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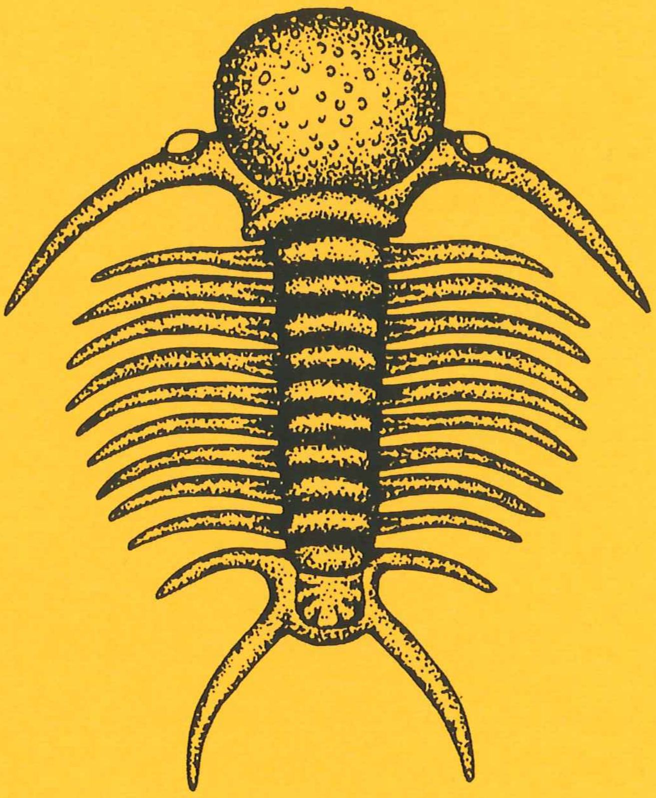

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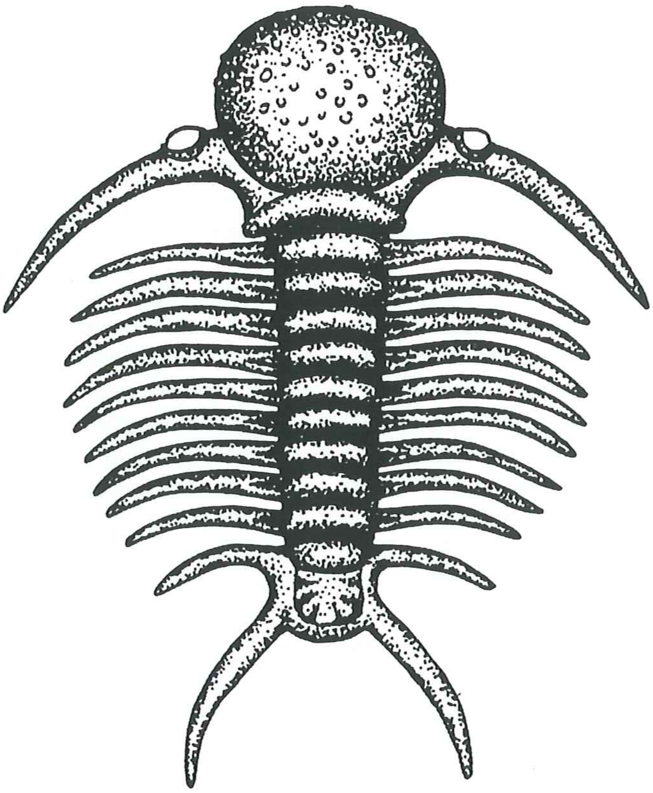

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Abstract: Köpings klint is located on Öland, SE Sweden and expose a sequence of Lower Ordovician rocks from the boundary between the Tremadoc and the Arenig. The strata are correlated with the *Paltodus deltifer*, the *Paroistodus proteus* and the *Oepikodus evae* conodont Zones. The sediment was mostly deposited in a shallow, subtidal marine environment, but the *Oepikodus evae* Zone is correlated with a major transgression. The species *Oepikodus evae* can be used as a facies indicator, suggesting outer shelf and generally deeper water environments than the subtidal zone, which is more normal for the platform deposits in the Lower Ordovician of Öland. Provincialism of conodonts, where two major faunal regions dominate, are known from the early Ordovician. The two major faunal regions are the North Atlantic faunal region and the Midcontinental faunal region. The conodonts from Köpings klint belong to the North Atlantic faunal region with few exceptions, as for example the taxon *Tropodus* sp. The feeding apparatuses of the species *Acodus deltatus* and *Oistodus lanceolatus* are here described as hyalion apparatuses. A hyalion apparatus consists of a pair of M-elements, a transition series of S-elements and two pairs of P-elements. The elements are placed in a symmetrical pattern, with the symmetrical Sa-element in a mirror plane in the centre.
Keywords: Conodonts, Lower Ordovician, Tremadoc, Arenig, biostratigraphy, Öland, Sweden, feeding apparatus, *Acodus deltatus*, *Oistodus lanceolatus*, provincialism, facies indicators.

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Phosphatic tooth-elements from a primitive vertebrate, the conodont animal (Sansom et al. 1992) can be found in strata of Palaeozoic, Jurassic and Triassic age. This investigation considers Lower Ordovician conodonts from Köpings klint, Öland, eastern Sweden (Fig.1). Biostratigraphy in strata of Ordovician age is based mainly on graptolites, trilobites and conodonts (Fig. 2). Conodonts are very numerous in some Ordovician rocks and their role in Ordovician biostratigraphy is essential. The standard conodont zones in Baltoscandia can be recognised almost world wide (Löfgren 1993). The conodont faunas found in this investigation are compared with coeval conodont faunas from Köpings klint (Bagnoli et al 1988), Närke (Löfgren 1993), Dalarna (Löfgren 1994) and Västergötland (Löfgren 1996).

Natural assemblages of conodont elements, where the feeding apparatus has been preserved in "life position" have helped to recreate the apparatus, which consists of a number of different elements (Sweet 1988; Nicoll 1995). The species *Acodus deltatus* and *Oistodus lanceolatus* is studied in detail in order to reconstruct their feeding apparatuses.

There are two major faunal provinces or realms of conodont faunas during the Lower Ordovician, the North Atlantic and the Midcontinental (Dzik 1983; Charpentier 1984; Lindström 1984; Bergström 1990). Scandinavia belongs to the North Atlantic realm, but a few Midcontinental species appears as "visitors" in low numbers.

Some conodont taxa are tied to specific depositional environments and can thereby be used as biofacies indicators (Lindström 1984; Pohler 1994; Rasmussen & Stouge 1995).

Methods

The seven samples were crushed into pieces of about the size of a golfball and weighed. They were than put into a buffered solution of acetic acid and acetate with a pH of about 4 (Jeppson et al. 1985) resulting in that the calcium carbonate reacted with the solution and non-calcium carbonate material was left dissolved. The residue is a mixture of mostly non-carbonate minerals, phosphatic shell fragments and other phosphatic fossils including conodont elements. After being washed through a 63 μm screen and dried, most of the mineral grains were separated by magnetic separation and the conodont elements could be manually separated from the non magnetic fraction under a microscope. Only the fractions between 63 μm and 0.5 mm were searched for conodonts. The technique is a standard technique and has been described by Jeppson et al. (1985).

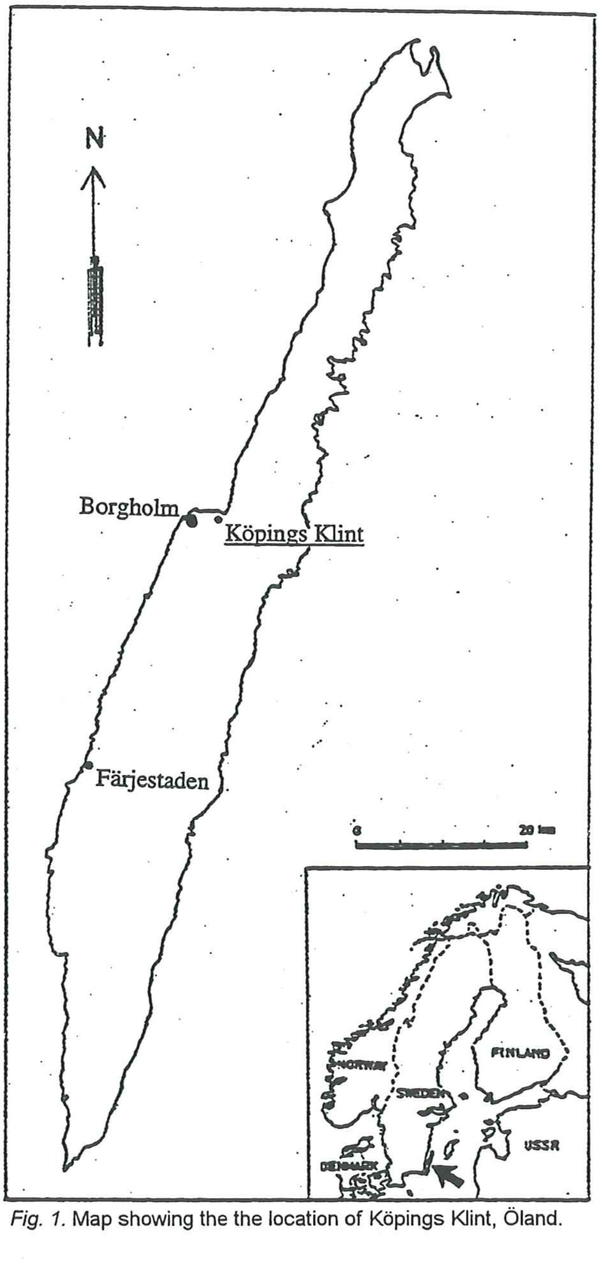

Fig. 1. Map showing the the location of Köpings Klint, Öland.

