

# The second fossil *Hyalonema* species (Porifera: Hexactinellida), from the Late Cretaceous Arnager limestone, Bornholm, Denmark

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The palaeontological history of the hexactinellid sub-class Amphidiscophora is little known and has been documented mainly by isolated spicules found in sediments. So far, only a few definite fossil records of rather complete body fossils of amphidiscophoran sponges, two from the Carboniferous and one from Late Cretaceous, have been published. A new finding of an entirely preserved fossil sponge described herein as *Hyalonema vetteri* sp. nov. in the Arnager Limestone on the isle Bornholm (Denmark) confirms the status of this lagerstätte as a unique window in the fossil record of the Porifera. The new species furthermore extend the record of the modern genus *Hyalonema* and family Hyalonematidae from Campanian back to the Coniacian.

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## Introduction

Hexactinellida (glass sponges) are Porifera with triaxial siliceous spicules, basically hexactins. Their fossil record goes back to the earliest Cambrian (Steiner et al. 1993; Reitner & Mehl 1995), or even late Proterozoic (Gehling & Rigby 1996), and their blossom time was in the late Mesozoic, especially Cretaceous, where the modern types of skeletal constructions radiated into the stem lineages of recent genera (Mehl 1992; Mehl-Janussen 1999; Dohrmann et al. 2013). Some hexactinellid taxa are characterised by rigid (dictyonial) skeletons of fused hexactins, or lychniscs (latern-like hexactine spicules), which are well represented in the fossil record. Together with “lithistid”

demosponges they acted as important bioconstructors, e.g., in Late Jurassic siliceous sponge reefs (Krautter 2002). Non-rigid hexactinellida, today comprising the sub-class Amphidiscophora and the order Lyssacosida, are the oldest hexactinellids in the fossil record. Lyssacosin sponges have been recorded with a worldwide distribution and in great numbers throughout the Paleozoic (e.g., Walcott 1920; Finks 1960; Rigby 1983, 1986; Rigby & Gosney, 1983). However, since the old sponge fossils with few exceptions are very different from recent sponges, furthermore they are normally found without any of the taxonomically important microscleres, the attribution of Pal-

aeozoic hexactinellids to recent taxa is normally not possible. In the Mesozoic record, we still have the problem of lacking microscleres in the fossil sponges, but since many of these body fossils are morphologically quite similar to recent representatives, a taxonomical attribution to recent sponge families, or even genera, is sometimes possible (e.g., Schrammen 1912; Salomon 1990; Mehl 1992).

The Mesozoic record of fossil nonrigid taxon Lyssacinosa is comparably poor. All together, about 28 more or less certain lyssacinosidan genera have been described mostly from the Late Cretaceous (e.g., Bowerbank 1869a, 1869b; Schrammen 1912; Rigby & Gosney 1983; Brückner 2006). The fact that the non-rigid hexactinellids are rarely found in Mesozoic strata is mainly due to their low preservation potential. In most cases, after death of the sponge and decay of its soft body, the non-fused spicules of the skeleton will fall apart and be found only as isolated spicules. Complete sponge fossils of the sub-class Amphidiscophora are even more rare. Although isolated amphidiscs have been found in Silurian and younger sediments (Mostler 1986), reliable body fossils of Amphidiscophora are extremely rare and have been found only at a few localities. Completely preserved amphidiscophoran body fossils, with amphi- and hemidisc microscleres *in situ*, are known so far only from the Carboniferous of the Ural (Librovič 1929; Kling & Reif 1969). An almost complete sponge fossil from the Campanian of Münsterländer Basin (Germany) was described according to its outer morphology and megascleres as *Hyalonema cretacea* Mehl & Hauschke, 1995. Also from the Late Cretaceous some isolated root tufts have been recorded and attributed to *Hyalonema* sp. (Mehl 1992).

