

Brachiopod taxonomy, stratigraphy and palaeoecology of the Maastrichtian chalk at Hemmoor, north-west Germany

FINN SURLYK AND ANE ELISE SCHRØDER



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The Maastrichtian chalk at Hemmoor in NW Germany contains a rich brachiopod fauna. A total of 29 species represented by about 10,000 individuals is obtained from washed bulk samples. The total number reaches 34 when 5 very rare, mainly fragmented species are added. The brachiopod fauna of the Maastrichtian chalk of northern Europe is also known from Denmark, Germany, Sweden, Poland, Belgium, the Netherlands and England. The Hemmoor succession represents the upper lower – lower upper Maastrichtian. It is biostratigraphically zoned by means of brachiopods, belemnites, ammonites, echinoids and bivalves. The brachiopod fauna allows recognition of the upper lower Maastrichtian *pulchellus-tenuicostata*, *tenuicostata-semiglobularis* and lower upper Maastrichtian *semiglobularis-humboldtii* brachiopod zones, allowing detailed correlation with the chalk in surrounding regions, notably Denmark and Rügen. The fauna is dominated by micromorphic species and three different ecological assemblages are recognized: a ‘standard’ chalk assemblage dominated by micromorphic species but also containing medium- and large-sized species, an assemblage comprising only micromorphic species, and an assemblage characterized by micromorphic species associated with medium-sized hemispherical species. The assemblages are interpreted as reflecting different water depths, availability and nature of substrates.

Keywords: Brachiopod biostratigraphy, Hemmoor Formation, NW Germany.

Finn Surlyk [finns@ign.ku.dk], Department of Geosciences and Natural Resource Management, University of Copenhagen, Øster Voldgade 10, 1350 Copenhagen K, Denmark. Ane Elise Schröder [aes@ign.ku.dk], Department of Geosciences and Natural Resource Management, University of Copenhagen, Øster Voldgade 10, 1350 Copenhagen K, Denmark; also Dipartimento di Scienze della Terra, Università degli Studi di Torino, Via Valperga Caluso 35, I-10125 Torino, Italy. <https://orcid.org/0000-0001-9371-400X>.

The Upper Cretaceous, Maastrichtian chalk succession in the large, now abandoned Hemmoor quarry in northern Germany is well known stratigraphically, palaeontologically and geochemically (Surlyk 1970a; Schulz & Schmid 1983; Schulz *et al.* 1984; Niebuhr 2006; Niebuhr *et al.* 2011). This is largely due to the tireless efforts of Friedrich Schmid who in the 1960s and 1970s organized sampling and washing of long series of bulk samples and oversaw numerous studies of different faunal groups. He was most helpful handing out material picked from the washing residues of the bulk samples to other workers. In the late 1960s Finn Surlyk (FS) thus received the brachiopod material from the first series of bulk samples collected at Hemmoor. This was later supplemented by material from additional samples.

The stratigraphic distribution of the brachiopods allowed the first detailed correlation between the Maastrichtian chalk of Denmark exposed at Møns Klint, the large Rørdal quarry and the cored Rørdal-1 borehole set down in the quarry, and the succession at Rügen described by Steinich (1965) and Hemmoor (Surlyk 1970a). Steinich (1965) had subdivided the Rügen succession into five brachiopod zones and a total of 12 brachiopod zones were subsequently established for the uppermost Campanian – Maastrichtian chalk (Surlyk 1982, 1984, 2025b; Surlyk *et al.* 2013). This zonal scheme was extended to southern Sweden (FS, unpublished data), Poland (Bitner & Pisera 1979; Machalski & Bitner 2024), Belgium (Simon 1998, 2000; Keutgen *et al.* 2010), eastern England (Johansen & Surlyk 1990) and to some extent also the

Netherlands (Keutgen *et al.* 2010).

The taxonomy and palaeoecology of the mainly micromorphic brachiopod fauna obtained from the washed bulk samples collected at Hemmoor has, however, not been published before. The Hemmoor succession forms the top part of what in the German literature has been termed the 'Ober-Kreide Richt-Profil' ('Upper Cretaceous Standard Section') for the middle Coniacian – Maastrichtian, based on the combined successions at Lägerdorf, Krons Moor and Hemmoor (Schmid 1982; Schulz *et al.* 1984; Niebuhr 2006; Niebuhr *et al.* 2011). Some of the sample material from the upper part of the Hemmoor succession were inadvertently thrown out during repeated office changes of FS over the last many years. Some of the rare species from these samples are accordingly not illustrated.

The aims of the present study are:

- 1) To describe the brachiopod fauna from the Maastrichtian chalk at Hemmoor.
- 2) To demonstrate their stratigraphic distributions which form the basis for the recognition of three brachiopod zones in the succession, covering the upper lower – lower upper Maastrichtian.
- 3) To describe and interpret the three ecological brachiopod assemblage types recognized in the succession.

Geological setting

Most of northern Europe was in the Late Cretaceous covered by the extensive, relatively deep epeiric Chalk Sea (Fig. 1) (e.g. Ziegler 1990; Surlyk *et al.*

2003). A thick succession of chalk was deposited in the sea well below the photic zone, reaching thicknesses up to several kilometres (Ziegler 1990; Vejrbæk *et al.* 2007). The North German Basin was limited to the north by the Ringkøbing-Fyn High (Fig. 2). The Danish Basin is located north of the high and is limited to the north by the Sorgenfrei-Tornquist Zone. Exposures of the Danish uppermost Campanian – Maastrichtian chalk are located over the eastern and north-eastern margin of the Ringkøbing-Fyn High, in the Sorgenfrei-Tornquist Zone and in a few cases over salt structures. The succession at Hemmoor in the North German Basin was deposited in an area characterized by major salt walls (Fig. 2), and the thickness is much reduced compared to the successions in the Danish Basin.

Material and methods

Bulk samples of chalk were broken down into skeletal elements and chalk mud by repeated heating in a supersaturated Glauber's Salt solution (Steinich 1965). Sample weights are not known by us but were in the range of 10–20 kg. A more effective method, resulting in a larger number of cleaner small fossils was developed by Surlyk (1972). It involves heating in a supersaturated Glauber's Salt solution followed by deep-freezing. This was repeated for about 15 times and was followed by washing, sorting into size fractions and subsequent picking of the small fossil specimens, such as brachiopods under a binocular microscope. In this way, about 44 brachiopod species represented by 35,000 individuals from 42 localities



Fig. 1. Palaeogeographic map of the Late Cretaceous Chalk Sea in northern Europe. The position of the Hemmoor quarry indicated with an asterisk. Modified from Ziegler (1990) and Surlyk *et al.* (2003).

were obtained from the Danish uppermost Campanian – Maastrichtian chalk (Surlyk 2025b). The Hemmoor samples have yielded 29 species and about 10,000 individuals (this study).

Stratigraphy

The North German Upper Cretaceous ‘Richt-Profil’ (‘Standard Section’) comprising the successions at Lägerdorf, Krons Moor and Hemmoor (Fig. 3) has traditionally been stratigraphically subdivided by macrofossils, notably belemnites, brachiopods and echinoids, and to some extent also bivalves. In more recent years magneto- and chemostratigraphy have played an increasing role. The succession at Hemmoor is referred to the upper lower – lower upper Maastrichtian Hemmoor Formation (e.g. Schulz *et al.* 1984; Niebuhr *et al.* 2011). It is possible that the top of the succession reaches into the upper upper Maastrichtian (Schulz *et al.* 1984). It overlies the upper upper Campanian – lower lower Maastrichtian Krons Moor Formation, the top of which was exposed with a few metres of flint-free chalk at the base of the Hemmoor succession. The Krons Moor–Hemmoor Formation boundary is thus marked by the incoming of abundant bands of flint nodules (Fig. 4). The Hemmoor Formation spans the lower–upper Maastrichtian boundary, which in the Boreal north European chalk is defined by the lowest occurrence of the belemnite *Belemnitella junior* Nowak, 1913. In practice, it is conventionally placed a few metres lower at a thin marl layer, the ‘Tonband’ (Fig. 4; now labeled M 900; see Schmid *et al.* 1984; Niebuhr 2006).

The lower Maastrichtian part of the Hemmoor succession belongs from below to the upper part of the *Belemnella sumensis*/*Acanthoscaphites tridens* belemnite/ammonite Zone, the *Belemnella cimbrica* belemnite Zone and the *Belemnella fastigata* belemnite Zone. The upper Maastrichtian part of the succession above the Tonband belongs to the *Spyridoceras tegulatus*/*Belemnitella junior* bivalve/belemnite Zone, followed by the *Tenuipteria argentea*/*Belemnitella junior* bivalve/belemnite Zone, the *Oxytoma danica*/*Tenuipteria argentea* bivalve Zone and at the top by the *Tylocidaris baltica*/*Oxytoma danica* echinoid/bivalve Zone. The regular echinoid *Tylocidaris baltica* (Schlüter, 1892) is in Denmark restricted to the upper upper Maastrichtian and it is thus possible that this interval is also represented in the uppermost part of the Hemmoor succession. This was suggested previously by Schulz *et al.* (1984) but is at variance with the datings obtained by benthic foraminifers. This difference in chronostratigraphic interpretation may reflect different definitions of chronostratigraphic boundaries based on macro- versus microfossils or more likely reflecting that the micropalaeontological data were

obtained from borehole cuttings (see Niebuhr 2006 for discussion). The interpretation of Schulz *et al.* (1984) is followed here.

The successions at Lägerdorf, Krons Moor and Rügen have been measured in great detail and is covered by a number system based on layers of flint nodules, burrow horizons, and pyrite-impregnated beds (Schmid 1975, 1982; Schulz 1978; Schulz *et al.* 1984). This number system is used throughout the study in its most up-to-date form following Niebuhr (2006) and Niebuhr *et al.* (2011). In the Hemmoor succession the Tonband was traditionally labelled T 100 (e.g. Schmid 1982; Schulz & Schmid 1983). At present, the numbers have been slightly changed by changing the prefix, so that the Tonband is now labelled M 900 (M for marl). The base of the Hemmoor Formation is placed at layer F 868 (F for flint) and the lower Maastrichtian part of the formation continues upwards to M 900. The beds or horizons in the upper Maastrichtian part are numbered from M 900 to F 949. The whole formation thus contains no less than 80 numbered beds or horizons. In the following all layer numbers are for simplicity preceded with an ‘H’ for Hemmoor, e.g. H 900.

The lower Maastrichtian part is 47 m thick, and the upper Maastrichtian is 85 m thick, giving a total Maastrichtian thickness of 132 m (Fig. 4). The top is, however, erosionally truncated, and the full thick-

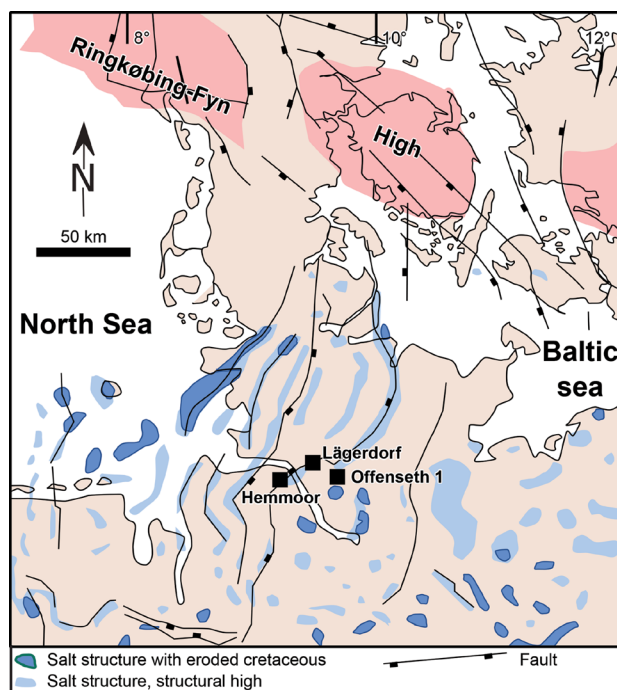


Fig. 2. Structural map of the north German and southern Danish parts of the North German Basin, showing the location of Hemmoor with respect to the salt walls characterizing this part of the basin. The basin is limited to the north by the Ringkøbing-Fyn High. Modified from Voigt & Schönfeld (2010).

ness is 155 m in the nearby borehole Offenseth 1 (Fig. 3; Niebuhr 2006). The Maastrichtian is for comparison about 310 m thick in the Stevns-1 borehole in eastern Denmark and much greater thicknesses are reached in the northern part of the Danish Basin. The strongly reduced thickness at Hemmoor may partly reflect the influence of major salt structures.

The chalk at Hemmoor is characterized by abundant *Zoophycos* burrows and thin marl layers. Large black flint nodules occur scattered and in layers. The so-called Paramoudra flint nodules (Bromley *et al.* 1975) are abundant between layers H 915 og H 933 (Fig. 4). This flint-rich level appears to be isochronous in northern Germany and is situated in the middle of the *Belemnella sumensis/Acanthoscaphites tridens* Zone in at least three sections at Krons Moor, Hem-

moor and Lüneburg, respectively. The chalk at Hemmoor passes into the Reitbrook Formation, which marks the end of chalk deposition in Germany. The Reitbrook Formation is a glauconitic, bioclastic limestone rich in flint nodules and layers and represents a marked fall in sea level. The boundary between the two formations is placed at the so-called 'Verletteten Lagen' in the *Tylocidaris baltica/Oxytoma danica* Zone (Niebuhr 2006).

