Silurian conodont faunas from Gotland

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The faunal succession of conodonts on Gotland is briefly described, and some taxonomic comments are presented. As presently known, the faunas are stratigraphically important for correlations with areas outside Gotland, at several levels. The *Pterospathodus amorphognathoides* Zone occurs in the Lower Visby Beds, indicating that the base of the Wenlockian is within that unit. *Kockelella walliseri* occurs, often together with *Monograptus priodon* and *Rhipidium tenuistriatum* and other characteristic fossils, in Slite unit f and other Slite units. These occurrences are here interpreted as representing a single horizon which is identifiable world-wide. A variety of *K. variabilis* occurs in the Hemse Marl NW part and dates at least parts of that unit as Late? Bringewoodian and earliest Early Leintwardinian [late? late Gorstian and earliest early early (sic!) Ludfordian]. The *Polygnathoides siluricus* Zone is dated as Late? Leintwardinian (late? early Ludfordian) and traced from the coast of the Näs peninsula in the southwest to the easternmost Östergarn peninsula, improving local correlations. The zone thus includes parts of the Hemse Marl SE part, which unit is identified in a wider area than earlier known, and parts of the Millklint Limestone (uppermost Hemse limestone unit). *H. snajdri crispa* appears in the lower Burgsvik Beds and the oldest *H. steinhornensis* with alternating denticles yet found on Gotland occurs in the Hamra unit b. In the Silurian type area in Britain such populations are only known from the latest Whitcliffian (late late Ludfordian). □*Conodonta, biostratigraphy, Silurian, Gotland.*

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The early history of the stratigraphical research of Gotland was described by Hede (1921). The 13 subdivisions (now called Beds) introduced by him (Hede 1921, 1925 a) have remained the stratigraphic frame work used both in the geological map descriptions and in most subsequent work, even though many represent a long time interval. In most of the map descriptions these Beds are further subdivided, but as most of these units have lacked names or symbols, they have been little used. Laufeld (1974 a) extended the lettering of the units begun by Hede, and that system is followed here. The short remarks on the lithologic character of each unit are taken from Hede's map descriptions, from Hede (1960) and from Laufeld (1974 a). Hede's Beds and some of his minor units were largely faunistic subdivisions; thus many of the Beds include the whole range of lithologies common on Gotland. Hede (1919, 1942) based his correlations with other areas chiefly on the sparse occurrences of graptolites in the least calcareous parts of some of the Beds. Martinsson (1967), using the ostracodes, improved correlations both within Gotland and with areas outside the island.

Several publications have dealt with, mentioned or illustrated conodonts from Gotland (e.g., Lindström 1964; Martinsson 1967; Fåhraeus 1968; Jeppsson 1969, 1972, 1976, 1979 a; Barnes *et al.* 1973), but few have discussed the faunas. However, Fåhraeus (1969) listed the faunas in 22 samples, most of them producing less than 25 elements each. I have earlier commented upon the Hemse and younger conodont faunas (1974) and described those in the Lower Visby, Upper Visby and Högklint Beds in Vattenfallet (1979 c).

Recently (Holland 1980), a formal subdivision of the Wenlockian and the Ludlovian has been decided upon. Each series is now divided into two stages. Thus we have an unambiguous base for the convenient terms early and late, useful in the corresponding parts of the chronology. In the Ludlovian a greater precision was potentially possible – and partly achieved (cf. Holland 1980; Holland *et al.* 1980) – following the introduction of four stages with nine substages (Holland *et al.* 1963). In order not to lose this greater precision in correlations, I use also these older units.

Collections

This preliminary review is based on over 600 samples (about 3–6 kg each), the majority of which was collected in the late sixties and early seventies. (Regarding localities, see appendix.) Thereafter collecting was largely postponed due to lack of funds for extracting the conodont elements. Research grants from the Swedish National Research Council during the latter part of the seventies have now made it possible to dissolve 0.5 kg of each sample and another 0.5–4 kg of some of the richest ones. Nearly all of them have produced at least some conodont elements, and it seems probable that no unit is barren. Most of the collections are small, and it is evident that from several stratigraphical units adequate faunas can be obtained only from samples weighing tens of kilograms. One example of what can be obtained from large samples is the fauna from Möllbos 1. The first 0.5 kg dissolved yielded only 4 specimens, and therefore nothing more was dissolved for some time. However, the sample also showed that the strata contained silicified fossils. I have organized the study of such fossils on Gotland and have been able to get 'unemployment grants' for the preparation of the samples, with the result that more than 700 kg have now been dissolved in acetic acid. One of the samples from Möllbos 1, G 77–28 (78.32 kg), has been picked for conodonts, and has produced about 577 elements representing an extremely well preserved conodont fauna, one of the very best I have from Gotland. Many other important conodont faunas deriving from that project are mentioned in the text. Their sample numbers are chosen so that they do not duplicate those of my other samples. However, in the unabbreviated sample designation they are separated by the letters PSSFG and LJ respectively. I have received many samples and collections from Claes Bergman, Stig M. Bergström, Kent Larsson, Sven Laufeld, Anders Martinsson, and Carl Pleijel. The numbers of these samples are here followed by the initials of the collector, but in the designation of my own samples I have omitted LJ.

State of preservation. – Many limestones on Gotland consist of more or less worn skeletal debris. The conodont elements, too, are more or less worn in these limestones. Where possible, samples have been taken from lithologies in which the elements should show the least wear, but not uncommonly the only conodont remains found are a few rounded fragments of mature, robust elements of the most robust species (usually the sp elements of *Hindeodella confluens* and the *H. steinhornensis* group). Being translucent, they can, however, be identified on internal structures. Larger samples might possibly increase the length of the species list, but the original relative frequencies of different species would remain unknown. The same is true of the numbers of each element within an apparatus (if only known from such localities), and the distribution of different age groups within a population.

In most samples the state of preservation is better, but usually all the bar elements are in pieces and all denticles broken except the blunt ones on sp and oz elements. This might well have been ascribed to careless laboratory treatment, but now and then a sample treated in the same way as the others, at the same time and by the same people, has produced perfect specimens. Thus, the inferior state of preservation is a result of breakage during the formation of the sediment or fracturing afterwards (see below).

In many samples the elements are internally fractured, often with many fractures per millimetre. In most elements these fractures are perpendicular to the denticles and to the process, respectively. That this fracturing has happened during or after diagenesis is evident from the fact that very often all the pieces of large or otherwise individually identifiable specimens can be found in the same sample. Further, many fractures can often be seen in the recovered pieces. Thus, the fracturing was probably caused by strain in the beds.

In many samples the elements are recrystallised. The surface of the elements has become irregular by overgrowth and by corrosion. The denticles change shape and may even show crystal facets. The white matter becomes less distinct. If recrystallisation occurred after fracturing, the pieces are often fused again, and thus more complete specimens may be recovered. When thermally affected, the organic carbon in the elements darkens (see Epstein *et al.* 1977), but any fusing material lacks organic carbon and remains light (Jeppsson 1976:109). Recrystallisation seems to be promoted by heating. The beds on Gotland are not thermally affected, and thus complete bar elements are much rarer there than they are in many samples from slightly metamorphosed areas. In a few samples the elements were not only fractured, but the pieces were displaced before recrystallisation occurred, and thus the elements look strongly malformed. Both kinds of recrystallisation have been interpreted as evidence for the healing of fractured elements by the animal. That this is not the case is evident from the fact that they are related to locality and not to taxa (Jeppsson 1976).

As noted above, none of the collections from Gotland is thermally affected. On the contrary, the light colour is so well preserved that taxonomically important differences in colour can be used in reconstructing apparatuses and in the routine identification of fractured specimens. Perhaps collections of this kind should be separated as a zero group in the scale of conodont alteration indexes introduced by Epstein *et al.* (1977).

However, the colour may also be affected by other factors. In darker beds the elements are often slightly darkened, probably by very finely disseminated pyrite or by organic matter. In red beds oxidization may bleach the elements and disseminated haematite may stain them.

Less than one out of ten samples from Gotland produces a rich and well preserved fauna. However, some samples produce the very best collections possible.

Annotated list of conodont taxa reported here from Gotland

Correct taxonomy and nomenclature of conodonts require much more work per taxon than most other well-known groups of fossils. As yet, only a few of the taxa recognized on Gotland have been adequately studied. Therefore, some of the names are used herein with less confidence than others, and it is certain that future revision of the scope and nomenclature of some of the taxa will have to be undertaken.

There are conflicting opinions, or none at all, regarding the apparatuses of most of the Silurian conodont taxa with platform elements. Therefore, presence of these taxa has been registered only on the occurrence of the platform element.

Except for *Panderodus* and *Pseudooneotodus,* taxa with only simple cones have only been identified to the genus. Confident identification of these to species level awaits major taxonomic and nomenclatural revisions.

For most of the taxa I also outline their known distribution on Gotland. In most cases, more details are given with the descriptions of the faunas.

Apsidognathus walmsleyi Aldridge 1974. Aldridge noted that also elements identified as from *Ambalodus galerus* may belong here, and that receives some support from my collections. Lower Visby Beds.

Aulacognathus bullatus (Nicoll & Rexroad [1969]). Lowermost? Lower Visby Beds.

Belodella. A recent discussion was given by Barrick 1977. At least from low levels in the Hemse Beds into the Hamra Beds.

'Carniodus'. Walliser (1964) assigned many different small elements to *Carniodus* while he incorporated others that showed broad similarities in *Neoprioniodus* and *Roundya*. Some of these have been interpreted as elements of *Pterospathodus* (see Jeppsson 1979 c), while others may belong to *Hadrognathus* and *Apsidognathus*. Pending their proper identification, those not shown to belong to *Pterospathodus* are here referred to *'Carniodus'*. Lower Visby Beds.

Dapsilodus Cooper 1976. This genus was discussed by Barrick (1977). Slite to Hamra Beds, inclusive.

Decoriconus Cooper 1975. This genus was discussed by Barrick (1977). There seem to be at least two species on Gotland. Lower Visby Beds to Eke Beds, inclusive.

Distomodus dubius (Rhodes 1953), sensu Jeppsson 1972. Upper Hemse Beds and Hamra Beds.

Distomodus kentuckyensis Branson & Branson 1947, sensu Klapper & Murphy 1975. Lower and Upper Visby Beds.

Hadrognathus staurognathoides Walliser 1964, sensu Walliser 1964. Lower Visby Beds and lower part of Upper Visby Beds (redeposited in the latter unit?).

Hindeodella confluens (Branson & Mehl 1933), sensu Jeppsson 1969. Högklint to Sundre Beds, inclusive.

Hindeodella excavata (Branson & Mehl 1933), sensu Jeppsson 1969. Lower Visby to Sundre Beds, inclusive.

Hindeodella gulletensis (Aldridge 1972), sensu Jeppsson 1979 c. Högklint Beds, unit a, to lower Slite Beds, inclusive.

Hindeodella polinclinata (Nicoll & Rexroad [1969]), sensu Cooper 1977. One of many synonymous names is *Spathognathodus tauchionensis* Saladžius, 1975. Aldridge (1979) discussed this taxon and the differences between its elements and those of some related taxa. There seem to be minor differences between collections from different areas (Aldridge 1979); however, I think that those from Gotland do belong in this species. Lower Visby Beds.

Hindeodella sagitta rhenana (Walliser 1964), sensu Aldridge 1975a. Högklint to lower part of Slite Beds, inclusive.

'Ozarkodina serrata' Helfrich 1975?. In the Klintberg c beds at Botvaldevik 1 in sample G 75-36 there is a very large, complete, strange oz element. As the element is unique, it is difficult to exclude the possibility that it is a strongly malformed gerontic specimen of *H. confluens*. However, it is close to what Helfrich (1975: appendix 1:32) described as *Ozarkodina serrata*. That name is probably a junior homonym to *Astacoderma serratum* Harley 1861. The latter name has not been published in any combination with the generic name *Ozarkodina*, but it has been shown to be a senior unused synonym to *H. confluens*, often placed in *Ozarkodina* (cf. Rhodes 1953; Jeppsson 1969, 1974; Klapper & Philip 1971; ICZN article 57). In some of my other samples from the Klinteberg Beds there are worn fragmentary specimens of possible elements of the same species. These do not deviate as much from *H. confluens* as the single oz element. In the Klinteberg a beds at Hällinge 2 in sample G 71-94 there is a very large tr element that at present cannot be placed in an apparatus. It somewhat resembles *'Trichonodella'* sp. A of Uyeno (1980, Pl. 10:17). It is possible that all these Klinteberg specimens represent the same taxon, and that it is the same as Helfrich's. Whether it is distinct from *H. confluens* at the species or subspecies level is unclear. Klinteberg Beds. Fig. 1 F.

Hindeodella snajdri (Walliser 1964). The apparatus-based concept of this taxon and its subdivision in subspecies in the late Ludlovian will be described by Schönlaub *et al.* Another subspecies occurs on Gotland in the late Wenlockian. Its relationship to *H. snajdri* s. str. is evident: the fusing of the cusp and adjacent denticles of the sp element to an edge very early in ontogeny strongly differs from the gerontic smoothing out of details seen in other taxa of *Hindeodella*. Also, the rest of the apparatus is so similar to the late Ludlovian representatives that the late Wenlockian taxon clearly should be separated at a subspecific level only. Uppermost Slite Beds to Sundre Beds, inclusive.

Hindeodella steinhornensis (Ziegler 1956). For a discussion, see Jeppsson (1974). The lineage can now be traced from *H. gulletensis* via scattered specimens in the late Wenlockian and early Ludlovian to more regularly occurring populations in the late Ludlovian.

Hindeodella wimani Jeppsson [1975]. Two subspecies are known (Jeppsson 1974). Burgsvik and Hamra Beds.

Hindeodella sp. m. This taxon is probably closely related to *H. confluens*. Characteristic is the fact that only the core of the cusp is transformed into white matter. The bases of the denticles are similarly constructed. Klinteberg and Hemse Beds.

Johnognathus huddlei Mashkova 1977. Lower Visby Beds.

Kockelella absidata Barrick & Klapper 1976. This is the third generic and second specific name on Walliser's (1964) *'fundamentata'*. The species is very variable. Thus, specimens from the Mulde and Klinteberg Beds at Loggarve 1 (see p. 132) differ in having fewer denticles.