The Coniacian Arnager formation crops out as an about 150 m long and 4 m thick section at the southern coast of the Danish island of Bornholm, which is located SW of Sweden (for location map and further details, e.g., Brückner & Janussen 2005). The entire formation is between 12 and 20 m thick and belongs to a horst platform within the Fennoscandian Border Zone (Gravesen et al. 1982; Jørgart & Nielsen 1995). Several publications deal with the stratigraphy and facies of the Arnager Limestone Formation (Bromley 1979; Christensen 1984; Tröger & Christensen 1991), and the first palaeoecological interpretation of the sponge-rich limestone was given by Noe-Nygaard & Surlyk (1985), who considered it to be fossil sponge mounds. However, Mehl (1992) argued for a turbiditic origin of the Arnager limestone. The section at Arnager Pynt is known for its exceptionally preserved fossils, which were first described (Brongniart 1828) as plants and were later re-interpreted and described as hexactinellid lyssacinosidan sponges (Ravn 1918; Brückner & Janussen 2005; Brückner 2006), including three uncertain amphidiscophoran genera and species (Mehl 1992).

## Material and Methods

The sponge fossil described in this paper was found on fallen down blocks from the Arnager limestone formation by Felix Vetter (Frankfurt a. M.) and given to the author for identification. It was studied and photo documented by light microscopy and compared with other described, complete *Hyalonema* species from Late Cretaceous (Mehl & Hauschke 1995). Spicule measurements, photographs and drawings were made using a Zeiss stereomicroscope with photo-equipment and ocular scale. The other specimen is deposited in Naturmuseum Senckenberg, Palaeobiology department (SMF), electronically catalogued (SESAM) and online available.

## Systematic palaeontology

Class **Hexactinellida** Schmidt, 1870

Subclass **Amphidiscophora** Schulze, 1886

Order **Amphidiscosida** Schrammen, 1924

Family **Hyalonematidae** Gray, 1857

Genus **Hyalonema** Gray, 1832

*Type species.* – *Hyalonema sieboldi* Gray, 1832.

*Diagnosis.* – “Hyalonematidae with mainly bell-like or ovoid body; the everted (when known) atrialia do not form notable rise; basalia are gathered in a compact twisted (in grown specimens) tuft, being represented by toothed anchors” [from Tabachnick & Menshenina 2002].

***Hyalonema vetteri* sp. nov.**

Figs. 1–2

*Material.* – One specimen, the holotype, SMF XXVI 528.

*Type locality.* – Near Arnager, Isle of Bornholm, Denmark.

*Type horizon.* – Arnager formation (Cretaceous: Coniacian).

*Etymology.* – This species is named in honour of Felix Vetter, finder of the holotype specimen.

*Diagnosis.* – *Hyalonema* with a cup- or calyx-formed body and unsegmented atrial cavity. Slender stalk of long thin root spicules twisted in clockwise direction. Body megascleres mainly diactins, also some hexactins/pentactins/stauractins and tauactins. Microscleres unknown.

*Description.* – The holotype is a small sponge, 58 mm in total length and 16 mm maximal width formed as a cup or calyx attached to a long stalk of basal spicules. Length of the stalk is 45 mm, but because it is somewhat curved, it may have been slightly longer in live position. The stalk proceeds 3–5 mm into basal part of the body. Its distal end-

ing is broken off and no basal anchors were observed. Its thickness is 5 mm at the top, narrowing to 4 mm in the middle, expanding to 6 mm towards the base. The calyx-shaped body is 15 mm high and 16 mm in width with a large shallow atrial cavity (osculum), 11 mm wide and about 8 mm deep.

**Spicules:** Only the long stalk spicules are well preserved, they measure about 50  $\mu\text{m}$  in thickness. Because the distal ends are broken off, their length cannot be measured, but the spicules seem to continue along the entire length of the stalk (at least 45 mm), and they proceed  $\sim 3$  mm into the basal part of the sponge body. Many diactins, mostly fragmental, are observed throughout the sponge body, especially near the base, and forming an indistinct marginal layer parallel to the surface. They are extremely variable, probably partly due to secondary diagenetic influence, and measure 0.5–2.0 mm in length and 50–100  $\mu\text{m}$  in thickness. Near the osculum some larger diactins seem to protrude beyond the body wall by 0.5–1.0 mm. Further spicule types, recognisable only as indistinct imprints, are stauractins (or maybe obscure pentactins or hexactins) and few tauactins, ray lengths 150–250  $\mu\text{m}$ , thickness  $\sim 30$   $\mu\text{m}$ . Because of the very incomplete fragmented condition of recognisable spicular structures, statistical spicule measurements were not possible.