The marl layer H 900 was correlated with marl layers at Rørdal in NW Denmark and at Rügen in NE Germany based on brachiopod stratigraphy (Surluk 1970a). It has been interpreted as a volcanic ash (Valeton 1960) and as a residue after dissolution of the chalk (Ernst 1984a) but is here interpreted as the southern feather edge of the cyclic chalk-marl suc-

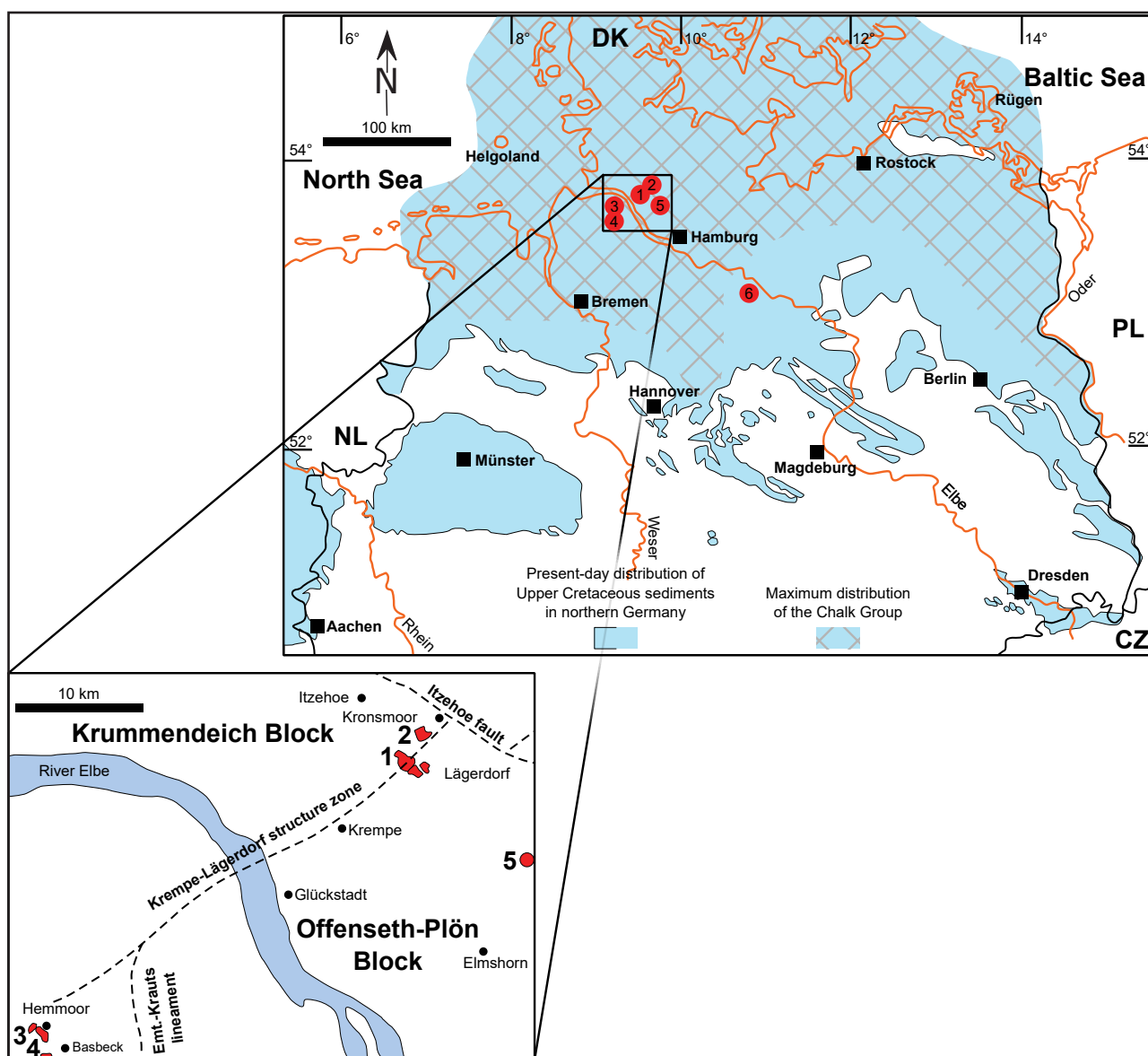


Fig. 3. Map showing the position of the key localities in the Upper Cretaceous 'Richt Profil' ('Standard Section') of northern Germany: Lägerdorf (1), Krons Moor (2), Hemmoor (3), Basbeck (4), Hoffenseth-1 borehole (5). Modified from Niebuhr *et al.* (2011).

cession of the Rørdal Member of Denmark. The Rørdal Member of the Møns Klint Formation was defined by Surlyk *et al.* (2010) and has received detailed palaeontological, ichnological, palaeoecological and isotope-geochemical studies (Lauridsen & Surlyk 2008; Lauridsen *et al.* 2009; Thibault *et al.* 2024a).

The following brachiopod species are stratigraphically important in the Hemmoor Formation and are used in the zonal subdivision of the succession and in correlation with successions elsewhere in northern Europe: *Gisilina gisii* (Roemer, 1841), *Gisilina jasmundi* Steinich, 1965, *Rugia tenuicostata* Steinich, 1963, *Rugia acutirostris* Steinich, 1965, *Rugia tegulata* Surlyk, 1970, *Meonia semiglobularis* (Posselt, 1894) and *Thecidea papillata* (von

Schlotheim, 1813) (Surlyk 1970a, 2025b). Their stratigraphic distribution was re-checked in a B.Sc. thesis (Springer 2011) based on all sample material available at that time, confirming the original interpretation of Surlyk (1970a).

Three brachiopod zones are recognized in the Hemmoor Formation. They are from below: the *pulchellus-tenuicostata* Zone, the *tenuicostata-semiglobularis* Zone and the *semiglobularis-humboldtii* Zone (Fig. 5; Surlyk 1970a, 1984, 2025b). The two lower zones belong to the upper lower Maastrichtian, while the last mainly belongs to the lower upper Maastrichtian as the base of the *semiglobularis-humboldtii* Zone coincides roughly with the

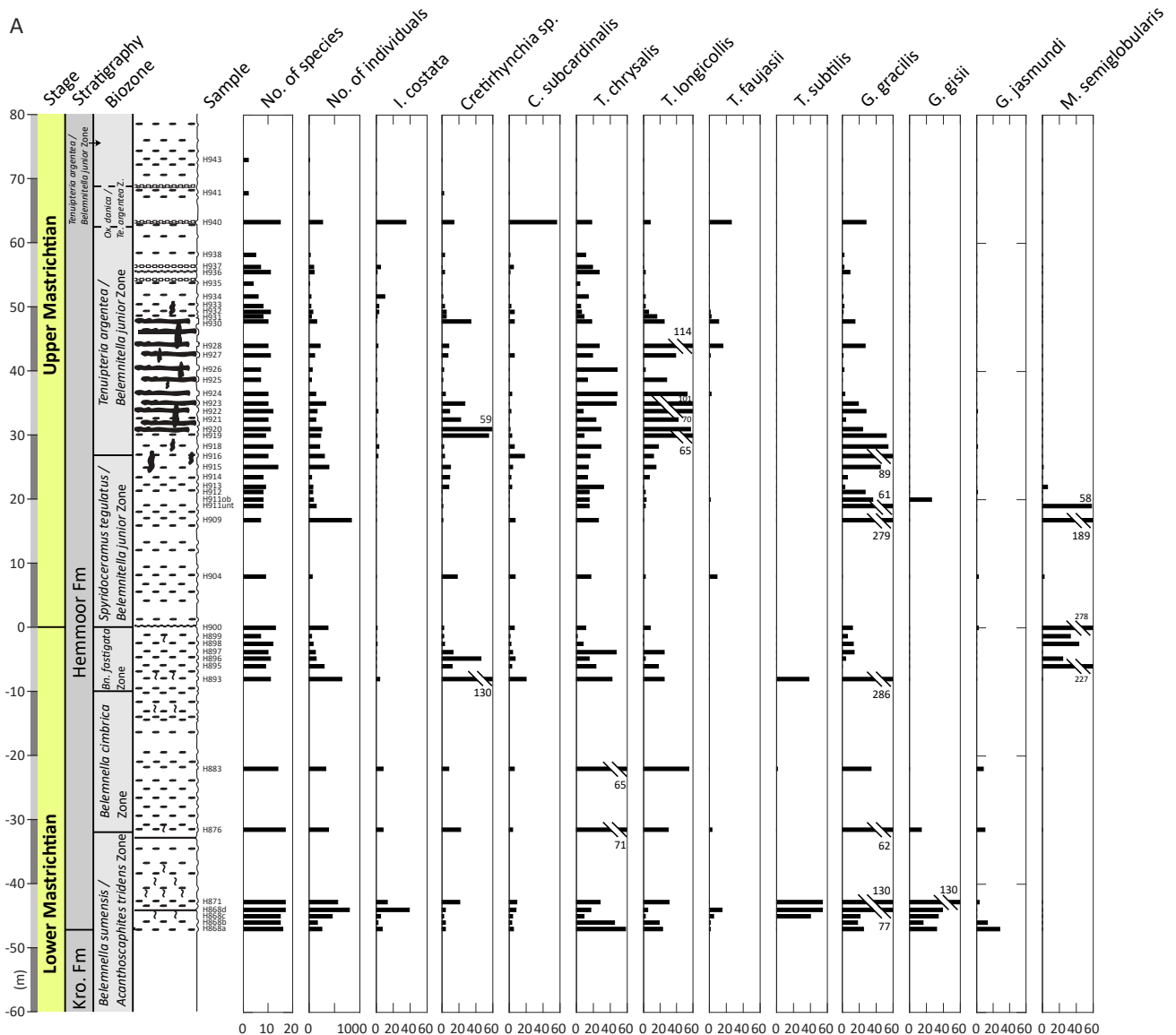


Fig. 4. A and B. Stratigraphic distribution, species richness and number of individuals of the brachiopods from the Maastrichtian of the Hemmoor succession. Rare species are omitted. The log and the sample number system of Schmid (1982) modified by Niebuhr *et al.* (2011) shown to the left. A few very rare or poorly preserved species are not included. The original sample weights are not well known, so the abundances in the individual samples have not been recalculated to a standard weight and are thus not fully comparable.

lower–upper Maastrichtian boundary. The presence of *Tylocidaris baltica* in the upper 18 m suggests that this part may reach up into the *humboldtii-stevensis* or even into the upper upper Maastrichtian *stevensis-chitoniformis* brachiopod Zone (Fig. 5). However, it is more likely that the latter zone correlates with the Reitbrook Formation. The uppermost Maastrichtian Højerup Member similarly shows clear evidence of

shallowing water depth.

The brachiopod zones are given binomial names following Murphy (1977) based on the names of the species defining the lower and upper boundary, respectively (Surlyk 1982). Each zone is defined by its boundaries in a stratotype. Only one species is used to define the lower zonal boundary; the upper boundary is then defined by the species defining the

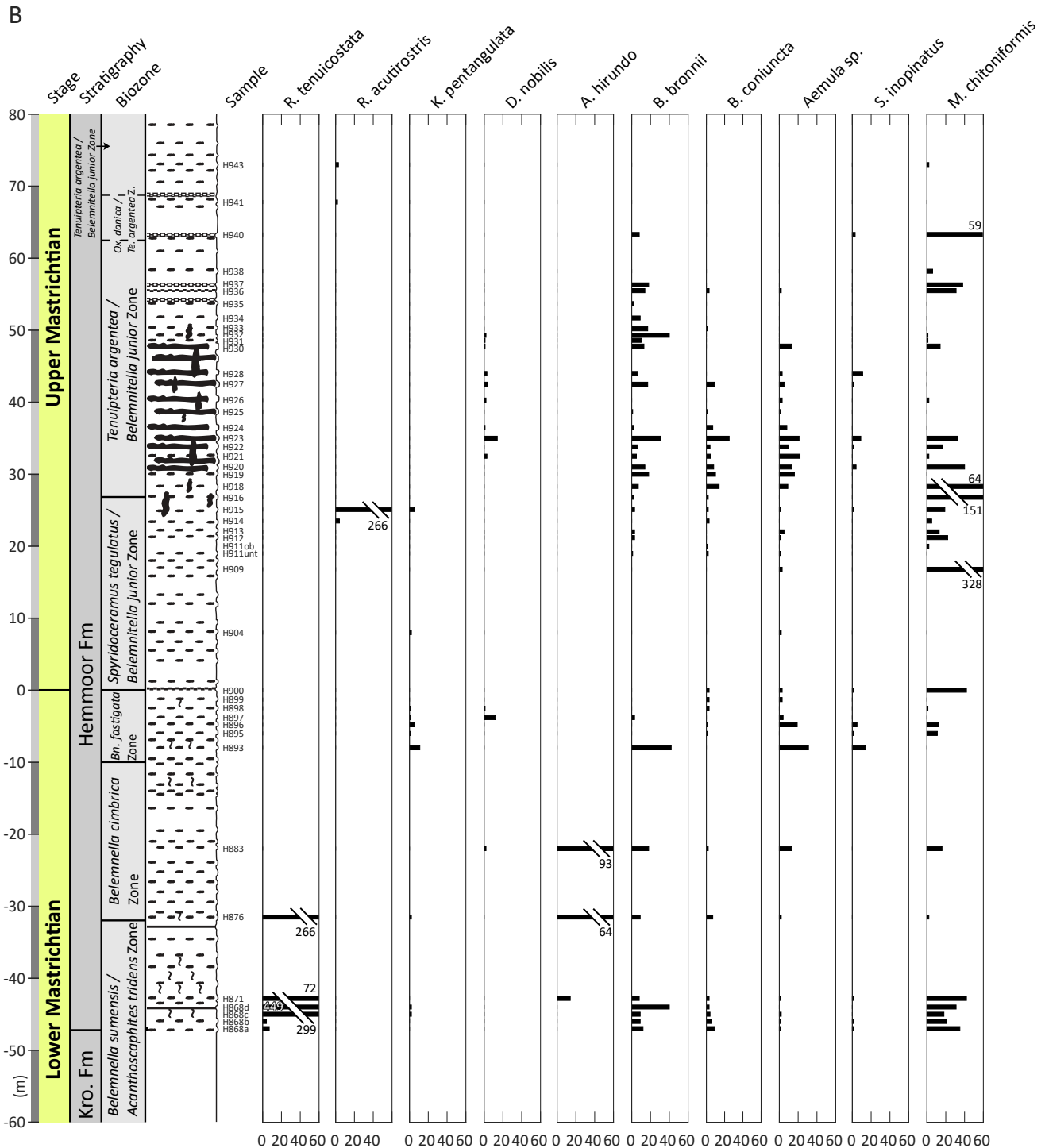


Fig. 4. Continued.