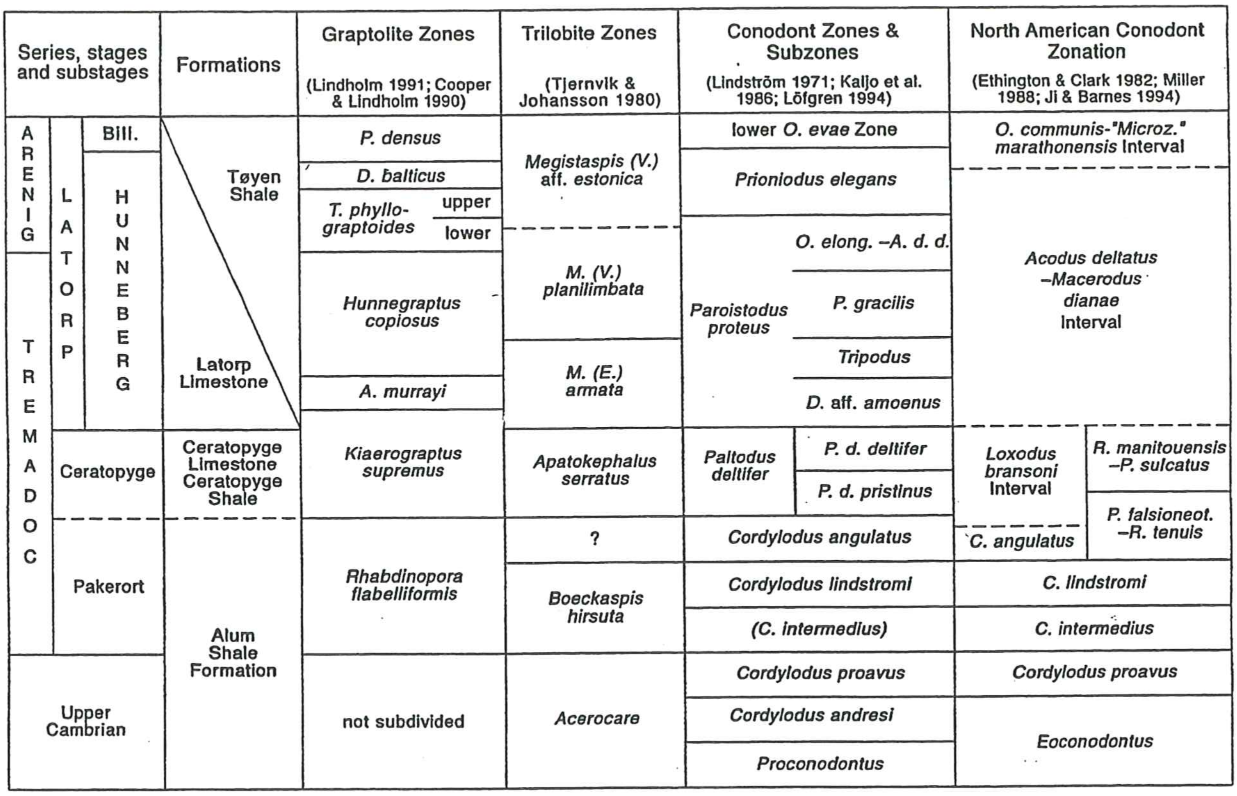

Fig. 2. Biozonation in the Lower Ordovician, from Löfgren (1997a).

All samples except Öl 97 - 1 yielded so many conodont elements that only a minor part of each sample was examined for conodonts. Consequently no frequency of conodont elements / kg unsolved rock could be calculated. All conodont elements were sorted taxonomically and counted.

The CAI index was judged by comparing the colours of the conodont elements with the colour chart in Epstein et al. (1977).

Material and biostratigraphy

The samples were collected by Drs. Stig M. Bergström and Jan Bergström in 1960, from a locality near the church of Köping (Köpings klint) in central Öland (Fig. 1). The locality at Köpings klint expose a sequence of Lower Ordovician rock from the boundary between the Tremadoc and the Arenig. The seven samples derive from the conodont zones: *Paltodus deltifer* Zone, *Paroistodus proteus* Zone and *Oepikodus evae* Zone (Fig. 2). The total number of elements counted are 13 607 specimens representing 29 identified species. The biostratigraphic subdivision of each sample and the number of conodonts is shown in the range chart in Fig. 3.

A description of the Lower Ordovician rocks at Köpings klint has been made by Regnéll (1942), Tjernvik (1956) and van Wamel (1974). The stratigraphy used in this work is mainly from van Wamel (1974) who introduced four new formations. These are in ascending order: the Djupvik Formation, the Köpings klint Formation, the Bruddesta Formation and the Horns Udde Formation (Fig. 4). The Bruddesta and the Horns Udde Formations are not represented in this investigation. The new formations, introduced by van Wamel (1974), replace the traditional names used by Regnéll (1942) and Tjernvik (1956). The lithology of these four formations can be further studied in van Wamel (1974) and Bagnoli et al. (1988).

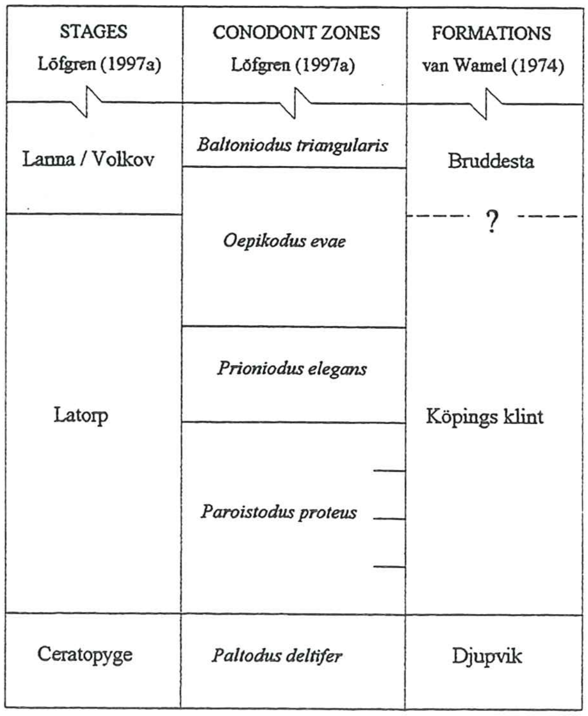

Fig. 3. Correlation between formations (van Wamel 1974), stages (Löfgren 1997a) and conodont zones (Löfgren 1997a) in the Lower Ordovician.

Species \ Sample	*Öl 97-1*	*Öl 97-2*	*Öl 97-4*	*Öl 97-4(b)*	*Öl 97-5*	*Öl 97-6*	*Öl 97-3*
Cordylodus sp.	4	2	2				
Paroistodus numarcuatus	2	408					
Paltodus deltifer	30	224					
Scolopodus peselephantis	10	48	179	65	34	58	14
Drepanoistodus sp.		92			1		
Drepanodus arcuatus		355	1371	1575	580	722	186
Oneotodus variabilis		9					
Paroistodus proteus			1048	665	378	346	
Acodus deltatus	—*P. deltifer* Zone—		461	316	289	61	10
Drepanoistodus forceps			168	147	78	348	260
Oelandodus elongatus			10	26	14		4
Cornuodus longibasis			4	17		4	3
Protoprioniodus papillosus			4		9		4
Scandodus furnishi			34	36	13		
Paroistodus sp.			1	30			
Paltodus subaequalis			152	177	84	139	
Periodon sp.			1	6			
Tropodus sp.				9	4		–*O. evae* Zone–
Acanthodus uncinatus					1		
Paracordylodus gracilis				1		727	
Tetraprioniodus robustus						46	
Oepikodus evae	2		—*P. proteus* Zone—				1082
Protopanderodus rectus		4			1		175
Paroistodus parallelus							102
Scolopodus rex							44
Oistodus lanceolatus			2	9		3	57
Prioniodus elegans							4
Lundodus gladiatus							3
Periodon flabellum							4
Total number of elements.	48	1142	3437	3079	1486	2454	1952

Fig. 4. Range chart showing the biostratigraphic subdivision and distribution of conodont elements in the samples Öl 97 - 1 to Öl 97 - 6 from Köpings Klint.

The seven samples are herein described in stratigraphic order and the colours are named from "Munsell's" rock colour chart.

The stinkstone horizon mentioned below is probably situated at the boundary between the Cambrian and the Ordovician (van Wamel 1974).

The *Paltodus deltifer* Zone

The boundary between the *Paltodus deltifer* Zone and the *Paroistodus proteus* Zone is identified as the level where *Paroistodus proteus* first appears (Löfgren 1994). This occurs at about the same level as the first appearance of *Paltodus* cf. *subaequalis* (Löfgren 1993). The index fossil *Paltodus deltifer* can be seen in Fig. 5A-E.

Öl 97 - 1 (50 cm above the stinkstone horizon)
Mainly two types of rock occur in this sample.
a, Glauconitic dark yellowish green (10 GY 4/4) sandstone with dark yellowish orange (10 YR 6/6) spots.
b, A 5 mm thick greenish grey (5 GY 4/1) fossiliferous limestone underlayers the sandstone described above. The fossils are mainly phosphatic brachiopods and shell fragments from other organisms in the same size as the brachiopod shells. The fossils are with few exceptions oriented with the convex side up.

The lowermost sample is from the *Paltodus deltifer* Zone of upper Tremadoc age (Löfgren 1997a). The total amount of elements in the sample is 48 from 5 different taxa. The occurrence of two elements of *Oepikodus evae* makes the assumption of the stratigraphic level a bit doubtful since *O. evae* is the index fossil in another zone higher up in the Arenig. The most abundant taxa are *Paltodus deltifer* (63 %), *Scolopodus peselephantis* (21 %) and *Cordylodus* sp. (10 %).
Remarks.- The occurrence of *O. evae* is considered being a result of contamination in the lab.

