Early Ordovician conodont biozonation at Finngrundet, south Bothnian Bay, Sweden

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Samples from about every 0.5 m of the Ordovician part of the Finngrundet drill core were investigated for conodonts and the resulting biostratigraphic subdivision was compared with the trilobite zonation of the same core (Tjernvik & Johansson, 1980; Bull. Geol. Inst. Univ. Upps., N.S. 8). Conodont and trilobite zonal boundaries coincide in the core in several cases. Thus, the lower boundary of the conodont zone of *Paroistodus originalis* closely coincides with that of the trilobite zone of *Megistaspis* (*M.*) *simon*, and the lower boundaries of the *Microzarkodina flabellum parva* Zone and the *Eoplacognathus? variabilis* Zone closely agree with those of the *Megistaspis* (*M.*) *limbata* Zone (as defined by Tjernvik & Johansson) and the *Asaphus expansus* Zone, respectively, in the core. Such congruence, in a single locality, between zonal boundaries based in various fossil groups does not prove exact time-equivalency between the corresponding chronozones, but if the pattern is shown to be consistent, it will be of help in future correlations. Some taxonomic remarks are made on critical taxa encountered in the core.

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To the memory of Per Thorslund

Introduction

The Finngrundet shoal is situated in the southern Bothnian Sea at 60°59'N, 18°37'E. Drilling was undertaken there in 1970 in a collaboration between the Department of Historical Geology and Palaeontology in Uppsala and the Geological Survey of Sweden to evaluate the Cambro-Ordovician sequence in the area. Further information on this project was given by Thorslund & Axberg (1979), who also presented results of spectrograph analyses of selected elements in samples taken at about 6 m intervals throughout the core and a preliminary report on the lithology and stratigraphy of the Cambrian – Tremadocian part of the core. Subsequently, Tjernvik & Johansson (1980) presented a meticulously prepared, trilobite-based, biozonation of the post-Tremadocian part of the core. (Note that Thorslund & Axberg used sea-level as zero-level for their measurements, while Tjernvik & Johansson used the top of the sequence, that is, a level 2.40 m higher up. In the present work, the figures of Tjernvik & Johansson have been used because most of the references are to "their" part of the sequence.)

In 1978, I was invited by Per Thorslund to investigate the conodont faunas in the core. This was a particularly interesting offer because of the ongoing parallel work to establish a trilobite zonation, and it was accepted with pleasure. Consequently, a total of 97 samples were taken from the core by Per Thorslund and Torsten Tjernvik for investigation. The majority of these samples were processed for conodonts at the Department of Historical Geology and Palaeontology in Uppsala, while 26 samples were dissolved and picked at the Department of Historical Geology and Palaeontology in Lund. Standard processing methods were used at both institutes, and no systematic differences in the handling of the samples have been discerned. Each sample includes from 0.05 to 0.10 m of the core (in most instances 0.06 m), and between 50 and 250 g of rock from each level were dissolved. As only relative percentages of conodont frequencies are employed in this study, the size of each sample is not given here. Absolute abundancies of conodonts vary considerably; most samples from the lower half of the core contained several hundred elements per 100 g rock (a few more than 2000 elements/ 100 g), while in the upper half of the core, about half of the samples contained less than

British Series	Baltic Stages and Substages		Finngrundet: Trilobite Zones (Tjernvik & Johansson 1980)	Finngrundet: Conodont Zones and Subzones		(m)
Llanvirn	Kunda	Valaste	*Asaphus "raniceps"* Zone	*E.? variabilis – M. ozarkodella* Subzone	*E.? variabilis* Zone	18.33, 18.50
				E.? variabilis – M.? flabellum Subzone		20.50
Arenig		Hunderum	*Asaphus expansus* Zone			32.30
	Volkhov	Langevoja	*Megistaspis (M.) limbata* Zone	*Microzarkodina flabellum parva* Zone		39.00, 39.10
			Megistaspis (M.) simon Zone	*Paroistodus originalis* Zone		45.48, 45.60
			Megistaspis (M.) lata Zone	*Baltoniodus triangularis* and *Baltoniodus navis* Zones		51.07, 51.50
	Latorp	Billingen	*Megistaspis (V.) estonica* Zone	*Oepikodus evae* Zone		56.50, 58.00
			Megalaspides (M.) dalecarlicus Zone			59.94
			Transition Beds	*Prioniodus elegans* Zone ?		61.00, 61.10
		Hunneberg	*Megistaspis (V.) planilimbata* Zone	*Paroistodus proteus* Zone		61.23, 61.32
			Megistaspis (E.) armata Zone			62.17, 62.68

Fig. 1. Correlation between main stratigraphic units discussed in this report. Conodont data from Lindström (1971) and Löfgren (1978).

100 elements per 100 g. No sample was barren of conodonts. In all, more than 27 000 elements were determined in the investigation.

Two samples, marked 65.85–65.90 m and 63.30–63.40 m, were obviously mislabelled (they have faunas from the *O. evae* Zone and *P. proteus* Zone, respectively). As their true position in the core could not be ascertained, they have been excluded from the biostratigraphical investigation.

The Finngrundet conodont collection belongs to the Department of Historical Geology and Palaeontology in Uppsala; figured specimens are deposited in the type collection there.

Acknowledgements

I would like to express my deep gratitude to Torsten Tjernvik and to the late Per Thorslund for much help and for stimulating and encouraging cooperation, to Richard Reyment, Head of the Institute of Palaeontology in Uppsala, for access to the Finngrundet core and for laboratory help placed at my disposal, and to Gerhard Regnéll, former Head of the Department of Historical Geology and Palaeontology in Lund for providing support and working facilities. The laboratory work in Lund was funded by a grant to him from the Swedish National Science Research Council. The scanning electron photography work was also financed by a grant from this Council. Birgit Jansson, Uppsala, and Kristina Lindholm and Gunnar Thuning, both of Lund, carried out the laboratory work. Thanks are also due to Sven Stridsberg, who took the photographs, to Christin Andréasson, who made the drawings, and to Helen Sheppard, who corrected the English.

Conodont occurrences

The *Paroistodus proteus* to *Oepikodus evae* Zones

The lowermost samples, from 62.63 – 62.68 m, 62.50 – 62.54 m and 62.25 – 62.30 m, come from the trilobite zone of *Megistaspis* (*Ekeraspis*) *armata* (Fig. 1). This is the oldest Arenigian trilobite zone distinguished in Balto-Scandia (Tjernvik & Johansson, 1980, p. 184). The conodont fauna encountered in the aforementioned samples (Fig. 2) seems to represent the lower part of the *Paroistodus proteus* Zone. The fauna is characterized by *Paroisto-*