In the Hemse Marl NW part at Kullands 1 in sample G 77-38 PSSFG there are four specimens of the sp element of what obviously is a well defined, distinct population. These have a denticle on the inner basal cavity lip. Similar specimens have also been found at Gerumskanalen 1 in sample G 77-37 PSSFG, at Gardsby 1 in sample G 82-27, and at Lilla Hallvards 1 in sample G 71-143. Walliser (1964) included similar specimens in what is now known as *K. absidata*. On the other hand Barrick & Klapper (1976) described the sp element of *K. stauros* as having one to two processes, the inner one with one to two denticles. However, at present I consider my specimens to be a variety of *K. absidata*, which is a very variable taxon (Walliser 1964, Pl. 23). The variation is evident also in my few specimens from Gotland, but at present it is

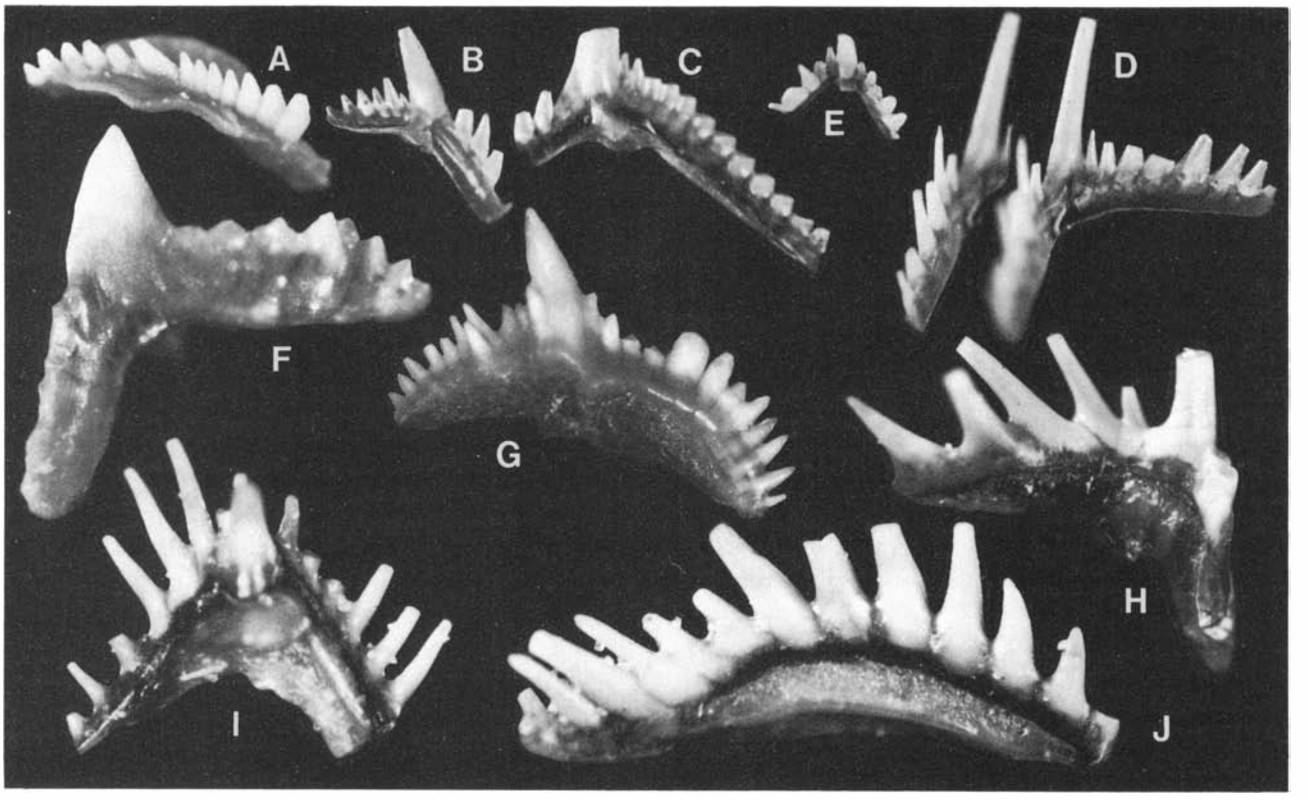


Fig. 1. □A–E. *Polygnathoides siluricus* Branson & Mehl 1933 sensu novum. Sample G 71-148 from Vaktård 3. The sp and hi elements are from individuals that were rather young, the ne element from one that was slightly older and the oz and pl elements from juvenile individuals. No tr element is illustrated. ×40. □A. An sp element. The two anteriormost denticles are broken away. LO 5590. □B. An oz element. LO 5591. □C. An ne element. The tips of both processes are broken away. The basal filling below the long process is preserved. LO 5592. □D. A hi element. Focus is on the lateral process in the left, incomplete, picture. That process is straight and about as long as the posterior one. The latter is deflected slightly outwards. LO 5593. □E. A pl element. LO 5594. □F. *Ozarkodina serrata*? A very large oz element. Note that the posterior process is malformed with an extra lateral process. ×32. Sample G 75-36 from Botvaldevik 1. LO 5595. □G–J. Gen. et sp. indet. □G. A 3.08 mm long oz element. ×18. Sample ES 137, collected at Millklint 1 by Anders Martinsson who described it as a 'thickly bedded limestone with strophomenaceans and *Atrypa*'. LO 5596. □H. A hi element. Note that the denticles of the posterior process point in different directions. ×40. Sample ES 202 collected by Anders Martinsson at Gogs 1. LO 5597. □I. A tr? element. ×40. Sample ES 202 (A.M.). LO 5598. □J. An unidentified 1.85 mm long element. The basal filling is preserved. I have not been able to identify the cusp in this element. ×43. Sample G 67-54 from Gogs 1. LO 5599.

difficult to use it in stratigraphy, as the outline changes strongly during ontogeny, and thus growth series must be illustrated; the white matter distribution is also crucial, particularly in mature specimens. The variety from Kullands 1 and Gerumskanalen 1 is closest to Walliser's (1964, Pl. 23) specimens from the middle part of his *A. ploeckensis* Zone. Regarding the other elements of the apparatus, my collections seem to confirm the reconstruction of Barrick & Klapper 1976, although non-sp elements very similar to those that occur with sp elements of *K. absidata* have a much wider distribution on Gotland than the sp elements. I also note that Barrick & Klapper (1976) referred 55 non-sp elements to *K. stauros* at their locality Ca 2, but only one sp element. Here I therefore identify non-sp elements occurring without sp elements as *Kockelella*? sp. Slite Beds to Hemse Beds, inclusive.

Kockelella? ranuliformis (Walliser 1964). The species is here identified on the sp element only. Upper part of the Lower Visby Beds to the Högklint Beds, inclusive.

Kockelella variabilis Walliser 1957, sensu Barrick & Klapper 1976. The species has been listed as present only if the sp element was found. Lower Hemse Beds.

Kockelella walliseri (Helfrich 1975). The variation in its platform element is large and my samples (like Viira's) include both narrow forms of the kind on which Helfrich (1975) based the name *Spathognathodus walliseri* and broad forms of the kind on which Viira (1975) based the name *Spathognathodus corpulentus*. The two names are here considered synonymous. It seems that Viira's description was published on 1975 08 15 but Helfrich's on 1975 06 09 (personal communication from Richard Aldridge, who has corresponded with the author and publisher, respectively, in the matter). Thus *walliseri* has priority. Another aspect that has to be considered is that Helfrich's description was given on microfiche which was not accepted as a publication by the Code in force in 1975 (compare Cooper 1980), but it seems probable that his names will be validated. Pending the outcome of this question, I will use the oldest name. Barrick & Klapper (1976) transferred '*S. walliseri*' to *Kockelella* and that seems to be well founded.

A collection of seven fairly small elements from the Slite d beds at Stora Myre 1 is intermediate between *K.? ranuliformis* and typical *K. walliseri* regarding the lateral process. Thus some sp elements lack a lateral process altogether, whereas a few have a process with up to a couple of denticles. The difference may depend on the elements being juvenile. The species has been listed as present only if the sp element was found. Slite Beds.

Kockėlella sp. a. I illustrated a large ne element of this taxon in 1974 (Pl. 12:5). It is closely similar to that of *K. absidata*, and I refer to it as *Kockelella* sp. a. I have now found four such elements from four localities on Gotland but identified only one, poorly preserved, possible sp element. Upper Hemse Beds.

Kockelella? sp. See *K. absidata* above. Upper Hemse Beds.

Ligonodina confluens Jeppsson 1972. Only those specimens originally referred to *L. c. confluens* are included here. Högklint c to Sundre Beds, inclusive.

Ligonodina aff. *confluens*. Described and illustrated in Jeppsson 1972 as *L. confluens* n. ssp.. Hemse Beds.

Ligonodina elegans Walliser 1964, sensu Jeppsson 1969. Hamra and Sundre Beds.

Lignodina excavata (Branson & Mehl 1933), sensu Jeppsson 1972.

Ligondina excavata novoexcavata Jeppsson 1972. Burgsvik to Sundre Beds, inclusive.

L. confluens, L. aff. *confluens* and *L. elegans* can easily be separated, as is the case with typical *L. excavata* in the Ludlovian. Apart from the frequent occurrence of more or less fragmentary stray specimens that cannot be positively identified as yet, there are also some other distinct populations. There are also problems in separating *Ligonodina* from some of the elements found in apparatuses with platforms. With these reservations, the following two taxa may be delimited:

Ligonodina silurica Branson & Mehl 1933? The elements have closely similar colour to those of *H. excavata* and *L. excavata*. Rexroad & Craig's (1971) description of the hi element stresses the distinguishing characters. The ne element was illustrated by them (Pl 80:11) and described as ?*Neoprioniodus latidentatus*. These two elements are those that are the easiest to identify, while the other elements do not differ so much from those of *L. excavata*. An evolutionary divergence is evident, as stratigraphically older populations are less distinct. However, the lineage can easily be followed down into the middle Wenlockian, but with regard to older populations, I have to reserve judgement on whether they belong here or to *L. excavata*. Into Hemse Beds.

Ligonodina sp. d is best known in the Hemse Marl SE part. The elements are brownish like those of *H. confluens*. The ne element is close to those of *Kockelella* in general shape. Thus, the cross section of the cusp is compressed and edged. The cusp, but not the rest of the element, resembles that of the corresponding element of *L. elegans*. The other elements exhibit some similarities in the direction of the processes to the corresponding elements of *L. elegans*. For example, the antero-lateral process of the hi element is directed obliquely back and down, but less so than in *L. elegans*. However, all the elements of *Ligonodina* sp. d are much more robust, and the robust denticulation is quite distinctive.

'Ozarkodina serrata' see *Hindeodella* above.

'*Ozarkodina* sp. nov.' of Aldridge *et al.* 1982. Halla Beds to Hemse Beds, inclusive.

Panderodus. I hope to complete a monograph on this genus during 1984. There are seven or eight species on Gotland, subdivisible into about ten subspecies. Each taxon has eight to ten kinds of elements, including two short, recurved ones (ne and tr elements). Pending completion of the necessary type studies six of these taxa are here called:

Panderodus equicostatus (Rhodes 1953). The elements consist largely of a base with a very short cusp. Upper Visby Beds to Sundre Beds, inclusive.

Panderodus gracilis (Branson & Mehl 1933). Pending a second study of the type, I am slightly unsure of applying this name but use it here because my taxon is close to one of the species that occurs in the type formation. In the Silurian subspecies the base is much shorter than the cusp. Upper Hemse Beds.

Panderodus langkawiensis (Igo & Koike 1967). (This name has priority over the name *P. spasovi*.) Lower Visby Beds.

Panderodus recurvatus (Rhodes 1953). There is a strong indication that the name will have to be replaced by an older synonym. One older and one younger subspecies occur on Gotland. Lower Visby Beds to Hemse Beds, inclusive.

Panderodus unicostatus (Branson & Mehl 1933). Two or three consecutive subspecies occur on Gotland. The cusp in the elements of this species is slightly shorter than the base. Often one of the elements is serrated (*P. serratus* is a younger synonym). Lower Visby Beds to Sundre Beds, inclusive.

Panderodus sp. g. Two very different subspecies are presently included here. The cusp is longer than the base, and the elements may grow very robust. Some existing names may be applicable to this taxon, but I am not sure enough to use any of them here. Lower Visby to Hemse Beds, inclusive.

Pedavis thorsteinssoni Uyeno [1981]? Eke Beds.

Pelekysgnathus dubius Jeppsson 1972. The specimens from the *P. siluricus* Zone on Gotland usually differ from those illustrated from Skåne (Jeppsson 1972), with the cusp being much larger than the single denticle. Broken and worn elements are thus difficult to separate from the ne element of *D. dubius*. Upper Hemse Beds.

Polygnathoides siluricus Branson & Mehl 1933 (an improved concept is now possible, see Fig. 1 A–E). Upper Hemse Beds.

Pseudooneotodus. In the lowermost beds some elements are three-tipped but most are one-tipped. As yet it is impossible to say if both kinds of elements derive from the same taxon. Distinctly two-tipped elements occur together with one-tipped as soon as the three-tipped have disappeared, and then the distinctness of the two tips gradually decreases during the Wenlockian. In some cases I use the names:

Pseudooneotodus tricornis Drygant 1974. Lower Visby Beds.

Pseudooneotodus beckmanni (Bischoff & Sannemann 1958). Lower Visby Beds to Hamra Beds, inclusive.

Pseudooneotodus beckmanni bicornis Drygant 1974, sensu Jeppsson 1979 c. Upper part of the Lower Visby Beds to Högklint Beds, inclusive.

Pterospathodus amorphognathoides Walliser 1964. The complete apparatus includes six or seven elements. Lower Visby Beds.

Pterospathodus pennatus procerus (Walliser 1964), for a discussion, see Jeppsson 1979c. Lower and Upper Visby Beds.

Walliserodus. The genus has recently been discussed by Barrick (1977). There are at least six kinds of elements in the apparatus. Lower Visby Beds to Slite Beds, inclusive, questionably in the Hamra Beds.

Gen. et sp. indet. In the Upper Hemse Beds two kinds of undescribed elements occur: a large sp element and large rough elements with up to three rows of denticles with rounded cross sections. A connection between these two kinds of elements is possible. Fig. 1 G–J.

Biostratigraphy

The Lower Visby Beds

The Lower Visby Beds crop out intermittently in a strip, about 55 km long, along the NW coast. The largest known exposed thickness above sea level is about 12 m. The beds consist of marlstone and highly argillaceous limestone. There is a gradual increase in the content of carbonate upwards through the unit which continues in the following Upper Visby Beds. The base of the Upper Visby Beds is drawn solely on the faunal change (but see below).

Except in the uppermost beds (see below), the conodont fauna seems to be uniform and is much more diverse than those of the rest of the sequence on Gotland. The total number of species cannot be given as yet, as there are many elements which have not been combined into reconstructed apparatuses. However, it is well above 20 and may even be above 30. It is also characteristic that most of the lineages which are more or less ubiquitous in younger faunas are rare or absent. Thus, *Hindeodella confluens*, the *H. steinhornensis group* and *Panderodus equicostatus* are absent, and *H. excavata* is rare. *Belodella* and *Dapsilodus* are also absent.