Palaeoecology

[illegible]

Fig. 5. The uppermost Campanian – Maastrichtian brachiopod zones of the Danish Basin as recognized in Surlyk (1984, 2025b), Rasmussen and Surlyk (2012), Surlyk *et al.* (2013) and correlated with international standards. Modified from Thibault *et al.* (2024b, fig. 5). (1) Birkelund (1957) and Surlyk & Birkelund (1977); (2) Schulz *et al.* (1984) amended by Niebuhr *et al.* (2011) for the Campanian–Maastrichtian boundary interval; (3) Surlyk (1984); (4) King *et al.* (1989); (5) Burnett (1998); (6) Slimani (2011); (7) Schiøler & Wilson (1993); (8) Surlyk *et al.* (2013). Members in grey correspond to marly chalk or cyclic chalk–marl alternations; members in white correspond to pure chalk. Belemnite/bivalve/echinoid zones: B.: *Belemnella*; Bt: *Belemnitella*. Macrofossil biozonation (from below): *Belemnitella langei*, *Microaster grimmensis*/*Cardiaster granulosus*, *Belemnella lanceolata*, *Belemnella inflata*, *Belemnella pseudobtusa*, *Belemnella obtusa*, *Belemnella sumensis*, *Belemnella cimbrica*, *Belemnella fastigata*, *Spyridoseramus tegulatus*/*Belemnitella junior*, *Tenuipteria argentea*/*Belemnitella junior*, *Tylocidaris baltica*/*Oxytoma danica*.

na of the Danish chalk was subdivided into a number of mode-of-life groups based on their interpreted preferred substrates (Surlyk 1972). At Hemmoor the following groups are represented: 1. minute forms able to use very small substrates; 2. Medium to very large-sized species confined to large, hard substrates; 3. Secondarily free-living species, resting directly on the chalk ooze; 4. Species cemented to very small substrates as larvae and subsequently free-living; 5. Species cemented to large hard substrates.

The stratigraphic distribution and abundances of all species found at Hemmoor reveal the presence of three different ecological assemblages, each dominating relatively thick parts of the succession. The assemblages are characterized by different species based on their interpreted mode-of-life.

Assemblage 1 is a sort of 'standard' brachiopod fauna of the Maastrichtian chalk dominated by micromorphic species and the medium-sized *Terebratulina chrysalis*. The key species are *Terebratulina chrysalis* (von Schlotheim, 1813), *Terebratulina longicollis* Steinich, 1965 and *Bronnothyris brononii* (Roemer, 1841). The generalist species *Terebratulina chrysalis* probably possessed a root-like pedicle like its close modern relative *T. retusa* (Linnaeus, 1758), allowing attachment to a great variety of substrates, ranging from large invertebrate skeletons to the fine-grained chalk ooze itself (Surlyk 1972). Its juvenile stages are, however, highly similar to the related micromorphic species of *Terebratulina*, *Gisilina* and *Rugia*. All the micromorphic species were able to use attachment to small skeletons of the ubiquitous bryozoans and other small skeletal fragments.

Assemblage 2 comprises almost only micromorphic species. They were able to use small invertebrate skeletons and fragments, notably bryozoans as substrates and dominate the brachiopod fauna completely in terms of both richness (species numbers) and abundances of the individuals species, reaching more than 700 individuals in some samples. The evolution of this micromorphic brachiopod fauna of the chalk took place relatively late in the life-time of the long-lasting Late Cretaceous Chalk Sea to reach a maximum in the late Campanian – Maastrichtian. In terms of abundances the micromorphic brachiopods closely follow the curves of the small bryozoan fauna (as measured by weight). The evolution of this specialized bryozoan fauna (Eckart Håkansson, pers. comm. 2026) is interpreted to have formed the basis for the relatively rapid evolution of the unusual, rich fauna of micromorphic brachiopods (Surlyk 1972; Surlyk & Birkelund 1977). The assemblage comprises species belonging to *Terebratulina*, *Rugia*, *Gisilina*, *Meonia*, *Dracius*, *Dalligas*, *Argyrotheca*, *Bronnothyris*, *Aemula* and *Scumulus*. The evolution of brachiopod micromorphism thus took place in a number of different taxonomic groups, indicating that this lifestyle

was a general advantage on the floor of the Chalk Sea and not just a mere coincidence in one or a few genera. This specialization of being a minute suspension feeder able to attach to very small hard substrates at the sediment-water interface was a high-risk affair. This was accommodated by a very high larval production and by reaching sexual maturity very early. That this was the case was demonstrated directly by age-studies of a number of species and by the very high proportion of juveniles of the micromorphic species, reflected by markedly right-skewed populations in the samples (Surlyk 1972, 1974).

Assemblage 3 is different from the two other assemblages as it in addition to micromorphic species is characterized the medium-sized hemispherical *Gyrosoria gracilis* (von Schlotheim, 1813) and *Magas chitoniformis* (von Schlotheim, 1813) plus the micromorphic, but also hemispherical *Meonia semiglobularis*. These species show little or no correlation with the bryozoan curves and it was originally interpreted that they developed a free-living mode-of-life as adults (Surlyk 1972). This would require that they passed the high-risk juvenile stages rapidly before developing a hemispherical shape and this was documented for *G. gracilis* by Surlyk (1972). An additional explanation for their lifestyle was demonstrated recently (Surlyk 2025a). A monospecific cluster of *M. chitoniformis* was thus described from a level in the Maastrichtian chalk of Denmark rich in large well-preserved siliceous sponges. The cluster was interpreted as representing a single spatfall attached to a sponge which was instantaneously buried by a debris flow of chalk ooze, resulting a complete preservation of the spatfall as a dense cluster. Similar clusters are known from other localities in the Danish Maastrichtian chalk, in all cases associated with rich sponge assemblages but at levels otherwise relatively poor in benthic fossils. Assemblage 3 is thus tentatively interpreted as reflecting periods with strong growths of sponges on the sea floor which could serve as attachments for these brachiopods. It is remarkable that the co-occurrence and dominance of *G. gracilis*, *M. chitoniformis* and *M. semiglobularis* characterize the stratigraphically same levels in the Hemmoor succession and in quarries south of Aalborg in Jylland, Denmark which are otherwise poor in shelly benthic fossils. The chalk of this level is pure, clean, rich in large sponges and poor in flint nodules and appear to represent the most deep-water chalk in the Danish and North German Basins. So, in conclusion assemblage 3 is interpreted as the deepest water fauna while assemblages 2 and 1 characterize progressively shallower water.

Assemblages 1–3 are thus interpreted as representing differences in water depth and in the growth of bryozoans and sponges on the seafloor during the life span of the succession. Assemblage 1 can be con-

sidered a sort of standard brachiopod fauna where the main species commonly occur in great abundances. In the Danish Maastrichtian it characterized what is interpreted as the most shallow water chalk with thin hardgrounds, dense layers of nodular flint and high contents of bryozoans and other benthic fossils. In the topmost Maastrichtian at Stevns Klint this chalk was deposited in low mounds with very high densities of bryozoans (see Surlyk *et al.* 2006, and references therein; Hansen & Surlyk 2014; Surlyk *et al.* 2026).

Large-sized species are rarely represented in the samples and where common they are represented by juveniles, for some species in large amounts. Some of the largest species in the Maastrichtian chalk of Hemmoor are thus almost only known from museum and private collections. This is the case with *Neoliothyryna obesa* Sahní, 1925, *N. fittoni* (von Hagenow, 1842) and the medium-sized *Kingena pentangulata* (Woodward, 1833) which all possessed stout pedicles as judged from the large, somewhat reinforced pedicle openings. They were thus restricted to the very scattered large hard substrates on the chalk seafloor, notably echinoids, large oysters and belemnites. The other large-sized species are characterized by developing a secondarily free-living mode-of-life with closed pedicle openings. The rhynchonellid species *Cretirhynchia retracta* (J. Sowerby, 1813) and *Homaletarhynchia limbata* (von Schlotheim, 1813) thus have relatively flat ventral valves and became free-living in the adult stage. They are represented by large numbers of juveniles again reflecting that a high production of larvae and rapid growth to adulthood were necessary for these species. The pedicle opening of the almost spherical adult shell of *Carneithyris subcardinalis* (Sahní, 1925) was also closed during growth and this species developed a life-style compared to a self-righting tumbler by Surlyk (1972).

Taxonomy

The Maastrichtian brachiopod fauna found in the north European chalk is mainly composed of micromorphic species and is well-known and first described in any detail by Steinich (1965, 1967, 1968a, b), followed by Surlyk (1969, 1970b, 1972, 1973, 1974, 1982, 1984, 2025b), Bitner & Pisera (1979), Surlyk & Johansen (1984), Johansen (1987), Johansen & Surlyk (1990), Simon & Owen (2001), Simon (2011), Sklenár & Simon (2009), Schröder & Surlyk (2020) and Machalski & Bitner (2024). Synonym lists are thus not presented here. The inner shell morphology is well known from these studies, especially through the works of Steinich. It is only relevant for generic assignments and is not described here. Species determinations are in contrast based on the external mor-

phology. Some of the craniacean brachiopods were described by Ernst (1984b) and Simon (2007). Other, mainly larger craniaceans and thecideans are rare in all the investigated chalk sections and are close to absent from the washing residues from the Hemmoor succession. Nomenclature and higher taxonomic categories follow The Treatise on Invertebrate Paleontology on Brachiopoda, even in the case of the very poorly chosen term 'beak' for 'rostrum' (Baker 2006; Bassett 2000; Holmer & Popov 2000; Kaesler 1997, 2000a, b, 2002, 2006; Lee & Smirnova 2006; Lee *et al.* 2006, 2007; MacKinnon & Lee 2006; Mancenido *et al.* 2002, 2007; Selden, 2007).

A total of 29 species, represented by about 10,000 individuals, is identified in the washing residues of the 47 bulk samples from Hemmoor. In addition, five species are represented by poorly preserved specimens or single fragments and are not figured here. The total number of species thus reaches 34 when they are included.

The following dimensional terms for the length of the ventral valve are used: micromorphic € [0;5] mm, small-sized € [5;10] mm, medium-sized € [10;20] mm, and large-sized € [20;100] mm. The term 'specimen' is used for any whole shell, dorsal or ventral valve and recognizable fragment. The term number of 'individuals' is calculated as the sum of whole shells and whatever the greater number of dorsal or ventral valves of a given species. This gives a minimum number of individuals. This is compared to the number of fragments in order to assess if it gives a reasonable and comparable picture of the fauna in each sample.

The basal part of the succession has been sampled several times over a period in the early 1970s because quarrying was extended deeper down. This means that four samples received from Friedrich Schmid are from the same level but with different numbers. They are here numbered as H 868 a-d and are all presented under the Material sections for each species. The level of marl band H 900 was later resampled to obtain more material from this stratigraphically important level. This sample is here labelled as H 900 b.

Some small sample glasses have been lost during repeated movements of office of FS after their content of brachiopods was determined to species and counted. The determinations were checked several times in the years before the accidents, but the missing material and a few rare and poorly preserved species were not photographed but these species are figured in Surlyk (2025b).

Order Craniida Waagen, 1885

Superfamily Cranioidea Menke, 1828

Family Craniidae Menke, 1828

Genus *Ancistrocrania* Dall, 1877

Type species *Ancistrocrania parisiensis* Defrance, 1818

Ancistrocrania tubulosa Nielsen 1909

Small-sized species up to 7.5 mm in length. Outline rounded to quadrangular. Ventral valve attached with almost all of its surface to a hard substrate. The valve consists of only the thickened margin, as the inner, central part of the shell is not or only very poorly calcified and muscle scars are thus virtually not developed. The margin consists of radial calcareous tubes which touch each other. The outer opening of the tubes is wider than the inner.

Material. A total of 4 individuals. H 897, H 898, H 918.

Chronostratigraphy at Hemmoor. Upper lower – lower upper Maastrichtian. *Belemnella fastigata* – *tegulatus*/B. junior belemnite/bivalve Zones, *tenuicostata* – *semiglobularis* to *semiglobularis-humboldtii* brachiopod Zones.

Pertinent references. Nielsen (1909), Gravesen & Jakobsen (2013), Surlyk (2025b).

Genus *Isocrania* Jaekel, 1902

Type species *Isocrania egnabergensis* (Retzius, 1781)

Isocrania costata (J. Sowerby, 1823)

Fig. 6

Shell small-sized and thick; subrectangular to subcircular in outline; dorsal valve low conical; up to 35 costellae formed by intercalation; costellae strong, prominent and protruding somewhat beyond shell

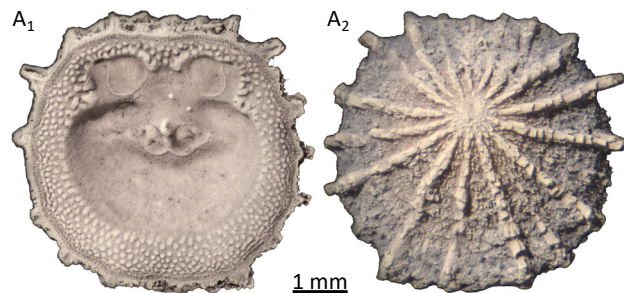


Fig. 6. *Isocrania costata* (Sowerby, 1823). A₁. Dorsal valve, internal view. A₂. Dorsal valve, external view. H 140. MGUH 35003.

margin; lateral costellae may curve slightly backwards; coarse, small spines between costellae; posterior adductors separated by a low septum of ventral valve; anterior adductors closely spaced, small, situated close to midline, separated by short, pointed septum; ventral valve may show imprints of tiny, hard substrates; posterior adductors of dorsal valve separated by a low septum, anterior adductors are closely spaced.