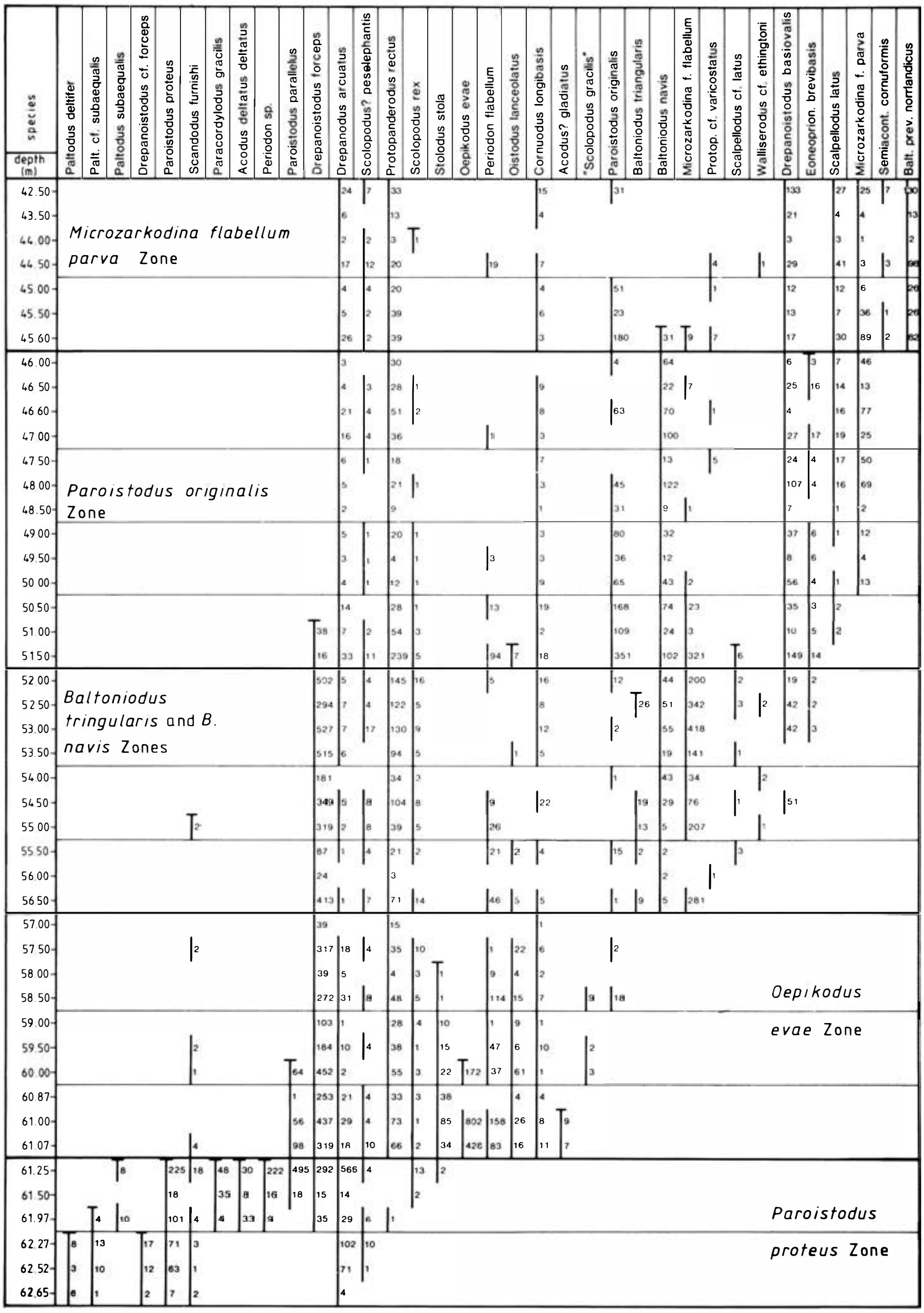


Fig. 2. Distribution of identified conodont taxa and number of elements of each taxon in the Finngrundet core in samples from the *P. proteus* Zone to the middle part of the *M. flabellum parva* Zone. Levels indicated in the left part of the diagram are those from which samples were taken (a piece of core usually from 0.03 m below to 0.03 m above the marked level). Short horizontal lines on top of the vertical distribution lines denote last occurrences which are interpreted as (local) extinctions. Heavy horizontal lines denote the boundaries between zones; thin horizontal lines are for help in reading the diagram.

dus proteus and primitive *Acodus* spp. typical of the Hunneberg Substage. On the other hand, the fauna does not contain any typical specimens of *Paltodus subaequalis* (= *Paltodus inconstans* of Lindström 1971), which is usually present in the *Paroistodus proteus* Zone (cf. Lindström, 1971, p. 29). Instead, *Paltodus* is represented by a few elements of the older species *P. deltifer* (Fig. 4 O – Q) and by elements here considered as early representatives of *P. subaequalis*, referred to as *P.* cf. *subaequalis* (Fig. 4 R–U). *Paltodus deltifer* is characteristic of the late Tremadocian, but its presence here does not motivate an assignment of the beds to a level below the Arenigian, as the majority of the diagnostic species in the samples are typical of the Latorpian. Moreover, a specimen of *Cordylodus angulatus* found in the youngest of the three samples indicates some redeposition of Tremadocian conodonts.

The rest of the fauna in the three samples has less diagnostic value. It includes elements of *Drepanodus arcuatus*, *Drepanoistodus* cf. *forceps* (Fig. 4 AF), *Scandodus furnishi* and *Scolopodus? peselephantis*.

The following samples, from 61.95 – 62.00 m and 61.48 – 61.53 m, come from the trilobite zone of *Megistaspis* (*Varvaspis*) *planilimbata* proper (cf. Tjernvik & Johansson, 1980). The lower of these samples has a more typical *Paroistodus proteus* Zone fauna than all the preceding ones had. Thus, there are typical representatives of *Paltodus subaequalis* (Fig. 4 V–Y) and *Drepanoistodus forceps* as well all other named species found in the preceding samples, except *Paltodus deltifer* and *Cordylodus angulatus*. *Acodus deltatus deltatus* (Fig. 4 Z, AA, AB), *Paracordylodus gracilis*, *Protopanderodus rectus*, primitive *Periodon*, and elements tentatively referred to as *Polonodus* (Fig. 4 AAB–AAE) all first appear at the level 61.95 – 62.00 m. In the sample from 61.48 – 61.53 m the fauna is less typical of the *P. proteus* Zone as elements of *Paltodus* are totally missing and about half of the drepanodontiform elements of *Paroistodus* are laterally costate and have been assigned to *P. parallelus*. This fact, and the appearance of *Scolopodus rex* might justify assigning the sample to the next higher zone, the *Prioniodus elegans* Zone, or even to a higher level. But due to the absence of *Stolodus stola*, a species that is almost invariably present in the *P. elegans* Zone and slightly younger Billingian beds, and also due to the presence of a few *Paltodus subaequalis* specimens at a higher level in the core, the assignment of this sample to the *P. proteus* Zone seems to be the best founded one.

The trilobite zone of *Megistaspis* (*V.*) *planilimbata* proper extends up to 61.32 m in the core. The interval above, up to 61.00 m, has been labelled "transition beds" by Tjernvik & Johansson (1980, p. 185). Equivalent beds in southern central Sweden have yielded index graptolites of the *Didymograptus bifidus* Zone as well as a *Prioniodus elegans* Zone conodont fauna (cf. Lindström 1971, p. 29; Tjernvik & Johansson 1980, p. 186). In the Finngrundet core, however, no *Prioniodus elegans* Zone has been encountered, but as only two samples (61.23 – 61.28 m and 61.05 – 61.10 m) come from the "transition beds" interval this is not surprising, as the interval with *P. elegans* in southern central Sweden is often very thin indeed (Lindström 1971, p. 29).

The uppermost of the "transition beds" samples (61.05 – 61.10 m) clearly belongs to the *Oepikodus evae* Zone, which is the zone succeeding the *P. elegans* Zone. The question is then whether the lower sample (61.23 – 61.28 m) comes from a level above, below, or possibly within the *P.elegans* Zone. To refer the sample to the *P. elegans* Zone proper would be misleading as there is no definite proof of the presence of strata belonging to this zone in the core. The best argument for referring the sample to a level slightly above a (fictive) *P. elegans* Zone, that is in the lowermost part of the *O. evae* Zone, is the presence of *Stolodus stola*, which has not been found below the *P. elegans* Zone before (Lindström 1977, p. 540). However, the frequency of *S. stola* elements is extremely low (only 2 specimens out of more than 2000 elements), and if this abundance was typical when *S. stola* first appeared, it is not surprising if it had been previously missed in these beds.

Arguments which attribute the sample to a level slightly below the *P. elegans* Zone, that is at the top of the *P. proteus* Zone, are the presence of a few elements of *Paltodus subaequalis*, and a fair amount of *Paroistodus proteus* among the *Paroistodus* elements and presence of *Acodus deltatus deltatus*. These species disappear in early Billingen time (Lindström 1971, p. 29, 1977, p. 7), and could not be expected to be present in beds younger than the *P. elegans* Zone. On the basis of these arguments the sample from 61.23 – 61.28 m has been tentatively placed in the uppermost part of the *P. proteus* Zone. This means that beds belonging to the *P. elegans* Zone could be present somewhere between 61.23 and 61.10 m. Interestingly, one geniculate element of *P. elegans* was found in the next younger sample; and indication that beds of the *P. elegans* Zone may, indeed, be or have been present. As noted by Lindström 1971, p. 29 the *P. elegans* Zone fauna is often found as a reworked fauna at the base of the *O. evae* Zone.

As mentioned above, the upper sample from the "transition beds" at 61.05 – 61.10 m can be confidently attributed to the *O. evae* Zone. The fauna in this sample is dominated by the zonal index species (38.7 %) and by *D. forceps* (28.8 %). All other species are below 10 % in frequency. Among those already present in earlier intervals are *Paroistodus parallelus, Protopanderodus rectus, Stolodus stola, Drepanodus arcuatus, Scolopodus? peselephantis, Scolopodus rex*, and *Scandodus furnishi*.