Öl 97 - 2 (170-180 cm above the stinkstone horizon)
A homogeneous crystalline limestone with some cracks with calcite filling. Some fossils of small (0.3 -0.5 cm in diameter) phosphatic brachiopods occur. The colour is

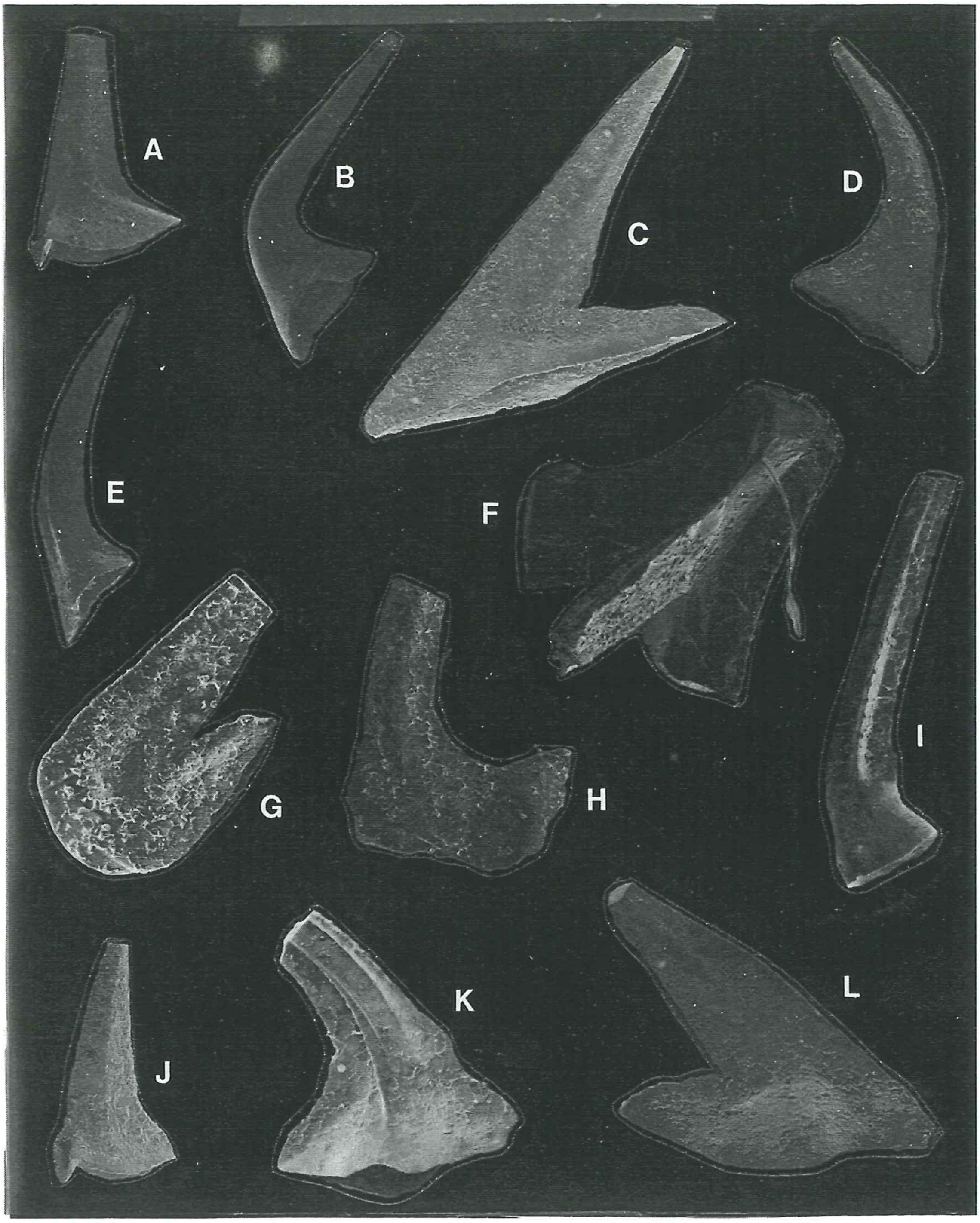

Fig. 5. Conodont elements from the *Paltodus deltifer* Zone and the *Paroistodus proteus* Zone. **A-E.** *Paltodus deltifer* (Lindström) from Öl 97 - 2 (*Paltodus deltifer* Zone), A. Sa-element x 100, B. Sc-element x 70, C. M-element x 100, D. Sb-element x 100, E. Sd-element x 100. **F.** *Tetraprioniodus robustus* Lindström x 150 from Öl 97 - 6 (*Paroistodus proteus* Zone). **G-H.** *Paroistodus proteus* (Lindström) from Öl 97 - 4 (*Paroistodus proteus* Zone), G. M-element x 130, H. Sc-element x 130. **I.** *Scolopodus ? peselephantis* (Lindström) x 200 from Öl 97 - 4 (*Paroistodus proteus* Zone). **J-L.** *Paltodus subaeqalis* Pander, from Öl 97 - 4 (*Paroistodus proteus* Zone), J. Sa-element x 100, K. Sb(?)-element x 100, L. M-element x 100.

pale brown (5 YR 5/2) with flames of light olive grey (5 Y 5/2). The upper surface appears eroded and is covered with a thin layer of light brown (5 YR 5/6) oxide.

The second sample from the *Paltodus deltifer* Zone is easier to place stratigraphically. The fairly large amount of conodont elements puts it without doubt in the *Paltodus deltifer* Zone. The total number of elements is 1142 from 8 species. *Paroistodus numarcuatus* (36 %), *Drepanodus arcuatus* (31 %) and *Paltodus deltifer* (20 %) are the three most frequent species.

Comparisons

The *Paltodus deltifer* Zone of Köpings klint is represented by one sample (703) in the investigation made by Bagnoli et al. (1988). The fauna in their work correspond rather well with the fauna found in this investigation. The taxon called *Paltodus peracutus*, representing more than 30 % in sample 703 in their work is probably found, but referred to as *Paltodus deltifer* in this investigation. This assumption is based on that the specimens shown as SEM pictures of the taxon in (Bagnoli et al. 1988, Plate 41, figs. 1-7) is identical to the ones referred to *Paltodus deltifer*, found herein.

The *Paltodus deltifer* Zone from the Siljan district of central Sweden (Löfgren 1994) is represented by one sample (DLS 86 - C 0.40 m). The sample has as Öl 97 - 1 (this paper), quite few conodont elements (totally 54 elements from 6 species). Taxa found in the "Siljan district" investigation (Löfgren 1994) correspond well with the two samples from the same zone described above, the most frequent species are therein *Drepanodus arcuatus* (44 %) and *Paroistodus numarcuatus* (40 %). The zonal fossil is only represented by 5 % compared to 63 % resp. 20 % in Öl 97 - 1 and Öl 97 - 2.

Löfgren (1996) also investigated the Lower Ordovician of Västergötland and the *Paltodus deltifer* Zone is there represented by eight samples (Vg 65 - 300, Vg 65 - 301, Vg 66 - 601, Vg 65 - 314, Vg 66 - 602, Vg 66 - 603, Vg 89 - B1 and Vg 89 - B2). The most numerous species in all these samples are as in Öl 97 - 2, *Paroistodus numarcuatus* ranging from about 20 % to about 40 % of the total amount of elements. The number of elements from the zonal fossil is a bit lower in all but one sample (Vg 66 - 03 with 25 %), with frequencies ranging from zero to about 16 %. The same is valid for *Drepanodus arcuatus* with a maximum frequency of about 15 % (Vg 89 - B2) compared to 31 % in Öl 97 - 2 and lacking in Öl 97 - 1. The most noteworthy with the Vg-samples is that almost all of them have at least one species (often two or even three) of the genus *Cordylodus* representing at least 10 % (more often about 15%) of the total number of elements. Compared to the samples in this investigation and in the "Siljan district" investigation it is an anomaly (explained by redeposition). In this investigation four specimens of *Cordylodus* sp. were found in Öl 97 - 1 (8 %) and two in Öl 97 - 2 representing less than one percent of the elements.

The *Paroistodus proteus* Zone

The *Paroistodus proteus* Zone includes the boundary between the Tremadoc and the Arenig (Löfgren 1997b). It has been subdivided into four subzones (Fig. 2) with different conodont associations (Löfgren 1993). The two uppermost subzones have earlier been found in Öland (Löfgren pers. comm). The lowermost subzone is recognised by the first appearance of the zonal fossil, in the lower middle subzone the zonal fossil is joined by *Drepanoistodus forceps* and *Paltodus subaequalis*. The upper middle *P. proteus* Zone begins with the first appearance of *Paracordylodus gracilis* and *Acodus deltatus*. The uppermost *Paroistodus proteus* Zone starts whith the first appearance of *Oelandodus elongatus* and *Periodon primus* (Löfgren 1993).The index fossil (*Paroistodus proteus*) can be seen in Fig. 5 G-H.

Öl 97 - 4 (195 cm above the stinkstone horizon)
Crystalline limestone interbedded with dark yellowish green (10 GY 4/4) glauconitic sandstone, with a thin dark yellowish green (10 GY 4/4) glaucoinitic horizon in the middle. There are also some glauconite grains scattered in the crystalline limestone. On the upper surface of the limestone irregularities are filled with the glauconitic sandstone. The irregularities could be digging trace fossils or loading patterns. The colour of the limestone is light brownish grey (5 YR 6/1), with flames of light olive grey (5 Y 6/1). Small brachiopods (about 5 mm in diameter) occur in the sample.

Acodus deltatus is numerous and together with the occurrence of *Oelandodus elongatus* this should place the sample in the uppermost *Paroistodus proteus* subzone. However, the very low frequency of *Oelandodus elongatus* (0.3 %) and the lack of *Periodon primus* leaves a possibility open to a position in the upper middle *P. proteus* subzone. The three most abundant species are *Drepanodus arcuatus* (40 %), *Paroistodus proteus* (30 %) and *Acodus deltatus* (13 %). The total number of elements is 3437 from 14 different species.

Öl 97 - 4 (b) (+195 cm above the stinkstone horizon)
The upper glauconitic sandstone described above from Öl 97 - 4 was separated and prepared separately.

No less than 3078 elements were counted in this sample representing 15 different species of which the most numerous are (as in Öl 97 - 4) *Drepanodus arcuatus* (51 %), *Paroistodus proteus* (21 %) and *Acodus deltatus* (10 %). *Tropodus* sp. is more numerous than in any other sample (0.3 %). Nine specimens of *Oelandodus elongatus* and four of *Periodon primus* were found, which at least indicates that this sample is from the uppermost *P. proteus* subzone.

Öl 97 - 6 (240 cm above the stinkstone horizon)
Greyish red (5 R 4/2) limestone with pale olive (10 Y 6/2) and light olive (10 Y 5/4) flames. Small brachiopods occur all through the sample.

The most numerous species in this sample is *Paracordylodus gracilis* (30 %). It is followed by *Drepanodus arcuatus* (29 %), *Drepanoistodus forceps* (14 %) and *Paroistodus proteus* (14 %). The great number of *Paracordylodus gracilis* and the increase of *Drepanoistodus forceps* makes this sample somewhat different from the three other samples from the *Paroistodus proteus* Zone. It should not be placed in another subzone since, both *Acodus deltatus* and *Oelandodus elongatus* are present. It is notable that these two species only occur in very small amounts, 2.4 % and 0.4 %. The number of elements in this sample is 2454 from totally 10 different species.

