

The last ammonite?

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A fragment of red-brown flint with imprints of two ammonite aptychi has been found loose on the beach of the Boesdal quarry on Stevns Klint. The quarry exposes only Lower Danian bryozoan limestone. The nearest occurrence of Maastrichtian strata is 400 m to the west in Skeldervig bay, north of Korsnæb, where 50 cm of chalk with small dark-grey and black flint nodules are exposed below the basal Danian Fish Clay over a stretch of 15 m. Maastrichtian chalk is normally dark-grey to black and has a thin white rind. Danian flint is much more variable in colour and degree of silicification, and red-brown varieties are common. The two aptychi clearly belong to the same ammonite individual and cannot have been redeposited from the crests of the top-Maastrichtian mounded bryozoan chalk. Finds of the ammonite *Hoploscaphites constrictus* and *Baculites* sp. have been reported in the literature from the lowermost Danian Cerithium Limestone. They are normally considered reworked, but their age should possibly be re-evaluated in the light of the new find. It is thus very likely that two ammonite genera survived the mass extinction at the K-T boundary and lived on as rare elements in the earliest Tertiary fauna.

Key words: K-T boundary, extinction, aptychus, ammonite, Danian, Stevns Klint, Denmark.

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The Ammonoidea is one of the most important higher taxonomic groups that underwent complete extinction at the Cretaceous-Tertiary boundary (the K-T boundary). There are, however, a few records of ammonites from the lowermost Danian at the famous K-T boundary locality Stevns Klint in eastern Denmark (Fig. 1). The boundary strata comprise uppermost Maastrichtian mounded bryozoan wackestone, overlain by the dark-grey to black basal Danian Fish Clay, about 5–10 cm thick, which passes gradually up into the nodular Cerithium Limestone, up to 0.5 cm thick. This is truncated by a prominent erosion surface which is overlain by Lower Danian bryozoan floatstone and rudstone deposited in large asymmetric mounds (Fig. 2). Layers of flint nodules are prominent in both the Maastrichtian bryozoan wackestone, the Cerithium Limestone, and the Danian bryozoan floatstone and rudstone. Maastrichtian flint is normally uniform dark-grey to black with a thin white rind. Lighter grey varieties occur but are uncommon, and brownish or reddish colours are very rare. Danian flint, in contrast, is much more variable both in colour and degree of sil-

icification. The colour varies from light grey, over dark grey and black, to red-brown and orange. The silicification is commonly incomplete, reflected by lighter coloured spots.

The present find was made during an excursion for first year geology students on the beach at Skeldervig immediately south of the sea-side entrance to the Boesdal quarry in the southern part of Stevns Klint (Fig. 1). It consists of a fragment of red-brown flint with imprints of two ammonite aptychi (calcitic parts of the ammonite jaw apparatus) (Fig. 3). One of the aptychus imprints is remarkably well preserved, whereas the other is partly embedded in the flint. The two aptychi are of the same original size, are mirror images of each other, and clearly represent one individual. This shows that they have not been reworked subsequent to their original burial.

The best preserved aptychus is 15.2 mm long and 8.7 mm wide. One side is almost straight and the other is curved. The surface shows a sculpture of delicate concentric ribs. The aptychus has a characteristic fold forming an acute angle to the straight side. It is simi-



Fig. 1. Map showing the location of the find of a flint nodule with two aptychi of *Hoploscaphites constrictus* (J. Sowerby 1817) at Stevns Klint, Denmark. The nearest exposure of Maastrichtian strata is situated at the open circle in the bay Skeldervig. Copyright, Kort & Matrikelstyrelsen G 15-99. Black dot shows the Boesdal Quarry. The find was done on the beach immediately to the west (left) of the coastal entrance to the quarry.