**Occurrence.** – Hitherto known only from the type locality and type stratum.

## Discussion and conclusions

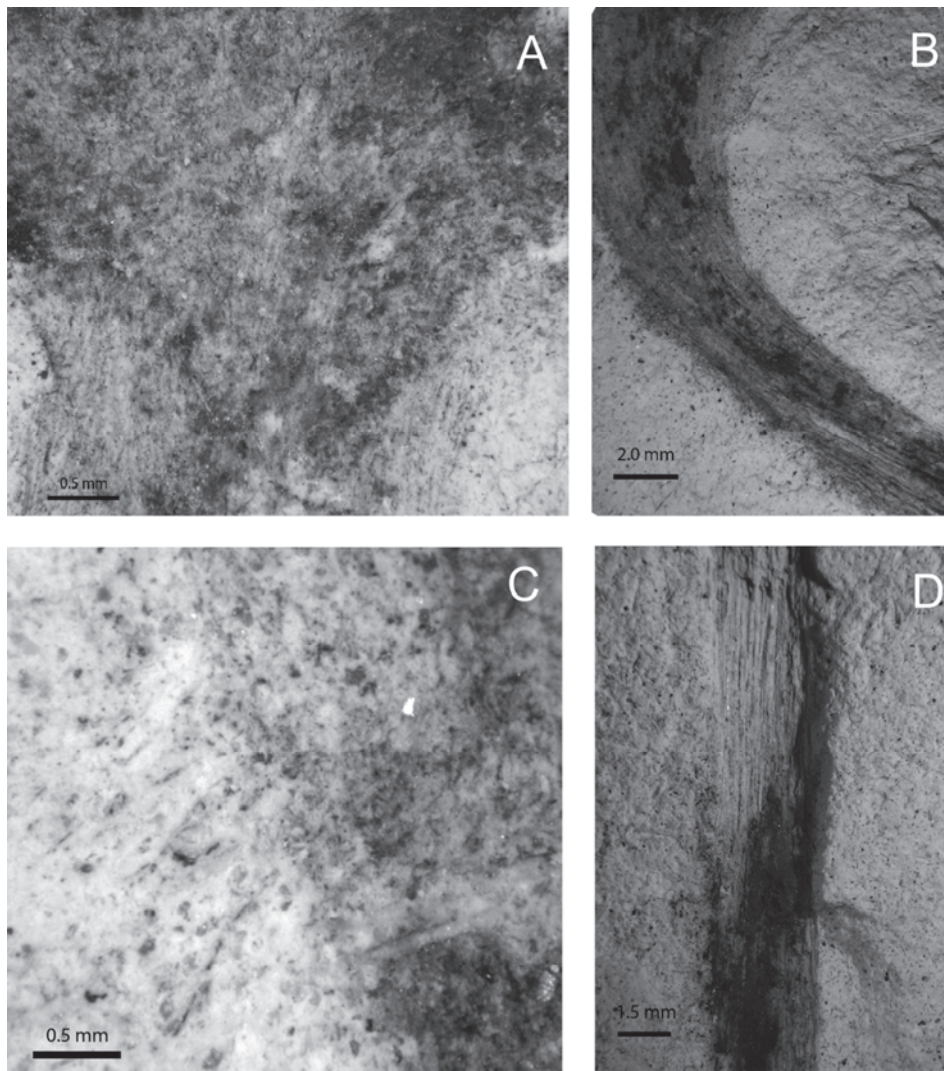
This species is attributed to genus *Hyalonema*, in spite of the lack of preserved microscleres (as it is the normal case in fossil sponges), because of its very typical shape with a twisted stalk of long root spicules bearing a cup-formed body with a wide central atrial cavity (osculum). Its main skeleton of primarily diactine primary spicules corresponds to the definition of the recent genus *Hyalonema* (Tabachnick & Menshenina 2002). Apart from the distance in geographical location and stratigraphical age, it differs from the only so far described fossil *Hyalonema* species, *H. cretacea* Mehl & Hauschke, 1995 from Campanian of Münsterland Basin (Germany), by its skeleton of the main body consisting of diactine primary spicules, whereas in *H. cretacea* stauractins and diactins were observed in equal proportions. *H. vetteri* smaller in size of both the body and spicules, the body form is roundish and possesses a thinner and more slender stalk of long root spicules, clearly clockwise twisted (not so in *H. cretacea*). Especially the root tuft spicules are much thinner, they measure only about 30  $\mu\text{m}$ , whereas in *H. cretacea* they measure about 100  $\mu\text{m}$  in diameter.