Remarks- The genus *Paracordylodus* could according to Lindström (1984) be pelagic and is according to the same author only occurring sporadically in shelf areas like the Baltic area, and seems to be rare or totally lacking in sediments from regressive events.

Öl 97 - 5 (260 cm above the stinkstone horizon)
The sample consists of two types of rock.
a, A "sugary" quite fine grained dark yellowish green (10 GY 4/4) glauconitic sandstone with some lumps of light brownish grey (5 YR 6/1) limestone, with light olive grey (5 Y 6/1) flames.
b, Crystalline limestone displaying some glauconite grains. The limestone has three colours in a flamelike pattern, pale reddish brown (10 R 5/4), pale olive (10 Y 6/2) and light olive brown (5 Y 6/6).

As in Öl 97 - 4 and in Öl 97 - 4(b) the three most numerous species are *Drepanodus arcuatus* (39 %), *Paroistodus proteus* (25 %) and *Acodus deltatus* (19 %). Only 0.9 % *Oelandodus elongatus* and the lack of *Paracordylodus gracilis* makes this sample very much like Öl 97 - 4 and Öl 97 - 4(b). The sample should therefore be placed in the uppermost *Paroistodus proteus* subzone. 1486 specimens representing 13 different species were found.

Comparisons
The *Paroistodus proteus* Zone from Köpings klint is represented by one sample (704) in Bagnoli et al. (1988), in which the conodont fauna is much similar the one found in Öl 97- 4, Öl 97 - 4(b) and Öl 97 - 5, only differing in a lower percentage of *Drepanodus arcuatus*. *D. arcuatus* never falls below 30 % in the Öl 97- samples, compared to 12 % in sample 704. Sample Öl 97 - 6 differs from sample 704 by the large number of *Paracordylodus gracilis*. The fauna described by Bagnoli et al. (1988) is probably from the same subzone as the samples in this investigation, this assumption is based on the occurrence of 20 elements of *Oelandodus elongatus* in sample 704.

Löfgren (1993) described one sample (Nä 87 - 2) from the uppermost *Paroistodus proteus* subzone at Gymninge in Närke, southern Sweden. The faunal characteristics is quite similar to all samples from the same subzone studied in this investigation, though some minor differences can be noted.. The frequency of *Paracordylodus gracilis* in Nä 87 - 2 is 8 %, compared to zero in Öl 97 - 4, Öl 97 - 4(b) and Öl 97 - 5, and dominating in Öl 97 - 6 where it constitutes 30 % of the total amount of elements. The occurrence of *Paroistodus parallelus*, though only about one percent, is another difference from the Öl 97 - samples. None of the Öl 97 - samples has a lower percentage of *Drepanodus arcuatus* than about 30 %, in contrast to Nä 87 - 2 with 22 %.

The *Oepikodus evae* Zone

The *Oepikodus evae* Zone is recognised in an interval from the first appearance of the index species (Fig. 6G-H.) to the first appearance of *Baltoniodus triangularis* (Löfgren 1994). The *Prioniodus elegans* Zone is located between the *Paroistodus proteus* Zone and the *Oepikodus evae* Zone (Löfgren 1997a and b). However, none of the samples in this investigation can be referred to the *P. elegans* Zone. Four elements of *Prioniodus elegans* in Öl 97 - 3, at least indicates that the Zone once has been present, but according to Löfgren (1994), the zonal fossil can be found also in the very lowermost *Oepikodus evae* Zone.

Öl 97 - 3 (260 cm above the stinkstone horizon)
Crystalline limestone with a very colourful hardground on top called "the Flowery Sheet" ("Blommiga bladet"). The colours are greyish red (4/2), dusky yellow (5 Y 6/4), dark yellowish green (10 GY 3/2) and occur in a flamelike pattern. Within the limestone thin horizons of fine grained glauconitic sandstone occur. Some shells from brachiopods are present as well as two pygidia from trilobites.

In this sample the genus *Paroistodus* is represented by *P. parallelus* which according to Löfgren (1994) occurs in the upper *P. proteus* zone and the lowermost half of the *O. evae* Zone, while the upper part of *O. evae* Zone has *P. originalis* instead. Four elements of *Oelandodus elongatus* occur in the sample and the species has been reported by Löfgren (1994) as having its last occurrence in the very lowermost *O. evae* Zone. Since there are so few elements of *Oelandodus elongatus* (0.2 %) present, the stratigraphic level of the sample cannot with certainty be referred to the very lowermost *O. evae* Zone, but most likely to the lower half. The most numerous species are *Oepikodus evae* (55 %), *Drepanoistodus forceps* (13 %) and *Drepanodus arcuatus* (10 %). Four elements of *Prioniodus elegans* occur, they are most likely reworked from a previously underlying *Prioniodus elegans* Zone that is totally eroded. It is, however, also possible that they are from the lowermost *O. evae* Zone (Löfgren 1994), and together with the four specimens of *Oelandodus elongatus* they will suggest a stratigraphic level of Öl 97 - 3 in the very lowermost *O. evae* Zone.
Remarks.-"Blommiga bladet" can be recognised over a great area at Öland and all the way to Russia and can according to Bagnoli & Stouge (1996) be referred to the Bruddesta Formation in Öland.

Comparisons
Three conodont faunas from the *Oepikodus evae* Zone of Köpings klint were described by Bagnoli et al. (1988) (samples 706, 707 and 708). Noteworthy is that none of these samples contain as many specimens of the zonal fossil as Öl 97 - 3, with 55 % compared to 6 %, 20 % and 3 % in sample 706, 707 respectively 708. Further can the species *Stolonodus stola*, found in all samples by Bagnoli et al. (1988) though not more than 10 % be noted, since no elements of that species was found in Öl 97 - 3.

In an investigation by Löfgren (1994) of the Siljan district in central Sweden, the *Oepikodus evae* Zone was shown to be represented by four samples (from below upwards) D 85 - 4, DLS 86 - F 2.60 m, DLS 86 - G 3.50 m and DLS 86 - H? 3.70 m. D 85 - 4 is the most similar sample to Öl 97 - 3, with comparable frequencies of most taxa, however, it differs in the frequency of

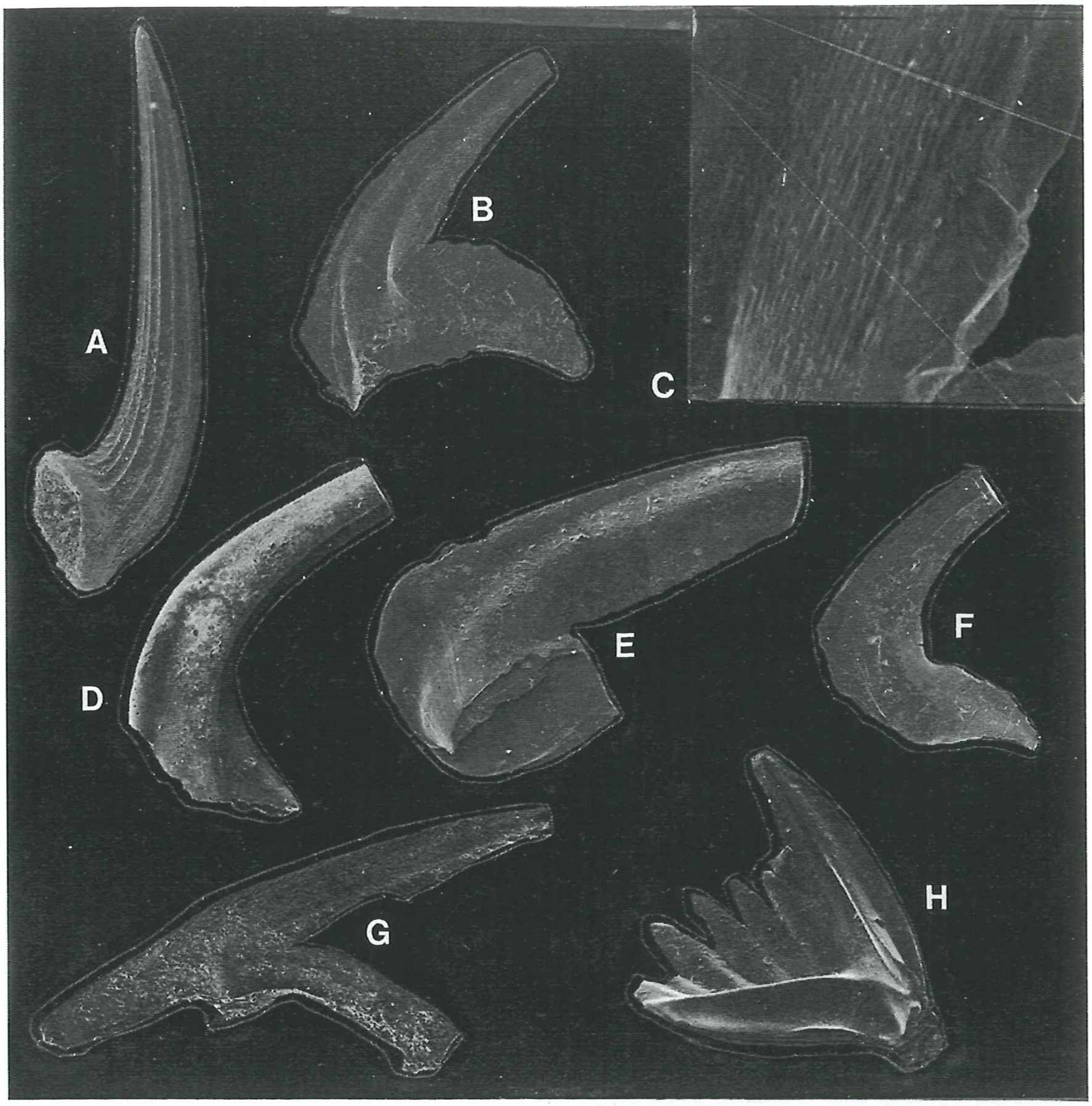

Fig. 6. Conodont elements from the *Oepikodus evae* Zone. **A.** *Scolopodus rex* Lindström x 70, from Öl 97 - 3 (*Oepikodus evae* Zone). **B-C.** *Protoprioniodus papiliosus* B. x 100 from Öl 97 - 3 (*Oepikodus evae* Zone), C. detail of B. showing microstructures x 700. **D.** *Protopanderodus rectus* (Lindström) from Öl 97 - 3 (*Oepikodus evae* Zone), Acontiodontiform element x 95. **E-F.** *Paroistodus parallelus* (Pander), from Öl 97 - 3 (*Oepikodus evae* Zone), E. M-element x 90, F. S-element x 70. **G-H.** *Oepikodus evae* (Lindström) from Öl 97 - 3 (*Oepikodus evae* Zone), G. M-element x 80, H. P-element x 100.

the zonal fossil with more than 25 %. *Oepikodus evae* is represented by 55 % in Öl 97 - 3 and by 25 % in D 85 - 4. The rate of *O. evae* in the following samples is decreasing from 14 % in DLS 86 - F 2.60 m, and totally missing in DLS 86 - G 3.50 m and DLS 86 - H? 3.70 m. *Periodon flabellum* is quite abundant in the three uppermost samples from the Dalarna investigation, represented by less than 0.5 % in Öl 97 - 3, and totally missing in D 85 - 4. As in Öl 97 - 3, *Oelandodus elongatus* occurs in D 85 - 4, though in very small amounts. The occurrence of *Oelandodus elongatus* indicates that the two samples can possibly be referred to lowermost *O. evae* Zone.