Material. – A total of 156 individuals. H 868 a, b, c, d, H 871, H 876, H 883, H 893, H 898, H 900, H 900 b, H 916, H 918, H 919, H 922, H 925, H 928, H 931, H 932, H 933, H 934, H 936, H 937, H 940.

Chronostratigraphy at Hemmoor. Upper lower – lower upper (upper – upper?) Maastrichtian, *Belemnella sumensis*, Bn. *cimbrica*, Bn. *fastigata*, *Belemnitella junior* belemnite Zones, *pulchellus-tenuicostata* to *semiglobularis-humboldtii* brachiopod Zones.

Pertinent references. Surlyk (1973, 2025b), Bitner & Pissera (1979), Ernst (1984b), Johansen & Surlyk (1990), Simon (2007), Lauridsen & Surlyk (2008), Hansen & Surlyk (2014), Machalski & Bitner (2024).

Order Rhynchonellida Kuhn, 1949

Superfamily Hemithiridoidea Zhonsnitskaia, 1956

Family Tetrarhynchiidae Ager, 1965

Subfamily Cretirhynchiinae Katz, 1974

Genus *Cretirhynchia* Pettitt, 1950

Type species: *Cretirhynchia plicatilis* (J. Sowerby, 1816)

Cretirhynchia retracta (Roemer, 1841)

The juvenile specimens are described below under *Cretirhynchia* sp. as this is by far the most common rhynchonellid brachiopod species in the Maastrichtian chalk (Steinich 1965; Surlyk 2025b). The material from Hemmoor only includes a few, poorly preserved larger fragments of the anterior denticulate and uniplicate commissure.

Chronostratigraphy at Hemmoor. The fragmentary nature of the very scarce material from the washing residue of specimens which can be referred to *C. retracta* does not allow any chronostratigraphic conclusions but as the juveniles described under *Cretirhynchia* sp. probably mainly comprises *C. retracta* it is inferred that it is represented almost throughout the succession. Outside Denmark, *C. retracta* has been safely recorded from Rügen in northern Germany (Steinich

1965). It is clearly more widespread, but the great variability of species referred to *Cretirhynchia* in the literature does not easily allow further information on the geographic distribution of *C. retracta*.

Pertinent references. Steinich (1965), Surlyk (1972, 1984), Simon & Owen (2001), Gravesen & Jakobsen (2013), Hansen & Surlyk (2014).

Family Basiliolidae Cooper, 1959

Subfamily Aphelesiinae Cooper, 1959

Genus *Homaletarhynchia* Simon & Owen, 2001

Type species *Homaletarhynchia limbata* (von Schlotheim, 1813)

Homaletarhynchia limbata (von Schlotheim, 1813)

Fig. 7

The genus *Cretirhynchia* was considered prone to major revision by Simon & Owen (2001). Motchurova Dekova & Simon (2007) transferred *C. limbata* to the genus *Homaletarhynchia* Simon & Owen, 2001 based on serial sections, study of the umbonal part and shell ultrastructure. Only a single, poorly preserved and flattened specimen of *H. limbata* has been safely identified in the washing residues and small specimens may be covered under *Cretirhynchia* sp. described below. The species is medium-sized and in most cases wider than long, ovate to subtriangular and the anterior margin is denticulate and uniplicate. The shell is biconvex with a strongly convex dorsal valve and a rather flat ventral valve. The greatest thickness is at the anterior margin of the shell. A marked ventral sinus is formed close to the shell midline. The surface of the shell is smooth but may have a sculpture of faint and narrow radial grooves. The beak is short and pointed and becomes gradually more incurved during growth. The minute foramen is hypothryid and surrounded by a collar-like deltidium but is apparently not completely closed like in *Cretirhynchia retracta*.

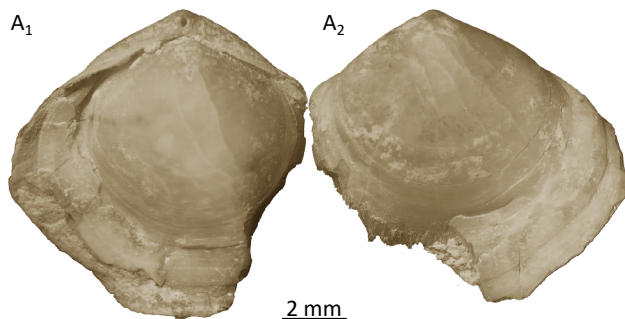


Fig. 7. *Homaletarhynchia limbata* (von Schlotheim, 1813). A₁, Dorsal view. A₂, Ventral view. MGUH 35004.

Material. Only a single specimen has been identified in the Hemmoor material in H 82. *H. limbata* has been recorded from Denmark (Surlyk 2025b), Rügen in northern Germany (Steinich 1965), Belgium by Motchurova-Dekova & Simon (2007), who also indicate a wide distribution in northern, central and eastern Europe without providing any details, and Norfolk in eastern England (Johansen & Surlyk 1990).

Chronostratigraphy. Specimens belonging to *H. limbata* are probably included under *Cretirhynchia* sp. described above but nothing can be said about its stratigraphic distribution.

Pertinent references. Steinich (1965), Motchurova Dekova & Simon (2007), Johansen & Surlyk (1990).

Cretirhynchia sp.

Fig. 8

Rhynchonellid brachiopods are almost only represented by juvenile micromorphic individuals in the washing residues and the few larger specimens are all damaged by compaction. Almost all belong to *Cretirhynchia retracta* (Roemer, 1841) as this is by far the most common rhynchonellid in the North European Maastrichtian chalk. But species diagnostic characters are not yet developed in the juvenile specimens from the washing residues, and this material is accordingly described under the heading *Cretirhynchia* sp. The following description thus only covers the juvenile stages. However, a single damaged relatively large specimen of *Homaletarhynchia limbata* Simon, 2001 has been identified and a few fragments of the anterior shell margin of *C. retracta* have also been found. They are accordingly briefly described above.

Small-sized. Pointed oval outline; anterior commissure rounded in dorsal view, but turns into straight and slightly incurved during growth; greatest width at shell midline, closer to anterior margin in larger specimens; shell flattened biconvex; very thin in

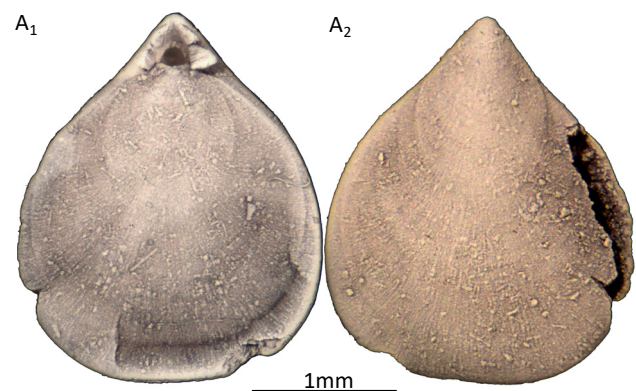


Fig. 8. *Cretirhynchia* sp. Small-sized juvenile individual. A₁, Dorsal view. A₂, Ventral view. MGUH 35005.

small specimens; hinge margin passes evenly into lateral margins; no ears; beak suberect; foramen large and triangular, limited by two narrow deltidial plates that grow slightly upwards and then outwards; long, tubular pedicle collar; no cardinal process; relatively strong, low inner socket ridges that pass directly into diverging, straight, long and ventrally directed crura.

Material. A total of 581 individuals. H 868 a, b, c, d, H 871, H 876, H 883, H 893, H 895, H 896, H 897, H 898, H 899, H 900, H 900 b, H 904, H 909, H 911 unt., H 913, H 914, H 915, H 916, H 918, H 919, H 920, H 921, H 922, H 923, H 924, H 925, H 926, H 927, H 928, H 930, H 931, H 932, H 933, H 934, H 936, H 938, H 940 unt., H 941.

Chronostratigraphy at Hemmoor. Upper lower – lower upper (upper-upper?) Maastrichtian, *Belemnella sumensis*-*Belemnitella* to *Belemnitella junior* belemnite Zones, *pulchellus-tenuicostata* to *semiglobularis-humboldtii* brachiopod Zones.

Pertinent references. Steinich (1965), Machalski & Bitner (2024), Surlyk (2025b).

Order Thecideida Elliott, 1958

Superfamily Thecideoidea Gray, 1840

Family Thecideidae Gray, 1840

Subfamily Thecideinae Gray, 1840

Genus *Thecidea* Defrance, 1822

Type species *Thecidea papillata* (von Schlotheim, 1813)

Thecidea papillata (von Schlotheim, 1813)

Medium-sized; pointed oval-ellipsoidal outline; length greater than width; both valves rather flat; beak becomes incurved during growth; margin of dorsal valve inclined towards the ventral valve and with a granular sculpture; outer surface of valves has laterally backwards curved costellae; number of costellae increases by intercalation to about 20; pseudodeltidium pointed triangular; commissure rectimarginate; low median septum; cicatrix on rostral extremity small. For description of inner morphology see Backhaus (1959).

Material. A total of 4 individuals. H 940 unt.

Chronostratigraphy at Hemmoor. Lower upper Maastrichtian, *Belemnitella junior* belemnite Zone, *semiglobularis-humboldtii* brachiopod Zone.

Pertinent references. Backhaus (1959), Simon (1998), Hansen & Surlyk (2014), Surlyk (2025b).

Genus *Vermiculothecidea* Elliott, 1953

Type species *Vermiculothecidea vermicularis* (von Schlotheim, 1813)

Vermiculothecidea vermicularis (von Schlotheim, 1813)

The material only includes two fragments. For a detailed description, see Backhaus (1959). Shell small and thick; irregular elongated outline; length greater than width; dorsal valve subcircular to oval; shell planoconvex to concavoconvex; commissure rectimarginate; beak incurved; no foramen.

Material. A total of 2 individuals. H 868 d.

Chronostratigraphy at Hemmoor. Upper lower Maastrichtian, *Belemnella sumensis* belemnite Zone, *pulchellus-tenuistriata* brachiopod Zone.

Pertinent references. Backhaus (1959), Pajaud & Patruilus (1964), Gravesen & Jakobsen (2013), Hansen & Surlyk (2014), Surlyk (2025b).

Superfamily Terebratuloidea Gray, 1840

Family Sellithyrididae Muir-Wood, 1965

Subfamily Rectithyridinae Muir-Wood, 1965

Genus *Neoliothyridina* Sahni, 1925

Type species *Neoliothyridina obesa* Sahni, 1925

Neoliothyridina obesa Sahni, 1925

Only a single fragment has been found. For full descriptions see Steinich (1965) and Surlyk (2025b).

Material. One individual. H 940.

Chronostratigraphy at Hemmoor. Lower upper Maastrichtian, *semiglobularis-humboldtii* brachiopod Zone.

Pertinent references. – Steinich (1965), Machalski & Bitner (2024), Surlyk (2025b).

Family Gibbithyrididae Muir-Wood, 1965

Subfamily Carneithyridinae Muir-Wood, 1965

Genus *Carneithyris* (Sahni, 1925)

Type species *Carneithyris subcardinalis* (Sahni, 1925)

Carneithyris subcardinalis (Sahni, 1925)

Fig. 9

The material comprises almost only minute, juvenile specimens; however, a few specimens reach a length of more than 13 mm. For a detailed description of the larger growth stages and adults see Steinich (1965) and Asgaard (1975).

Adult shell large-sized; rounded ovate in outline; greatest width close to the midline. Juvenile specimens strongly elongate and ovate; shell thin and biconvex; hinge line forms sharp angle with lateral shell margins; commissure rectimarginate; shell smooth; beak pointed, suberect with small, sharply delimited area; foramen hypothyrud and triangular in juvenile specimens; deltidial plates are fused at a shell width of 1 mm.

Material. A total of 215 individuals. H 868 a, b, c, d, H 871, H 876, H 883, H 893, H 895, H 896, H 897, H 898, H 899, H 900, H 900 b, H 904, H 909, H 913, H 914, H 915, H 916, H 918, H 919, H 920, H 922, H 924, H 927,

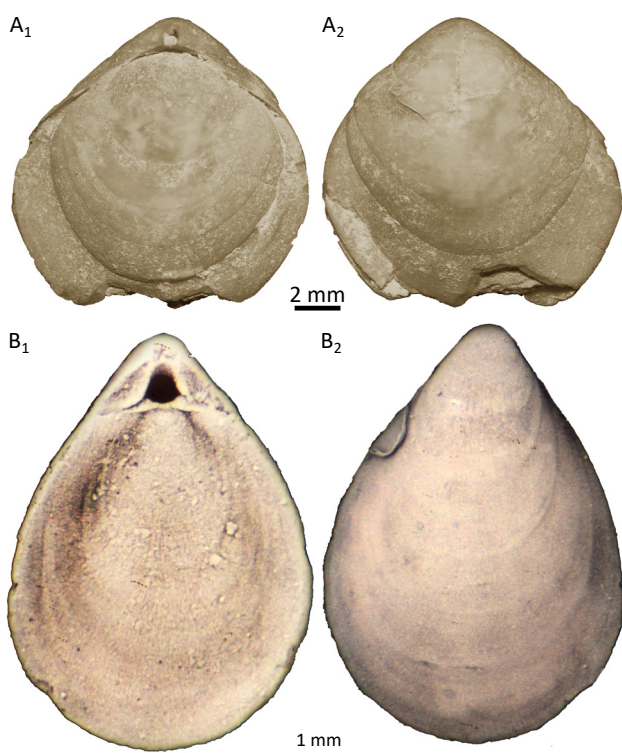


Fig. 9. *Carneithyris subcardinalis* (Sahni, 1925). Medium-sized not fully grown individual. A₁. Dorsal view. A₂. Ventral view. MGUH 35006. Small-sized juvenile individual. B₁. Dorsal view. B₂. Ventral view. MGUH 35007.