Most abundant are *Pterospathodus amorphognathoides, Hindeodella polinclinata, Panderodus unicostatus,* and *'Carniodus'*. Other regular constituents are *Panderodus* sp. g. ssp. v., *P. recurvatus, P. langkawiensis, Walliserodus, Decoriconus, Pseudooneotodus* (one-tipped elements dominate, but three-tipped also occur), and *Distomodus*. Of slightly less regular occurrence are *Apsidognathus walmsleyi, Hadrognathus staurognathoides, Johnognathus huddlei, Ligonodina excavata,* and a number of other species of *Hindeodella* and *Ligonodina*. the rarest taxon identified as yet is *Aulacognathus bullatus* (one good specimen). This taxon occurs at a locality which appears to represent the lowermost part of the Lower Visby Beds. Another rare taxon which may be restricted to that part is the ostracode *Barymetopon infantile* Martinsson 1964.

P. amorphognathoides is regularly present in collections from the part of the Lower Visby Beds here discussed; therefore the upper boundary for the *P. amorphognathoides* Zone is here drawn immediately above the last proven occurrence of that taxon. In Britain, at the type locality for the base of the Wenlockian, *P. amorphognathoides* occurs both in the uppermost Llandoverian and in the basal Wenlockian, as do all forms considered characteristic of the *P. amorphognathoides* Zone (Aldridge 1975b:613). There, the faunal change concurs with a lithological change from fine blue grey mudstone to calcareous siltstone (Aldridge 1975 b). Thus the *P. amorphognathoides* Biochron may well range still higher there (Aldridge 1975 b). On Gotland there is no described lithologic change between the Lower and Upper Visby Beds, only the faunistic one (cf. Martinsson 1967:359). However, the two units weather differently; the Lower Visby Beds produce a sticky clay which is not easily washed away from the section, while the clay in the Upper Visby Beds weathers to dust. In any event, the *P. amorphognathoides* Range-Zone does extend into the Wenlockian and that is an indication that the base of the Wenlockian is at least a couple of metres down in the Lower Visby Beds. A very large change in the conodont faunas seems to occur worldwide at or close to the end of the *P. amorphognathoides* Biochron. The details of the changes on Gotland will be discussed separately.

The top part of the Lower Visby Beds. – By definition, the top of the Lower Visby Beds is to be drawn at the abrupt faunal change. However, in practice it has often been drawn lower at many localities (Martinsson 1967:358). Thus, the beds at Nygårdsbäckprofilen 1 was by Hedström (1910) referred to the unit which now is called Upper Visby Beds, but Hede (1940) identified 2.5 m of Lower Visby Beds there. Neither of them found Lower Visby Beds at Vattenfallet from where they were reported by Jaanusson (1979). Similarly, at Rönnklint 1 Hedström (1910) reported that the Lower Visby Beds reach about 9 m above sea level and Hede (1940) gave 8 m, but Jaanusson (oral information 1981 08 24) draws the boundary some metres higher up. Samples from the top 2 to 3 m of the Lower Visby Beds lack one or more of *Pterospathodus amorphognathoides, Pseudooneotodus tricornis* and *H. polinclinata* but have instead one or more of *Pterospathodus pennatus procerus* and *Pseudooneotodus beckmanni bicornis*. The rest of the conodont fauna consists both of some surviving taxa from the older fauna and some new ones that continue in the Upper Visby Beds, like *Kockelella? ranuliformis*. Collections now available have both a much lower frequency and much lower diversity than older ones. The low conodont frequency seems to indicate a rapid rate of sedimentation and, thus, the interval between the *P. amorphognathoides* Zone and the Upper Visby Beds was very short. The change in frequency makes it difficult to establish the upper range especially of the many rare taxa present in older parts of the Lower Visby Beds. This problem is further complicated by reworking, but reworked specimens usually can be distinguished by their darker colour, especially of the basal filling and adjacent parts.

The fauna described previously from the Lower Visby Beds at Vattenfallet (Jeppsson 1979 c) belongs here and not to the *P. amorphognathoides* Zone. To that list can now be added that three species of *Panderodus* have been identified in both samples, *P. equicostatus*, *P. unicostatus* and *P. langkawiensis*.

The Upper Visby Beds

The early Wenlockian Upper Visby Beds crop out in the coastal cliffs along the NW coast for about 60 km. They consist of between some and 16 m of marlstone, argillaceous limestone and tabulate-dominated mounds.

I have earlier described the Upper Visby conodont faunas in the Vattenfallet section (Jeppsson 1979 c). To that description can now be added that *Panderodus* sp. a is *P. equicostatus*, *P.* sp. b is *P. unicostatus*, a taxon which also occurs in sample G 70-22, and questionably also in most other samples from this unit, and that 'gen. et sp. indet.' is *Hadrognathus* (as yet it cannot be excluded that the two specimens may be reworked). Also, in Fig. 70, read *H. gulletensis* for *H. s.* aff. *scanica* and *H.* aff. *confluens* for *H.* aff. *gulletensis*. My collections from other localities do not differ significantly from those from Vattenfallet.

The Högklint Beds

The early Wenlockian Högklint Beds crop out in an area about 80 km long by 1 km wide along the coast in the northwest. They consist of between less than 20 m and 35 m of bioherms and other kinds of limestones. The Beds are subdivided into four lettered units.

I have earlier (Jeppsson 1979 c) described the sequence of conodont faunas through the Högklint Beds in the Vattenfallet section. To that description can be added that the species identified as *Panderodus* sp. a is *P. equicostatus*. Regarding corrections in 1979c, Fig. 70, see above. Two of the conodont taxa found there – *H. sagitta* and *K.? ranuliformis* – have been used as zonal fossils (Walliser 1964; Barrick & Klapper 1976, respectively). In Vattenfallet *K.? ranuliformis* is not known above unit b, but that may well be due to the rarity of the taxon and the small samples available from the now inaccessible upper part of the section. *H. sagitta rhenana* occurs only in the upper part of unit c and in unit d. *H. s. rhenana* further occurs in the Högklint c at Galgberget 1.

In the area around the bay Kappelshamnsviken *H. s. rhenana* occurs in the Högklint b at Nymånetorp 1 in sample G 81-65 from 0.05–0.13 m above the reference level, and – together with *K.? ranuliformis* – in the Högklint b at Svarven 1 in sample ES 177 (A.M.) and in Högklint c in sample G 78-3 CB from 0.30 m above the reference level. A few specimens of *K.? ranuliformis* also occur in samples ES 113 (A.M.) and ES 178 (A.M.) from the same unit and locality. Both taxa occur at Västös Klint 1 in sample G 77-34 PSSFG.

On Fårö, *H. s. rhenana* occurs in the lower–middle Högklint Beds at Lautershornsvik 2 in sample G 73-73, in the slightly younger (Hede 1936:14) Högklint Beds at Lautershornsvik 3 in sample G 73-72, and, together with *K.? ranuliformis*, in the same unit at Aursviken 1 in sample G 77-25 CB. *K.? ranuliformis* occurs also in sample G 77-26 CB from Langhammarshammar 1.

The incoming of *H. s. rhenana* may be stratigraphically useful in a small area like Gotland, especially as the strike of the beds is close to an original depth contour (regarding larger regions, see Jeppsson 1979 c). If so, it would indicate that the 'pre-*H. s. rhenana*' part of the Högklint Beds thins out NE of Lickershamn and that the Högklint b lithology persists longer there. Alternatively the appearance of *H. s. rhenana* is progressively younger in the southwest direction. The only other significant event in the faunas is the appearance of *H. confluens* which occurs in the Högklint b at Svarven 1, in sample ES 178 (A.M.).

The Tofta Beds

The early Wenlockian Tofta Beds crop out in an area about 1–2 km wide and 50 km long. They chiefly consist of limestones rich in *Spongiostroma* and stromatoporoids. The Beds are up to 8 m thick but thin out to the NE and probably also to the SW.

The conodont faunas at hand from the Tofta Beds are few and small, but the diversity seems not to be extremely low.

At Vale 1 in sample G 77-14 *H. confluens* morphotype γ occurs; the elements are small but not juvenile. That morphotype was earlier only reported from Ludlovian and younger beds. There are further some fragmentary specimens that resemble those from the Högklint d, which I (1979c) have identified as resembling morphotype ε of *H. confluens*. The fauna also contains *Ligonodina* sp.

At Klockaremyr 1 in sample G 71-73, *H. sagitta rhenana* occurs together with *H.* cf. *confluens*.

The lower parts of the Slite Beds

The outcrops of the Wenlockian Slite Beds form an area up to 20 km wide and about 115 km long. Limestones occupy the northwestern part, except in the extreme southwest, and occur also in outliers across the belt in the northeastern half of the area. Marlstone forms a belt widest in the soutwest and narrowing in NE direction. However, marl is known all the way up to easternmost Fårö.

The lower part of the Slite limestones is divided into 5 lettered units, of these a, b and d occur only locally. Together the five units are up to 20 m thick in the SW and up to 10 m on Fårö (Hede 1936). Only in the extreme southwest are marly equivalents of these limestones known.

All conodont faunas extracted to date are small, and very little can yet be said about these beds (three faunas will be discussed together with the Slite f). Some of the small collections now at hand do not differ much from a Högklint fauna, e.g., a collection from the Slite unit b beds at Kluvstajn 1 (sample G 73-16) includes *H. gulletensis*, *H. excavata* and *P. equicostatus*. In a fauna from the Slite d beds at Martille 7 (sample G 73-18) *H. sagitta rhenana* occurs together with *H. confluens*, *Ligonodina*, *P. equicostatus* and *P.* sp.

Other collections are more like those from younger beds; thus, sample G 79-206 from the Slite c beds at Hällagrund 1, 0.05–0.10 m above the contact to the Högklint Beds, contains *H. excavata*, *H. confluens*, *P. equicostatus*, and *P. unicostatus*.

Slite f and contemporaneous beds

The Slite f (Laufeld 1974 a) is a distinct unit consisting of up to 2 m of fine-grained argillaceous limestone, in places intercalated with thin layers of marlstone (Hede 1960; Laufeld 1974 a). The unit has also been called the *Rhipidium tenuistriatum* beds after the pentamerid that in places is abundant in the unit. It is known both in the southwest where the outcrops form a narrow strip ending about 1.8 km ESE of Västerhejde church (Hede 1940), and in the northeast, in southwestern Fårö (Hede 1936, 1960) and adjacent parts of the main Gotland (Hede 1933:52). Probably this kind of sediments, formed on Gotland only during a short interval of time, was laid down only in a narrow belt, while Slite Marl was deposited southeast of it and different limestones northwest of it. For over 50 km along the strike of the beds, only such lithologies crop out, and time-stratigraphic equivalents have to be identified using fossils. This remains to be done, except for Hede's (1933:43) report of *R. tenuistriatum*? from the Klinthagen area.

Another characteristic fossil for this unit is *Monograptus priodon* (see Hede 1927 a:28). This taxon has a much more wide-spread occurrence on Gotland than *R. tenuistriatum*. In the southwest, it thus occurs, e.g., also in the limestones at Hallbro Slott 6 (Hede 1942 loc. 19, 20) west of the strip with *R. tenuistriatum*, and in the Slite Marl east of it. Considering the slight general dip of the strata in the area and the topographical levels of these localities, they may well be outliers and the

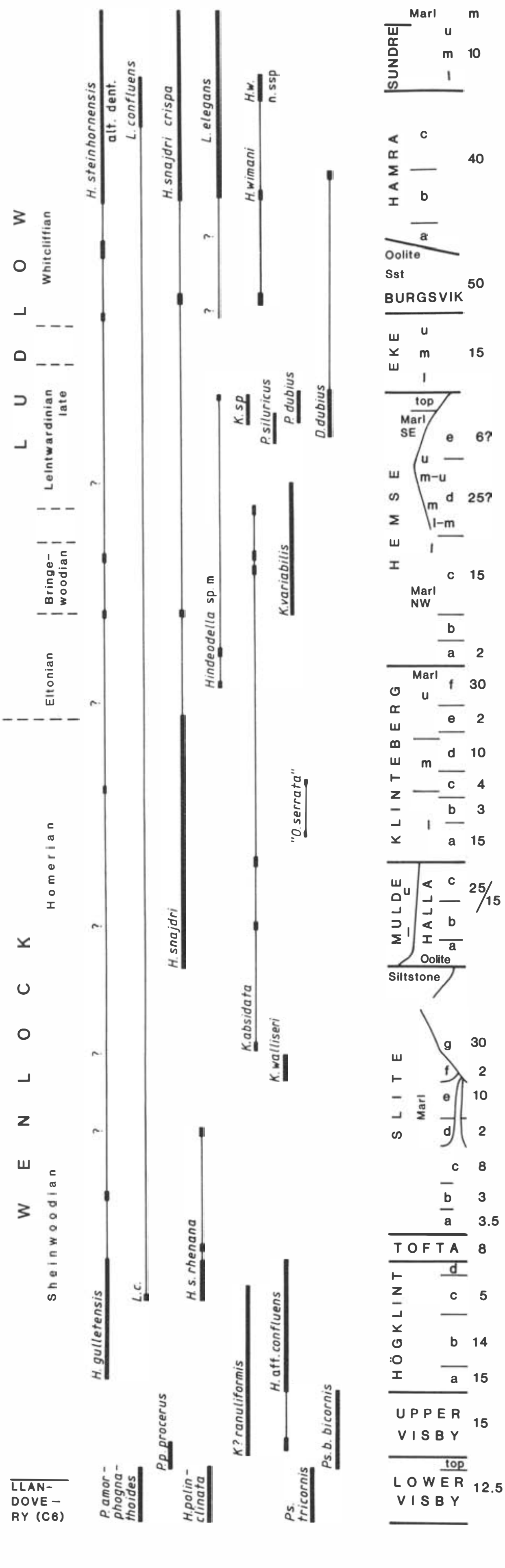


Fig. 2. A stratigraphical – geographical diagram of the strata exposed on Gotland. The diagram shows two of the dimensions of the beds, time and place, when projected onto a N 45°E plane *i.e.* a plane approximately parallel to the strike.

The SW-NE co-ordinates used for a locality are easily derived by adding its S-N and its W-E UTM co-ordinates, in the CJ area. In the CK area (*i.e.* northern Gotland) 100 must be added and on easternmost Fårö, 200. Localities on Stora Karlsö have to be measured. These co-ordinate lines are shown on the large inset map. In order to facilitate identification of the SW-NE co-ordinates for the marked localities, and to aid the addition of other localities, most of the vertical lines in the pattern designating limestone areas are placed at 40, 50, 60, and so on, and at 45, 55, 65, and so on. Other co-ordinate systems can, of course, be used equally easily, and NW-SE diagrams for selected areas can be constructed in a similar way.

The age (time coordinate) is still rather uncertain for most localities, as it is based on conodonts only. Therefore, all localities in the same unit are placed on the same horizontal line if there is no evidence of different ages.