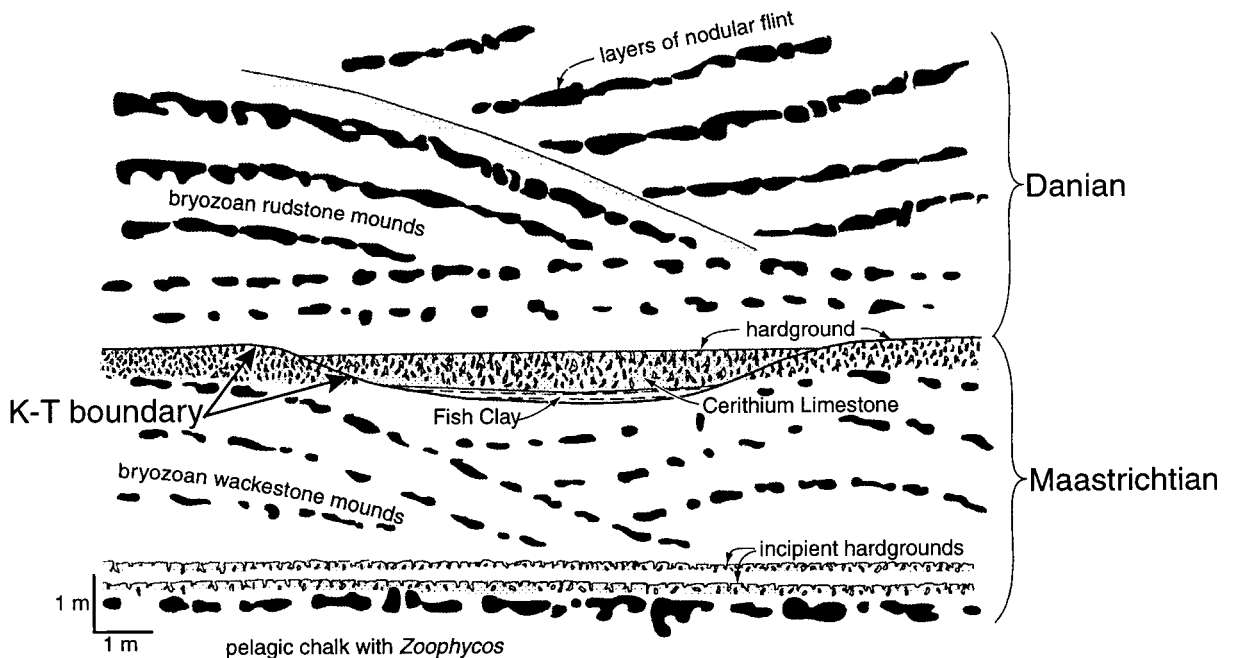


Fig. 2. Schematic stratigraphic section of the Maastrichtian-Danian boundary (= K-T boundary) at Stevns Klint. At the base pelagic coccolith chalk with *Zoophycos* and a sparse benthic fauna, topped by two incipient hardgrounds representing a major sea-level fall. The upper hardground is overlain by low mounds composed of bryozoa-rich chalk wackestone. Then follows the basal Danian Fish Clay which passes gradually upward into the lowermost Danian Cerithium Limestone. The top of the Cerithium Limestone and the intervening crests of the Maastrichtian mounds are truncated by an erosion surface which forms a complex hardground. The hardground is overlain by impressive Lower Danian mounds of bryozoa and echinoderm floatstone and rudstone.

lar to aptychi referred to *Hoploscaphites constrictus* (J. Sowerby 1817) by Birkelund (1993, Pl. 17, Figs 2–4).

The flint with aptychi was found loose on the beach, but the K-T boundary is situated close to sea level at the locality, and the adjacent Boesdal quarry exposes only Lower Danian bryozoan floatstone and rudstone. The beach rubble included only Danian flint and limestone. The nearest occurrence of Maastrichtian strata is about 400 m further west in the bay Skeldervig north of Korsnæb where up to about 50 cm of Maastrichtian chalk, with small scattered nodules of black grey to black flint, is exposed over a stretch of about 15 m (see Fig. 9 in Surlyk 1997). It is thus extremely unlikely that the flint fragment originates from nearby Maastrichtian strata. A piece of the flint fragment was investigated for dinoflagellate cysts but the dissolution residue did not contain any organic material (S. Piasecki, pers. comm. 1999).

Previous finds of ammonites in the lowermost Danian Cerithium Limestone include *Baculites vertebralis* (Lamarck 1801) and *Hoploscaphites constrictus* (J. Sowerby 1817) (Rosenkratz 1924, 1939, 1966; Birkelund 1979, 1993). Some of these are reworked internal moulds which may be slightly phosphatized, but some fragments of *Baculites* are well preserved. A well preserved specimen of *Hoploscaphites constrictus* was found in the Cerithium Limestone south of Højerup by Arne Thorshøj Nielsen (pers. comm. 1999) and moulds of small *Baculites* are not uncommon (C. Heinberg, pers. comm. 1999). The sedimentary infilling of the ammonites is apparently Maastrichtian chalk based on analysis of the content of coccoliths (E. Thomsen in Birkelund 1993, p. 42, see also Kennedy 1993). However, the basal Danian coccolith assemblage consists almost exclusively of reworked Maastrichtian coccoliths (e.g. Perch-Nielsen et al. 1982). According to E. Thomsen (pers. comm. 1999) the infill shows great similarity to the Maastrichtian chalk immediately below the Fish Clay with regard to lithology and coccolith content, but it also resembles the lower part of the Cerithium Limestone. It is thus not possible to definitively conclude if the ammonites were reworked from the crests of the Maastrichtian chalk mounds or if they actually represent rare survivors into the earliest Danian.