H 930, H 932, H 933, H 936, H 937, H 938, H 940 unt.

Chronostratigraphy at Hemmoor. Upper lower – lower upper Maastrichtian, *Belemnella sumensis* to *Belemnitella junior* belemnite Zones, *pulchellus-tenuicostata* to *semiglobularis-humboldtii* brachiopod Zones.

Pertinent references. Steinich (1965), Surlyk (1972, 2025b), Bitner & Pisera (1979), Asgaard (1975).

Superfamily Cancellothyridoidea Thomson, 1926

Family Cancellothyrididae Thomson, 1926

Subfamily Cancellothyridinae Thomson, 1926

Genus *Terebratulina* d'Orbigny, 1847

Type species *Terebratulina retusa* (Linnaeus, 1758)

Terebratulina chrysalis (von Schlotheim, 1813)

Fig. 10

Small to medium-sized; elongate-subpentagonal; commissure rectimarginate to slightly uniplicate, truncated; ears large and well defined; shell biconvex and rather thin; surface finely costellate; new costellae formed by intercalation; number reaching up to about 100; costellae of juvenile forms ornamented by small nodules; costellae become almost smooth during growth; beak short, suberect; area small, sharply delimited; foramen changes from hypothyrud, over submesothyrud to mesothyrud in large forms; inner socket ridges rather shallow; teeth small and trian-

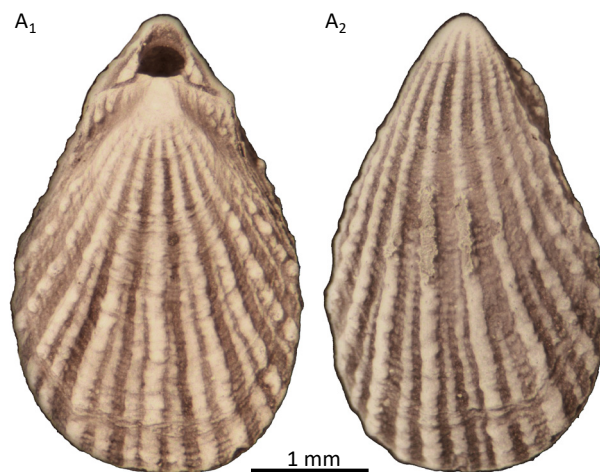


Fig. 10. *Terebratulina chrysalis* (von Schlotheim, 1813). Juvenile individual. Becomes relatively wider during ontogeny with numerous intercalated costellae. A₁. Dorsal view. A₂. Ventral, slightly oblique view. H 115. MGUH 35008.

gular; crural processes fused to brachial loop, forming a tube during growth. Strong spicular skeleton in mantle, anterior body wall and lophophore arms; plectolophe.

Material. A total of 969 individuals. H 868 a, b, c, d, H 871, H 876, H 883, H 893, H 895, H 896, H 897, H 898, H 899, H 900, H 900 b, H 904, H 909, H 911 unt., H 911 ob., H 912, H 913, H 914, H 915, H 916, H 918, H 919, H 920, H 921, H 922, H 923, H 924, H 925, H 926, H 927, H 928, H 930, H 931, H 932, H 933, H 934, H 935, H 936, H 937, H 938, H 940 unt.

Chronostratigraphy at Hemmoor. Upper lower – lower upper Maastrichtian, *Belemnella sumensis* to *Belemnitella junior* belemnite Zones, *pulchellus-tenuicostata* to *semiglobularis-humboldtii* Zones.

Pertinent references. Steinich (1965), Surlyk (1969, 1972, 1984, 2025b), Bitner & Pisera (1979), Johansen (1987), Johansen & Surlyk (1990), Simon (2000, 2011), Schröder & Surlyk (2020), Machalski & Bitner (2024).

Terebratulina longicollis (Steinich, 1965)

Fig. 11

Micromorphic; markedly elongate subpentagonal; shell relatively thick, biconvex; ears small, well defined; 8–10 straight costae; no costellae; sculpture of costae consists of small transverse half-rings; beak suberect, short; circular mesothyrid foramen; deltidial plates converge anteriorly; pedicle collar well developed; inner socket ridges thin, long; outer socket ridges shallow; teeth triangular, pointed; descending branches fused at early stage; brachidium very strong with long, anteriorly directed crura; dorsal transverse bridge with anteriorly directed median

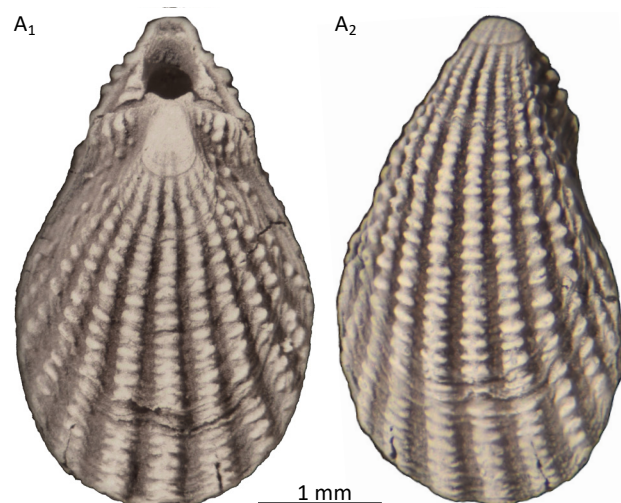


Fig. 11. *Terebratulina longicollis* (Steinich, 1965) A₁. Dorsal view. A₂. ventral, slightly oblique view. H 125. MGUH 35009.

ridge; well-developed spicular skeleton in mantle, anterior body wall, lophophore arms; plectolophe as adult.

Material. A total of 934 individuals. H 868 a, b, d, H 871, H 876, H 883, H 893, H 895, H 896, H 897, H 899, H 900, H 900 b, H 904, H 911 unt., H 911 ob., H 912, H 914, H 915, H 916, H 918, H 919, H 920, H 921, H 922, H 923, H 924, H 925, H 926, H 927, H 928, H 930, H 931, H 932, H 933, H 934, H 936, H 940 unt.

Chronostratigraphy at Hemmoor. Upper lower – lower upper Maastrichtian, *Belemnella sumensis* to *Belemnitella junior* belemnite Zones, *pulchellus-tenuicostata* to *semiglobularis-humboldtii* brachiopod Zones.

Pertinent references. Steinich (1965), Surlyk (1972, 1982, 1984, 2025b), Johansen & Surlyk (1990), Machalski & Bitner (2024).

Terebratulina faujasii (Roemer, 1841)

Fig. 12

Micromorphic; rounded, wide subtriangular outline; shell thick, biconvex to planoconvex; commissure rectimarginate in subadults, changing to uniplicate in fully grown adults; ears large and clearly delimited; up to 10 strong, straight costae with prominent sculpture of transverse half-rings; beak suberect, short and blunt in adults; foramen large, mesothyrid; pedicle collar short and strongly developed; deltidial plates triangular, approaching each other anterior to the foramen; crura short; descending branches fuse to a connecting bridge; complete brachial ring formed in adults; well-developed spicular skeleton in mantle, anterior body wall and lophophore arms; adult lophophore a plectolophe.

Material. A total of 94 individuals. H 868 a, b, c, d, H 876, H 904; H 911 ob., H 924, H 927, H 928, H 930, H 931, H 932, H 940 unt.

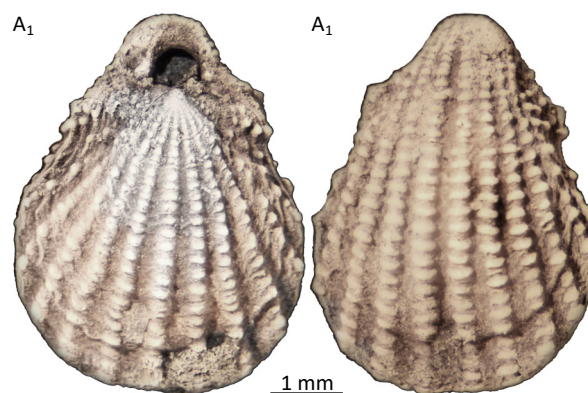


Fig. 12. *Terebratulina faujasii* (Roemer, 1841). A₁. Dorsal view. A₂. Ventral view. H 130. MGUH 35010.

Chronostratigraphy at Hemmoor. Upper lower Maas-trichtian, lower upper Maastrichtian. *Belemnella sumensis*, *B. cimbrica* and *Belemnitella junior* belemnite Zones, *pulchellus-tenuicostata* to *semiglobularis-humboldtii* brachiopod Zones.

Pertinent references. Steinich (1965), Surlyk (1972, 1982, 1984, 2025b), Bitner & Pisera (1979), Johansen (1987), Johansen & Surlyk (1990), Simon (2000), Machalski & Bitner (2024).

***Terebratulina subtilis* Steinich, 1965**

Fig. 13

Micromorphic; subpentagonal to subtriangular; shell thin, biconvex to almost planoconvex; ears indistinctly delimited; commissure rectimarginate; up to about 50 very fine costellae with a sculpture of very small tubercles; characteristic alternation between wide and narrow costellae; beak short and suberect; area small, sharply defined; foramen submesothyrid, limited by two narrow, triangular deltidial plates; pedicle collar long, well developed; hinge weak; inner socket ridges thin; descending branches of crura and crural processes fuse to form a complete brachidial ring; brachidium rather slender; a strongly developed spicular skeleton developed in arms; lophophore was a plectolophe.

Material. A total of 187 individuals. H 867, H 882 ob., H 883, H 876, H 893.

Chronostratigraphy at Hemmoor. Upper lower Maas-trichtian, *Belemnella sumensis*, *fastigata* and *Belemnitella junior* belemnite Zones, *pulchellus-tenuicostata* brachiopod Zone.

Pertinent references. Steinich (1965), Surlyk (1972, 1982, 2025b), Johansen & Surlyk (1990).

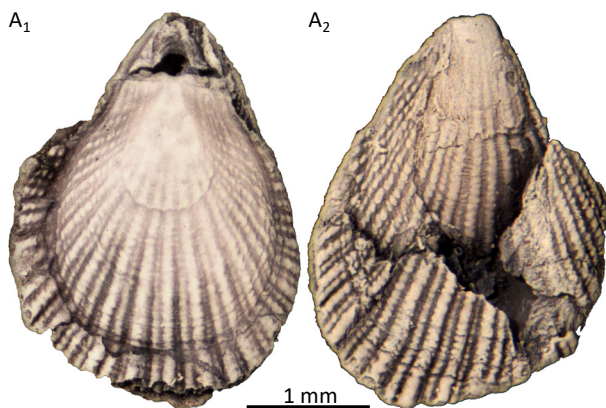


Fig. 13. *Terebratulina subtilis* Steinich, 1965. A₁. Dorsal view. Outer margin strongly compressed and deformed by sediment compaction. A₂. Ventral view. H 93. MGUH 35011.

Subfamily Cricosinae Cooper, 1973

Genus *Gyrosoria* Cooper, 1973

Type species *Gyrosoria gracilis* (von Schlotheim, 1813)

***Gyrosoria gracilis* (von Schlotheim, 1813)**

Fig. 14

Small to medium-sized; shell thick and plano- or slightly concavoconvex; juveniles elongate, adults subcircular to circular in outline; hinge margin passes evenly into lateral margins; costellae curve backwards laterally; up to 40–60 new costellae formed by intercalation; ornamentation with small grain-like tubercles, giving string-of-pearl like appearance; marked growth lines, commonly in groups; beak short, pointed and incurved during growth; foramen small and moves into dorsal valve during incurving of beak; pedicle collar strong, forming tube or gutter on inner side of ventral valve; hinge very strong; inner socket ridges well defined, laterally limited by deep sockets; teeth strong, pointed; strong crura; median branch of fused descending branches strongly ventrally curved with small posterior extension; dorsal valve with two large, triangular to pointed, oval adductor muscle scars; strong spicular skeleton in mantle, anterior body wall and arms; adult lophophore is a plectolophe.

Material. A total of 1522 individuals. H 868 a, b, c, d, H 871, H 876, H 883, H 885, H 893, H 896, H 897, H 898, H 899, H 900, H 900 b, 909, H 911 unt., H 911 ob., H 912, H 913, H 914, H 915, H 916, H 918, H 919, H 920, H 921, H 922, H 923, H 924, H 926, H 927, H 928, H 930, H 932, H 933, H 934, H 936, H 937, H 938, H 940 unt.

Chronostratigraphy at Hemmoor. Upper lower – lower upper Maastrichtian, *Belemnella sumensis* to *Belemnitella junior* belemnite Zones, *pulchellus-tenuicostata* to *semiglobularis-humboldtii* brachiopod Zones.

Pertinent references. Steinich (1965), Surlyk (1972,

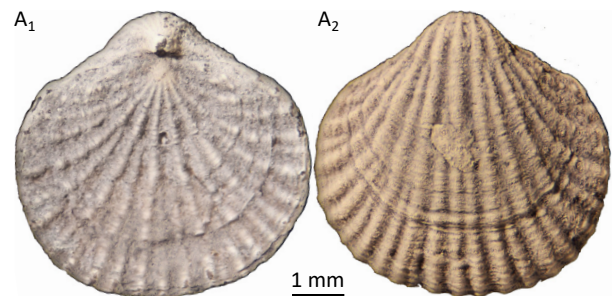


Fig. 14. *Gyrosoria gracilis* (von Schlotheim, 1813). A₁. Dorsal view. A₂. Ventral view. H 115. MGUH 35012.