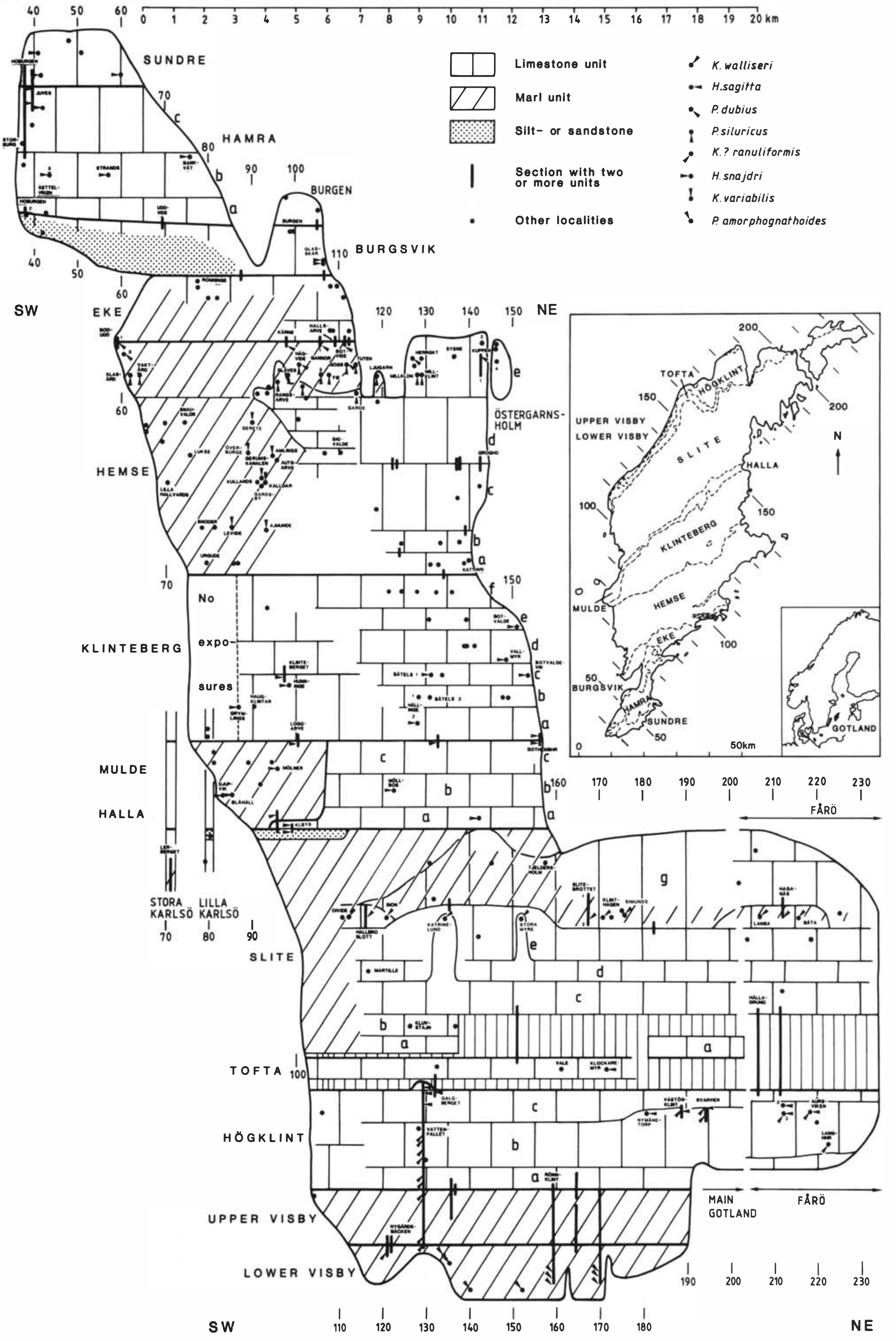
Where the dip of the beds is normal and the topographic effects are negligible the diagram is easy to construct and to interpret. In other intervals, different lithologies and units may be superimposed on each other. This is the case with the Slite Marl, which occurs SE of the limestones, and with the Slite f which occurs southeast of some of the other Slite limestones, chiefly basal Slite g. Similarly, the Mulde Beds are superimposed on the Halla Beds of Lilla Karlsö. The diagram of the upper part of the Hemse Beds is as complicated as the Slite Beds.

The outline of the figure is strongly simplified and also wider than the exact boundaries in order to avoid interference with the symbols for shore localities and other marginal localities.

The names of the different Beds are given adjacent to the figure, as are the letters of many of the subunits. The narrow stratigraphic column to the right on this side facilitates the identification of the others.

Most of the sampled localities are marked, but names are included only for those mentioned in the text. Some of the names are abbreviated, but these may be identified using the locality list.

The distribution of selected taxa is given, both as range lines and with marks directly on the locality symbol.


0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 km
Limestone unit
Marl unit
Silt- or sandstone
Section with two or more units
Other localities
K. walliseri
H.sagitta
P. dubius
P.siluricus
K.? ranuliformis
H. snajdri
K. variabilis
P. amorphognathoides
SUNDRE
HAMRA
BURGEN
BURGSVIK
SW
EKE
NE
ÖSTERGARNSHOLM
HEMSE
No exposures
KLINTEBERG
MULDE
HALLA
STORA KARLSÖ
LILLA KARLSÖ
SLITE
TOFTA
HÖGKLINT
UPPER VISBY
LOWER VISBY
MAIN GOTLAND
FÅRÖ
TOFTA
HÖGKLINT
UPPER VISBY
LOWER VISBY
SLITE
HALLA
KLINTEBERG
HEMSE
MULDE
EKE
BURGSVIK
HAMRA
SUNDRE
N
50km
GOTLAND
SW
NE

continuation, respectively, of this same horizon. *M. priodon* also occurs at Klinthagen, at least 9 m below the unit with *R. tenuistriatum?* (Hede 1933:43). In the northeast, in the areas of the Slite g expansion, *M. priodon* also occurs in the Slite Marl.

Small conodont faunas have been extracted from some localities with Slite f and contemporaneous beds. A typical fauna is that from the *R. tenuistriatum* beds in the shallow quarry Oivide 1, sample G 79-44 from 0.5 m below top. Stratigraphically most important is *K. walliseri.* In addition the fauna includes a few specimens of each of *Hindeodella excavata, H. confluens, Pseudooneotodus beckmanni, Panderodus equicostatus,* and *Ligonodina excavata*?. Sample ES 158 (A.M.) from the same locality has produced no *K. walliseri,* but instead two specimens of *Dapsilodus*,a genus known only from a few scattered localities on Gotland.

K. walliseri further occurs in the *R. tenuistriatum* beds (Slite f) at Sojvide 1, in sample G 81-58, and at Sion 1, in sample G 72-3.

At Hallbro Slott 6, *K. walliseri* occurs in sample G 73-12, 2.45–2.55 m below the '*Leperditia*-shale' described by Hedström (1910). Three other samples from higher levels in the 5 m section failed to produce this taxon. Hede (1942) reported *Monograptus priodon* from 5–5.5 m above the 2 m thick '*Leperditia*-shale' at a nearby locality. The lettered units have not been extended to this area, e.g., even Hede (1942) used Hedström's terminology. However, Hede's (1940) lithological descriptions, which are the base for the lettered units, are so similar to Hedström's (1910) descriptions that it is fairly safe to conclude that the '*Leperditia*-shale' is Slite e and the beds below it, Slite c (Slite d is missing here, Hede 1940:49, line 11). Hede (1940, 1960) did not extend the lettering above e (that was done by Laufeld 1974a) and he described the *R. tenuistriatum* beds only as the lower part of 'the next unit'. However, the lithologic character of the beds above the '*Leperditia*-shale' are those of Slite g. Thus, *K. walliseri* is found here 4.45–4.55 m below the base of Slite g, in the Slite c.

Further to the NE in the area where no *R. tenuistriatum* Beds are known, *K. walliseri* has also been found in the unit c beds at Katrinelund 1 in sample G 69-32 from about 1 m below the uppermost exposed beds. The species probably occurs in the Slite d beds at Stora Myre 1 (see p. 124).

South of the large bay Kappelshamnsviken, *K. walliseri* has been found in the lower part of Slite g, both at Simunds 1 in sample G 81-68 and at Klinthagen 2 in sample G 73-1. I have not been able to identify the section with both *R. tenuistriatum* and *M. priodon* described by Hede (1933:45) from the Klinthagen area as there are many quarries 1.8 km E of Stora Banne. However, his section was also from the lower part of Slite g.

In the quarry Slitebrottet 2 *K. walliseri* occurs in sample G 73-50 from about 36 to 36.5 m below sea level and in sample G 73-49 from 2.0 m above G 73-50. Dr. Hermann Jaeger has told me that in 1960 he found *M. priodon* in Slitebrottet 1, from about 1 m above the floor, that is about 2.5 m above my sample G 73-49.

On Fårö *K. walliseri* occurs in the *R. tenuistriatum* beds at Lansa 2 in sample G 73-70, and at Båta 1 in sample G 77-27 CB. It also occurs about 1 m below the upper boundary (Hede 1960:71) of the Slite Marl at Haganäs 1, in sample G 69-10. From the same 1.0 m thick unit of Slite Marl, Hede (1942, Loc. 35; 1960, Loc. 25) reported *M. priodon.* At this locality the Slite Marl is overlain by Slite g. Three other samples from higher beds – including one from the bed just above that from which G 69-10 was taken – failed to produce *K. walliseri.*

The absolute conodont frequencies at these localities indicate that the rate of sedimentation was very different; 10 m at Hallbro Slott 6 and at Klinthagen 1 may correspond to only a few decimetres or less at Haganäs 1 and a few metres at Slitebrottet 2 (Jeppsson, in preparation). Thus, the sediments here discussed at the three former localities correspond to a comparable length of time.

Correlations within Gotland. – On Gotland *K. walliseri* occurs in all varied common lithologies on Gotland except reef limestone, and its distribution, like that of *M. priodon* is not correlated with lithology. One interpretation would be that both taxa had patchy distributions during a rather long time interval during which the Slite c to lower Slite g were deposited, one after the other. Alternatively, the interval containing *K. walliseri* on Gotland was short and these units were deposited side by side. This would mean that the base of the Slite g is oldest in the Klinthagen area – where also older Slite beds are developed as limestones – and progressively younger in a southeast direction where the Slite g expanded out over the Slite Marl. If so, the regional picture in *K. walliseri* time may have been one of an unchanged(?) high rate of sedimentation of skeletal carbonate sand, with still coarser carbonates in the northwest, locally with *Megalomus* beds. A narrow zone of *Rhipidium*-rich marl and marly limestone was locally developed in the former marginal carbonate sedimentation area, and a low rate of the continuous grain-by-grain sedimentation in some areas outside this zone would have permitted the formation of hardgrounds. In Slitebrottet 2 at least the beds 4 m above sample G 73-50 are graded and cross-bedded in a way that strongly resembles Bouma's units c, d (and e?), and Bergman (1981, 1982) has found that a mud-carrying current deposited one of the lowermost accessible strata at Haganäs 1, just above a hardground. (Whether these sediments are to be described as flysch or instead as a related kind of 'bulk-deposited' sediments are outside the scope of this publication. 'Bulk-deposited' sediments seem, however, to be very important in the strata on Gotland.) A slightly raised sea level during the deposition of Slite f and contemporaneous beds may have caused marl to be deposited in the former marginal limestone area and produced starvation further out. When normal sea level was restored again, the area of carbonate sedimentation rapidly expanded seawards outside the old margin. The occurrence of graptolites in Slite f and contemporaneous beds agrees with a raised sea level, as they are usually interpreted as indicative of a more open marine environment. Berry & Boucot (1972) – citing Hede's (1942) data from Gotland – described the *M. priodon* group of graptolites as that which occurs in the most shallow areas; it occurs in the *Eocoelia* marine benthic life zone, which is the second one from the shore. On Gotland, *K. walliseri* occurs with *Panderodus equicostatus*, a species which seems to be characteristic of shallow water sediments there, while, e.g., *P. recurvatus* is not found.

Correlations outside Gotland. – In Estonia, in the middle part of the Paramaja Member of the Jaani 'stage', *K. walliseri* also occurs with graptolites, but here they have been identified as

Monograptus ex. gr. *flemingi* and *M. f.* cf. *primus* (see Viira 1975). '*M. flemingi*' is a descendent of *M. priodon* and treated as only subspecifically distinct by Jaeger & Schönlaub (1977). A comparison of the Estonian and Gotland specimens to see if the nomenclatural difference corresponds to a taxonomic one seems worthwhile. Viira found 5 sp elements of *K. walliseri* in an interval 37.5 m thick of the Ohesaare core, about 100 m below beds with *H. sagitta rhenana.* On Gotland the latter taxon occurs in the upper parts of the Högklint Beds, the basal Tofta Beds, and in Slite d, thus only below *K. walliseri.*

Another specimen of *K. walliseri* was reported from the Ukmärge core from Lithuania (Viira 1975).

Aldridge (*in* Bassett 1974:757) found two specimens of this taxon from within 3 m of the top of the Barr Limestone in central England, and later (1975 b) reported that it is common in this Limestone. The Barr Limestone is 9 or 10 m thick and was correlated with the upper *C. centrifugus,* the *C. murchisoni* and the lower *M. riccartonensis* Zones by Cocks *et al.* (1971, Fig. 4), and tentatively with the whole or part of the *M. riccartonensis* Zone by Bassett (1974). The lower part of this range corresponds to the Upper Visby Beds and the upper part to the Högklint a and b. However, the Barr faunal list also includes *Dicoelosia biloba* (see Bassett 1974:757), a brachiopod which has been found only in the Slite Beds and in younger units on Gotland, according to Bassett & Cocks (1974:11, 42). In the Upper Visby and in the Högklint Beds they found *D. verneuiliana.* Thus, both *K. walliseri* and *D. biloba* indicate a closer similarity with the Slite Beds than with older beds, and the correlation of the Barr Limestone with the graptolite zones may have to be restudied.

Aldridge (1975b:614) also recorded one specimen from the Dolyhir Limestone in Wales, co-occurring with *H. s. rhenana.* The Dolyhir Limestone was tentatively correlated with the top *C. centrifugus, C. murchisoni* and basal *M. riccartonensis* Zones by Bassett (1974). Aldridge *et al.* (1982) reported *K. walliseri* from the Brinkmarsh Formation.

Walliser (1964:88, 101) reported 1 sp element from the upper part of the *Ostracodenkalk* in the Rheinisches Schiefergebirge, where it occurs with *H. s. rhenana.*

Helfrich (1975) found a total of 14 sp elements of *K. walliseri* in a horizon up to about 2.1 m thick of the Cosner Gap Member of the Mifflinton Formation, at three localities in Virginia and West Virginia. At two of these it occurs in the lower local range of specimens identified by Helfrich as *H. s. bohemica,* at the third locality it is present just below the lowest occurrence of *H. s. bohemica.*

Barrick & Klapper (1976) identified 7 sp elements of *K. walliseri* from the middle part of the Fitzhugh Member of the Clarita Formation at two localities in Oklahoma. There it occurs in the uppermost samples with *K.? ranuliformis* and slightly above, in a horizon less than 1.0 m thick. At one locality it occurs with *H. s. rhenana.* On Gotland, *K.? ranuliformis* is not known above the middle part of the Högklint Beds, i.e. about 10 to about 40 m below Slite f. In Britain *K. walliseri* and *K.? ranuliformis* are similarly separated (Aldridge 1975b). In the sections described by Barrick & Klapper (1976) the Wenlockian is strongly condensed – it is not more than 4.5–6.5 m at the most in the two sections with *K. walliseri* – and evidence of stratigraphical leaks and reworking were reported from other levels in their sections. Therefore it may be wise to leave the question open whether the co-occurrence of the two taxa in their samples indicates a contemporaneity or not.