Some species appear in the core for the first time at this level. Besides *O.evae*, these are: *Acodus? gladiatus, Periodon flabellum* (primitive form), *Oistodus lanceolatus* and *Cornuodus longibasis*. On the other hand, *Paracordylodus gracilis, Acodus deltatus deltatus* and *Paltodus subaequalis* have disappeared.

A fauna virtually identical to this as regards the conodont species present was found at 61.00 m. The zonal index, *O. evae*, dominates (47.5 %). *Drepanoistodus forceps* amounts to 25.9 %, while all other species are below 10 %. One sample from 60.85 – 60.90 m, a level immediately above that of the last discussed sample, has an *O. evae* Zone fauna of the kind just described, but the zonal index species is missing and *D. forceps* is the most numerous species with 70 % of the elements. However, *O. evae* reappears in the next higher sample, from 60.00 m, but there only amounts to 19.5 %, and is thus considerably less numerous than in the older samples from the *O. evae* Zone. On the other hand, *D. forceps* with 51 % in the sample from 60.00 m is more numerous than in the previous samples where *O. evae* was present. Other changes in species frequency between these samples are negligible. In the sample from 60.00 m the oldest specimens of "*Scolopodus gracilis*" and *Semiacontiodus* sp. appear.

The interval described above, from 61.10 to 60.00 m, with a typical *O. evae* Zone fauna, coincides closely with that distinguished as the trilobite zone of *Megalaspides* (*Megalaspides*) *dalecarlicus* by Tjernvik & Johansson (1980), which includes beds from 61.00 to 59.94 m in the core.

In the next interval, conodont samples were taken from 59.50, 59.00, 58.50 – 58.57, 58.50, 58.00, 57.50, and 57.00 m, comprising the intervals distinguished as the *Megistaspis* (*Varvaspis*) *estonica* Zone and the basal 1 m of the *Megistaspis* (*Megistaspis*) *lata* Zone by Tjernvik & Johansson (1980). These samples have an impoverished *O. evae* Zone fauna and lack species typical of younger beds. They have been considered to come from the upper part of the *O. evae* Zone. In all these samples, *O. evae* and *Paroistodus parallelus* are missing, but the latter species is replaced from 58.50 m and upwards in younger beds by *Paroistodus originalis*, which, however, is very infrequent. *Stolodus stola* has its latest appearance at 58.00 m, while "*Scolopodus gracilis*" (Fig. 4 AK) disappears after 58.50 m, and only appears again in the *E. ? variabilis – M. flabellum* Subzone. In all seven samples from the interval 59.50 to 57.00 m *Drepanoistodus forceps* is the most numerous species with a frequency normally around 50 %, except for the two top samples, where its frequency exceeds 70 %. *Periodon flabellum* is fairly frequent in four of the samples from this interval with a maximum of 27 % at 58.50 – 58.57 m. *Protopanderodus rectus* is present in all seven samples and with frequencies of about 10 %. *Cornuodus longibasis, Protopanderodus rectus, Scolopodus rex* and *Drepanodus arcuatus* occur consistently, but in lower numbers in the interval, while other species present in the lower part of the *O. evae* Zone appear only sporadically here.

The *Baltoniodus triangularis* to *Paroistodus originalis* Zones

At 56.50 m *Baltoniodus triangularis, B. navis* and *Microzarkodina flabellum flabellum* first appear. They indicate the beginning of the Volkhovian. As *B. triangularis* and *B. navis* appear for the first time in the same sample, it is impossible to distinguish a separate *B. triangularis* Zone here. However, it is quite possible that this zone may be present somewhere between 57.00 m and 56.50 m, as the interval with only *B. triangularis* usually has a very limited vertical extension in Balto-Scandia (cf. Lindström 1971, p. 31). As *B. triangularis* and *B. navis* occur together in many samples in the interval between the upper boundary of the *O. evae* Zone at 56.50 m and the lower boundary of the *Paroistodus originalis* Zone at 51.50 m in the Finngrundet core, this interval is referred to collectively as the *B. triangularis* and *B. navis* Zones. Within this interval the following species appear for the first time in the core: *Protopanderodus* cf. *varicostatus*, (at 56.00 m), *Scalpellodus* cf. *latus* (at 55.50 m) and *Drepanoistodus basiovalis* (at 54.50 m), each of which, however, at most constitutes a few percent of the fauna. The last mentioned species occurs together with its predecessor, *D. forceps*, which is by far the most numerous of the two in the interval. Actually, it is the most numerous species of all in this interval, having a frequency of more than 45 % in all but one sample (at 52.50 m). Not until the level 51.50 m does *D. basiovalis* outnumber *D. forceps* in any sample. Species rather common in the *B. triangularis* and *B. navis* Zones are *Protopanderodus rectus* (from 6 to 15 %) and *Microzarkodina flabellum flabellum* (from 11 to 35 %, but totally absent from the samples at 56.00 and 55.50 m). Other species are much less common in the interval, the two *Baltoniodus* species for instance, together amount to more than 10 % only in the sample from 54.00 m, and usually have a combined frequency below 5 %, while *Cornuodus longibasis* is below 3.5 % in the entire interval. *Periodon flabellum* is of importance only in the lower half of the interval, where it has a maximum of 12 % at 55.50 m. *Scolopodus rex, Scolopodus? peselephantis* and *Drepanodus arcuatus* are present in most samples from the interval, but in numbers below 2.5 %. Some specimens of *Oistodus lanceolatus, Paroistodus originalis* and *Walliserodus* cf. *ethingtoni* were also found in the interval. *Scandodus furnishi* has its last occurrence at 55.00 m.

The first specimens of *Eoneoprioniodus brevibasis* (= *Scandodus brevibasis* of Lindström 1971) appear at 53.00 m, but they only make up 0.2 % of the fauna. In fact, this low frequency prevails up to 51.50 m, where the species reaches an abundance of 1 %. At 51.50 m *Paroistodus originalis* also shows a sharp increase in abundance (from 1.2 to 26 %). As 51.50 m is also the level where *Drepanoistodus basiovalis* first outnumbers *D. forceps;* the *P. originalis* Zone is judged to have its base here.

The boundaries of the combined *B. triangularis* and *B. navis* Zones (56.50 to 51.50 m) coincide approximately with those of the trilobite Zone of *Megistaspis* (*Megistaspis*) *lata* (58.00 – 51.07 m; Tjernvik & Johansson 1980, p. 190) in the core. The conodont Zone of *P. originalis* (51.50 – 45.60 m) corresponds even closer to the contemporary trilobite Zone, that of *Megistaspis* (*Megistaspis*) *simon* (51.07 – 45.48 m; Tjernvik & Johansson, 1980, p. 191).

In the *P. originalis* Zone the zonal index species is the most numerous one in the interval up to and including the sample from 48.50 m. Its frequency in the interval is generally about 40 %. In the same interval *Drepanoistodus* is much less common than in the previous interval (a drop in frequency of *Drepanoistodus* elements from about 50 to about 15 %). Nonetheless, *D. basiovalis* is one of the three or four most frequent species in the lower part of the *P. originalis* Zone. Elements of *D. basiovalis* are by far more numerous than those of *D. forceps,* a species which is last observed at 51.00 m. In the interval up to 48.50 m, *B. navis* usually has a frequency of between 15 and 20 %, except in the two lowermost samples, where it is about 8 %. *Protopanderodus rectus* is also fairly common with a frequency between 5 and 20 %. *Microzarkodina flabellum parva* (Fig. 4 A–G) appears at 50.00 m for the first time. It replaces *M. flabellum flabellum* (Fig. 4 H–N) in the lower part of the zone, but occasional specimens of the older subspecies occur throughout the zone. Specimens of *M. flabellum* are much less common than in the *B. triangularis* and *B. navis* Zones, and in the lower half of the *P. originalis* Zone they usually have a frequency of about 5 %. *Eoneoprioniodus brevibasis* is usually present in numbers between 1 and 2 %, but has a maximum of 7.5 % at 49.50 m. In the same interval *Cornuodus longibasis* is present in all samples and with slightly higher frequencies with a maximum of 5 % at 50.50 m, while *Periodon flabellum* only occurs in three samples with a frequency of about 5 %. *Scolopodus rex, Scolopodus? peselephantis, Drepanodus arcuatus* and *Scalpellodus latus* appear quite regularly in samples from the interval, but usually in frequencies below 1 %. Typical elements of *Scalpellodus latus* (Fig. 4 AL–AP) appear at 51.00 m, thus at approximately the same level as in Jämtland (N. Sweden), although in that area the preceding taxon, *S.* cf. *latus* (Fig. 4 AQ–AS, AZ, AAA), has not been found. *Oistodus lanceolatus* occurs for the last time at 51.50 m. *Protoprioniodus* cf. *simplicissimus* has one of its sparse occurrences at Finngrundet at 51.50 m. At 51.00 and 50.00 m there are questionable appearances of *Drepanoistodus?* cf. *venustus,* which otherwise is not present until the uppermost part of the zone.