2025b), Sklenár & Simon (2009).

Family Chlidonophoridae Muir-Wood, 1959

Subfamily Chlidonophorinae Muir-Wood, 1959

Genus *Gisilina* Steinich, 1963

Type species *Gisilina gisii* (Roemer, 1841)

Gisilina gisii (Roemer, 1841)

Fig. 15

Micromorphic; outline strongly rounded to somewhat triangular; strongly biconvex; shell relatively thick; commissure rectimarginate; ears small and poorly defined; strong, straight and smooth costae in some cases with a sculpture of small, very weak knobs; new costae formed at the ears and the number may reach 20; beak pointed and suberect to more incurved in adults; foramen slightly indented into dorsal valve and hypothyrid changing to ovoid mesothyrid during growth; triangular deltidial plates which do not contact each other; interarea narrow; long, strongly developed pedicle collar; hinge teeth short with thickened bases; descending branches fuse to form a thin, slightly ventrally curved bridge; lophophore arms with strong spicular skeleton; adult lophophore was a plectolophe.

Material. A total of 281 individuals. H 868 a, b, c, d, H 871, H 876, H 911 ob.

Chronostratigraphy at Hemmoor. Upper lower – lower upper Maastrichtian, *Belemnella sumensis*, *cimbrica*, *fastigata* to *Belemnitella junior* belemnite Zones, *pulchellus-tenuicostata* to *semiglobularis-humboldtii* brachiopod Zones.

Pertinent references. Steinich (1965), Surlyk (1982, 2025b), Johansen & Surlyk (1990).

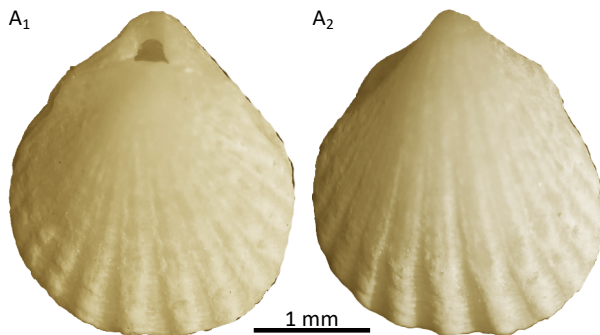


Fig. 15. *Gisilina gisii* (Roemer, 1841). A₁. Dorsal view. A₂. Ventral view. H 82 ob. MGUH 35013.

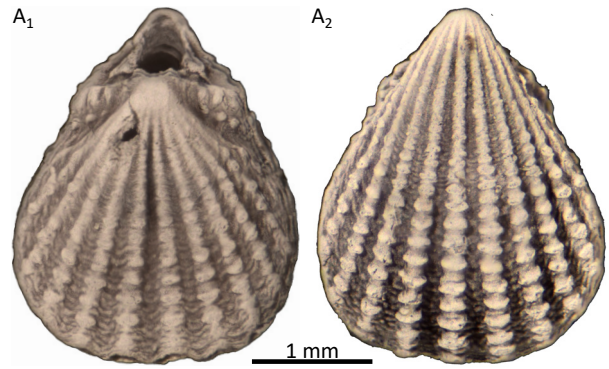


Fig. 16. *Gisilina jasmundi* Steinich, 1965. A₁. Dorsal view. A₂. Ventral view. H 79 unt. MGUH 35343.

Gisilina jasmundi Steinich, 1965

Fig. 16

Micromorphic; shell relatively thick; ovate to rounded subtriangular in outline; biconvex; ears large and well delimited; commissure rectimarginate; up to about 14 straight, strong costae with prominent sculpture of transverse half-rings; costae becomes wider in adults; beak suberect, interarea small and narrow; foramen rather large, submesothyrid; deltidial plates triangular; pedicle collar well developed; inner socket ridges high; teeth short; brachidium delicate; crura short; crural processes directed towards each other but do not meet; descending branches fused into long, thin, ventrally directed bridge; arms with strong spicular skeleton; well-developed plectolophe.

Material. A total of 69 individuals. H 868 a, b, H 871, H 876, H 883, H 900, H 900 b, H 904, H 912, H 918, H 922.

Chronostratigraphy at Hemmoor. Upper lower – lower upper Maastrichtian, *Belemnella cimbrica* and *Belemnitella junior* belemnite Zones, *pulchellus-tenuicostata* to *semiglobularis-humboldtii* brachiopod Zones.

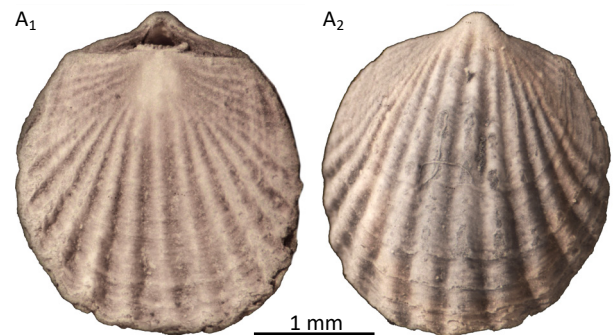


Fig. 17. *Meonia semiglobularis* (Posselt, 1894). A₁. Dorsal view. A₂. Ventral view. H 95. MGUH 35024.

Pertinent references. Steinich (1965), Surlyk (1972, 1982, 1984, 2025b) and Johansen & Surlyk (1990).

Genus *Meonia* Steinich, 1963

Type species *Meonia semiglobularis* (Posselt, 1894)

Meonia semiglobularis (Posselt, 1894)

Fig. 17

Micromorphic; elongate in juvenile stages, adults almost as wide as long with a semicircular outline; straight hinge line; shell planoconvex; ventral valve almost hemispherical; broad dorsal sinus; commissure rectimarginate in juveniles, slightly unisulcate in adults; costae strong, straight and rounded in cross section in juveniles, changing to V-shaped in adults; beak short and erect, becomes incurved during growth; area very small; foramen hypothryid changing to mesothryid during growth and finally very small and permesothryid; triangular, narrow deltidial plates which restrict foramen anteriorly during growth; hinge teeth blunt; teeth sockets deep; crural processes at the end of thin, long crura; cardinal process crenulated; descending branches meet to form a bridge; strong spicular skeleton of mantle, anterior body wall and arms; schizolophe.

Material. A total of 861 individuals. H 895, H 896, H 898, H 900, H 900 b, H 904, H 909, H 911 unt., H 913, H 915.

Chronostratigraphy at Hemmoor. Uppermost upper lower – lower upper Maastrichtian. *Belemnella fastigata* to lower *Belemnella junior* belemnite Zones, *semiglobularis-humboldtii* brachiopod Zone.

Pertinent references. Posselt (1894), Steinich (1965), Surlyk (1970a, 1972, 1984, 2025b), Surlyk & Dieni (1988), Surlyk & Johansen (1984), Johansen (1987), Lauridsen & Surlyk (2008), Hansen & Surlyk (2014).

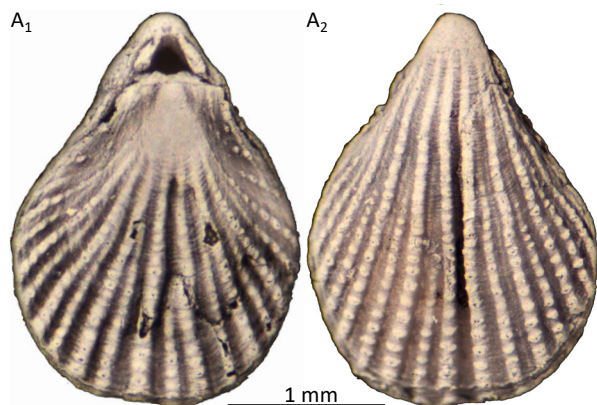


Fig. 18. *Rugia tenuicostata* Steinich, 1963. A₁. Dorsal view. A₂. Ventral view. H 79 unt. MGUH 35016.

Genus *Rugia* Steinich, 1963

Type species *Rugia tenuicostata* Steinich, 1963

Rugia tenuicostata Steinich, 1963

Fig. 18

Micromorphic; elongate-subtriangular, becomes pointed ovate during growth; biconvex, dorsal valve flatter; ears indistinct; commissure rectimarginate, costellae straight, new ones formed by intercalation; tuberculate knobs on costellae give a fretsaw-like profile; beak short, suberect pointed to slightly rounded during growth; interarea narrow; deltidial plates with laterally pointing flexure in the middle; teeth stump and delicate; long, thin crura that fuse in acute angle; well-developed spicular skeleton of mantle and plectolophe.

Material. A total of 903 individuals. H 868 a, b, c, d, H 871, H 876.

Chronostratigraphy at Hemmoor. Lower upper Maastrichtian, *Belemnella cimbrica* belemnite Zone, *pulchellus-tenuicostata* brachiopod Zone.

Pertinent references. – Steinich (1963, 1965), Surlyk (1970a, 1972, 1984, 2025b), Bitner & Pisera (1979), Johansen & Surlyk (1990), Simon (2000).

Rugia acutirostris Steinich, 1965

Fig. 19

Micromorphic; outline of juvenile specimens elongate subpentagonal; changes gradually to elongate pointed ovate during growth; both valves gently inflated. Ears small and mainly poorly delimited; about 6–8 radial costae formed at $W=0.2-0.3$ mm; new costellae added by intercalation to reach a number of about 40; they are weakly knobbed or more rarely smooth and curve gently laterally in larger specimens; beak sharply pointed and suberect. Foramen very small,

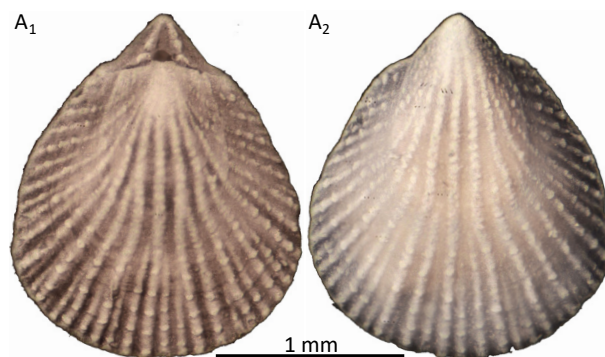


Fig. 19. *Rugia acutirostris* Steinich, 1965. A₁. Dorsal view. A₂. Ventral view. H 115. MGUH 35017.

subtriangular, hypothyril and laterally delimited by elongate triangular, narrow deltidial plates; pedicle collar very long.

Material. A total of 275. H 914, H 915, H 941, H 943.

Chronostratigraphy at Hemmoor. Lower upper Maas-trichtian, *Belemnitella junior* belemnite Zone, *semiglobularis-humboldtii* brachiopod Zone.

Pertinent references. – Steinich (1965), Surlyk (1970a, 1972, 1982, 1984, 2025b), Bitner & Pisera (1979), Johansen (1987), Johansen & Surlyk (1990).

***Rugia tegulata* Surlyk, 1970**

Fig. 20

Only few, poorly preserved specimens in Hemmoor samples. Micromorphic; outline subtriangular to pointed oval; shell rather thick, slightly biconvex; five costae formed initially, number of costellae increases rapidly by intercalation to about 20; costellae with strong sculpture of transverse plate-like scales; beak suberect; interarea small; foramen triangular, hypothyril, limited by deltidial plates with constriction in the middle; crura long and thin; very strong spicular skeleton; adult lophophore seems to have been a plectolophe.

Material. A total of 4 individuals, H 937.

Chronostratigraphy at Hemmoor. Lower upper Maas-trichtian, *Belemnitella junior* belemnite Zone, *semiglobularis-humboldtii* brachiopod Zone.

Pertinent references. Surlyk (1970b, 2025b), Lauridsen & Surlyk (2008).

Subfamily Draciinae Steinich, 1967

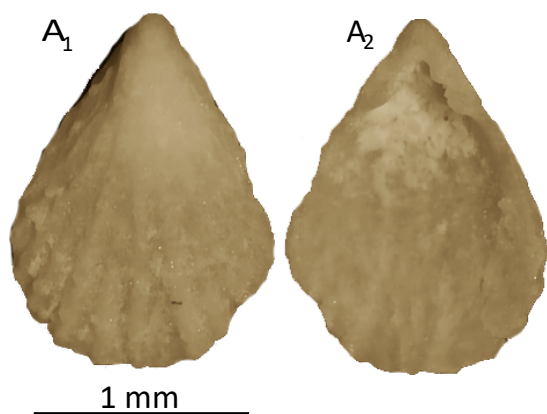


Fig. 20. *Rugia tegulata* Surlyk, 1970. A₁. Ventral valve, external view. A₂. Ventral valve, internal view. Poorly preserved juvenile individual. H 137. MGUH 35018.

Genus *Dracius* Steinich, 1967

Type species *Dracius carnifex* Steinich, 1967

***Dracius carnifex* Steinich, 1967**

Fig. 21

Micromorphic; oval to subpentagonal; outline more or less irregular; shell planoconvex to weakly concavoconvex; commissure rectimarginate in regular specimens; dorsal valve smooth; ventral valve with up to 35 strong costellae with irregular thorn-like tubercles; foramen indented into dorsal valve in adults; crura strong and extend from bases of inner socket furrows; short ascending branches and a transverse band; the lophophore was an early plectolophe.

Material. A total of 10 individuals. H 868 d, H 871, H 876, H 900 b.

Chronostratigraphy at Hemmoor. Upper lower to lowermost part of the lower upper Maastrichtian, *Belemnella sumensis*, *cimbrica* and *fastigata* belemnite Zones, *pulchellus-tenuicostata* to lowermost *semiglobularis-humboldtii* brachiopod Zones.

