. 4) are caused by the step-like changes of dimension of their producers, connected with successive instars. However, size variation of wood borers is generally greater than in free-living insects (Andersen & Nilssen, 1983). The strong size variation is especially typical of xylem eaters (Haack & Slansky, 1987).

The shape and dimension of the borings in specimen B resemble those produced by larvae of the hymenopteran genus *Sirex*. They are polyphagous of both coniferous and deciduous dead trees (Schnaider, 1976). Borings ascribed to this genus have previously been under description from the Miocene (Gellehorn, 1894).

The borings represent probably a late stage of the colonisation of dead wood that is typical for xylem eaters (Haack & Slansky, 1987). Both types of borings seem to have had a terrestrial origin in dead wood. In each case the bored wood was transported to the sea of the Skole Basin and fragmented during transport. Silification of the bored wood probably had started during the burial stage before the transport to the deep-sea environment of the Kliwa Sandstone.

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Streszczenie

DRĄŻENIA OWADÓW W OLIGOCEŃSKIM DREWNIE Z PIASKOWCÓW KLIWSKICH (POLSKIE KARPATY ZEWNĘTRZNE)

Jacek Rajchel & Alfred Uchman

Drążenia w kopalnym drewnie są rzadko spotykane. Najczęściej opisywano ichnorodzaj *Teredolites*, będący efektem drążenia małży z rodzin Teredinidae i Pholadidae. Drążenia owadów, aczkolwiek znane od początku XIX wieku są spotykane znacznie rzadziej. Do najczęściej opisywanych należą drążenia larw chrząszczy z rodzaju kołatek – *Anobium* (Tab. 1).

Obecnie znanych jest około 40 000 gatunków owadów drążących w drewnie (Haack & Slansky, 1987). Większość z nich to larwy lub formy młodociane chrząszczy (Coleoptera) z rodzin: Anobiidae, Bostrychidae, Buprestidae, Cerambycidae, Lytidae, Platypodidae i Scolytidae, termitów i błonkoskrzydłych (Hymenoptera) z rodzin Siricidae i Xyphidridae, a także motyli (Lepidoptera) z rodzin Cossidae i Sessidae (Haack & Slansky, 1987). Drążenia tych owadów mogą być związane z określonym gatunkiem drzewa żywego, martwego lub rozłożonego drewna, jak również z różnymi anatomicznie jego częściami. W zależności od gatunku owada i wymienionych uwarunkowań, drążenia ich posiadają różnorodne kształty i rozmiary (Haack & Slansky 1987).

Przedmiotem opracowania są drążenia larw owadów, rozpoznane w dwu fragmentach (AGHT 12301 i 12302) skrzemionkowanych drewien, znalezionych w okolicach Dynowa (Fig. 1). Znalezione drewna pochodzą z gruboławicowych piaskowców kliwskich serii menilitowej jednostki skolskiej, powstałych z piaszczystych spływów z północnej krawędzi basenu. Piaskowce te zajmują pozycję powyżej horyzontu rogowcowo-marglowego tej serii i są wieku oligoceńskiego (rupel) (Kotlarczyk, 1988; Rajchel, 1989). Drewna z drążeniami należą prawdopodobnie do Taxodiaceae lub Cupressaceae. Fragmenty zsylifikowanych drewien są znane w podobnej pozycji stratygraficznej z kilku stanowisk w obrębie jednostki skolskiej (Brzyski, 1979; Kotlarczyk, 1979). Są one jednak pozbawione drążeń owadów.

Drążenia w okazie A (AGHT 12301) są całkowicie podobne do drążeń larw współczesnego chrząszcza z rodzaju *Anobium* i zostały opisane jako ichnorodzaj ?*Anobichnium* Linck, 1949. Stwierdzono występowanie około 25 takich drążeń zawartych we fragmencie drewna o rozmiarach 18×10×10 cm (Fig. 2, 3). Drążenia te, proste lub zakrzywione, są w przekroju poprzecznym okrągłe lub eliptyczne, zazwyczaj o średnicy 1,4–3,0 mm (Fig. 4). Zmiany średnicy drążeń nie są ciągłe lecz skokowe. Najczęściej posiadają one 1,5, 2 lub 3 mm średnicy i związane są ze skokowym wzrostem (kolejnymi wylinkami) drążących je larw, aczkolwiek zróżnicowanie to jest większe niż u współczesnych populacji *Anobium* (Andersen & Nilssen, 1983; Haack & Slansky, 1987). Część drążeń posiada 2–3 mm długości, a najdłuższe dochodzą 10 mm. Prawdopodobnie, drążenia te nie były dłuższe niż 20 mm. Większość drążeń usytuowana jest tangencjalnie do powierzchni pnia. Niektóre drążenia posiadają półkoliste zakończenia. Wszystkie drążenia wypełnione są półprzeźroczystą krzemionką. Nie stwierdzono peloidów występujących często w drążeniach larw *Anobium* (Selmeier, 1984).

W okazie B (AGHT 12302) występuje pojedyncze drążenie w postaci prostego, gładkościennego, nieznacznie zakrzywionego tunelu, o długości 6 cm (Fig. 5). Jest on usytuowany prawie równolegle do powierzchni pnia. Jego średnica zmienia się od 4,7×4,2 do 4,9×4,6 mm i jest on obustronnie niekompletny, gdyż znajduje się w stosunkowo małym fragmencie drewna. Kanał ten jest wypełniony ciemno zabarwioną krzemionką. Jest on podobny do drążeń larwy współczesnej błonkówki – trzpiennika z rodzaju *Sirex*.

Obydwa typy drążeń utworzone zostały w warunkach lądowych, prawdopodobnie w obumarłym drzewie. Nawiercone drewno było początkowo przetransportowane i pogrzebane w piaszczystych osadach płytkomorskich, a następnie przeniesione w głąb morza w spływie piaszczystym ulegając częściowej destrukcji. Sylifikacja tych drewien rozpoczęła się prawdopodobnie w środowisku morskim, równocześnie z sylifikacją ławicy piaskowca kliwskiego.