Of the samples Nä 87 - 1, Nä 87 - 3 and Nä 87 - 4 (Löfgren 1993) from the *Oepikodus evae* Zone in Närke, the one most similar to Öl 97 - 3 is Nä 87 - 3. This sample is mainly differing in the number of *O. evae,* with 55 % in Öl 97 - 3 compared to 11 % in Nä 87 - 3, and in the number of *Drepanoistodus forceps* with 51 % in Nä 87 - 3 and 13 % in Öl 97 - 3. However the sample closest to Öl 97 - 3 stratigrafical should probably be Nä 87 - 1 since *Oelandodus elongatus* (7 % in Nä 87 - 1 and less than one percent in Öl 97 - 3) and *Prioniodus elegans* (less than one percent in both Nä 87 - 1 and Öl 97 - 3), both known from the lowermost *O. evae* Zone (Löfgren 1994) occur in both samples.

Remarks.-The varying occurrence of the zonal fossil in the samples can possibly depend on the fact that the taxon is tied to a specific facies. This is discussed further below.

Results

The two lowermost samples (Öl 97 - 1 and Öl 97 - 2) studied herein are placed in the *Paltodus deltifer* Zone, i.e. the upper Tremadoc.

Öl 97 - 4, Öl 97 - 4(b), Öl 97 - 5 and Öl 97 - 6 are all placed in the *Paroistodus proteus* Zone. The *Paroistodus proteus* Zone can according to Löfgren (1993) be subdivided in four subgroups of which only the uppermost one (of Arenig age) is represented in this investigation.

Öl 97 - 3 is placed in the lower region of the *Oepikodus evae* Zone, since both *Acodus deltatus* and *Prioniodus elegans* occur.

Öl 97 - 5 and Öl 97 - 3 were noted as taken from the same level in the section but have different lithologies and they do not belong to the same conodont zone. The section is probably variable in lateral direction.

Discussion

In the *Paltodus deltifer* Zone (Öl 97 - 1) the occurrence of two elements of *Oepikodus evae* is neglected and considered to be a result of contamination or reworking. The low total number of elements in this sample makes this assumption perhaps a jump to conclusions, since two elements represent more than four percent of the total number of elements in the sample.

In almost every sample in the *Paroistodus proteus* Zone the assignment to subzone is based on the occurrence of very few specimens. *Oelandodus elongatus* is together with *Peroidon primus,* the diagnostic species for the uppermost *Paroistodus proteus* subzone. If they are considered to be a result of contamination, most of the samples from the *Paroistodus proteus* zone should be placed in the middle upper *Paroistodus proteus* Zone instead of the uppermost *P. proteus* subzone. In Öl 97 - 6 *Paracordylodus gracilis* represents no less than 30 % of the total amount of elements. *Paracordylodus gracilis* is known to occur in large numbers in some horizons and its occurrence in great numbers is referred to as a bioevent by Löfgren (1993).

The fact that the biostratigraphy at Köpings klint is complex is shown from the samples Öl 97 - 6 and Öl 97 - 3 which were taken from the same level in the section but do not belong to the same conodont zone. A hardground called "Blommiga bladet" or "the Flowery sheet" is the upper surface of sample Öl 97-3. "Blommiga bladet" is according to Bagnoli & Stouge (1996) located in the Bruddesta Formation of the Lower Volkhov stage of the Baltic stages (Fig. 3). Since both Öl 97-6 from the upper *Paroistodus proteus* Zone and Öl 97-3 from the lower *Oepikodus evae* Zones are from the same level and the upper boundary of the *Oepikodus evae* Zone is correlated with the boundary between the Latorp and the Volkhov stages (Löfgren 1995), it is possible that the *Oepikodus evae* Zone only is represented by a few centimetres in Köpings klint, and that the *Prioniodus elegans* Zone is totally missing. Öl 97 - 6 and Öl 97 - 3 were most certainly not sampled from the same horizontal place in the section, showing that the sediments varies in lateral direction, and perhaps the "missing" *Prioniodus elegans* Zone is to be found in another investigation of Köpins Klint. Bagnoli et al. (1988) describe one sample (705) from the *Prioniodus elegans* Zone in Köpings klint, but the zonal fossil is only represented by two elements, answering to less than one percent of the total amount of the specimens and the rest of the taxa are also known from the *Paroistodus proteus* Zone.

Colour alteration Index (CAI)

Since conodont elements change colour successively as a response to increased heating, they can be used as a palaeothermometer or rather as a tool for judging the degree of metamorphism in the rock (Epstein et al. 1977; Bergström 1980). The irreversible colour change sequence, amber-brown-black-grey-white-transparent is graded in an eight degree scale. The colour of the conodont elements of this investigation varies from hyaline amber (some specific "hyaline" species) to amber, corresponding to a CAI value of 1-1.5, meaning that the Lower Ordovician rocks of Köpings klint never have been heated above 90 degrees Celsius.

The feeding apparatuses of *Oistodus lanceolatus* and *Acodus deltatus* and systematics

These two species were selected to be studied specifically because their feeding apparatuses have not been described in detail previously and because of their wide appearance, the taxa being reported from both North America, Europe and Australia. Both species have only coniform elements. The terminology used in this part is mainly from Lindström (1955 and 1964) and Sweet (1988). The number of safe identified elements is shown under each description. In the case of *Oistodus lanceolatus* the remaining residue of Öl 97 - 3, not included in the biostratigraphic part, was searched selectively for that species.

Family Oistodontidae Lindström, 1970
Genus *Oistodus* Pander, 1856
Oistodus lanceolatus Pander, 1956
Figs. 7, 8

Synonymy.-Lindström (1955): *Oistodus lanceolatus,* the M-element, Plate 3, figs. 58 - 59. *Oistodus delta*, the Sa-element, Plate 3, figs. 3 - 9. *Oistodus triangularis,* the Sb-element, Plate 4, figs. 17 - 18. *Oistodus triangularis,* the Sc-element, Plate 4, figs. 14 - 16. • Lindström (1964): *Oistodus lanceolatus,* fig. 26. (A?) B-E, Pa-(?), Sd-, Sc-, Sb- and Sa-elements. • Bagnoli et al. (1988): *Oistodus* aff. *O. lanceolatus,* Plate 40, figs. 1, 3(?). M- and Pa(?)-elements. • Löfgren (1994): *Oistodus lanceolatus*. Plate 6, figs. 38 - 40, Sb-(?), Sa- and M-elements.

Material.-Five specimens from the *Paroistodus proteus* Zone (sample Öl 97 - 4, Öl 97 - 4(b) and Öl 97 - 6). Two specimens from sample Öl 97 - 4, nine specimens

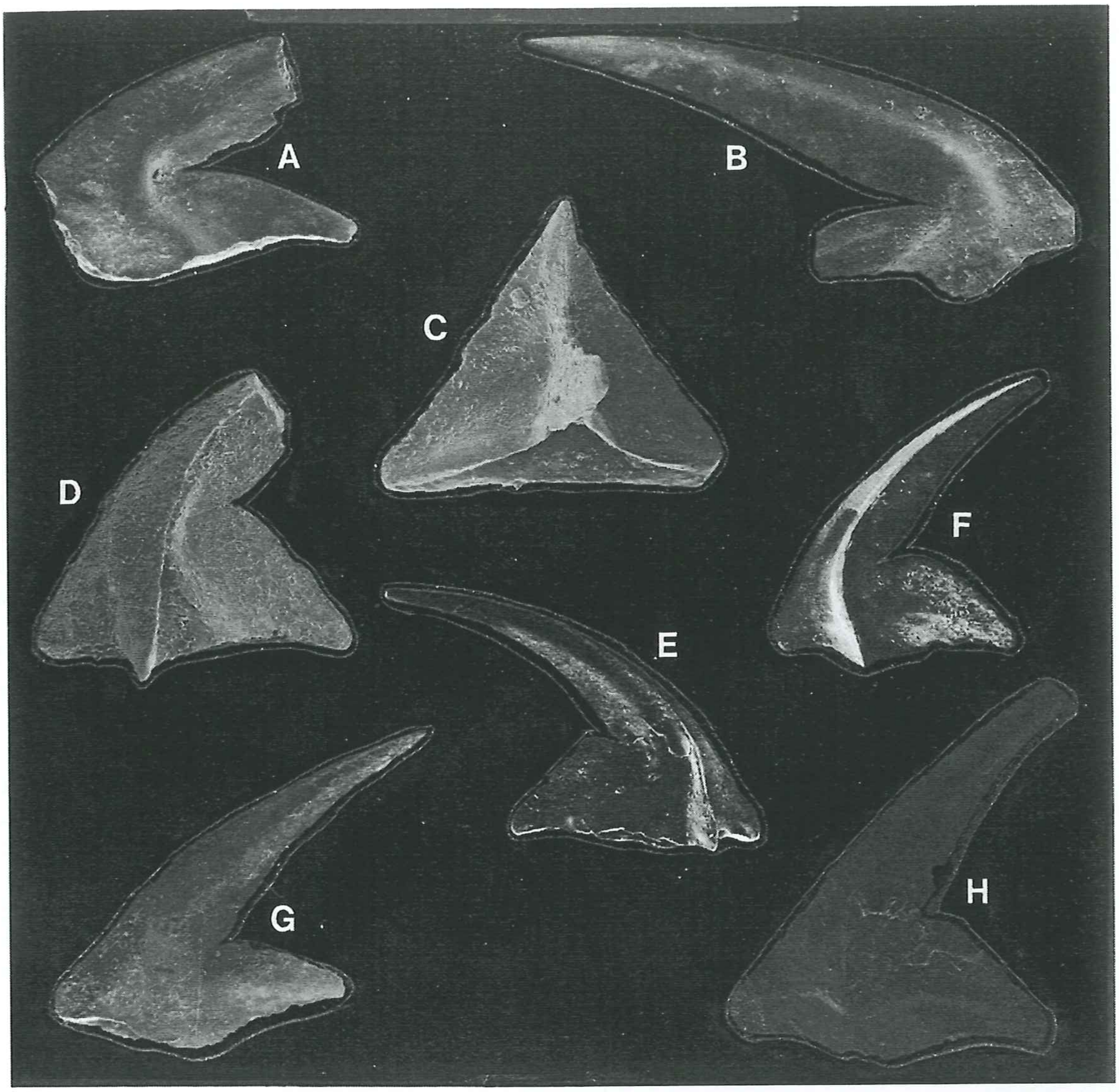

Fig. 7. **A-H.** *Oistodus lanceolatus* Pander from Öl 97 - 3 (*Oepikodus evae* Zone), A. M-element x 100, B. M-element x 70, C. Sa-element x 130, D. Sb-element x 100, E. Sc-element x 70, F. Sd-element x 70, G. Pa-element x 100, H. Pb-element x 100.