Nicoll & Rexroad (1968:60) reported that some of their specimens of *K.? ranuliformis* had an extra denticle on the cup. Cooper (1980:221) quoted them as having described this as a rudimentary extra process and evidently interpreted this to be the beginning of a lateral process (although the term 'rudimentary' would not imply this). Such specimens also occur on Gotland (Jeppsson 1979c:244, Fig. 72:2) and are within the range in variation of *K.? ranuliformis.* They should not be invoked in a discussion of the age of *K. walliseri.*

From Australia, Bischoff (1975:8) noted the presence of this taxon in 'higher horizons in the Borenore section'. Judging from the rest of the publication (Talent *et al.* 1975), this section is in New South Wales.

To sum up, although only slightly over 30 sp elements of *K. walliseri* have previously been reported, they have been found at 12 localities in 8 areas on three continents. Until now, I have found another 11 or 12 localities on Gotland with 28 sp elements apart from those from Stora Myre 1 (see above). At the present, beds with *K. walliseri* are assigned to various levels in the Wenlockian. This may indicate that the total range of the taxon includes a large part of the Wenlockian. If so, we would expect it to occur more than once in some of the areas or to exhibit some strong ecologic restrictions. However, in most areas the species was only found in a very thin interval. In different areas, this interval may be below, in, or above beds with *H. s. rhenana,* or in beds with '*H. s. bohemica*'. The picture is similarly diffuse in relation to graptolite ranges: above, in or below the *M. riccartonensis* Zone, and both with *M. priodon* and with its descendent *M. p. flemingi.* To suggest that *K. walliseri* may be useful for stratigraphy would thus challenge the supremacy in stratigraphy awarded to several other taxa. The variable distribution with respect to *H. sagitta* presents few problems, for as noted on p. 137, *H. sagitta* and *H. snajdri* are among the most facies-dependent Silurian conodonts. In most cases, it must be borne in mind that correlation with the type area or with graptolite zones is indirect, and errors may have accumulated in the process. There is now also so much evidence for ecological restriction of many graptolites.

In conclusion, we should consider the hypothesis that *K. walliseri* was distributed world-wide for a short interval in the early Wenlockian, probably in the late Sheinwoodian.

Slite g, Slite Marl and Slite Siltstone

The Wenlockian Slite g is up to 30 m thick and is the highest Slite limestone. Bioherms are abundant, as are more or less coarse-grained limestones. During the time of the deposition of Slite g the limestone belt expanded many kilometres, in the northeast over 10 km, out over the Slite Marl. The contact is exposed in many places. The oldest exposed Slite Marl is only slightly older than the oldest local Slite g; according to the conodont faunas the oldest Marl exposed is contemporaneous with the Slite f (see above). Most of the exposed Slite Marl is a lateral equivalent of the Slite g to the northwest or is younger, except in the Bara area and on Karlsöarna (the islands in the SW) where Halla limestone follows directly on the Slite limestone. The upper part of the Slite Marl has been subdivided into Lerberget Marl and the *Pentamerus gothlandicus* Beds (Hede 1927 b) in Stora Karlsö. The latter unit can be identified across Gotland to the east side of the island. The Slite Siltstone – up to 4.5 m – occurs only in the southwest (Hede 1921; Sivhed 1976; Bergman 1980), but the highest Slite Beds in the NE, the *Atrypa reticularis* Beds, may be developed as a sandy limestone (Hede 1928:40).

The conodont faunas available from the Slite g are small and include only long-ranging taxa, e.g., *Hindeodella excavata, H. confluens, Panderodus equicostatus, P. unicostatus* and *Ligonodina*, probably *L. excavata*.

The yield from the Slite Marl is more varied; beds with hardgrounds may produce large faunas while other levels give small but rather diversified faunas. As an example, many samples from sections in the Lerberget Marl at the type locality on Stora Karlsö have produced the following taxa: *Hindeodella excavata, H. confluens* (less frequent than *H. excavata*), *L. excavata, Panderodus unicostatus, P. recurvatus*, a third species of *Panderodus*, probably *P.* sp. g., *Pseudooneotodus* (broad-tipped), *Walliserodus*, and *Decoriconus*. None of these permit detailed correlations. In other faunas *P. equicostatus* occurs, usually together with *P. unicostatus*, i.e. the same panderodontid fauna as in the Slite g. However, *P. recurvatus* does occur in the upper Slite Marl also in the eastern part of the island. I have found it at Tjeldersholm 1, in sample G 73-8 from 0.35–0.40 m below the reference level, i.e. below the *Pentamerus gothlandicus* Beds there, too. Thus there is also some evidence for slightly deeper water in the eastern part of the area.

The samples from Slitebrottet 1 and 2, above the sample with *K. walliseri* (see above) include *H. excavata, H. confluens, L. silurica, P. equicostatus, P. unicostatus, P. recurvatus, P.* sp., *Pseudooneotodus beckmanni*, and *Kockelella absidata*. An sp element of *K. absidata* occurs in sample G 73-44, from about 17.2 m above the highest one with *K. walliseri* and another one in sample G 73-43 from 1.75 m above G 73-44.

A fauna from the topmost Slite Siltstone at Klintebys 1, in sample G 70-23, includes *Hindeodella snajdri* and *Panderodus equicostatus*.

The Halla, Mulde, and Klinteberg Beds

The late Wenlockian Halla Beds consist of about 15 m of oolite and argillaceous limestone in the northeast where they are subdivided into 3 units (Hede 1928:45, 1960), now lettered a to c (Laufeld 1974a). The Halla Beds thin out toward the SW and disappear south of Klintehamn except for a thick pile of limestones with reefs on Karlsöarna, the islands west of the main Gotland (Hede 1927b:41–42, 47–50).

The late Wenlockian Mulde Beds consist of about 25 m of marlstone in the SW but they thin out and disappear in the area where the Halla Beds are still less than one metre thick. In a NW direction it can be noted that no Mulde Beds were reported by Hede (1927b) from Lilla Karlsö, below the Klinteberg Beds.

The late Wenlockian and early Ludlovian Klinteberg Beds, as presently known, crop out in an area about 12 km wide and 50 km long. There is an outlier on Lilla Karlsö. The beds consist of up to 70 m of limestone in the east where they have been subdivided into 6 units (Hede 1929, 1960), now lettered a to f (Laufeld 1974a). In the west, the facies is partly different, and there they are presently subdivided informally into lower, middle and upper (Laufeld 1974a).

Conodont faunas from the major part of these beds typically include a member of the *H. snajdri* lineage. In this interval *H. sagitta bohemica* is often reported (e.g., Fåhraeus 1969), but at least the specimens from Gotland should be referred to *H. snajdri* (see p. 123).

The conodont faunas in the Halla Beds may be illustrated with the following species lists.

In the Halla a – the Bara oolite – at Bara 1 in sample G 70-13 there are a few specimens of *H. snajdri, H. excavata, P. beckmanni*, and *Panderodus*.

In some faunas, e.g., one extremely well preserved from the Halla b at Möllbos 1 from sample G 77-28 PSSFG (see also p. 122), *H. confluens* is the dominating *Hindeodella* species, while *H. excavata* is very rare. *P. equicostatus* occurs in good numbers as do *L. excavata, H. snajdri*, and *P. beckmanni*. The taxon illustrated as *Ozarkodina* sp. nov. by Aldridge *et al.* 1982 is represented by juvenile elements.

In other faunas *P. equicostatus* is lacking, as are all other species of *Panderodus*. This is so in many samples both from Halla c and the basal Klinteberg Beds at Gothemshammar 1, 2 and 9, where *H. confluens* and *H. snajdri* seem to be equally frequent.

In the west, in the Mulde Beds, slightly different faunas have been found. Thus, at Mölner 1 in sample G 71-6 from the top bed in the quarry, *H. excavata* dominates while *H. confluens* is rare. *H. snajdri* is even less frequent, but does occur. Both *P. equicostatus* and *P. unicostatus* occur. *Decoriconus* has not been identified in this sample but occurs in sample G 71-7, 1.70 m below G 71-6. In sample ES 166 (A.M.) an oz element of *Kockelella* occurs, probably of *K. absidata*. Faunas of the same general aspect have also been found in several samples from Djupvik 2 and Blåhäll 1. At Djupvik 2, *K. absidata* is present in samples G 70–26 and G 70–28 from 0.95–1.5 m below and 2.24 m above the reference level, respectively. Small collections from other localities in the Mulde Beds give the same picture of *H. excavata* as the dominating *Hindeodella* species while *H. snajdri* and *H. confluens* are rare; a co-occurrence of *P. equicostatus* and *P. unicostatus*, and sporadic presence of *Pseudooneotodus* and *Decoriconus*.

The contact between the Mulde and the Klinteberg Beds is exposed at Loggarve 1. Sample G 77-21 from the topmost Mulde Beds (0–0.05 m below the boundary) has produced a very well preserved fauna dominated by *H. excavata*, but also with *H. snajdri, P. equicostatus, Pseudooneotodus, Decoriconus*, and '*Ozarkodina* sp. nov.' of Aldridge *et al.* 1982. An ne element, which probably belongs to *K. absidata*, has also been found. An sp element of *K. absidata* occurs in the next sample (G 77-22) from 0–0.05 m above the boundary, i.e. in the basal Klinteberg Beds (see also p. 123).

With few exceptions the collections at hand from the Klinteberg Beds are very small, and thus the present account is a very preliminary one. *H. snajdri* continues through most of the Klinteberg Beds both in the southwest and in the east. Thus it occurs *inter alia* in the basal Klinteberg Beds at Gothemshammar 2 and 6 (see above), in the lower–middle Klinteberg Beds at Hunninge 1 in sample G 71-3 from about 5.5 m below the top of the quarry and about 2.3–3 m above the floor of the quarry; questionably in unit a at Hällinge 2; in unit c at Båtels 1 in samples G 71-90 and G 71-91 from 0.90 and 2.10 m above the lowermost exposed beds, respectively; and in unit d at Vallmyr 1 in sample ES 138 (A.M.). In the east the highest find is from unit e at Botvalde 1, in sample G 75-37. The highest find of *H. snajdri* to date in the southwest is from Klinteberget 1 in sample G 67-29 from about 8 m below the top of the section. In Britain similar forms occur in the late Homerian (Aldridge 1975b). With the exception of two questionable specimens from the Hemse Beds *H. snajdri* is absent from younger beds on Gotland until another subspecies appears in the Burgsvik Beds.

In the Klinteberg c beds at Botvaldevik 1 in sample G 75-36 *'O. serrata'*? occurs. The species may also occur in other samples (see p. 123).

The rest of the known faunas may be illustrated by the following species lists.

From Grymlings 1, the most southwesterly locality with Klinteberg Beds on main Gotland, the following species have been identified in sample G 71-1: *H. excavata, H. confluens, H. snajdri* and *P. equicostatus*.

In the lower Klinteberg Beds at Haugklintar 2, in sample G 70-31, a much less abundant but otherwise similar fauna occurs except that *H. snajdri* has not been found, and there is a *Ligonodina* species, perhaps *L. excavata,* included.

In the Klinteberg Beds unit f at Sutarve 2 in sample G 77-31 PSSFG, *H. confluens, H. excavata, P. unicostatus, P. recurvatus?, Ligonodina silurica*? and *Hindeodella* sp. m. occur.

The Hemse Beds

The outcrops of the Ludlovian Hemse Beds form a diagonal belt across Gotland about 15 km wide and 65 km long. The maximum thickness is usually given as about 100 m (Hede 1921, 1960) but is probably less. In the NE the Hemse Beds consist of about 50 m of limestone subdivided into 5 units (Hede 1929:25–54, 1958:142–144, 1960:47–48) which now are lettered a to e (Laufeld 1974:11–12). The thin unit a may contain bioherms as do unit d and unit e. These two units together are 20 m thick according to Hede 1929 but up to 25 m thick and up to 6 m thick, respectively, according to Hede 1960. The limestones continue into the 'north-central' area where these subdivisions have not been mapped. However, as the limestones consist largely of bioherms and their lateral equivalents it is likely that they are mostly representative of unit d (compare Laufeld 1974a:12) or younger, i.e. unit e and even Eke Beds (compare Martinsson 1967). Laufeld (1974a) separated his localities as undiff. L-M, M-U and U.

Marlstones are exposed to the south and west of the limestones. They are here stratigraphically divided into three parts. Hede (1972b:24) subdivided the central area of marl into an older part in the northwest and a younger one in the southeast, and, following Laufeld (1974a:12), they are here separated as NW and SE Marl. Hede did not extend this subdivision to the western coast, but judging from the conodont faunas the boundary continues from Kvinngårde (compare Hede 1927b:24) southwestward to the inner part of Linviken or slightly further to the south; Vaktård 3 and Klasård 1 have typical Hemse Marl SE conodont faunas. On the other side of the island, faunas of similar age occur in the fissure filling (mapped as thin-bedded crinoidal limestone by Watkins 1975, Figs. 3 and 4) in the Hemse d? reef at Ljugarn 1. This filling, consisting of limestone and marl, may thus be considered an eastern outlier of the Hemse Marl SE.

The topmost Hemse Marl is usually separated as a distinct unit (Munthe 1910; Laufeld 1974a, b; Larsson 1979).

On average, the Hemse Beds are more productive of conodonts than the Slite and Klinteberg Beds. Also the known diversity is larger; altogether over 20 species have now been delimited. However, only a few localities, with Hemse Marl SE, have ten or more species and only 5 to 7 species regularly occur. The three species *H. excavata, H. confluens* and *P. unicostatus* probably together make up about 75% or more of the number of elements in most samples. About half of the number of species occur only as stray specimens, many of them are represented by fewer than ten specimens each in my Hemse collections.

The Hemse Beds expose the very pronounced ecologic constraint of some species. Thus, *Panderodus recurvatus* occurs practically only in the areas where marl was laid down, where it is present throughout the sequence, while *Panderodus* sp. g. has been found throughout the limestone sequence but is restricted to that. *P. unicostatus* is present everywhere and *P. equicostatus* nowhere. Other taxa seem to be largely stratigraphically restricted. Thus, *Polygnathoides siluricus* occurs across the island independent of lithology. Others combine both restrictions, thus *Panderodus gracilis* occurs only in the distal parts of the Hemse Marl SE and in the topmost Hemse Beds.