The reworking hypothesis also presents some problems. The Maastrichtian chalk beneath the Fish Clay is un lithified even today. Only the crests of the Maastrichtian mounds (Fig. 2) became lithified in connection with erosion and hardground formation after deposition of the Cerithium Limestone. Ammonites could thus only be reworked before dissolution of the aragonite shell, and reworking of Maastrichtian ammonite casts or moulds could not have taken place during deposition of the Cerithium Limestone.

The stratigraphic origin of the present find is equally inconclusive. The finding site and, more importantly, the red-brown colour of the flint strongly suggest an

Early Danian age of the find. The aptychi were clearly silicified *in situ* as shown by the co-occurrence of two aptychi from one individual in one piece of flint. This excludes reworking of the aptychi from the topmost Maastrichtian and subsequent redeposition into the lower Cerithium Limestone. Flint formation is a rather late diagenetic phenomenon and reworked flint nodules are not known from the Maastrichtian-Danian of Denmark.

The sum of evidence thus strongly suggests an earliest Danian age of the two aptychi. The specimens of *Hoploscaphites constrictus* and *Baculites vertebralis* found in the Cerithium Limestone have hitherto been considered reworked. This interpretation should perhaps be reconsidered in the light of the new find. Well preserved specimens of baculitid ammonites have been recorded from the upper part of unit IV f-7 of the Meersen Member (Maastrichtian type area) which is probably a correlative to the Cerithium Limestone (Jagt 1999). There is thus increasing evidence for short-term survival of two ammonite genera into the earliest Danian.

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Dansk sammendrag

Et stykke rødbrunt flint med aftryk af to aptychi (dele af ammonitters kæbeapparat) er fundet løst på stranden ved Boesdal kalkbrud i den nordligste del af Skeldervig på Stevns Klint. I kalkbruddet er der kun blotet bryozokalk fra Nedre Danien. Den nærmeste forekomst af lag af Maastrichtien alder er 400 m længere mod vest i Skeldervig nord for Korsnæb, hvor der ved foden af klinten er blottet ca. 50 cm skrivekridt med små mørkegrå til sorte flintknolde over en strækning af ca. 15 m. Fundomstændighederne tyder således på en Tidlig Danien alder af flintstykket, selvom det ikke kan udelukkes, at det er udsmidsmateriale fra brydning andetsteds. Flint fra Maastrichtien er oftest mørkegrå til sort med tynd hvid skorpe. Flint fra Danien er langt mere varieret både med hensyn til forkislingsgrad og farve. Rødbrune til orange farver er således almindeligt forekommende. Det er det mest afgørende tegn på, at flintstykket med de to aptychi kunne være af Tidlig Danien alder. De to fossiler tilhører klart samme individ, og de kan altså ikke være omlejlrede fra toppen af de lave Maastrichtien bryozobanker og ef-



Fig. 3. A: Imprints of two ammonite aptychi probably of *Hoploscaphites constrictus* (J. Sowerby 1817), MGUH 25314, embedded in red-brown flint. Found loose on the beach at the sea-side entry to the Boesdal quarry, northern part of Skeldervig bay, Stevns Klint. B: (p. 119) Reverse side of the red-brown flint nodule showing poorly silicified white parts. Scale in millimetres.

terfølgende aflejret i Cerithiumkalken fra nederste Danien. Fra litteraturen kendes adskillige fund af ammonitterne *Hoploscaphites constrictus* og *Baculites* sp. fra Cerithiumkalken. De er normalt betragtet som omljrede fra toppen af Maastrichtien bankerne, men deres stratigrafiske alder skal måske revurderes i lyset af det nye fund. Det er således i høj grad muligt at to ammonit-slægter overlevede masseuddøenen ved Kridt-Tertiær grænsen, og at de levede videre som et sjældent element i den tidligste tertiære fauna.

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