from Öl 97- 4(b) and three specimens from sample Öl 97 - 6. From the *Oepikodus evae* Zone (Öl 97 - 3) 170 specimens. Totally 189 specimens.

Previous reconstruction attempts

Lindström (1964, p. 80) described the S-transition series and the Pa-element of the *O. lanceolatus* apparatus with the names: oulodus (Pa), cordylodus (Sd), cladognathus (Sc and Sd) and roundya (Sa); the M-element is not mentioned in this connection.

Sweet (1988, p. 61) described the apparatus of *Oistodus* as having one P-element, one M-element and the rest of the elements forming a symmetry-transition (or S) series.

Description

The feeding apparatus of *Oistodus lanceolatus* consists of 13 elements, a pair of M-elements, a set of three pairs and one symmetrical S-element, and two pairs of P-elements. All elements are geniculate, which means that they have a sharp angle between the base and the cusp. The apparatus is of the Hyalion type (from the Greek *hyalion*: mirror) and consists of coniform elements, which all but one (the Sa-element), has a mirror image element on the other side of a symmetry plane. The symmetry plane split the apparatus in a left hand side and a right hand side, with the symmetrical Sa-element in the symmetry plane (Nicoll 1995). All elements of *Oistodus lanceolatus* are more or less hyaline and are quite easy to recognise, but can be confused with the much less hyaline *Protoprioniodus papiliosus* (Fig. 6B-C.), which has a concave basal margin in contrast to the straight to convex one of *Oistodus lanceolatus*. If locking at a close-up of *Protoprioniodus papiliosus* one can see microstructures (Fig. 6C) on the surface, which are lacking on *Oistodus lanceolatus*.

The M-element.-The M-elements (Fig. 7A-B) have a convex basal margin and acute angles of both the posterobasal corner and the anterobasal corner (the element in Fig. 7A is broken). The basal cavity is quite

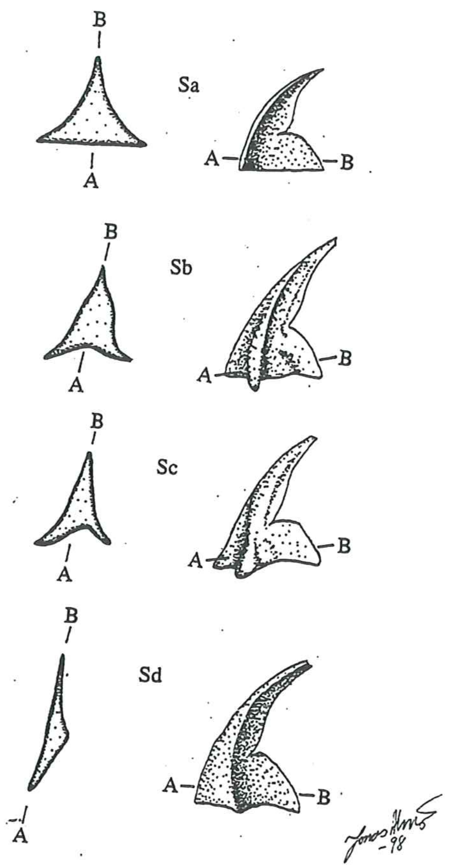

Fig. 8. The S-transition series (x 30) from *Oistodus lanceolatus* Pander, and the elements in cross-section.

shallow and ends with a point about where the cusp begins. A carina occurs on both sides of the curved cusp. If studied from above, the element is flexed towards the symmetry plane in the middle. The length of the cusp varies, but a mature specimen has a cusp about twice the length of the base. *Material.* -33 specimens.

The Sa-element.-The Sa-element (Figs. 7C and 8) is symmetrical. If observed from the posterior it is triangular. The cusp is about the same length as the base, but specimens from other samples (Nä 87-4 from the *Oepikodus evae* Zone, Löfgren 1993) have been observed, in which the length of the cusp is twice the length of the base. The anterior side of the cusp is flat and wide, and reaches from the tip to both anterior corners of the base. This results in the triangular surface that gives the element its triangular form. In lateral view the cusp is curved and as in all geniculate elements, the angle between the cusp and the base is sharp. For cross-section se Fig. 8. *Material.*-Eight specimens.

The Sb-element.-The anterior edge of the Sb-elements (Figs. 7D and 8) splits into two edges about halfway between the apex and the base. The interior one runs to the anterobasal corner and the exterior one runs on to the side of the base, creating a winglike outgrowth. Between the two edges, the anterior of the cusp is a bit concave, see cross-section (Fig. 8). A carina is sometimes present on the cusp, and where the cusp reaches the base the carina is curved to the posterior. The base is high and the aboral margin is straight or slightly convex. A fully-grown specimen has a cusp about twice the length of the base. *Material.*-14 specimens.

The Sc-element.-The Sc-elements (Figs. 7E and 8) can be described as the Sb but the split of the anterior margin is located higher up on the cusp. The exterior edge meets the base at about the same place as in the Sb element, still creating a winglike outgrowth (Fig. 7E and 8). The base is shorter and has a almost straight oral margin from the sharp angle between the base and the cusp. *Material.*-Eight specimens.

The Sd-element.-The Sd-elements (Figs. 7F and 8) are modified from the Sc, where the exterior edge is developed into a costa, beginning at the apex and running along the curved cusp to the place where the cusp meets the base, where it bends off posteriorly. The basal margin is straight to convex and the costa meets the basal margin where the convexity is the greatest. For cross-section see Fig. 8. The upper margin of the base is curved. *Material.*-Seven specimens.

The Pa-element.-The Pa-element (Fig. 7G) is rather similar to the M-element but the angle between the cusp and the base is not as acute. The element is not as flexed towards the symmetry plane as the M-element and the cusp has a thin edge on the external side. The cusp is more erect than in the M-element and it is not curved but straight. A convex outline of the aboral margin and sharp angles at both the posterobasal corner and the anterobasal corner is typical for the Pa-element. *Material.*-18 specimens.

The Pb-element.-The Pb-element (Fig. 7H) is similar to the Sd-element but the cusp is more erect and not as curved. A costa, similar to the one described in the Sd-element, is running along the exterior side to where the convexity of the aboral margin is the greatest. The costa is not as sharp as the one it is compared with in the Sd-element. *Material.* -Eight specimens.

Remarks.- There is a possibility that the Sd-element and the Pb-element described herein are the same element type, only differing within the morphological differentiation range for the same element type. If that is the fact the "true" Pb-element is probably very similar to the Pa-element.

Family Prioniodontidae Bassler, 1925
Genus *Acodus* Pander, 1856
Acodus deltatus Lindström, 1955
Figs. 9, 10

Synonymy.-Lindström (1955): *Acodus deltatus altior,* the Sc-element, Plate 3, fig. 29. *Acodus deltatus* n. sp., the Pa-element, Plate 3, fig. 30. *Oistodus linguatus,* the M-element, Plate 3. figs. 41 - 42. *Distacodus rhombicus*