In the upper half of the *P. originalis* Zone, represented by samples from 48.00 m up to and including the sample from 46.00 m, there is a conspicuous drop in frequency for *P. originalis* compared with the lower half of the zone. In the upper part, its occurrence is irregular; the species is totally missing from three samples, while the frequency in the other three samples varies from 2 to 20 %. But even that maximum is below average for the preceding interval. *Baltoniodus navis* is more numerous than in the lower part of the zone, with two maxima of 40 and 37 %. *Microzarkodina flabellum* also has higher frequencies than in the previous interval, with a mean of 21 %, compared with 8 % in the lower half of the zone, while *Periodon flabellum* is missing in all samples but one, where it has a frequency of less than 1 %. The frequency of *Protopanderodus rectus* varies between 5 and 19 %, that is about the same as in the lower half of the zone, and *Drepanoistodus basiovalis* has highly varying numbers (between 1 and 27 %) with a mean of 12 %. Specimens of *Scalpellodus latus* are not uncommon. They vary from 4 to 12 % in the upper half of the *P. originalis* Zone. *Eoneoprioniodus brevibasis* occurs last at the upper boundary of this zone. The species is quite abundant in some samples in the interval, with a maximum of 11 % at 46.50 m. *Drepanodus arcuatus,* never abundant in the Finngrundet core, has unusually high frequen-

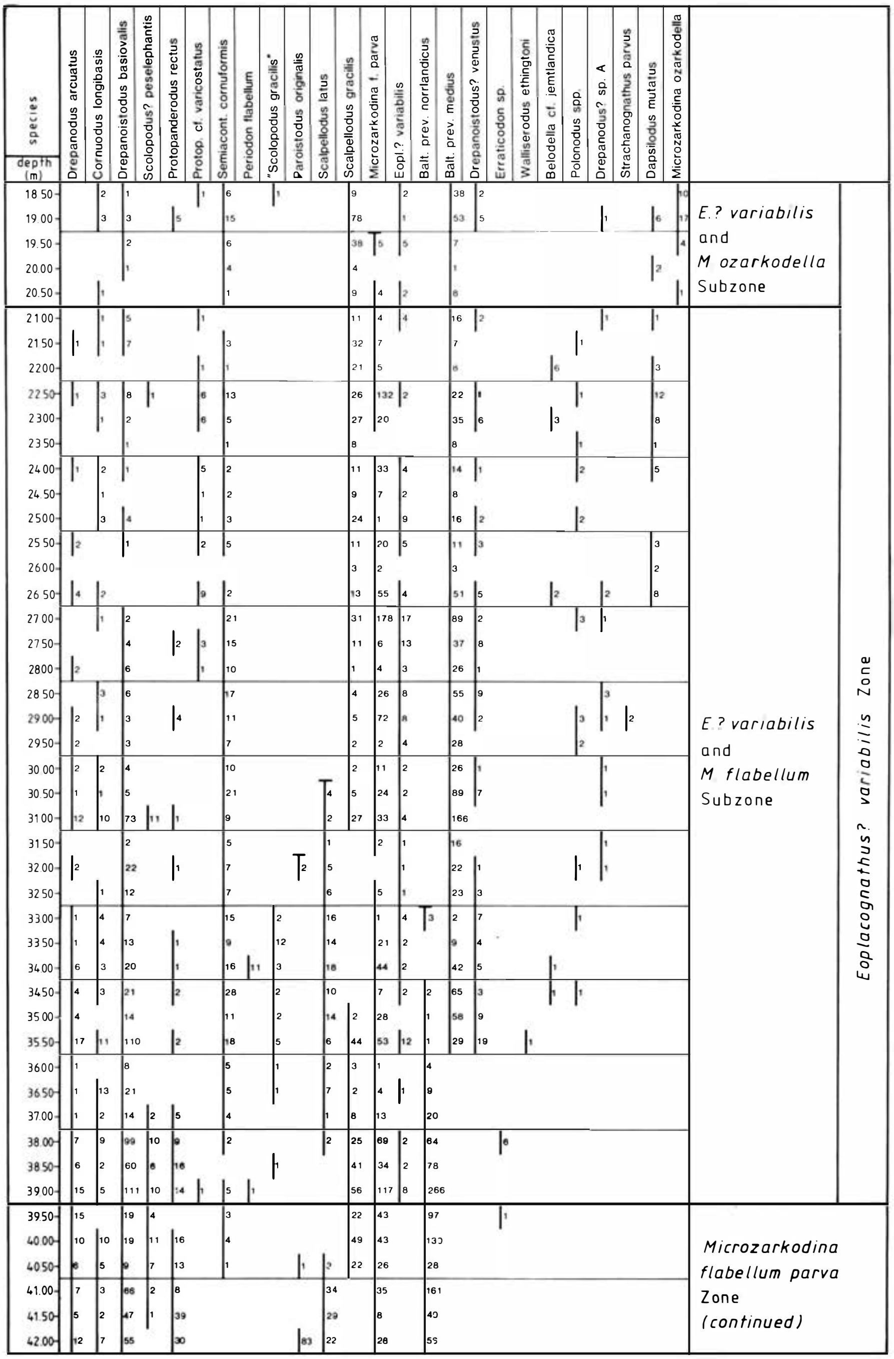


Fig. 3. Distribution of identified conodont taxa and number of elements of each taxon in the Finngrundet core in samples from the middle part of the *M. flabellum parva* Zone to the top within the *E. ? variabilis – M. ozarkodella* Subzone. Levels indicated in the left part of the diagram are those from which samples were taken (a piece of core usually from 0.03 m below to 0.03 m above the marked level). Short horizontal lines on top of the vertical distribution lines denote last occurrences which are interpreted as (local) extinctions. Heavy horizontal lines denote the boundaries between zones and subzones; thin horizontal lines are for help in reading the diagram.

cies in this interval, with a mean of about 4 %. *Cornuodus longibasis* and *Scolopodus? peselephantis* occur persistently, but with only a few percent each, while *Scolopodus rex*, *Protopanderodus* cf. *varicostatus* and *Drepanoistodus?* cf. *venustus* occur more sporadically and in very low numbers.