Pertinent references. Steinich (1967), Surlyk (1984, 2025b), Johansen & Surlyk (1990).

Superfamily Kingenoidea Elliott, 1948

Family Kingenidae Elliott, 1948

Subfamily Kingeninae Elliott, 1948

Genus *Kingena* Davidson, 1852

Type species *Kingena lima* Defrance, 1828

***Kingena pentangulata* (Woodward, 1833)**

Specimens poorly preserved and fragmentary. Small to medium-sized; subtriangular or subcircular to subpentagonal during growth; shell very thin, al-

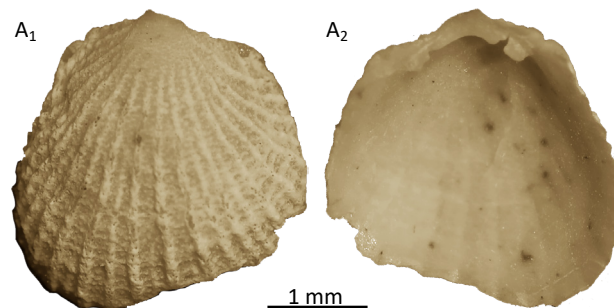


Fig. 21. *Dracius carnifex* Steinich, 1967. A₁. Ventral valve, external view. A₂. Ventral valve, internal view. H 85. MGUH 35019.

most always deformed by sediment compaction; biconvex; largest width anterior to midline; hinge margin almost straight, passes evenly into lateral shell margins; commissure rectimarginate; surface of shell with closely spaced, regular, long, cone-shaped tubercles; beak suberect to almost erect in very large specimens; area wide, sharply delimited; foramen large, trapezoidal, permesothyrid with increasing incurved beak, limited by relatively wide, triangular deltidial plates; teeth strong, pointed; well-developed hinge plate connected to medium septum; short crura with strongly diverging descending branches that extend from a marked break from the ends of the crura. A posteriorly directed loop extends from the front of the septum.

Material. total of 32 individuals. H 868 d, H 876, H 893, H 895, H 896, H 897, H 898, H 904, H 915.

Chronostratigraphy at Hemmoor. Upper lower – lower upper Maastrichtian, *Belemnella sumensis*, *fastigata* and *Belemnitella junior* belemnite Zones, *pulchellus-tenuicostata* to *semiglobularis-humboldtii* brachiopod Zones.

Pertinent references. Owen (1970), Surlyk (1984, 2025b), Johansen & Surlyk (1990), Simon (2000).

Superfamily Laqueoidea Thomson, 1927

Subfamily Dalligadinae MacKinnon & Lee, 2006

Genus *Dalligas* Steinich, 1968

Type species *Dalligas nobilis* Steinich, 1968

Dalligas nobilis Steinich, 1968

Fig. 22

Micromorphic; juveniles elongate ovate, changes to subcircular during growth; weakly biconvex to planoconvex, dorsal valve almost plane; shell thin; commissure rectimarginate; small specimens smooth, but

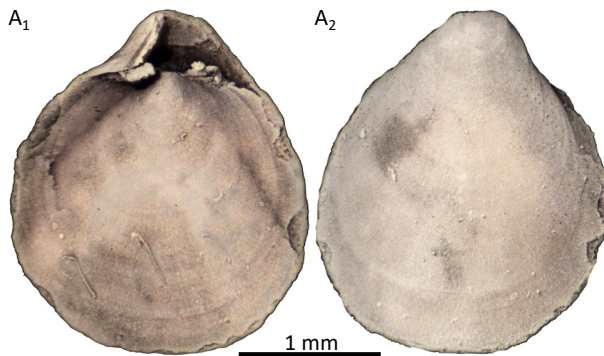


Fig. 22. *Dalligas nobilis* Steinich, 1968. A₁. Dorsal view. A₂. Ventral view. H 97. MGUH 35020.

dorsal valves may develop weak radial ribs; ventral valve may have more than 40 slightly tuberculate costellae; beak weakly suberect; foramen relatively large, elongate triangular, hypothyrid, does not extend into dorsal valve; inner socket ridges very shallow; no cardinal process; median septum with steep anterior margin and slightly incurved posterior margin from where two short, stump, triangular branches extend; crura and descending branches missing.

Material. A total of 44 individuals. H 897, H 898, H 921, H 923, H 924, H 926, H 927, 928, H 930, H 931, H 932.

Chronostratigraphy at Hemmoor. Upper lower Maastrichtian – lower upper Maastrichtian, *Belemnella cimbrica* (?), *fastigata* and *Belemnitella junior* belemnite Zones, *pulchellus-tenuicostata* to *semiglobularis-humboldtii* brachiopod Zones.

Pertinent references. Steinich (1968b), Johansen & Surlyk (1990), Surlyk (2025b).

Superfamily Megathyridoidea Dall, 1870

Family Megathyrididae Dall, 1870

Genus *Argyrotheca* Dall, 1900

Type species *Argyrotheca cuneata* Risso, 1826

Argyrotheca hirundo (von Hagenow, 1842)

Fig. 23

Micromorphic; outline subtriangular; highly variable but shell mainly clearly elongate; largest width anterior to the shell midline; shell biconvex; ventral valve strongly convex; dorsal valve rather flat; poorly delimited ears and shell margin may be extended laterally into two pointed wings, but this is uncommon; anterior commissure rectimarginate to slightly ventrally curved; two costae are formed at W=1.0 mm;

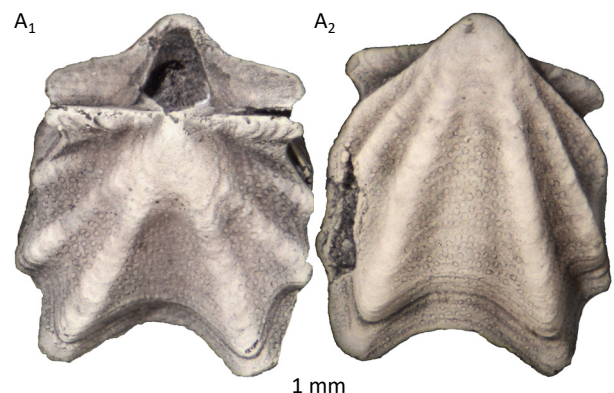


Fig. 23. *Argyrotheca hirundo* (Hagenow, 1842). A₁. Dorsal view. A₂. Ventral view. H 83. MGUH 35021.

two more formed laterally to the two first at $W=1.6$ mm; the number may in this way increase to 6; costae are arranged into two bundles separated by a median sinus; a single costa commonly formed in the sinus at $W=1.6$ mm or later; large forms have up to 7–8 clear growth lines; beak pointed and suberect; area planar to slightly concave; foramen large, triangular, hypothryd and limited laterally by narrow deltidial plates; strongly developed pedicle collar has a posteriorly directed anterior margin; dorsal median septum is high and touches the ventral valve.

Material. A total of 171 individuals. H 871, H 876, H 883.

Chronostratigraphy at Hemmoor. Upper lower Maastrichtian, *Belemnella occidentalis* belemnite Zone, *pulchellus-tenuicostata* to *tenuicostata-semiglobularis* brachiopod Zones.

Pertinent references. Steinich (1965), Surlyk (1984, 2025b), Johansen & Surlyk (1990), Simon (2000).

Genus *Bronnothyris* Popiel-Barczyk & Smirnova, 1978

Type species *Bronnothyris bronnii* (Roemer, 1841)

Bronnothyris bronnii (Roemer, 1841)

Fig. 24

Small-sized; semicircular or subpentagonal to subrectangular, variable; largest width almost always along hinge line; small forms biconvex; dorsal valve becomes flat during growth; ears poorly defined; broad median sinus giving a bilobate outline; a total of eight costae in two bundles; costae flat, extend only slightly beyond margin; up to eight strong growth lines; beak pointed or truncated, erect to slightly suberect; deltidial plates narrow; foramen large, triangular; pedicle collar well developed; ventral median septum very thin and high.

Material. A total of 336 individuals. H 868 a, b, c, d, H 871, H 876, H 883, H 893, H 897, H 911 unt., H 912,

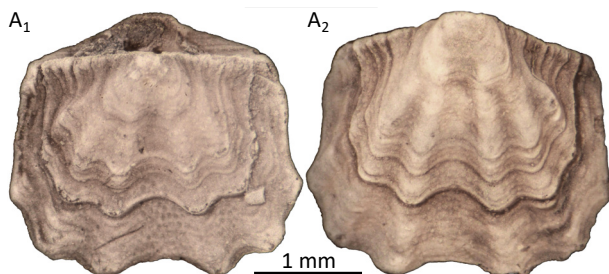


Fig. 24. *Bronnothyris bronnii* (Roemer, 1841). A₁. Dorsal view. A₂. Ventral view. H 130. MGUH 35022.

H 913, H 915, H 916, H 918, H 919, H 920, H 921, H 922, H 923, H 924, H 925, H 927, H 928, H 930, H 931, H 932, H 933, H 934, H 935, H 936, H 937, H 940 unt.

Chronostratigraphy at Hemmoor. Upper lower – lower upper Maastrichtian. *Belemnella sumensis* to *Belemnitella junior* belemnite Zones, *pulchellus-tenuicostata* to *semiglobularis-humboldtii* brachiopod Zones.

Pertinent references. Steinich (1965), Surlyk (1969, 1972, 1984, 2025b), Bitner & Pisera (1979), Johansen & Surlyk (1990), Machalski & Bitner (2024).

Bronnothyris coniuncta (Steinich, 1965)

Fig. 25

Micromorphic; hemicircular; hinge line extended into two wings; flattened biconvex; commissure rectimarginate; up to eight costae in two strongly diverging bundles separated by median sinus; costae not very strong, extend only slightly beyond shell margin; beak pointed or truncated; interarea broad, flat; foramen large, triangular, hypothryd, limited by narrow deltidial plates; strong pedicle collar, planar with straight anterior margin; high dorsal median septum; ventral septum very thin.

Material. A total of 140 individuals. H 688 a, b, c, d, H 871, H 876, H 883, H 895, H 896, H 898, H 899, H 900, H 900 b, H 911 unt., H 911 ob., H 914, H 915, H 916, H 918, H 919, H 920, H 921, H 922, H 923, H 924, H 925, H 927, H 933, H 936.

Chronostratigraphy at Hemmoor. Upper lower – lower upper Maastrichtian, *Belemnella occidentalis* to *Belemnitella junior* belemnite Zones, *pulchellus-tenuicostata* to *semiglobularis-humboldtii* brachiopod Zones.

Pertinent references. Steinich (1965), Surlyk (1984, 2025b), Bitner & Pisera (1979), Johansen & Surlyk (1990).

Superfamily Platidioidea Thomson, 1927

Family Platidiidae Thomson, 1927

Subfamily Platidiinae Thomson, 1927

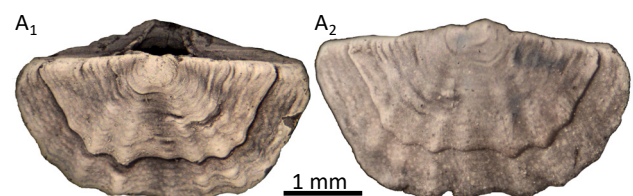


Fig. 25. *Bronnothyris coniuncta* Steinich, 1965. A₁. Dorsal view. A₂. Ventral view. H 133. MGUH 35023.

Genus *Aemula* Steinich, 1968

Type species *Aemula inusitata* Steinich, 1968

Aemula inusitata Steinich, 1968

Fig. 26

Micromorphic; shell relatively thin; oval to subcircular outline, commonly very irregular; planoconvex to slightly concavoconvex; commissure rectimarginate in regular specimens; dorsal valve smooth, occasionally with visible growth lines; ventral valve with small, cone-shaped tubercles; beak short, suberect; area small, sharply delimited; hinge line almost straight; foramen large, amphithyrid, delimited by narrow deltidial plates; dorsal valve with semicircular indentation formed by resorption of dorsal umbo; teeth very short and blunt; inner socket ridges strong and extend outside posterior shell margin; brachidium poorly developed with two small wing-like ascending branches sitting on low triangular septum; branches are strong and blunt; strongly developed spicular skeleton; schizolophe.

Material. A total of 31 individuals. H 868 a, d, H 898, H 911 ob., H 912; H 915, H 916; H 920, H 921, H 932.

Chronostratigraphy. Upper lower – lower upper Maastrichtian, *Belemnella sumensis*, *B. fastigata* to *Belemnella junior* belemnite Zones, *pulchellus-tenuicostata* to *semiglobularis-humboldtii* brachiopod Zones.

Pertinent references. Steinich (1968a), Surlyk (1972, 1984, 2025b), Bitner & Pisera (1979), Johansen & Surlyk (1990).

Aemula sp.

Fig. 27

Aemula sp. was first recognized in macrofossil material (collected by Friedrich Schmid) from the Hemmoor chalk quarry in northern Germany where

several specimens were found by FS preserved in life position still sitting in their original attachment points on the test of the irregular echinoid *Echinocorys*. This find was quite remarkable for a pedunculate brachiopod, which will normally always become detached from its substrate after death following decay of the pedicle. It was the key species in a palaeoecological study (Surlyk 1974) where it was described as *Aemula* sp. It is considered a new species but a formal description must wait until specimens clearly showing the internal morphology are found.