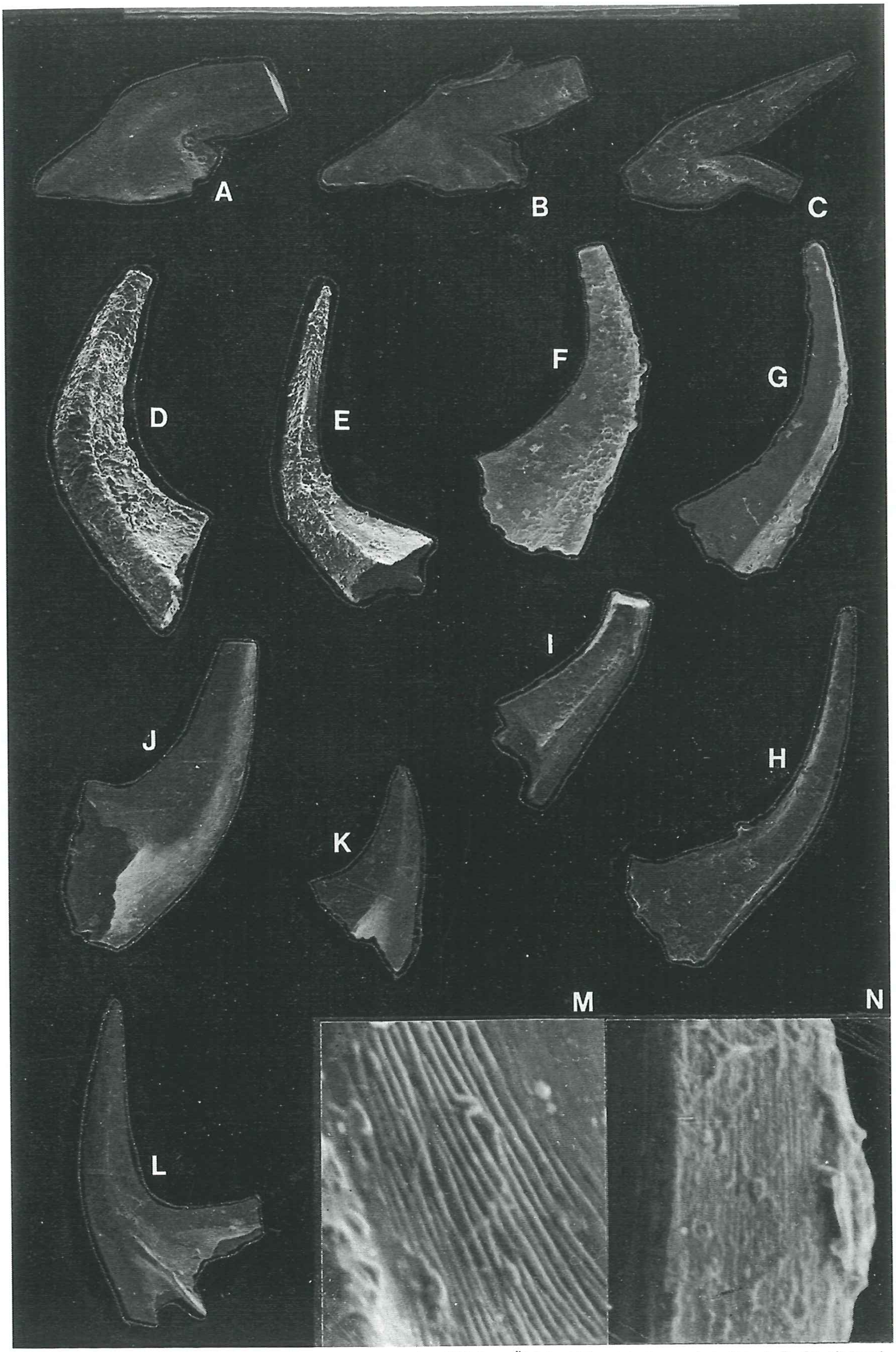

Fig. 9. **A-N.** *Acodus deltatus* Lindström, A-C. M-elements x 130 from Öl 97 - 4 (*Paroistodus proteus* Zone), D. Sa-element x 130 from Öl 97 - 4 (*Paroistodus proteus* Zone), E. Sa-element x130 from Öl 97 - 3 (*Oepikodus evae* Zone), F. Sb-element x 130 from Öl 97 - 4 (*Paroistodus proteus* Zone), G. Sc-element x 130 from Öl 97 - 4 (*Paroistodus proteus* Zone), H. Sc-element (internal view) x 130 from Öl 97 - 4 (*Paroistodus proteus* Zone), I. Sd-element x 130 from Öl 97 - 5 (*Paroistodus proteus* Zone), J. Pa-element x 130 from Öl 97 - 5 (*Paroistodus proteus* Zone), K. Intermediate form of P-element x 130, (juvenile) from Öl 97 - 6 (*Paroistodus proteus* Zone), L. Pb -element x 130 from Öl 97 - 5 (*Paroistodus proteus* Zone), M. Detail from L. x 1500, showing microstructures. N Detail from G. x 1500, showing microstructures.

n. sp., the Sa-element(?). • McTavish (1973): *Acodus deltatus deltatus,* Plate 1. figs. 1 - 9 and 12 - 14., 1, 2, 6, 7 and 12(?) P-elements, 3, 4, 9, 13 and 14 (?) S-elements and 5 and 8, M-elements. • Bagnoli et al. (1988): *Baltoniodus ? deltatus*, Plate 38, figs. 8 - 14., Pa-, Pb-, Sb-, Sc-, Sd- and M-element. • Löfgren (1993): *Acodus deltatus deltatus,* fig. 5. Q - V., Sc-, Sd(?)-, P(?)-, Sd(?)-, Pb(?)- and M-element.

Material.-Totally 1 137 specimens from the following samples: from the *Paroistodus proteus* Zone Öl 97-4, 461 specimens, Öl 97-4(b), 316 specimens, Öl 97-5, 289 specimens and from Öl 97-6, 61 specimens. From the *Oepikodus evae* Zone (Öl 97-3) 10 specimens.

Previous reconstruction attempts

van Wamel (1974 p. 118, figs. 1-9) described seven different element types in the apparatus. The prioniodiform - (fig. 1), the prioniodinaform - (fig. 2), the gothodiform - (fig. 4), the oepikodiform - (fig. 6), the roundyaform - (fig. 8) and the oistodiform - element (fig. 9) correspond well with specimens found in this investigation but the rest i.e. the prioniodinaform - (fig. 3) and the trapezognathiform - element (fig. 5:a and 5:b), probably belong to other apparatuses.

Ethington & Clark (1982) suggested that the feeding apparatus of *Acodus deltatus* consists of six different element types: drepanodiform-element (Sb), prioniodiform-element (Pb), gothodiform-element (Sc), distacodiform-element (Sd), trichonodelliform-element (Sa) and oistodiform-element. These are shown as drawings in figure 4, in Ethington & Clark (1982) and as SEM-photos in their plate 1, figs 1-6.

Description

Seven different element types can be recognised in the apparatus of *Acodus deltatus.* The type of apparatus is a so-called Hyalion apparatus (Nicoll 1995), this means that it can be compared with the apparatus of *Oistodus lanceolatus* described above. As in *Oistodus lanceolatus* the total number of elements in the apparatus is at least 13, a pair of M-elements, a set of three pairs and one symmetrical S-element and two pairs of P-elements. All elements have microstructures on the surface (Fig. 9 M, N).

The M-element.-The M-element (Fig. 9A-C) is geniculate and has a straight to convex aboral margin. Both the anterobasal and the posterobasal corners have acute angles, the base is elongated anteriorly. Some of the elements have a curved posterior part of the base (Fig. 9C); these are probably the unbroken ones. Anterior margin is straight from the apex of the cusp to about the same level where the cusp meets the base, where it has a sharp bend, continuing on the base at an angle of about 140 degrees. Some specimens have a smooth curve along the anterior margin. The cusp is straight distally, subparallel with the aboral margin and flexed to the interior. *Material* .-143 specimens.

The Sa-element.-The Sa element (Figs. 9D-E and 10) is symmetrical and has two more or less distinct lateral costae as well as a central posterior keel. The keel runs from the apex along the posterior margin of the curved cusp to the posterobasal corner. The costae run from the apex, one on each side of the element to the aboral margin. In cross-section (Fig. 10), the base is convex anteriorly to the costae and slightly concave from the costae to the keel. The basal cavity is quite deep, triangular, with one side of the triangle located along the anterior margin. This is typical for all elements in the apparatus, except for the geniculate ones. *Material.*-Two specimens.

The Sb-element.-The Sb element (Figs. 9F and 10) is smooth on the external side. Usually the element is smooth even on the internal side but some specimens (very few) have a carina which runs from the apex to the basal margin, halfway between the basal corners. The Sb-element has a deep basal cavity which is located in the same way as in the Sa-element. The basal margin is convex, but the "walls" of the basal cavity seem very thin. Thus, the basal margin is very often broken. The element is curved posteriorly and bent towards the symmetry plane, that splits the apparatus in a right hand side and a left hand side. For cross-section, see Fig. 10. *Material.* -71 specimens.

The Sc-element.-The Sc-element (Figs. 9G-H and 10) is very similar to the Sb-element although it has a carina on its external side (Fig. 9G and 10) that runs from the apex to the basal margin halfway between the basal corners. A deep triangular basal cavity, with one side located along the anterior side of the element and a curved cusp, bent towards the symmetry plane is typical for all S-elements in this apparatus. For cross-section, see Fig 10. *Material.*-46 specimens

The Sd-element.-The Sd-element (Fig. 9I) has four edges (Fig. 10). One can be referred to as a keel that runs from the apex along the posterior margin to the posterobasal corner. There is also one keel or edge that runs from the apex along the anterior edge to the anterobasal corner. The other two edges are located on each side of the element, but not symmetrically. The edge (costa) on the internal side runs from the apex and is located close to the anterior margin. The external costa runs from the apex, along the external side, not always centred but mostly near the centre or perhaps a bit more to the posterior side of the element. The external costa is often longer than both the anterior and the posterior edge. A curved cusp flexed to the interior (some specimens appear "twisted") is characteristic for this element type. *Material.* -163 specimens.

The Pa-element.-The Pa-element (Fig. 9J) has a curved but not flexed cusp. A wide basal cavity, triangular in cross-section is located on the internal side of the element. A carina is present on the internal side, it runs

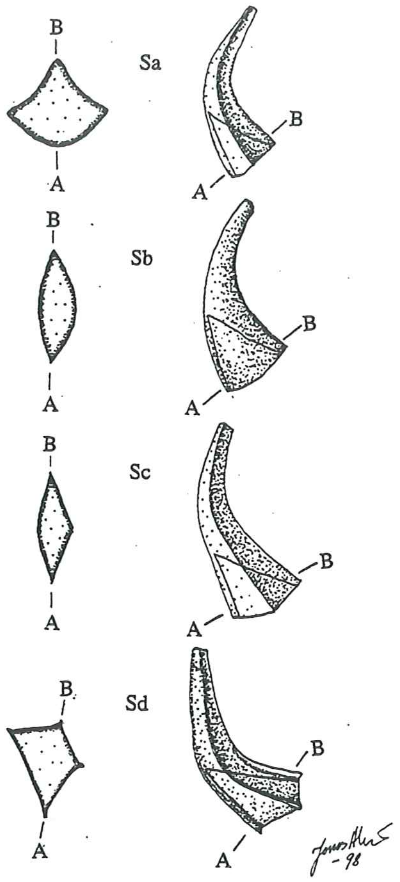

Fig. 10. The S-transition series (x 45) from *Acodus deltatus* Pander, and the elements in cross-section.

from the apex to the same place as where the element widens at the upper part of the base, where the carina turns in sharply and creates a wide basal cavity, triangular in cross-section. The cusp is proclined. *Material.*-The total number of Pa- and Pb-elements is 155 specimens.

The Pb-element.-The Pb-element (Fig. 9L) is very similar to the Pa-element but the cusp is more erect. All three edges of the triangular basal cavity are sharper and longer than in the Pa element and can be described as processes or perhaps nascent processes. Mc Tavish (1973) described a subspecies, *Acodus d. longibasis,* from the Lower Ordovician in Australia, which has an elongate posterior process with denticles. No P-element of *Acodus deltatus* in this investigation has denticles. *Material.*-see Pa-element.