The recent genus *Hyalonema* is a deep-sea sponge taxon, as characteristic for the Hexactinellida in general, with worldwide distribution (Tabachnick & Menshenina 2002).



**Fig. 1:** *Hyalonema vetteri* sp. nov., holotype, SMF XXVI 528, from the Coniacian of Bornholm, Denmark. The stalk of long monaxone spicules proceeds well into the basal part of the clup-shaped body.

With its flexible long twisted and very resistant stalk of twisted anchoring root spicules, it is well adapted to life on soft bottoms in deep water, also in environments with strong current regimes and increased sedimentation rates. According to Noe-Nygaard & Surlyk (1985), the Arnager limestone is interpreted as fossil sponge mounds with the sponges preserved *in situ*. However, this interpretation is not consistent with the fact that mainly soft-bodied lysacinosan and amphidiscophoran Hexactinellida are found in the Arnager chalk, because their fossil preservation requires a rapid embedding of the living sponges, e.g., by turbiditic sedimentation events (e.g., Mehl 1992; Mehl & Hauschke 1995), which rather corresponds to a lower slope than to a carbonate platform palaeoenvironment. Detailed sedimentological studies of the Arnager Pynt section later confirmed the interpretation of the Arnager Limestone as deposits of distal mud turbidites (Brückner 2006).



**Fig. 2:** (A–D) *Hyalonema vetteri* sp. nov., holotype, SMF XXVI 528 from the Coniacian of Bornholm, Denmark. (A) Detail of the basal part of the body; (B) Upper part of the stalk which is twisted in the clockwise direction; (C) Outer margin of the sponge body with remains of radially arranged diactins protruding beyond the dermal surface; (D) Lower part of the dense root tuft consisting of long, thin, monaxonal spicules.

The second finding in the fossil record of an almost complete *Hyalonema* specimen confirms this interpretation, as the body construction of the Hyalonematidae is extremely fragile and requires special conditions for preservation, including rapid embedding in live position. On the other hand, the rope-like stalks of long twisted monaxone spicules is fairly robust, and isolated root tufts are often caught in trawls, or by longline-fisheries, whereas complete *Hyalonema* specimens are rather rare, even in areas where the genus is common (such as the Japanese Sagami Bay, pers. obs.). Thus it is not unexpected that *Hyalonema* tufts have been reported from some sponge-rich localities, such as the Arnager Limestone (Mehl 1992), rather it is surprising that only few such occurrences are known from literature. However, it seems that such unspectacular fossils are not noticed or neglected by many collectors, misinterpreted as worthless plant-fossils fragments, and therefore not present in most of the Late Cretaceous sponge collections and also not mentioned in the corresponding

literature (e.g., Schrammen 1912). The author of this article is aware of *Hyalonema* stalks, or stalk-fragments, from the Campanian of Höver, where they are probably even common (Janussen in prep.).

Thus, it can be expected that further fossil occurrences of *Hyalonema*, as well as other amphidiscophoran Hexactinellida will be discovered, to the degree that these become known and valued fossils both for science and for the amateur collectors.

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