Aemula sp. is micromorphic; shell thin; outline subcircular to circular, occasionally irregular with minor indentations; shell initially plano-convex to biconvex, but dorsal valve becomes planar and in some cases even weakly concave during growth; the concavity of the outer part of the dorsal valve may, however, be due to sediment compaction; anterior margin rectimarginate; beak short and suberect; surface of shell smooth, tubercles completely absent; growth lines rare to absent; foramen large, amphithyrid and the indentation in the dorsal valve is semicircular formed by resorption of the umbonal part; narrow deltidial plates; inner socket ridges prominent; a median septum is observed in specimens from the stratigraphically lowest samples (H 868 a, b, c). A spicular skeleton has not been observed. *Aemula* sp. differs from *Aemula inusitata* Steinich in the completely smooth ventral valve, in its regular outline, indentations of the shell margin being rare and not prominent. The species is common and occurs in a large number samples. It only co-occurs with *Aemula inusitata* in a very few samples and is clearly a different, new species. It is generally larger than *A. inusitata* so the lack of tubercles on the outer side of the ventral valve does not reflect that the specimens are juveniles.

Material. A total of 218 individuals. Samples H 868 a, b, c, H 871, H 876, H 883, H 893, H 896, H 893, H 896, H 897, H 899, H 900, H 900 b, H 904, H 909, H 911 unt., H 912, H 913, H 915, H 918, H 919, H 920, H 921, H 922, H 923, H 924, H 925, H 926, H 927, H 928, H 930, H 936.

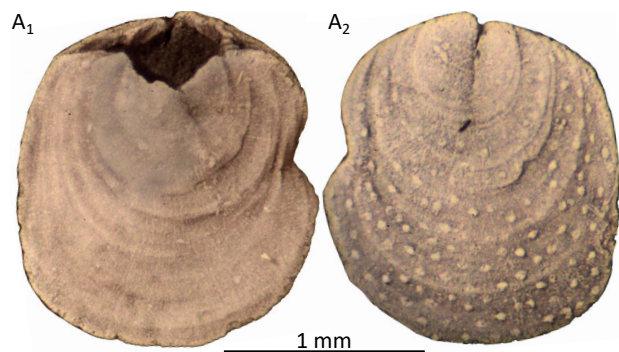


Fig. 26. *Aemula inusitata* Steinich, 1968. A₁. Dorsal view. A₂. Ventral view. MGUH 35024

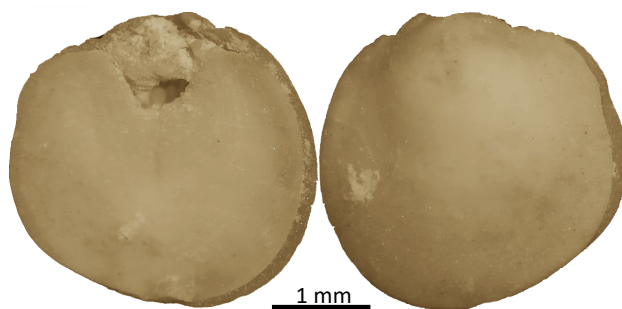


Fig. 27. *Aemula* sp. A₁. Dorsal view. A₂. Ventral view. MGUH 35025.

Chronostratigraphy at Hemmoor. Lowest specimen found in sample H 868 a, b, c from the boundary between the Krons Moor and the Hemmoor Formations (see Engelke 2006). The highest specimen is from sample H 936, 20 m below the top of the succession (Fig. 4). It thus occurs in all the macrofossil zones at Hemmoor except the two highest, the *Oxytoma danica*/*Tenuipteria argentea* and *Tylocidaris baltica*/*Oxytoma danica* bivalve/echinoid Zones which are very poor in brachiopods in terms of both species and specimens. It is thus known from the upper lower Maastrichtian *Belemnella sumensis*/*Acanthoscaphites tridens* to the lower upper Maastrichtian *Tenuipteria argentea*/*Belemnitella junior* belemnite/ammonite/bivalve Zones, and from the *pulchellus*–*tenuicostata* to the *semiglobularis*–*humboldtii* brachiopod Zones (Figs 4, 5). It has not been recognized outside the Hemmoor section and is virtually unknown from the thickly developed complete Maastrichtian succession in Denmark from where 35,000 specimens have been recorded (Surlyk 2025b). However, it has recently been found in a sample (Holtug-1) from the topmost Maastrichtian at Stevns Klint (Surlyk *et al.* 2026).

Pertinent reference. Surlyk (1974), Johansen & Surlyk (1990, p. 865, pl. 2b), where it is described as *Aemula* sp. which “may be conspecific with the *Aemula* n. sp. illustrated from the Maastrichtian chalk of Hemmoor, northwest Germany (Surlyk 1974)”.

Genus *Scumulus* Steinich, 1968

Type species *Scumulus inopinatus* Steinich, 1968

Scumulus inopinatus Steinich, 1968

Fig. 28

Micromorphic; outline elongate ovate, commonly irregular; transition from hinge line to lateral margins even and rounded; ventribiconvex; commissure rectimarginate to slightly sulcate; shell smooth; beak

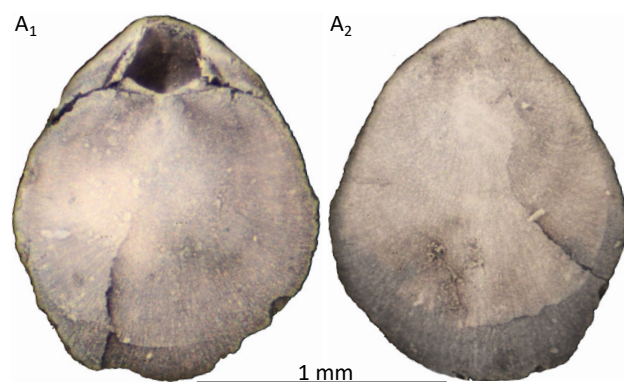


Fig. 28. *Scumulus inopinatus* Steinich, 1968. A₁. Dorsal view. A₂. Ventral view. H 93. MGUH 35344.

short, straight and stump; area broad and triangular; deltidial plates very narrow; foramen large, amphithyrid, extending into dorsal valve; pedicle collar strongly developed; teeth small, pointed; crura parallel in early stages; crural arms converge and fuse with well-developed dorsal septum; spicular skeleton very strong; zygolophe.

Material. A total of 53 individuals. H 868 a, b, H 871, H 893, H 895, H 896, H 899, H 900 b, H 915, H 920, H 922, H 923, H 927, H 928, H 940 unt.

Chronostratigraphy at Hemmoor. Upper lower – lower upper Maastrichtian, *Belemnella sumensis* to *Belemnitella junior* belemnite Zones, *pulchellus*–*tenuicostata* to *semiglobularis*–*humboldtii* brachiopod Zones.

Pertinent references. Steinich (1968a), Johansen & Surlyk (1990), Surlyk (2025b).

Suborder Terebratulidina Muir-Wood, 1955

Superfamily Uncertain

Family Uncertain

Genus *Magas* J. Sowerby, 1816 in 1815-1818

Type species *Magas chitoniformis* (von Schlotheim, 1813)

Magas chitoniformis (von Schlotheim, 1813)

Fig. 29

Small to medium-sized; juveniles elongate oval; adults subcircular; shell punctate and becomes very thick during growth; juveniles biconvex, changing to nearly planoconvex during growth; broad flat sinus; anterior commissure slightly unisulcate; six to nine well-defined growth lines; surface smooth; beak almost erect in juveniles, becomes strongly incurved during growth; foramen triangular, submesothyrid limited by narrow deltidial plates; foramen hidden

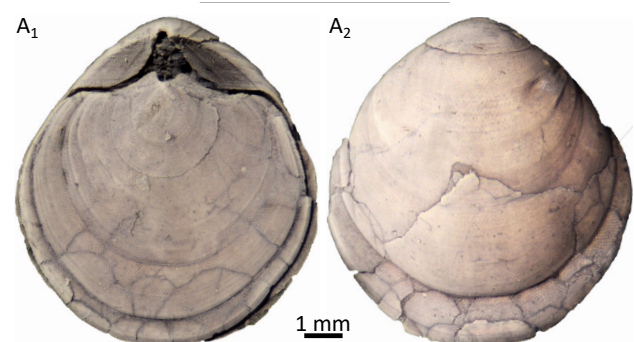


Fig. 29. *Magas chitoniformis* (von Schlotheim, 1813). A₁. Dorsal view. A₂. Ventral view. H 115. MGUH 35345.

by incurved beak in adults; hinge line straight; hinge rather strong; hinge teeth prominent and half-circular-shaped; strong, high median septum; crura short, diverge strongly, two ascending branches formed as elongate, triangular plates at posterior margin of septum; two thin descending branches fuse with ascending branches; ventral valve with low median keel extending from posterior margin to anterior of the midline; coherent spicular skeleton not observed; star-shaped spicules occur laterally to median septum and on brachidium.

Material. A total of 1039 individuals. H 868 a, b, c, d, H 871, H 876, H 883, H 895, H 896, H 898, H 909, H 900 b, H 911 ob., H 912, H 913, H 914, H 915, H 916, H 918, H 920, H 921, H 922, H 923, H 926, H 930, H 931, H 932, H 936, H 937, H 938, H 940 unt., H 943.

Chronostratigraphy at Hemmoor. Upper lower – lower upper Maastrichtian, *Belemnella sumensis* to *Belemnitella junior* belemnite Zones, *pulchellus-tenuicostata* to *semiglobularis-humboldtii* brachiopod Zones.

Pertinent references. Steinich (1965), Surlyk (1972, 1984, 2025a, b), Bitner & Pisera (1979), Johansen & Surlyk (1990), Hansen & Surlyk (2014), Machalski & Bitner (2024).

Discussion

The Maastrichtian brachiopod fauna at Hemmoor is dominated by small-sized, micromorphic species in terms of species numbers. Thus, no less than 17 species out of the total species number of 29 belong to this category. In addition, two very abundant species, *Carneithyrus subcardinalis* and *Cretirhynchia* sp. are almost only represented by small-sized juveniles. Most of the specimens referred to the latter probably belong to the large-sized *Cretirhynchia retracta* (Roemer, 1841), which is by far the most common rhynchonellid brachiopod found in the chalk of northern Europe (Surlyk 2025b). *Homaletarhynchia limbata* (von Schlotheim, 1813) is most likely also represented by juveniles described under *Cretirhynchia* sp. as a medium-sized specimen which clearly belongs to this species has also been found (Fig. 7).

Stratigraphic changes in the brachiopod fauna show some characteristic distributions. A few species occur in almost all samples. They comprise *Cretirhynchia* sp., *Carneithyrus subcardinalis*, *Terebratulina chrysalis*, *Terebratulina longicollis*, *Gyrosoria gracilis* and *Bronnothyris bronnii* and constitute important elements in most Maastrichtian chalks of northern Europe. Large-sized species are uncommon and almost only found by hand-picking in the field. It is remarkable that the pedicle openings of the two large-

sized species *Cretirhynchia retracta* and *Carneithyrus subcardinalis* were closed during ontogeny and they both obtained a free-living mode-of-life as adults and thus did not need rare large hard substrates for attachment (Surlyk 1972). This may explain the great numbers of juvenile specimens of these species.

The micromorphic species of the ‘standard brachiopod fauna’ (assemblage 1) tend to occur in great numbers at the same levels, in the middle of the upper lower Maastrichtian part and likewise in the middle of the lower upper Maastrichtian part. The part from around H 900 and into the lower part of the lower upper Maastrichtian is in contrast poor in individuals. The same is seen in the Danish chalk where the mid-Maastrichtian represents a low in both abundances and species richness (assemblage 2). This may reflect changes in sea level with a high in the mid-Maastrichtian. Another characteristic feature is the mass-occurrences at certain levels of the two medium-sized, hemispherical species *Magas chitoniformis*, *Gyrosoria gracilis* and to some extent also *Meonia semiglobularis* which all occur out of phase with the frequency distributions of the other species. This is also recorded in the Danish chalk where these three species tend to occur together commonly in great numbers (assemblage 3). These levels are characterized by the abundance of large, well-preserved siliceous sponges. Mainly monospecific clusters of *M. chitoniformis* and to some extent also *G. gracilis* in the Danish Maastrichtian are interpreted as representing single spatfalls attached to a large soft-bodied organism most probably a sponge which was suddenly buried possibly by a chalk ooze debris flow (Surlyk 2025a).

The relatively small numbers of species compared to the Danish Maastrichtian reflects the absence of the two stratigraphic levels in Denmark richest in brachiopods, the lower part of the *pulchellus-pulchellus* Zone in the mid lower Maastrichtian and the *stevensis-chitoniformis* Zone in the uppermost Maastrichtian. In Denmark both levels have very high abundances of benthic fossils, flint nodules and a few hardgrounds, indicating relatively low sea level but still sub-photoc water depths.

Conclusions

A fauna of 29 mainly micromorphic brachiopod species represented by about 10,000 individuals is obtained from 47 bulk samples (about 10–20 kg) of chalk from the now water-filled Hemmoor quarry. The bulk samples were disintegrated by the Glauber’s Salt method, involving repeated heating-freezing for about 15 times. The succession belongs to the Maastrichtian Hemmoor Formation. The lowest and highest occurrences of stratigraphically significant

species allow subdivision of the succession into the *pulchellus-tenuicostata*, *tenuicostata-semiglobularis* and *semiglobularis-humboldtii* brachiopod Zones. The two first zones are upper lower Maastrichtian, whereas the third is lower upper Maastrichtian. The so-called 'Tonband' marl bed (H 900) is conventionally taken to mark the lower–upper Maastrichtian boundary. It is interpreted as representing the feather edge of the cyclic chalk-marl Rørdal Member in Denmark and is correlated with the lowest marl bed of this member and with a similar marl bed in Rügen. Former interpretations of the 'Tonband' as a bentonite or as a residue after dissolution of chalk are discarded. The brachiopod zonation allows a precise correlation to the Maastrichtian chalk of Denmark and Rügen. Three different ecological assemblages are recognized in the brachiopod fauna and are interpreted as representing different water depths and availability of substrates for attachment.

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