The *Microzarkodina flabellum parva* Zone

At 45.60 m the first specimens of *Semiacontiodus cornuformis* appear, which marks the base of the *Microzarkodina flabellum parva* Zone (Figs. 2 and 3). Also, the first specimens of *Baltoniodus prevariabilis norrlandicus* appear at this level. In the lowermost part of the zone the last representatives of *Microzarkodina flabellum flabellum* and *B. navis* were found. At 44.00 m the last specimens of *Scolopodus rex* occur. The most numerous species in the zone is *B. prevariabilis norrlandicus* with a frequency usually around 20 %, but with no less than 51 % at 41.00 m and 45 % at 40.00 m. Other fairly common species are *Microzarkodina flabellum parva* with about 20 % near the upper and lower boundaries of the zone, but only about 5 % in the middle part, and *Drepanoistodus basiovalis* with a maximum of about 30 % in the middle part of the zone and about 10 % near the lower and upper boundaries. *Protopanderodus rectus* is more abundant in the lower half of the zone (about 15 %) than in the upper half (about 10 %). There is a marked variation in the frequency of *Paroistodus originalis* in the zone. In the lowermost part it amounts to about 30 %, but from 44.50 m and upwards it occurs only sporadically, except for a last maximum of 28 % at 42.00 m. The most astonishing appearance in this zone is that of *Scalpellodus gracilis*, which appears at 40.50 m and then replaces *Scalpellodus latus*. This appearance of *S. gracilis* is much earlier than observed in Jämtland (Löfgren, 1978), where this species first occurs in the upper part of the *E.? variabilis – M. flabellum* Subzone. This difference in the first appearance of *S. gracilis* is partly explained by the fact that *S. latus* evidently did not become extinct when it was replaced by *S. gracilis* at Finngrundet. In the lower part of the *E.? variabilis – M. flabellum* Subzone in the Finngrundet core it reappears, replacing *S. gracilis*, but is again, and now definitely, substituted by that species in the middle part of the subzone. Most probably it is the equivalent of this last replacement of *S. latus* by *S. gracilis* that was recorded (Löfgren, 1978, p. 29) in Jämtland, while the first replacement did not occur at all in that area, or was overlooked due to scarcity of typical elements in the critical interval. Elements of *Scalpellodus* are fairly common in the *M. flabellum parva* Zone, especially in the upper third, where it usually has a frequency of about 15 %. Persistently appearing in almost every sample, but in numbers still usually below 5 %, are *Cornuodus longibasis* and *Scolopodus? peselephantis*, while *Drepanodus arcuatus* occurs in all samples from the interval and in numbers around 5 %. *Semiacontiodus cornuformis* is more infrequent; it never reaches 2 % in the *M. flabellum parva* Zone. In this zone, there are also single appearances of *Walliserodus* cf. *ethingtoni*, *Protopanderodus* cf. *varicostatus*, *Drepanoistodus?* cf. *venustus*, and *Periodon flabellum*. One specimen of *Eoneoprioniodus* (possibly a successor of *E. brevibasis*) was found in the middle part of this zone, and also a specimen of *Erraticodon* at 39.50 m.

The lower and upper boundaries of the *M. flabellum parva* Zone (45.60 – 39.00 m) closely agree with those of the corresponding trilobite zone, that of *Megistaspis* (*Megistaspis*) *limbata* (45.58 – 39.10 m; Tjernvik & Johansson, 1980, p. 192).

The *Eoplacognathus? variabilis* Zone

At 39.00 m the first identifiable elements of *Eoplacognathus? variabilis* were found. Their appearance has been used to denote the lower boundary of the *E.? variabilis – M. flabellum* Subzone, as well as the lower boundary of the *E.? variabilis* Zone.

The earliest occurrence of *B. prevariabilis medius* is at 35.50 m. The taxon has an interval of co-occurrence with its predecessor *B. prevariabilis norrlandicus* up to 33.00 m, and by 32.50 m the older subspecies has disappeared completely. *Baltoniodus prevariabilis* has quite varying numbers in the subzone. There are at least three maxima with more than 40 %, one at the lower boundary, one at 35.00 – 34.50 m, and one at 31.50 – 28.00 m. Between these maxima the frequencies are normally between 10 and 30 %. *Microzarkodina flabellum parva* varies in the interval 39.50 – 33.50 m between 4 and 25 % with a mean of 15.5 %; between 33.00 and 29.50 there is a minimum with usually below 10 %, and between 29.00 and 22.50 m the frequency fluctuates highly with four maxima with more than 40 % and three minima, two of which are below 10 %. In the uppermost part of the subzone the frequency is more even and not so high (about 15 %). Elements of *Drepanoistodus basiovalis* are quite numerous in the lower part of the subzone. From 39.00 to 35.50 m it has frequencies from about 20 to about 35 %. At 35.50 m another *Drepanoistodus* species, *D.? venustus* appears, and from 35.00 m frequencies of *Drepanoistodus* elements are generally lower, although there is a maximum of 35 % at 32.00 m. From 30.50 m and higher up in the subzone *Drepanoistodus* frequencies hardly ever exceed 10 %. Elements of *Scalpellodus* (*S. gracilis*, except in the middle part of the subzone, where *S. latus* reappears briefly, cf. p. 122) generally amount to between 10 and 20 % in the interval 39.50 to 32.50 m. Between 32.00 and 26.00 m the abundance declines and never reaches 10 %. The uppermost part of the subzone, between 25.50 and 21.00 m is characterized by widely fluctuating frequencies from 12 to 54 %, with at least two maxima (37 % at 25.00 m and 54 % at 21.50 m). *Semiacontiodus cornuformis* is considerably more common than previously. It is present in all samples but three in the interval and has frequencies below 10 % up to 35.00 m, usually 10–20 % between 34.50 and 27.50 m, and again below 10 % from 27.00 to 21.00 m. The most marked decrease in numbers compared with the *Microzarkodina flabellum parva* Zone is shown by *Protopanderodus*, represented by elements of *P. rectus* and *P.* cf. *varicostatus*. In no sample from the subzone does their combined frequency reach 10 %, and it is usually below 5 %. *Protopanderodus rectus* is the dominating one of the two species up to 29.00 m, while *P.* cf. *varicostatus* prevails in younger beds. Among the less common species in the subzone is *Eoplacognathus? variabilis*, the zonal index species, which is below 5 % in all samples in the lower half of the subzone, but generally slightly more numerous in the upper half with a maximum of 12 % at 27.50 m. Other platforms, like those of *Polonodus* are still less common. *Conuodos longibasis*, as in the previous intervals, hardly ever exceeds 5 %, but it has a notable maximum at 36.50 m of about 20 %. "*Scolopodus gracilis*" (Fig. 4 AG–AK) which had been missing from Finngrundet since the upper part of the *O. evae* Zone now reappears at 38.50 m, then appears in all samples from 36.50 to 33.00 m with a frequency of usually a few percent, but has a maximum of about 13 % at 33.50 m. There is a single appearance of elements of *Erraticodon* sp. (Fig. 4 AT–AY) at 38.00 m and *Dapsilodus mutatus* occurs from 26.50 m and upwards in frequencies below 7 %. *Drepanodus arcuatus* occurs in many samples in the subzone, but not as persistantly as previously and always in frequencies below 5 %. *Scolopodus? peselephantis* occurs in a low percentage in all samples up to 37.00 m, then only at 31.00 and 22.50 m, while *Paroistodus originalis* has its only occurrence in the subzone (and last occurrence in the core) at 32.00 m. Occasional specimens of *Belodella* cf. *jemtlandica*, *Periodon flabellum*, *Walliserodus ethingtoni*, *Drepanodus?* sp. A. and *Strachanognathus parvus* also occur in the subzone.

At 20.50 m the first elements of *Microzarkodina ozarkodella* appear, denoting the base of the next higher subzone, the *E.? variabilis – M. ozarkodella* Subzone. Actually, two isolated elements of *M. ozarkodella*-type were found as early as 31.00 m, but were judged to be aberrant forms of *M. flabellum*. Occasional elements of this kind can even be found in the *B. navis* Zone, but in extremely low frequencies. Also, a few elements of *M. flabellum* still prevail in the basal metres of the *E.? variabilis – M. ozarkodella* Subzone, but *M. ozarkodella* is the greatly dominating one of the two species, with about 10 % relative frequency. The fauna in this subzone is less varied than that of the previous one. There are for instance no other platform species than *E.? variabilis*, and elements of *Protopanderodus rectus* as well as *Protopanderodus* cf. *varicostatus* are extremely scarce. The two most numerous species are *Baltoniodus prevariabilis medius* and *Scalpellodus gracilis*. *Semiacontiodus cornuformis*, *Drepanoistodus basiovalis* and *Cornuodus longibasis* are present in most samples in low numbers, while only occasional specimens of *Drepanoistodus? venustus*, *Dapsilodus mutatus*, *Drepanodus?* n.sp. A and "*Scolopodus gracilis*" were found.

Comments on the biostratigraphical subdivision

As can be seen from the subdivision described above and illustrated in Fig. 1, several conodont and trilobite zonal boundaries coincide closely. In several of these cases, the actual zonal boundaries may have proven to be even closer to each other, if the spacing of the conodont samples had been closer in these critical intervals. One explanation of this close coincidence between trilobite and conodont zones could be that mutual boundaries denote major environmental changes or even stratigraphic gaps. Some kind of alteration in the environment can, and must perhaps, be intrinsic to any change in the fauna. The sole exception may possibly be when a phyletic change within a lineage leads to the replacement of an older species by its immediate successor. Several such phyletic exchanges occur at or near conodont zonal boundaries at Finngrundet, but only one, the replacement of *Microzarkodina flabellum parva* by *M. ozarkodella*, is the main criterion for drawing a (sub)zonal boundary. As the upper boundary of a zone is coincident with, and defined by, the level where the next higher zone has its lower boundary, first appearances of taxa are more often used to delimit zones than last occurrences. One or more such first appearances are thus by definition normally encountered at a zonal boundary. If, however, several first appearances of new taxa coincide with last occurrences of old ones at a zonal boundary, a major change in the environment or a stratigraphic gap can be suspected.