Remarks.-The great diversity among the geniculate elements may indicate that this species has more than one pair of M-elements.

Only two Sa-elements were found, and it must be stressed that this probably not is sufficient material. Ethington & Clark (1982) described the feeding apparatus of *Acodus deltatus* from North America and they have a drawing of the trichonodelliform element that corresponds very well with the elements found in this investigation; however, the SEM-pictures (Ethington & Clark 1982, plate 1) of the trichonodelliform element differs, not only from their drawing, but also from the elements in my collection. According to Bagnoli et al. (1988) it is not impossible that no Sa-element is to be found in the *Acodus deltatus* feeding apparatus. Bagnoli et al. (1988) suggested that the feeding apparatus of *Acodus deltatus* could be a multielement apparatus that lacks the trichonodelliform element. Their theory is supported by the very low number of Sa-elements found in this investigation. It is, however, notable that both Ethington & Clark (1982) and myself have found the same element type as Sa, and maybe the Sa-element for some reason has a lower potential to be preserved. Another possibility is that the species described by Ethington & Clark (1982) is a Midcontinental species, very similar to the species referred to as *Acodus deltatus* from the Baltic faunal province and that some of the specimens found here are "visitors" just like *Tropodus* sp.

There is a considerable diversity among the P-elements and it is possible that Pa- and Pb- elements do not have distinct morphologies from each other. Another possibility is that there are three pairs of P-elements in the apparatus. I have described the "end members" among the P-elements, which are the most numerous ones. An intermediate form of P-element can be seen in Fig. 9K.

Conodont provincialism

It is generally accepted that two major realms or faunal regions existed during the late Tremadoc and the Arenig, the Midcontinent faunal region and the North Atlantic faunal region (see for instance Dzik 1983; Charpentier 1984; Lindström 1984; Bergström 1990). The Midcontinent faunal region is best known from central North America, but has also been recognised in Siberia, Australia and Korea. The North Atlantic faunal region is found in Europe, eastern North America and Australia (Bagnoli & Stouge 1991). Conodonts from the Midcontinent faunal region are thought to have been adapted to life in tropical shelf seas, while the conodonts in the North Atlantic faunal region are thought to have inhabited cold water regions in high latitudes and/or deeper water in low latitude areas (Pohler 1994). This theory also involves salinity as a possible factor of conodont provincialism, where the Midcontinental faunal region conodonts inhabited waters with higher salinity than the North Atlantic ones (Pohler 1994). Similar provincialism of other animal groups (mainly trilobites) from the Precambrian to the Tremadoc has been described by Conway Morris & Rushton (1988). Charpentier (1984) compared the number of endemic conodont species in Laurentia (Midcontinental faunal region) and Baltica (North Atlantic faunal region) during the Early Ordovician and found that 28 % of the species in Laurentia were endemic, compared to 41 % in Baltica.

In this investigation the species *Tropodus* sp., known as a species from the Midcontinental fauna occurs, and

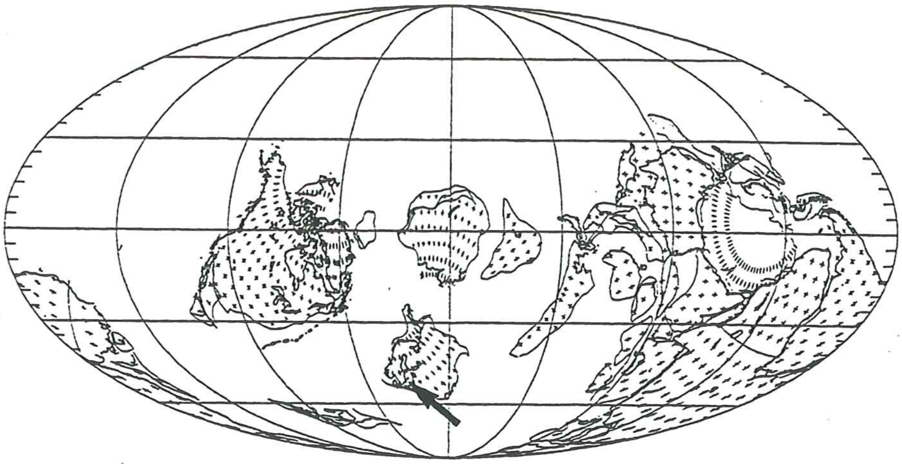

Fig. 11. Palaeogeographical map showing the position of continents during the Arenig in the Lower Ordovician. The arrow is pointing at Öland (Baltica). Laurentia (North America) is located to the left and the Iapetus Ocean betwen these two continents. From Scotese and mcKerrow (1990).

is considered being a Midcontinental "visitor" in Baltica. The geographical position of Baltica during the Early Arenig is shown in Fig. 11. The genus *Tropodus* was reported from the United States by Kennedy (1980) and from Greenland by Smith (1991), both Midcontinental areas.

Bagnoli & Stouge (1991) divided the conodont genera into five different groups based on their paleogeographic distribution. The five groups are: the Pandemic group, the Warm water group, the Cold water group, the Temperate water group and the Warm water China group. The genera found in this investigation belong to either the Pandemic group, including genera that are widely spread, or the Cold water group, including genera from the North Atlantic faunal region (Bagnoli & Stouge 1991).

Conodonts as biofacies indicators

Bagnoli (1994) compared localities on each side of the Iapetus Ocean; the localities consists of slope and platform deposits in Newfoundland and platform deposits from Öland, Sweden. The conclusions of that investigation was that differentiation in conodont faunas could be correlated with transgression - regression cycles. *Oepikodus evae* is a key species for determining the maximum transgression event of the Lower Ordovician (Bagnoli 1994). Pohler (1994) found that no less than five different conodont biofacies could be distinguished in the Arenig Cow Head Formation of western Newfoundland. The *Oepikodus evae* Zone in the Cow head group can be correlated with the same zone in Öland (Bagnoli 1994). Pohler (1994) found that *Oepikodus evae* is related to the facies of the edge and to the lower slope of the shelf, i.e. deeper waters than the upper shelf and together with the fact that *Oepikodus evae* occurs in Öland during a transgression (Bagnoli 1994), the species could be used as an indicator of depth (Bagnoli & Stouge 1996).

Rasmussen & Stouge (1995) recognised four conodont biofacies in the Arenig - Llanvirn, from studies of the Stein Formation, deposited along the Scandinavian Caledonian front. The four conodont biofacies are, from shallower to deeper water, the *Scalpellodus - Microzarkodina* biofacies, the *Baltoniodus* biofacies, the *Drepanoistodus* biofacies and the *Protopanderodus - Periodon* biofacies. The *Microzarkodina* biofacies consists of bioclastic packstones with echinoderms, deposited in a shallow subtidal environment (Rasmussen & Stouge 1995). The *Baltoniodus* biofacies is also deposited in a subtidal environment but deeper than the *Microzarkodina* biofacies (Rasmussen & Stouge 1995). In the *Drepanoistodus* biofacies limestones, wackestones and mudstones are the dominating sediments i.e. deposited in deeper water, in an open marine subtidal environment. Associated fossils are trilobites and brachiopods (Rasmussen & Stouge 1995). The *Protopanderodus - Periodon* biofacies is deposited in a deeper environment with lime-mudstones, marl and isolated limestone-nodules, trilobites and brachiopods are more common than echinoderms (Rasmussen & Stouge 1995).

The introduction of an *Oepikodus evae* biofacies for the deepest environments in Scandinavia by Bagnoli & Stouge (1996) improves the possibility to distinguish the environment of deposition to in addition to the four biofacies introduced by Rasmussen & Stouge (1995), at least during the Arenig and Llanvirn.

Discussion

The only species that with any certainty can be associated with a specific event in this investigation is *Oepikodus evae*, which according to Bagnoli (1994), is associated with the maximum transgression during the Arenig. Pohler (1994) showed that *Oepikodus evae* is more linked to deeper waters than most of the other species in this investigation. Lindström (1984) suggested that the genus *Paracordylodus* (found in high numbers in Öl 97 - 6) was pelagic and at least not associated with regression events. *Paracordylodus* could therefore possibly indicate a deeper depositional environment, perhaps the same as *Oepikodus evae*, or even deeper.

It is difficult to make any conclusions about the depositional environment, by only looking at the conodont associations, but it can be a complement to sedimentological studies i.e. cementation, grain size and sediment chemistry etc. Another problem is that species of the same genus could have been adapted to different environments and that they could have changed environment during the evolution.

The investigation of Rasmussen & Stouge (1995), considered the Arenig and Llanvirn (*Microzarcodina parva - Eoplacognathus suecicus* Zones) and their results is perhaps not directly applicable to the *Paltodus deltifer* to the *Oepikodus evae* Zones.

Conclusions

The samples collected by Drs. Stig M. Bergström and Jan Bergström in 1960 from Köpings klint, Öland, derives from the *Paltodus deltifer*-, the *Paroistodus proteus*- and the *Oepikodus evae* conodont zones in the Tremadoc and the Arenig (Fig. 2). The conodont zones are referred to the Djupvik and the Köpings klint formations (Fig. 4). The conodont faunas found in this investigation, correspond rather well with faunas of comparable age from Köpings klint and other parts of Sweden.

The lithologies in the section varies, with a trend of more glauconitic sandstone and green limestone in the basal part and more red to brown limestone in the upper part. The biostratigraphy at Köpings klint is complex and variable in lateral direction. This can be illustrated by comparing the samples Öl 97 - 5 and Öl 97 - 3 which were reported as being sampled at the same level in the section, but not belong to the same conodont zone (Öl 97 - 5 from the *Paroistodus proteus* Zone and Öl 97 - 3 from the *Oepikodus evae* Zone).

The species *Oistodus laceolatus* and *Acodus deltatus* is described as having hyalion type feeding apparatuses consisting of seven different element types; M-, Sa-, Sb-, Sc-, Sd-, Pa- and Pb-elements. All but the symmetrical Sa-element occur in mirror image pairs.

The conodont faunas found in this investigation belong to the North Atlantic faunal province, though some "visitors" from the Midcontinental province occur in low numbers in some samples. The species *Oepikodus evae* (*O. evae* Zone) and probably also *Paracordylodus gracilis* (*P. proteus* Zone) can be tied to transgressive events and can thereby be used as biofacies indicators, indicating outer shelf environments. Both species occur in large numbers in some samples.

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