Hemse Marl NW. – The Hemse Marl NW probably represents a rather long time span. Further studies will probably result in several stratigraphically distinctive conodont faunas being identified in it.

A few platform elements of *Kockelella variabilis* have been found at Levide 3 in sample G 79-8, at Gerumskanalen 1 in samples G 71-39 and G 77-37 PSSFG, at Överburge 1 in sample G 79-5, at Källdar 2 in sample G 71-35, at Amlings 1 in sample G 77-39b PSSFG, and at Gerete 1 in sample G 79-6. At Snoder 3 in sample G 71-10 from the bottom of the small ditch there is a juvenile specimen which either belongs here or to *Ancoradella*. *K. variabilis* also occurs at Ajmunde 1 in sample G 71-40. That locality is within the area which Hede (1927b) mapped as Klinteberg Beds. However, the locality is only 100–200 m NW of the approximate (Hede 1927b:23) boundary to the Hemse Beds, and the whole known fauna is the same as that in the Hemse Marl NW. Thus, it seems to be better to consider the locality an outlier or an extension of the same beds as those exposed at the other localities with *K. variabilis*.

Kockelella variabilis is rather long-ranging, but it changes strongly with time as illustrated by Walliser (1964:40, Pl. 16) from Cellon. The sequence is closely similar elsewhere (cf. e.g. Rexroad & Craig 1971; Klapper & Murphy 1974; Barrick & Klapper 1976), and it may be possible to subdivide the species into subspecies of stratigraphical importance. The specimens from Gotland are closest to those from the middle part of the *A. ploeckensis* Zone as defined at Cellon but strongly different from those in older strata and from those in the *P. siluricus* Zone. Similar specimens occur in Britain in the Upper Bringewood Formation (Rhodes & Newall 1963) and also in the lowermost lower Leintwardine Formation at the type locality for the base of the Ludfordian = the base of the Leintwardinian (Aldridge 1975b: 615, Pl. 1:19).

Sp elements of *Kockelella absidata* occur in collections from the Hemse Marl NW at Lukse 1 in sample G 71-12 and at Amlings 1 in sample G 77-39c PSSFG. *K.* cf. *absidata* occurs at Autsarve 1 in sample G 71-43. A distinct population occurs at Kullands 1 in sample G 77-38 PSSFG, at Gerumskanalen 1 in sample G 77-37 PSSFG, at Gardsby 1 in sample G 82-27, and at Lilla Hallvards 1 in sample G 71-143 (see p. 123). At Cellon such specimens occur in the lower and middle *A. ploeckensis* Zone (Walliser 1964). The locality Lilla Hallvards 1 has a *M. chimaera* Zone graptolite fauna (Jaeger 1981). In the type area for the Ludlovian, *M. chimaera* occurs in the Upper Elton Formation (Holland *et al.* 1963:101), but its upper range there is not known because the Lower Bringewood Formation there has not yielded any graptolites.

Fåhraeus (1969) dissolved two samples from the Hemse Marl NW, reported *Ancoradella* from both, and illustrated the oral surface of a fragmentary specimen. In small specimens the upper surface is indistinguishable from that of specimens of *Kockelella* (Walliser 1964:29). I have recollected both localities but not yet found *Ancoradella*, although *K. variabilis* occurs at Källdar 2.

The rest of the conodont fauna can be illustrated by the following faunal lists in stratigraphically ascending order:

Urgude 2, in sample G 79-10, a rather small collection comprises *H. excavata, P. unicostatus*?, *Kockelella*?, *Dapsilodus*.

Snoder 3, in sample G 71-10, from the bottom of the small ditch: *H. excavata* (dominant), *H. confluens, P. unicostatus, P. recurvatus, Kockelella*?, *Belodella*?, *H. steinhornensis*? (an unquestionable specimen of this species occurs in sample G 71-43 from Autsarve 1, in a closely similar fauna).

Lukse 1, in sample G 71-12: *H. confluens, H. excavata, H. steinhornensis, P. unicostatus, P. recurvatus, K. absidata, Decoriconus,* and *Belodella.*

Snauvalds 1, in sample G 71-14 (a small fauna): *H. excavata, H. confluens, P. unicostatus, P. recurvatus.*

The conodont faunas in the older Hemse limestones. – The conodont faunas in the Hemse a, b, c, d, undiff. L to M-U limestones are rich but similar, and as yet it has mostly been difficult to use them for correlation of the limestone units with the marls. Most of the faunas are dominated by large robust fragmentary elements of *H. confluens* and a distinct subspecies of *Panderodus* sp. g. In most samples there are also robust fragments of a species of *Ligonodina.* These fragments cannot be distinguished from *L. excavata* but they are too poorly preserved for a positive identification. That taxon can be positively identified in some samples. *H. excavata* is subordinate in frequency and *P. unicostatus* occurs in most samples. In the easternmost area there are a few specimens of *Hindeodella* sp. m. Scattered occurrences of some other taxa complete the picture. Some faunal lists can illustrate the faunas.

In the Hemse a at Katthammarsvik 1, sample G 67-30, *H. confluens* dominates over *H. excavata,* and *Panderodus* sp. g. over *P. unicostatus.* Fragments of *Ligonodina,* probably *L. excavata,* and of *Hindeodella* sp. m. also occur.

In the Hemse c at Grogarnshuvud 1 occur *H. confluens* (which dominates), *H. excavata, H.* sp. m., *Panderodus* sp. g., *P. unicostatus, L. excavata, L.* aff. *confluens,* and *H. steinhornensis.*

In the lower–middle Hemse limestone at Källdar 2, in sample G 71-35, *H. confluens* (dominates), *H. excavata, P. unicostatus, P.* sp. g., *P. beckmanni* and *K. variabilis* occur.

In the lower–middle Hemse limestone at Sigvalde 2, in sample G 71-115 from 0–0.1 m below the reference level and below the reference point, *H. confluens, H. excavata* (rare), *Panderodus* sp. g., *P. unicostatus* and *L.* aff. *confluens* occur.

The Polygnathoides siluricus Zone. – The Leintwardinian Hemse Marl SE, and at least parts of unit e, the Millklint Limestone, contain *P. siluricus.* The species is usually rare, the frequency of the sp element often being about one specimen per thousand. Fortunately, this horizon is also characterized by a very high absolute frequency of conodont elements. The faunas further show a very high diversity. Another still rarer taxon is *Kockelella* sp. a. It occurs in samples with *P. siluricus* and in the succeeding fauna.

The very well-preserved fauna from Vaktård 3 in sample G 71-148 is typical for the most westerly localities. *H. confluens* strongly dominates over *H. excavata; P. unicostatus, P. recurvatus, P. gracilis, D. dubius* and *P. siluricus* occur in frequencies between 100 and 10 specimens per kilogram. *P. beckmanni* is slightly less frequent in my collections, but it is probable that a finer screen would retain more than 10 elements per kilogram. In addition, a few elements of *Ligonodina* are found. Evidence combined from several localities indicates that both *L. excavata* and another species may occur. A fragmentary specimen of a three-branched element completes the fauna list. Similar faunas with *P. siluricus* occur in the Hemse Marl at Klasård 1 in sample G 71-150. There *Decoriconus* and a single juvenile specimen of *Belodella* have also been found.

Further to the northeast, the faunas are similar except that *Panderodus gracilis* does not occur at this level, but *Ligonodina* sp. d does. Such faunas occur in the Hemse Marl SE at Gläves 1, in sample G 75-30, at Hägvide 1 in G 71-129 (both with *Pelekysgnathus dubius*), at Gannor 3 in G 71-125, and at Fie 3 in G 71-128.

P. siluricus is also found, at Rangsarve 1, to the west of these localities, within the area where the Hemse Marl NW is overlain by reef limestone. Here it is at a topographically higher level than the closest Hemse Marl NW localities. The fauna is slightly different from that at Gläves 1, Hägvide 1, Gannor 3, and Fie 3, principally in the presence of *L. silurica*?, which is the most abundant species of *Ligonodina* at Rangsarve, and in the rarity of *D. dubius.* This locality may be at a slightly lower level than my others with *P. siluricus.* The fauna deviates strongly from those in the Hemse Marl NW, and considering the local topography, I find it likely that the beds correspond in age to the lower part of the Hemse Marl SE. Within the same limestone area, but 13 km to the ENE, in the large quarry Garde 1, *P. siluricus* occurs in the three samples G 82-35, G 71-224, and G 82-36. They are from the uppermost 1.64 m of the exposed sequence. The collections presently available are small, but seem to agree best with those from Rangsarve 1. Thus, *D. dubius* remains to be found at Garde 1. Fåhraeus' (1969) report of a single specimen of *P. siluricus* from Ekese (about 5 km ENE of Garde 1) may indicate a similar fauna there.

In the northeasternmost part of the area with Hemse Marl SE, at Gogs 1, the fauna is known from very large collections, many of which have been prepared by Anders Martinsson. Samples, collections, and specimens have also been received from Kent Larsson, Carl Pleijel and Björn Sundquist. The fauna includes a number of very rare species, some of which are poorly known or undescribed. The following taxa have been recognized to date: *H. confluens, H. excavata, P. unicostatus,* and *D. dubius* are regularly present and *P. recurvatus* occurs in good numbers in many samples. Less frequent, and absent from some half-kilogram samples, are *P. siluricus* and both kinds of undescribed elements included under gen. et sp. indet. Very rare are *Belodella, Decoriconus, Pelekysgnathus dubius* and *Pseudooneotodus*. There are also at least two, but probably several, species of *Ligonodina* and/or another genus with similar denticulation.

A similar fauna occurs at Tuten 1, in sample G 81-51. The first 0.5 kg have produced *H. confluens, H. excavata, P. unicostatus, P. siluricus, L. excavata, L. silurica*?, gen. et sp. indet., a few specimens that are questionably identified as *Panderodus* sp. g., and *Belodella*.

Closely similar, but badly fragmented, collections have also been found further to the NE, in the fissure filling of Hemse Marl SE at Ljugarn 1 in sample G 79-50, in the Millklint Limestone at Millklint 1 in sample ES 137 (A.M.) and at Millklint 3 in sample G 69-32. Like those from Gogs 1 and Tuten 1, all three faunas include gen. et sp. indet. There is at least one real difference from the Gogs fauna: *Panderodus* sp. g occurs, as in older Hemse limestone units, and *P. recurvatus* is absent except for stray specimens at Ljugarn 1.

In the Hemse beds at Kuppen 1, in sample G 81-44 from 0–0.11 m above the reference level, there is an identical fauna. The fauna differs markedly from studied Hemse d faunas, in which *D. dubius* and gen. et sp. indet. are absent. Hede (1929:38) described what is now (Laufeld 1974a, cf. Hede 1960) separated as d and e, as one stratigraphic unit, and described the Millklint Limestone only as the highest lithologic unit within it (Hede 1929:49). His description of the beds in question (1929:40) at Kuppen 1, is closely similar to that of the strata at Millklint. However, he did not introduce the term Millklint Limestone until some pages after he had described both Kuppen 1 and the type area. Anyhow, the similarities in the conodont faunas are so large that I here refer the beds above the reference level to the Hemse e. Similarly, the marls and limestones at Rangsarve 1 should be referred to the Hemse Marl SE and unit e respectively.

My correlations agree closely with those based on ostracodes by Martinsson (1967). For example, ostracodes and conodonts both indicate that beds at Rangsarve (Martinsson's Linde area) and in the east are to be correlated with the Hemse Marl SE. As is to be expected when more fossils are put in stratigraphic use it is possible to refine some biostratigraphical divisions slightly; in particular, the *P. siluricus* Zone on Gotland is very thin and does not include the top of the Hemse Marl, which can thus be separated.

The age of the P. SILURICUS Zone. – Hede (1919, 1942:20, loc. 1 c, 2 c) reported *Monograptus bohemicus* from Vaktård 3 and Klasård 1. Some of Hede's other finds of *M. bohemicus* on Gotland are at localities which he mapped as Hemse Marl SE, and at least one (Bodudd 3) – as far as can be judged – has a *Pelekysgnathus dubius* fauna, and thus represents the uppermost Hemse Marl. In Great Britain, at that time, *M. bohemicus* was only known in strata that were referred to the *M. nilssoni* Zone (Hede 1919), the lowermost Ludlovian graptolite Zone. However, it does occur higher; Jaeger (1975) reported it from Cellon in the upper part of the *Cardiola-Niveau*, i.e. in the upper part of the *P. siluricus* Zone, an occurrence he dated as younger than *M. leintwardinensis*. He has also concluded (1981:12) that a graptolite fauna from the Hemse Marl NW beds at Lilla Hallvards 1 belongs in the *M. chimaera* Zone, which succeeds the *M. nilssoni* Zone. Thus the Hemse Marl SE cannot belong to the *M. nilssoni* Zone. Walliser (1964:97) found the *P. siluricus* Zone between *M. fritschi linearis* and *M. ultimus* at Hviždalka in Bohemia, and Kříž & Schönlaub (1980) showed that the basal bed of the *P. siluricus* Zone at Můslovka in the same area contains *M. fritschi linearis* (*M. bohemicus* occurs just below the *P. siluricus* Zone there).

Thorsteinsson & Uyeno (1980 [1981]:23) also discussed the age of the *P. siluricus* Zone. They referred to Klapper & Murphy (1974) as concluding 'that the lower range of *P. siluricus* overlaps the Zone of *M. chimaera* in Nevada'. Apparently their reference is to Figs. 6 and 8 in Klapper & Murphy's publication, where *M. chimaera* is shown to range about 120 and 80 feet, respectively, above the interval with *P. siluricus*. However, Klapper & Murphy did not themselves refer to this graptolite range as the *M. chimaera* Zone, a term which they used for an older interval with the *A. ploeckensis* Zone (Klapper & Murphy 1974:12, Fig. 7). That correlation agrees well with that discussed above for parts of the Hemse Marl NW.

The *P. siluricus* Zone is known from many other areas, but not yet from the type area for the Silurian in Great Britain. However, Martinsson (1967) reported an ostracode fauna with *Neobeyrichia scissa* and *N. lauensis* from several of the Hemse Marl SE localities with *P. siluricus*, and using this, he could correlate them (and the top of the Hemse Marl) with the late Leintwardinian. This agrees closely with the European graptolite and conodont evidence dicussed above, and it is thus the most likely age of the *P. siluricus* Zone.

The uppermost part of the Hemse Marl. – The conodont faunas in the top of the Hemse Marl are similar to those in the Hemse Marl SE except that *P. siluricus* and some other of the very rare taxa have not been found, while at least *P. dubius* is slightly more frequent. The faunas show similar changes from the west to the east. At Bodudd 1 in sample G 81-30, from the lowermost beds exposed, there is a very well preserved fauna. It includes *P. gracilis* (about 20 elements per kg) together with *H. excavata, H. confluens, P. unicostatus, D. dubius, P. dubius, P. beckmanni*, and at least one unidentified species. At Bodudd 3 in a much larger collection (sample G 71-151) *Decoriconus, P. recurvatus*, and *Belodella* also occur.