At Finngrundet, only the boundary between the

P. proteus and *O. evae* Zones (at 61.10 m) appears to be of this kind, with four appearances of new species and four last occurrences (and one phyletic transition). As can be seen from the trilobite fauna, however (Tjernvik & Johansson, 1980, p. 185–187), the interval around this boundary is characterized by a mixture of older and younger faunal elements. This can hardly be compatible with a major environmental turnover at the boundary. The other conodont zonal boundaries at Finngrundet are each characterized by a more diffuse faunal change with only a few first appearances and last occurrences of taxa at or near the boundary, while the majority of the species continue across the boundary.

To conclude, the close correspondence between several conodont and trilobite zonal boundaries at Finngrundet should not be taken as proof that the corresponding chronozonal boundaries coincide exactly. On the other hand, no major faunal breaks or stratigraphic gaps could be detected to explain the agreement. It is to be hoped that this attempt to correlate trilobite and conodont zones can be helpful in future stratigraphic correlations of Early Ordovician rocks.

Taxonomy

As the purpose of this investigation was mainly biostratigraphical, the systematic part has been restricted to some short taxonomic observations. Most of the species encountered at Finngrundet were also found in rocks of the same age in Jämtland (Löfgren 1978), and the reader is referred to that work for taxonomic comments and descriptions. In some cases the additional material from Finngrundet has added new taxonomic data and some of these taxa are thus commented on below.

Acodus deltatus deltatus Lindström

Fig. 4Z, AA, AB

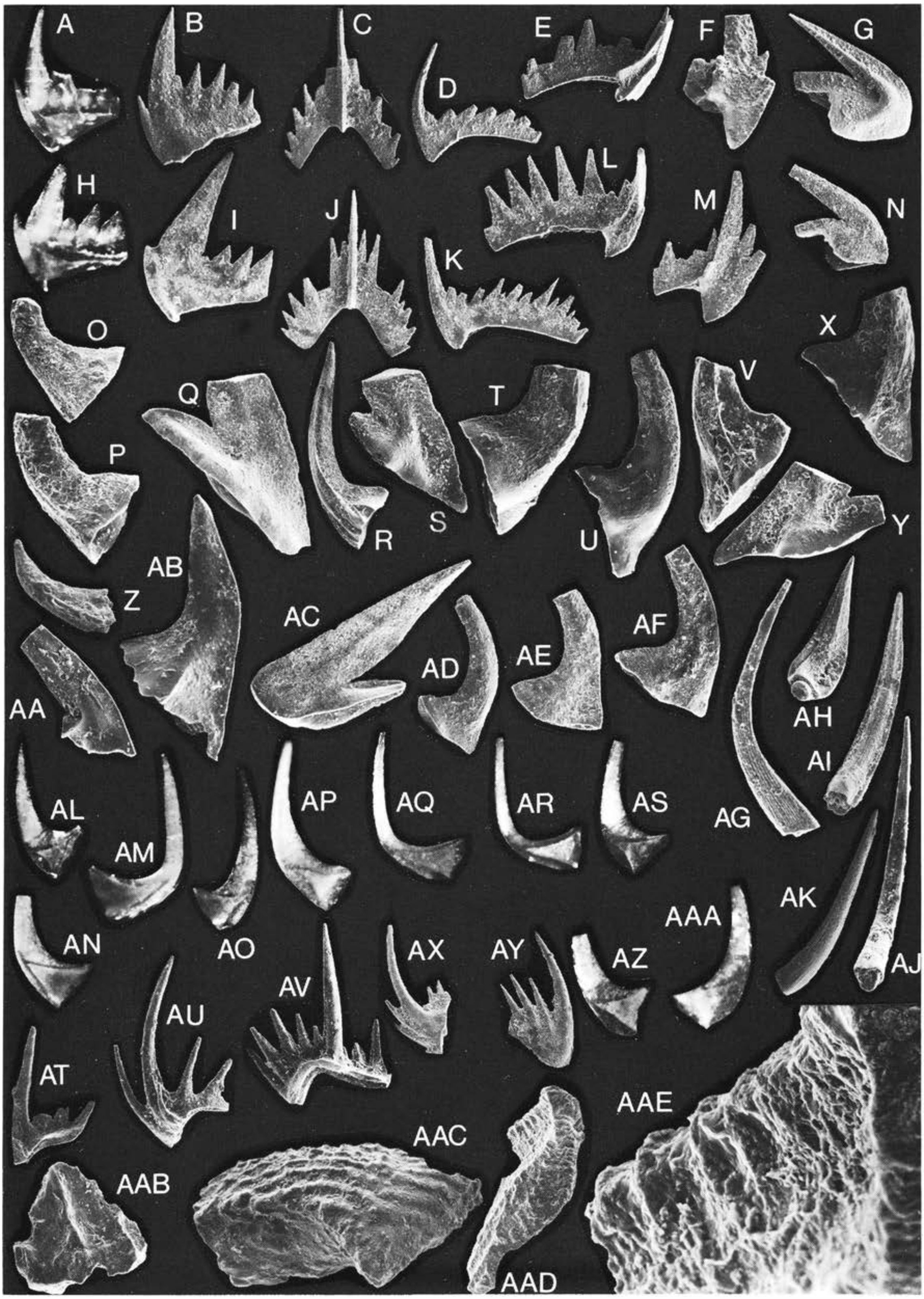
1955 *Acodus deltatus* n. sp. – Lindström, p. 544, Pl. 3:30

1977 *Acodus deltatus deltatus* Lindström – Lindström, p. 7, *Acodus*-Plate 2:8–13 (includes synonymy through 1975)

The specimens found agree well with Lindström's (1955, 1977) descriptions. Among the ramiform elements there are dolabrate and tertiopedate as well as quadriramate specimens.

Material. – 71 elements.

Fig. 4. Conodont elements from the Finngrundet core. All pictures except A, H, AL–AS, AZ and AAA are SEM pictures. □ A–G: *Microzarkodina flabellum parva* Lindström. □ A: Ozarkodiniform element PU no. B523 from 22.50 m, X48. □ B: Ozarkodiniform element PU no. B533 from 33.50 m, X70. □ C: Trichonodelliform element PU no. B534 from 22.50 m, X56. □ D: Cordylodontiform element PU no. B535 from 33.50 m, X80. □ E: Asymmetric ramiform element PU no. B536 from 22.50 m, X48. □ F: Asymmetric ramiform element PU no. B537 from 29.00 m, X70. □ G: Oistodontiform element PU no. B538 from 33.50 m, X80. □ H–N: *Microzarkodina flabellum flabellum* (Lindström). All elements from 52.50 m. □ H: Ozarkodiniform element PU no. B524, X55. □ I: Ozarkodiniform element PU no. B540, X55. □ J: Trichonodelliform element PU no. B541, X50. □ K: Cordylodontiform element PU no. B542, X55. □ L: Asymmetric ramiform element PU no. B543, X60. □ M: Asymmetric ramiform element PU no. B544, X55. □ N: Oistodontiform element PU no. B545, X60. □ O–Q: *Paltodus deltifer* (Lindström). All elements from 62.25 – 62.30 m. □ O: Drepanodontiform element PU no. B549, X50. □ P: Prioniodontiform element PU no. B550, X65. □ Q: Oistodontiform element PU no. B551, X55. □ R–U: *Paltodus* cf. *subaequalis* Pander. All elements from 62.50 – 62.54 m. □ R: ?Prioniodontiform element PU no. B553, X42. □ S: Oistodontiform element PU no. B554, X50. □ T: ?Drepanodontiform element PU no. B555, X75. □ U: Drepanodontiform element PU no. B556, X50. □ V–Y: *Paltodus subaequalis* Pander. All elements from 61.95 – 62.00 m. □ V: Drepanodontiform element PU no. B546, X62. □ X: Drepanodontiform element PU no. B547, X62. □ Y: Oistodontiform element PU no. B548, X46. □ Z, AA, AB: *Acodus deltatus deltatus* Lindström. □ Z: Ramiform element PU no. B560 from 61.95 – 62.00 m, X60. □ AA: Oistodontiform element PU no. B561 from 61.48 – 61.53 m, X80. □ AB: Prioniodontiform element PU no. B562 from 61.95 – 62.00 m, X60. □ AC–AE: *Drepanoistodus forceps* (Lindström). All elements from 61.23 – 61.28 m. □ AC: Oistodontiform element PU no. B557, X40. □ AD: Drepanodontiform element PU no. B558, X40. □ AE: Drepanodontiform element PU no. B559, X50. □ AF: *Drepanoistodus* cf. *forceps* (Lindström). Drepanodontifrom element PU no. B552 from 62.25 – 62.30 m, X60. □ AG–AK: "*Scolopodus gracilis*" Ethington & Clark. AG–AJ from 33.50 m, AK from 59.50 m. □ AG: PU no. B566, X90. □ AH: PU no. B563, X60. □ AI: PU no. B564, X80. □ AJ: PU no. 565, X50. □ AK: PU no. B539, X50. □ AL–AP: *Scalpellodus latus* (van Wamel). AL, AN, AO short-based drepanodontiform elements; AM long-based drepanodontiform element; AP scandodontiform element. □ AL: Early form PU no. B525 from 50.50 m, X40. □ AM: PU no. B526 from 46.66 m, X40. □ AN: PU no B527 from 42.50 m, X40. □ AO: Early form, PU no. B528 from 51.00 m, X50. □ AP: PU no. B529 from 42.50 m, X50. □ AQ–AS, AZ, AAA: *Scalpellodus* cf. *latus* (van Wamel). AQ–AR long-based drepanodontiform elements; AS, AZ and AAA short-based drepanodontiform elements. □ AQ: PU no. B567 from 52.00 m, X47. □ AR: PU no. B530 from 51.50 m, X70. □ AS: PU no. B531 from 52.50 m, X47. □ AZ: PU no B532 from 51.50 m, X54. □ AAA: PU no. B568 from 52.50 m, X80. □ AT–AY: *Erraticodon* sp. All elements from 38.00 m. □ AT: ?Hindeodelliform element PU no. B572, X60. □ AU: Cladognathodontiform element PU no. B573, X60. □ AV: Zygognathodontiform element PU no. B574, X35. □ AX: Ozarkodiniform element PU no. B575, X35. □ AY: Neoprioniodontiform element PU no. B576, X35. □ AAB–AAE: *Polonodus?* sp. All elements from 61.23 – 61.28 m. □ AAB: Ramiform element PU no. B569, X45. □ AAC: Platform element (posterior up), PU no. B570, X45. □ AAD: Platform element (posterior to the right), PU no. B571, X40. □ AAE: Detail of AAD, X230.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Drepanoistodus cf. *forceps* (Lindström)

Fig. 4 AF

cf. 1955 *Oistodus forceps* n. sp. – Lindström, p. 574, Pl. 4:9–13, Fig. 3M

cf. 1973 *Drepanoistodus forceps* (Lindström, 1955) – Lindström, p. 75, *Drepanodus* -Plate 1:5, 6

cf. 1978 *Drepanoistodus forceps* (Lindström) – Löfgren, pp. 53–55, Pl. 1:1–6, Fig. 26A (includes synonymy through 1977)

An array of drepanodontiform elements from the Hunnebergian, of a kind generally attributable to *Drepanoistodus* are included in *D.* cf. *forceps*. Some of these elements are similar to forms originally described as *Drepanodus amoenus* by Lindström (1955), some similar to those described by him as *Drepanodus homocurvatus*, while a few are close to forms described by him as *Drepanodus planus* in the same publication. Had these elements been found associated with oistodontiform elements of *D. forceps*, their assignment would have been no problem. In fact, associations like this can be found slightly higher up in the core in beds of Billingen age. But in oldest Arenigian beds no oistodontiform elements of that kind have been encountered. I tend to agree with Lindström (1973:75) that elements like those described as *Drepanodus amoenus* from the late Tremadocian may have been associated with oistodontiform elements closely similar to those of coeval *Paroistodus*. As a taxon with drepanodontiform elements virtually indistinguishable from those of slightly younger. *D. forceps* (cf. Fig. 4 AF and AD–AE), *D.* cf. *forceps* was most probably the immediate predecessor of that species, and it is most natural to assign both taxa to the same genus. More numerous collections than those at hand are needed to eventually ascertain what the oistodontiform element of *D.* cf. *forceps* looked like. Until then, open nomenclature is to be preferred for this taxon.
Material. – 31 drepanodontiform elements.

Erraticodon sp.

Fig. 4 AT–AY

Seven hyaline elements, one from the top of the *M. f. parva* Zone and six from a sample low down in the *E.*? *variabilis* – *M. flabellum* Subzone have been referred to as *Erraticodon* sp. The type-species of this genus, *E. balticus* Dzik (Dzik 1978:66), was recovered from the Llanvirnian *E. foliaceus* and *E. robustus* Zones. Although the specimens in the present study show no striking resemblance to elements of *E. balticus*, that species seems to be the one most closely related to the Finngrundet taxon among hitherto described *Erraticodon* species.

Three of the Finngrundet specimens are very similar to each other (one is illustrated in Fig. 4 AT), and can probably be designated as corresponding to the hindeodelliform element of *E. balticus*, but they have no anterior process, a twisted, denticulated posterior process and an inner-lateral flare of the base, which might develop into a short process.

One element is ozarkodiniform (Fig. 4 AX). It has longer denticles on the anterior process than in the corresponding specimens figured by Dzik (1978, Fig. 6a, Pl. 15:1), but this may be due to ontogenetic differences. The element of ?*Erraticodon* sp. figured by Ethington & Clark (1982, Pl 4:18) is probably another example of the same element type.

The neopriodontiform element in the present collection (Fig. 4 AY) agrees excellently with the specimen(s) figured by Dzik.

An element which should have occupied an S position can be described as cladognathodontiform (Fig. 4 AU). It has a denticulated posterior process and two asymmetrically directed lateral processes, each with one denticle. The element looks like a symmetry-transition variant of the trichonodelliform element of *E. balticus*.

The element found in this study most probably corresponding to the plectospathodiform element of *E. balticus* is a digyrate, zygognathodontiform element with two processes twisted in opposite directions (Fig. 4 AV).

Most of the *E. balticus* specimens figured by Dzik have one especially large denticle on the posterior process, while the elements in the present study have subequally long denticles on that process. It is unlikely that the variation in *E. balticus* was great enough to include the Finngrundet specimens. On the other hand, the great similarity between the neoprioniodontiform element of *E. balticus* and of *E.* sp. indicates that the taxa are at least congeneric. Hindeodelliform and neoprioniodontiform elements of *Erraticodon* were also found in the *E. suecicus* – *P. sulcatus* Subzone and a trichonodelliform element, designated as Gen. et sp. indet. B (Löfgren 1978, Pl. 1:41–44), in the *E. foliaceus* Subzone of Jämtland. At least the trichonodelliform element, approximately contemporaneous with the material on which Dzik based *E. balticus*, should belong to that species.

As for the other Jämtland specimens and those from Finngrundet, they could belong to one or more older *Erraticodon* species. Due to the small amount of specimens at hand, open nomenclature should be used for the time being.

Ethington & Clark (1982) described *Erraticodon* elements from beds in Utah which may be approximately coeval with the *Erraticodon*-bearing beds at

Finngrundet. Yet, the Utah taxon, called *E.* aff. *E. balticus*, seems to have greater affinities to *E. balticus* than to the Finngrundet specimens, as only its hindeodelliform elements seem to differ appreciably from those of *E. balticus* (Ethington & Clark, 1982, p. 45). The even older Australian species, *E. patu*, described by Cooper (1981, p. 1666) has a distinctly different set of elements than those recovered from Finngrundet.
Material. – 7 elements.