Stray specimens of *P. gracilis* occur also further to the east, at Kärne 3 (S of Burgen) at least up to about 0.75 m below the top of the Hemse Beds in sample G 71-196, and at Hallsarve 1 in samples G 69-26 and G 69-27 from 0.15–0.25 m and 0–0.05 m below the reference level (= the base of the Eke Beds), respectively. At the former locality *P. dubius* also occurs; the collections at hand from Hallsarve are much smaller. *P. dubius* also occurs at Gannor 1 in sample G 71-120 from 0.65 m below the reference level and at Botvide 1, less than 1 m below the boundary. At that locality in sample G 66-248 SL from 0.50–0.55 m below the boundary, *Hindeodella* sp. m has been found.

The youngest Hemse limestones. – A very large conodont collection from the Millklint Limestone at Millklintdalen 2, sample G 77-44 PSSFG, contains *H. confluens, H. excavata, P. unicostatus, P.* sp. g, *P. recurvatus, D. dubius, Ligonodina* sp., *Kockelella* sp. a, and questionably also *P. dubius.* A much smaller collection from Herrgårdsklint 1 (sample G 71-80) contains *H. confluens, H. excavata, L. excavata, P. unicostatus,* and questionably also *P. dubius.* At Kuppen 1, in sample G 81-45, from 0.11–0.14 m above the reference level, *H. confluens, H. excavata, D. dubius, P. dubius* (many specimens per kg), *Pseudooneotodus, P. unicostatus, P.* sp. g, *Ligonodina, Kockelella*? sp., and *Hindeodella* sp. m occur. This fauna differs from that in G 81-44 (see above), inter alia in the greater frequency of *P. dubius* and the absence of gen. et sp. indet. Two smaller collections from Kuppen 2, G 81-46 from 0.03–0.08 m and G 81-47 from about 2.5 m above the reference level there, have only produced *H. confluens, H. excavata*?, *P.* sp. g, *P. unicostatus*?, *Ligonodina,* and *Kockelella*? sp. Samples from Östergarnsholm 1, 2, and 3 (G 78-19 CB, G 78-18 CB, and G 78-20 CB, respectively) and sysne 1 (sample G 81-49) contain similar faunas; *D. dubius* occurs in the samples from Östergarnsholm 3 and Sysne 1 (the collections available from the other two localities are too small for any conclusion), and a possible specimen of *P. dubius* and another of '*Ozarkodina* sp. nov.' of Aldridge *et al.* 1982 in the collection from Östergarnsholm 3. It is possible that *D. dubius* occurs below the *P. siluricus* Zone on Gotland; thus, the beds on Östergarnsholm and at Sysne may be older than that zone. However, other samples must be younger; thus they indicate that the Hemse limestones reach above the *P. siluricus* Zone (cf. Martinsson 1967). As yet I have no good faunistic characteristic to distinguish any possible outliers of the Eke Beds (see below), but at least the collections with *P. dubius* and/or *D. dubius* agree closest with the uppermost Hemse Marl.

The Eke Beds

The Late Leintwardinian to early Whitcliffian Eke Beds crop out in an area some kilometres wide and 28 km long. Outliers in the area of the Hemse Marl SE mapped by Hede (1925b) extend the area by another 10 km. Martinsson (1967:373) identified outliers also in the Hemse limestone area, extending the distribution a further 18 km to the NE. Regarding evidence of the former extension, see also Jeppsson 1982. In most of the area, the beds consist of about 10 m of calcareous mudstone and argillaceous limestone abundant in calcareous algae. In the NE the lower levels are to a large extent developed as crinoidal limestone with small bioherms.

The lower few metres of the Eke Beds are exposed in many places, and I have many fairly large faunas from them. The yield is lower than in the Hemse Beds, and the diversity of the faunas is much lower. Only *H. excavata, H. confluens,* and *Panderodus unicostatus* are regular, and *Pseudooneotodus beckmanni* occurs in some samples. Thus, the faunal constituents are those that dominate the upper Hemse faunas, with the difference that all the 'exotic' taxa have disappeared.

Higher in the Eke Beds this fauna is replaced by a distinctly different one. The meagre faunas are dominated by *Panderodus equicostatus,* with *Pseudooneotodus beckmanni* and *Decoriconus* in most collections. Two specimens of *Dapsilodus* have been found, one at Ronnings 1 in sample G 79-47 and another at Ronehamn 3 in sample G 69-51. Taxa with bar elements are equally rare; one sp element of *H. steinhornensis* has been found in G 69-51, and the oldest find on Gotland of *L.* cf. *elegans,* one fragmentary hi element, derives from Ronnings in sample G 71-190. Another species of *Ligonodina* – probably *L. excavata* – also occurs at this level, represented by a fragment in sample G 69-51. Most interesting, however, is a single fragmentary specimen of an icriodontid in sample G 71-190. The specimen is difficult to identify, but is closest to *Pedavis thorsteinssoni* Uyeno 1981, and may well belong there.

The Burgsvik, Hamra and Sundre Beds

The Whitcliffian Burgsvik Beds crop out in a belt about 50 km long and largely less than 1 km wide. In the Burgsvik area, the beds consist of up to 45 m of sandstone and claystone overlain by up to 2 m of mixed beds, including oolites, pisolites and sandstone (see Stel & de Coo 1977). In the south, the lithologies are similar, but in the extreme NE, at Burgen, the Burgsvik Beds are only 7–8 m thick and oolites and biohermal limestones are the most important lithologies.

The latest Ludlovian Hamra Beds crop out in an area 30 km long. There are also some outliers 15–20 km further to the NE. In the southwest the Hamra Beds are mostly 20–25 m thick, but locally reach 40 m. They are subdivided into three units, designated a, b, and c, the lower one consisting of algal nodules and the other two of more or less argillaceous limestone and biohermal and associated detrital limestones. In the outliers to the NE there is less than 10 m of biohermal limestone remaining.

The uppermost stratigraphical unit on Gotland is the latest Ludlovian Sundre Beds. They crop out in an area up to 18 km long along the coast in the southeast and reach a maximum of 10 m of crinoidal and biohermal limestones.

Faunas from the Burgsvik Beds. – On Närsholmen, the northeasternmost land-area with Burgsvik Beds, conodonts have been found in the oolithic lower Burgsvik Beds at Glasskär 1 in sample G 72-18. As yet only a few tens of specimens have been extracted, but the fauna is diverse and includes *H. confluens, H. wimani, H. snajdri, L. excavata novoexcavata* and *P. equicostatus.* In Skåne *H. wimani* appears in beds containing *H. s. scanica.* Thus, it is possible that the Bjärsjölagård Limestone in Skåne is to be correlated with parts of the Burgsvik Beds on Gotland and the white sandstone (unit 4 of Eichstädt 1888, unit 2 of Grönwall 1897) in the Öved–Ramsåsa Group in Skåne may be correlated with the sandstones in the upper part of the Burgsvik Beds.

Faunas from the top Burgsvik Beds and the Hamra a. – Relatively large samples have been dissolved from the uppermost Burgsvik Beds and lowermost Hamra Beds, but the faunas recovered are very small. At Uddvide 2, nine specimens of *H. steinhornensis* have been found in samples from four levels in the Burgsvik Beds and four more in one sample from the basal Hamra Beds. In the latter sample *H. confluens* and *L. excavata novoexcavata* also occur. At Hoburgen 2 the meagre faunas are dominated by *H. excavata,* while *H. steinhornensis* has not been identified. The faunas there also include *P. equicostatus, H. confluens,* and *L. excavata novoexcavata.* The specimens of *H. steinhornensis* from Uddvide 2 are very similar to the youngest *H. s. scanica* from Klinta in Skåne, but none of the relevant elements are well enough preserved to say whether the denticles alternate in size or not. I have described the interval at Klinta with these elements as that of the younger *H. s. scanica* fauna (1974). That fauna is characterized by the absence of other species of *Hindeodella, Ligonodina,* and *Distomodus*.The collections at hand from the Burgsvik Beds at Uddvide thus agree also in this aspect. The differences between Uddvide 2 and Hoburgen 2 may either indicate a biofacies difference or more probably, an age difference. If so, the beds at Hoburgen 2 are probably the younger.

Faunas from Hamra b. – At Bankvät 1, in sample G 81-39, *H. confluens, H. snajdri crispa,* and a population of *H. steinhornensis* with alternating denticulation occur in good numbers. *H. wimani* and *L. elegans* are rare. It is notable that neither *H. excavata* nor *Panderodus* has been identified among the several hundred elements extracted. One specimen of the latter taxon occurs in sample G 72-2 from Bankvät 1. A closely similar fauna occurs at Strands 1 in sample G 75-14, which has *H. confluens, H. steinhornensis, H. snajdri crispa, H. wimani,* and *L. elegans.*

During the Whitcliffian and earliest 'post-Whitcliffian' much happened in the evolution of the conodonts, e.g., *H. steinhornensis* became more abundant and evolved alternating denticulation, *H. s. snajdri* evolved into *H. s. crispa* (Schönlaub *et al.*, in prep.), the lineage of *H. wimani* appeared and evolved rapidly, and that of *L. elegans* is again commonly represented in collections. *H. wimani* appears in the lower Burgsvik Beds (see above). *H. steinhornensis* with alternating denticulation is rare in the collection from Strands, dominates in those from Bankvät, and is not found in the other Hamra b collections; thus, Bankvät seems to represent the very youngest Hamra b and Strands a slightly older level. Also the first definite *L. elegans* appears at Strands. Further taxonomic studies are necessary to identify the levels defined by the evolutionary events.

In the type area for the Ludlovian in Britan, *H. steinhornensis* with alternating denticulation occurs in the very latest Whitcliffian, but the other more or less contemporaneous developments in other taxa have not been recognized (Aldridge, written communication). This may indicate that the uppermost units on Gotland are younger than the Upper Whitcliffe Formation in the type area. On the other hand Martinsson (1967) has shown that low levels in the Downton Castle Sandstone Formation are younger than the Sundre Beds. Thus several tens of metres of sediments on Gotland may have been formed during an interval poorly represented in the type area of the Ludlovian.

The faunas from Strands and Bankvät are very similar to the Wenlockian ones from Gothemshammar in which a different subspecies of *H. snajdri* and *H. confluens* dominate, while *H. excavata* and *Panderodus* are rare or absent. The fauna may also be compared with those from the upper parts of the Högklint Beds in Vattenfallet (Jeppsson 1979c). There *H. confluens* appears slightly before *H. sagitta,* a close relative of *H. snajdri, H. excavata* is much rarer than in the lower Högklint Beds, and *Panderodus* is very rare. Another close relative of *H. snajdri, H. steinhornensis,* also often occurs in faunas in which *Panderodus* and *H. excavata* are rare or absent, e.g., in Skåne (Jeppsson 1974) and in the *Beyrichienkalk* (Jeppsson 1981). None of these three closely related taxa is limited to collections in which *Panderodus* and *H. excavata* are rare or absent, but they seem to be more rare in other collections. As is the case in the Halla Beds (see p. 132), *H. snajdri* is rarer, and the faunas more normal further to the southwest. Thus, *H. snajdri* occurs in sample G 77-33 PSSFG (3.99 kg) from Kättelviken 5 but is not found in five 0.5 kg samples higher up in the section. Sample G 77-33, which is from less than 5 m above the base of the Hamra Beds, has also yielded *H. excavata, H. confluens, H. steinhornensis, P. equicostatus, Belodella, Pseudooneotodus, Dapsilodus*?, and *L. excavata*?.

Faunas from the Hamra c. – Some of the beds at Juves have produced rich faunas, which I plan to describe in another publication. The following taxa have been found to date: *H. confluens, H. excavata, H. snajdri crispa, H. steinhornensis, H. wimani* n. ssp., *L. confluens, L. elegans, L. excavata novoexcavata, P. equicostatus, P. unicostatus, P. beckmanni,* and questionably *Belodella.* Of these *H. wimani* and *Belodella* are very rare, and several of the other taxa are not met with in the smaller collections. Other localities do not seem to add much to the picture of the fauna, although *P. unicostatus* has not been found at Hoburgen 3.

In Anders Martinsson's sample Hoburgen I from the upper Hamra Beds at Storburg 1 there is an element of *Distomodus dubius.* In Britain this taxon continues into the basal Downton Beds (Aldridge 1975b), but on Gotland this is the only find to date from post-Leintwardinian beds. The species is regular in the Hemse Marl SE, e.g., at Gogs, and it may be significant that Anders Martinsson designated the Hoburgen I sample as 'Gogs lithology'.

Sundre faunas. – In the Sundre Beds at Juves *H. excavata, H. confluens, H. steinhornensis, L. confluens, L. excavata novoexcavata, Panderodus equicostatus,* and *P. unicostatus* occur. Most or all of the differences between this list and that from the Hamra c at the same locality can be accounted for by the smaller sizes of the collections from the Sundre Beds. Other Sundre faunas available contain a similar set of species.

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Christin Andreasson drafted fig. 1, Ingrid Lineke typed the manuscript, and Sven Stridsberg took the photographs.

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Appendix: Localities

In the list of references to each locality, an asterisk marks the publication in which a full description of the locality is found. For localities described in Laufeld 1974b, Laufeld & Jeppsson 1976 and Larsson 1979, earlier literature is not cited. Grid references refer to the Swedish National Grid system and (within parentheses) the Universal Transverse Mercator (UTM) system.

AJMUNDE 1. Earlier referred to as Klinteberg Beds, Klinteberg Marl top. In my opinion, the same unit as other localities referred to Hemse Marl NW. Beds with *Kockelella variabilis. Age:* Ludlovian; probably Bringewoodian.
References: Laufeld 1974a, b*; Laufeld & Jeppsson 1976; Larsson 1979.

AMLINGS 1. Hemse Beds, Hemse Marl NW part. Beds with *Kockelella variabilis. Age:* Ludlovian; probably Late Bringewoodian, possibly earliest Leintwardinian.
References: Laufeld 1974a, b*; Laufeld & Jeppsson 1976; Larsson 1979.

AURSVIKEN 1. Högklint Beds, the middle of three Högklint units separated by Hede (1936), probably high in that unit; lower–middle part (Laufeld 1974b). Beds with *Kockelella? ranuliformis* and *Hindeodella sagitta rhenana. Age:* Early Wenlockian.
References: Laufeld 1974a, b*.

AUTSARVE 1. Hemse Beds, Hemse Marl NW part. *Age:* Ludlovian; probably Bringewoodian.
References: Laufeld 1974a, b*.

BANKVÄT 1. Hamra Beds, unit b. Beds with *Hindeodella snajdri crispa. Age:* Latest Ludlovian.
References: Laufeld 1974a, b*; Larsson 1979; Jeppsson 1982.

BARA 1. Halla Beds, unit a, i.e. Bara Oolite. Beds with *Hindeodella snajdri. Age:* Late Wenlockian.
References: Laufeld 1974a, b*; Larsson 1979; Jeppsson 1982.