Microzarkodina flabellum parva Lindström

Fig. 4 A–G

1971 *Microzarkodina parva* n. sp. – Lindström, p. 59, Pl. 1:14
1975 *Microzarkodina parva* Lindström – Lindström, p. 193, *Microzarkodina*-Plate 1:7
1976 *Microzarkodina flabellum parva* Lindström – Dzik, Fig. 35a–h

Lindström (1971, p. 59) introduced the name *M. parva* for a successor of *M. flabellum*. He stated that the main difference between the two species was that in *M. flabellum* the denticles reach about half the height of the cusp in the ozarkodiniform element, while in *M. parva* the denticles reach considerably less than half the height of the cusp. Several subsequent authors (including Löfgren, 1978) have experienced difficulties when trying to distinguish between the two taxa, especially in less well preserved collections. Yet, Lindström (1971, 1975) is no doubt right when he states that there is a morphologic difference between stratigraphically older and younger representatives of *Microzarkodina* with one denticle in front of the cusp in the ozarkodiniform element. In the rich and relatively well preserved *Microzarkodina* faunas from Finngrundet distinction between the two taxa was thus possible with the younger taxon replacing the older within the *P. originalis* Zone.

Besides the already mentioned difference of relative cusp/denticle height, there is another useful criterion for distinguishing the ozarkodiniform elements of *M. f. parva* from those of *M. f. flabellum*. In the latter, the angle between the anterior margin of the base (along the anterior margin of the anterior denticle) and the anterior edge of the cusp is more pronounced, and thus makes the tip of the anterior denticle diverge more strongly away from the cusp than in *M. f. parva* (cf. Fig. 4A, B with Fig. 4H, I).

The differences between the taxa are extremely slight in the other element-types and, in agreement with Dzik (1976) it is suggested that they should only be regarded as separate at the subspecific level.

Material. – 1708 elements, of which 628 are ozarkodiniform.

Paltodus cf. *subaequalis* Pander

Fig. 4 R–U

cf. 1856 *Paltodus subaequalis* n. sp. – Pander, p. 24, Pl. 1:24, text-fig. 4a
cf. 1977 *Paltodus subaequalis* Pander – Lindström, p. 427, *Paltodus*-Plate 1:7–9 (includes synonymy through 1975)

Most of the ramiform (drepanodontiform) elements found lack the lateral costae that characterize drepanodontiform elements of *P. subaequalis*, but the general outline is very similar.

The oistodontiform elements are few, but seem to agree more closely with those of typical *P. subaequalis* than with those of *P. deltifer*, that is, there is a rather distinct inner lateral carina.

There are also co-occurring prioniodontiform (acodontiform) elements with a rather more flaring base than in corresponding elements of *P. deltifer*, but not as wide a base as in those of *Acodus deltatus deltatus*. In addition to "normal" anterior, posterior and lateral costae prioniodontiform elements here referred to *P.* cf. *subaequalis* carry short extra costae on the anterio-lateral and posterio-lateral faces of the base (Fig. 4 R). Similar costae in otherwise normal prioniodontiform elements of *P. deltifer* from the late Tremadocian of Västergötland (Sweden), have also been observed by the author.

In the Tremadocian and earliest Arenigian, species of *Paltodus* and *Acodus* were obviously very similar, and as there are some unidentified elements of one or more *Acodus* species present at the same level as *P.* cf. *subaequalis* at Finngrundet, it cannot be excluded that the prioniodontiform elements discussed belong to *Acodus* rather than to *Paltodus*. However, the presence of additional costae seems to be more characteristic of *Paltodus* than of *Acodus*. Moreover, the predecessor of *P. subaequalis* had (similar) prioniodontiform elements, and it seems reasonable to assume that at least early representatives of *P. subaequalis* could also have had the same kind of elements. Typical populations of *P. subaequalis*, on the other hand, seem to lack well defined prioniodontiform elements (Lindström (1977) and the author's own observations).
Material. – 28 elements.

Scalpellodus cf. *latus* (van Wamel)

Fig. 4 AQ–AS, AZ, AAA

cf. 1974 *Protopanderodus latus* n. sp. – van Wamel, p. 91, Pl. 4:1–3 cf. 1978 *Scalpellodus latus* van Wamel – Löfgren, pp. 99–100, Pl. 5:10, 14, Pl. 6:1–4, 7, 21 (includes synonymy through 1977)

Scalpellodus cf. *latus* was recovered from the *Baltoniodus triangularis* and *B. navis* Zones at Finngrundet, and is the oldest representative of *Scalpellodus* known. The taxon is apparently the predecessor of typical *S. latus*, like those first described by van Wamel (1974) from the *P. originalis* Zone, and recovered from the *P. originalis* Zone to the middle part of the *E.? varabilis-M. flabellum* Subzone in Jämtland (Löfgren 1978). The morphological differences between *S.* cf. *latus* and *S. latus* are slight, mainly discerned in the short-based drepanodontiform element. In *S.* cf. *latus* the anterior edge along the base stops well above the aboral margin, and the anterior margin of the base below this point is slightly flaring. There is thus an evident break in the otherwise smooth curve of the anterior margin. In *S. latus* the entire anterior margin makes a smooth curve, and the anterior edge almost reaches the aboral margin. In long-based drepanodontiform elements of *S.* cf. *latus* the base is wider and shorter relative to the cusp than in *S. latus*. The scandodontiform element of *S.* cf. *latus* seems to be indistinguishable from that of *S. latus*.

As *S.* cf. *latus* seems to be more restricted geographically than *S. latus*, it seems reasonable to distinguish between the two taxonomically, even if *S.* cf. *latus* might be regarded only as an early representative of *S. latus*. With the meagre material at hand, however, it is difficult to evaluate the variation within *S.* cf. *latus*, and thus open nomenclature has been employed.

Material. – 20 elements.

REFERENCES

Cooper, B.J. 1981: Early Ordovician conodonts from the Horn Valley Siltstone, central Australia. *Palaeontology 24*, 147–183. London.

Dzik, J. 1976: Remarks on the evolution of Ordovician conodonts. *Acta Palaeontologica Polonica 21*, 395–455. Warszawa.

Dzik, J. 1978: Conodont biostratigraphy and paleogeographical relations of the Ordovician Mójcza Limestone (Holy Cross Mts., Poland). *Acta Palaeontologica Polonica 23*, 51–72. Warszawa.

Ethington, R.E. & Clark, D.L. 1982: Lower and Middle Ordovician conodonts from the Ibex Area western Millard County, Utah. *Brigham Young University Geology Studies 28:2*, 1–155. Provo, Utah.

Lindström, M. 1955: Conodonts from the lowermost Ordovician strata of south-central Sweden. *Geol. Fören. Stockholm Förh. 76*, 517–604. Stockholm.

Lindström, M. 1971: Lower Ordovician conodonts of Europe. *Geol. Soc. Am. Mem. 127*, 21–61. Boulder, Colorado.

Lindström, M. 1973: *Drepanoistodus. In* Ziegler, W. (ed): *Catalogue of Conodonts 1*, 68–76. Stuttgart.

Lindström, M. 1975: *Microzarkodina. In* Ziegler, W. (ed.): *Catalogue of Conodonts 2*, 185–193. Stuttgart.

Lindström, M. 1977: *Acodus* and *Paltodus. In* Ziegler, W. (ed.): *Catalogue of Conodonts 3*, 1–20, 415–433. Stuttgart.

Löfgren, A. 1978: Arenigian and Llanvirnian conodonts from Jämtland, northern Sweden. *Fossils and Strata 13*, 1–129. Oslo.

Pander, C.H. 1856: Monographie der fossilen Fische des Silurischen Systems der Russisch-Baltischen Gouvernements. *K. Akad. Wiss. St. Petersburg*, 1–91. St. Petersburg.

Thorslund, P. & Axberg, S. 1979: Geology of the southern Bothnian Sea. Part I. *Bulletin of the Geological Institutions of the University of Uppsala, N.S. 8*, 35–62. Uppsala.

Tjernvik, T.E & Johansson, J.V. 1980: Description of the upper portion of the drill-core from Finngrundet in the south Bothnian Bay. Geology of the southern Bothnian Sea. Part II. *Bulletin of the Geological Institutions of the University of Uppsala, N.S. 8*, 173–204. Uppsala.

van Wamel, W.A. 1974: Conodont biostratigraphy of the Upper Cambrian and Lower Ordovician of north-western Öland, south-eastern Sweden. *Utrecht Micropaleontol. Bull. 10*, 1–126. Netherlands.

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