BÅTA 1. Slite Beds, unit f. i.e. *R. tenuistriatum* Beds. Beds with *Kockelella walliseri. Age:* Early Wenlockian.
References: Laufeld 1974a, b*; Larsson 1979.

BÅTELS 1. Klinteberg Beds, unit c. Beds with *Hindeodella snajdri. Age:* Late Wenlockian.
References: Laufeld 1974a, b*.

BLÅHÄLL 1. Mulde Beds, lower part. *Age:* Late Wenlockian.
References: Laufeld 1974a, b*; Larsson 1979; Claesson 1979; Poulsen *et al.* 1982.

BODUDD 1. Hemse Beds, Hemse Marl uppermost part and Eke Beds, basal part. The Hemse Beds contain the *Pelekysgnathus dubius* fauna. *Age:* Ludlovian; Late Leintwardinian.
References: Laufeld 1974a, b*; Larsson 1979; Jeppsson 1982.

BODUDD 3. 633050 164550 (CJ 3065 2972), ca 5000 m SW of Näs church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 152 Burgsvik.

Shore exposure on the northern side of the bulge in the coast line, with five bushy service-trees *(Sorbus),* only three of them alive and standing.

Hemse Beds, Hemse Marl uppermost part. Strata with the *Pelekysgnathus dubius* fauna. *Age:* Ludlovian; Late Leintwardinian.
References: Hede 1919:21, Loc. 9; Hede 1942:20, Loc. 1C.

BOTVALDE 1. 638860 167638 (CJ 6588 8526), ca 1800 m NE of Gothem church. Topographical map sheet 6J Roma NV & NO. Geological map sheet Aa 169 Slite.

Shallow 'quarry', about 40 m SW of the road and a few metres E of the edge of the pine forest, 450 m NW of the road intersection at Tummungs.

Klinteberg Beds, unit e. Beds with *Hindeodella snajdri. Age:* Wenlockian; Late Homerian.

Reference: Hede 1928:61, lines 5–10.

Note: Hede's description of the beds and of their stratigraphical position (Hede 1928:61) is closely similar to his description of the beds that are now referred to unit e (Hede 1929:20), and the beds can be considered to belong to unit e. Botvalde 1 is thus the northernmost known locality with that unit.

BOTVALDEVIK 1. Klinteberg Beds, unit c. *Age:* Late Wenlockian.

Reference: Larsson 1979*.

BOTVIDE 1. Hemse Beds, Hemse Marl uppermost part and Eke Beds lowermost part. The Hemse Beds contain the *Pelekysgnathus dubius* fauna. *Age:* Ludlovian; Late Leintwardinian.

References: Laufeld 1974a, b*; Jeppsson 1974:10; Larsson 1979; Laufeld & Martinsson 1981; Jeppsson 1982; Cherns 1982.

DJUPVIK 2. 635556 164074 (CJ 2776 5504), ca 4450 m WNW of Eksta church. Topographical map sheet 6I Visby SO. Geological map sheet Aa 164 Hemse.

Cliff section just SW of the disturbed beds below the place where there are some trees NW of the road, about 675 m SW of the harbour of Djauvik.

Reference level: There are four deeply caved marl beds (bentonites?) in the section and some less distinct ones. The middle two are about 2 m above the base of the section and about 0.2 m apart. The lower of these is selected as the reference level. The remaining two distinct marl beds occur 1.5 m below and 1.10 m above the reference level; *Tussilago farfara* grows in the uppermost bed.

Mulde Beds, lower part. Beds with *Hindeodella snajdri. Age:* Late Wenlockian.

Reference: Hede 1927b (to the whole 1.1 km long section).

Note: The thicknesses between the marl beds are so similar to those described by Laufeld 1974a from Djupvik 1, that they are almost certainly the same horizons. Thus the same reference level can be used at the two localities.

FIE 3. 635294 167097 (CJ 5770 5005), ca 1700 m NE of När church. Topographical map sheet 6J Roma SV. Geological map sheet Aa 156 Ronehamn.

Ditch exposure along the field road (not marked on the topographical map) about 10 m E of the road between Kauparve and Hägdarve.

Hemse Beds, Hemse Marl, southeastern part. Beds with *Polygnathoides siluricus. Age:* Ludlovian; Leintwardinian.

GALGBERGET 1. Högklint Beds, unit c and Tofta Beds, basal part. The Högklint Beds contain *Hindeodella sagitta rhenana. Age:* Early Wenlockian.

References: Laufeld 1974a, b*; Larsson 1979; Claesson 1979; Laufeld & Martinsson 1981; Jeppsson 1982.

GANNOR 1. Hemse Beds, Hemse Marl, uppermost part and Eke Beds, basal part. The Hemse Beds contain the *Pelekysgnathus dubius* fauna. *Age:* Ludlovian; Late Leintwardinian.

References: Laufeld 1974a, b*; Eisenack 1975, Fig. 30; Laufeld & Jeppsson 1976; Larsson 1979; Claesson 1979.

GANNOR 3. Hemse Beds, Hemse Marl SE part. *Polygnathoides siluricus* Zone. *Age:* Ludlovian; Leintwardinian.

References: Laufeld 1974a, b*.

GARDE 1. 636109 166785 (CJ 5513 5853), ca 3100 m N12°E of Garde church. Topographical map sheet 6J Roma SV. Geological map sheet Aa 170 Katthammarsvik.

Abandoned, large quarry (marked on both maps) 650 m SE of point 53,46. My section was measured about 50 m west of the eastern end of the quarry.

Reference level: The lower surface of the oldest bed with large (up to 100 mm) stromatoporoids, the boundary between the two units in Hede 1929.

Hemse Beds, unit e. At least the beds from 0.2 m below the reference level belong in the *Polygnathoides siluricus* Zone. *Age:* Ludlovian; Leintwardinian.

Reference: Hede 1929:47, line 39–p. 48, line 19.

GARDSBY 1. 635366 165328 (CJ 4015 5222), ca 2200 m N (and slightly E) of Fardhem church. Topographical map sheet 6J Roma SV. Geological map sheet Aa 164 Hemse.

Exposure 5 m N of the road in the small ditch, perpendicular to the road, 25 m NW of the solitary house 350 m ESE Gardsby.

Hemse Beds, Hemse Marl NW part. *Age:* Ludlovian; Bringewoodian or Leintwardinian.

GERETE 1. Hemse Beds, Hemse Marl NW part. Beds with *Kockelella variabilis. Age:* Ludlovian; Bringewoodian or Leintwardinian.

References: Laufeld 1974a, b*; Franzén 1977; Larsson 1979.

GERUMSKANALEN 1. Hemse Beds, Hemse Marl NW part. Beds with *Kockelella variabilis. Age:* Ludlovian; probably Late Bringewoodian, possibly earliest Early Leintwardinian.

References: Laufeld 1974a, b*; Laufeld & Jeppsson 1976; Jeppsson 1982.

GLASSKÄR 1. Burgsvik Beds, lower part. Fauna with *Hindeodella wimani* and *H. snajdri. Age:* Ludlovian; Whitcliffian.

References: Laufeld 1974a, b*; Larsson 1979.

GLÄVES 1. Hemse Beds, Hemse Marl SE part. The locality was unavailable in 1971 but in 1975 the ditch along the northern side of the main road and along the western side of the approach road to the farm had recently been deepened. My sample is from the ditch along the approach road 5 m from the main road. *Polygnathoides siluricus* Zone. *Age:* Ludlovian; Leintwardinian.

References: Laufeld 1974b*; Jeppsson 1974:7; Larsson 1979.

GOGS 1. Hemse Beds, Hemse Marl SE part. *Polygnathoides siluricus* Zone. *Age:* Ludlovian; Leintwardinian.

References: Laufeld 1974a, b*; Jeppsson 1972:63, Fig. 1B, 1974:7, 12, 1976:108, 109, 113–117; Janvier 1978; Larsson 1979; Jeppsson 1982; Brood 1982:24–25.

GOTHEMSHAMMAR 1. Halla Beds, unit c and Klinteberg Beds, unit a. Beds with *Hindeodella snajdri. Age:* Late Wenlockian.

References: Laufeld 1974a, b*; Larsson 1979.

GOTHEMSHAMMAR 2. Halla Beds, unit c and Klinteberg Beds, unit a. Beds with *Hindeodella snajdri. Age:* Late Wenlockian.

References: Laufeld 1974a, b*; Larsson 1979; Claesson 1979.

GOTHEMSHAMMAR 3. Halla Beds, unit c and Klinteberg Beds, unit a. Beds with *Hindeodella snajdri. Age:* Late Wenlockian.

Low section on the shore, partly covered by scree from the raised beach ridge. Drive 3.3 km from road 146 to where the road splits into three parallel ones close to each other. The locality is immediately NW of a large *Salix* shrub to the left of the northern road.

References: Laufeld 1974b*; Larsson 1979; Poulsen *et al.* 1982.

GOTHEMSHAMMAR 6. Halla Beds, unit c. Beds with *Hindeodella snajdri. Age:* Late Wenlockian.

References: Laufeld 1974b*; Claesson 1979.

GROGARNSHUVUD 1. Hemse Beds, unit c. *Age:* Early Ludlovian.

References: Laufeld 1974a, b*; Larsson 1979; Claesson 1979; Laufeld & Martinsson 1981; Jeppsson 1982; Sundquist 1982a.

GRYMLINGS 1. 635566 164505 (CJ 3210 5485), ca 1970 m NNE of Eksta church. Topographical map sheet 6I Visby SO. Geological map sheet Aa 164 Hemse.

Exposure 1 m W of the road at the intersection of the roadside ditch and the drainage ditch that crosses the road 750 m WSW of Grymlings.

Klinteberg Beds, lower–middle part. Beds with *Hindeodella snajdri. Age:* Late Wenlockian.

Note: This is the most southwesterly exposure available for the Klinteberg Beds except for Karlsöarna.

HAGANÄS 1. Slite Beds, Slite Marl (the part which is contemporaneous with unit f) and unit g. The lowermost exposed Slite Marl contains *Kockelella walliseri. Age:* Early Wenlockian.

References: Laufeld 1974a, b*; Larsson 1979; Bergman 1981, 1982; Sundquist 1981, 1982b.

HÄGVIDE 1. Hemse Beds, Hemse Marl SE part. *Polygnathoides siluricus* Zone. *Age*: Ludlovian; Leintwardinian.
References: Harper 1969:188 (USNM Loc. 10026) *not* Fig. 3; Laufeld 1974a, b*; Larsson 1979.

HÄLLAGRUND 1. Högklint Beds, unit c and Slite Beds, unit c. *Age*: Early Wenlockian.
References: Laufeld 1974a, b*.

HALLBRO SLOTT 6. 63860 16417 (CJ 3104 8530), ca 4500 m W and slightly S of Västerhejde church. Topographical map sheet 6I Visby NO. Geological map sheet Aa 183 Visby & Lummelunda.
Section 300 metres E of Allhagemyr. For a measured section, see Hedström 1910, Pl. 55.
Reference level: The lower boundary of Hedström's (1910) '*Leperditia* shale', about 1.8 m thick, and consisting of marly limestone and marl.
Slite Beds, units c, e, and g. *Samples*: G 73–12, 2.55–2.45 m below the reference level, strata with *Kockelella walliseri*; G 73–13, 0.05–0.15 m above the reference level; G 73–14, 0.80–0.90 m above the reference level; G 73–15, 2.50 m above the reference level. *Age*: Early Wenlockian.
Reference: Hedström 1910, Fig. 5, Pl. 55.
Note: To avoid confusion, I recommend that the localities in the Hallbro Slott area numbered by Hedström 1910p. 1479, should keep their numbers; therefore this locality is numbered 6 even though it is the first Hallbro Slott locality to be described in the formal system.

HÄLLINGE 2. Klinteberg Beds, unit a. Beds questionably with *Hindeodella snajdri*. *Age*: Late Wenlockian.
References: Laufeld 1974a, b*.

HALLSARVE 1. Hemse Beds, Hemse Marl uppermost part, and Eke Beds, lowermost part. The Hemse Beds probably contain the *Pelekysgnathus dubius* fauna. However, *P. dubius* itself remains to be found. *Age*: Ludlovian; Late Leintwardinian.
References: Laufeld 1974a, b*; Jeppsson 1974:10; Larsson 1979; Cherns 1982.

HAUGKLINTAR 2. Klinteberg Beds, lower part. *Age*: Late Wenlockian.
References: Laufeld 1974a, b*.

HERRGÅRDSKLINT 1. Hemse Beds, unit e. Beds probably with the *Pelekysgnathus dubius* fauna. *Age*: Ludlovian; Late Leintwardinian.
References: Laufeld 1974a, b*; Larsson 1979.

HOBURGEN 2. Burgsvik Beds, top part and Hamra Beds, unit a. *Age*: Ludlovian, Whitcliffian.
References: Laufeld 1974a, b*; Jeppsson 1974:13; Larsson 1979; Claesson 1979; Laufeld & Martinsson 1981; Jeppsson 1982.

HUNNINGE 1. Klinteberg Beds, lower-middle part. Beds with *Hindeodella snajdri*. *Age*: Late Wenlockian.
References; Laufeld 1974a, b*; Larsson 1979.

JUVES 2, 3, 4, 5. Hamra Beds unit c and Sundre Beds, lower part. Beds with *Hindeodella snajdri crispa*. *Age*: Latest Ludlovian.
References: Jeppsson 1972:59, 60; Barnes *et al.* 1973; Laufeld 1974a, b*; Jeppsson 1974:11, 45, 79; Laufeld & Jeppsson 1976*; Larsson 1979; Claesson 1979; Jeppsson 1982.

KÄLLDAR 2. 635145 165412 (CJ 4095 5172), ca 1150 m W of Linde church. Topographical map sheet 6J Roma SV. Geological map sheet Aa 164 Hemse.
About 1.5 m high, north-facing section in the abandoned quarry just N of Kälder.
Hemse Beds, lower–middle part. Beds with *Kockelella variabilis*. *Age*: Ludlovian; Bringewoodian or possibly earliest Leintwardinian.
References: Hede 1927b:33 line 3–12; Fåhraeus 1969:12.

KÄRNE 3. 644770 166630 (CJ 5266 4525), ca 3800 m ESE of Burs church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 156 Ronehamn.
Exposures (fresh in 1971) in a N-S running ditch 150 m SE Kärne (that Kärne which is on the south slope of Burgen). West of the ditch there is an E-W boundary between two fields. The contact is found 30 m north of this boundary.
Hemse Beds, Hemse Marl uppermost part and *Eke Beds*, basal part. The Hemse Beds contain the *Pelekysgnathus dubius* fauna. *Age*: Ludlovian; Late Leintwardinian.

KATRINELUND 1. Slite Beds, unit c. Beds with *Kockelella walliseri*. *Age*: Wenlockian.
References: Laufeld 1974a, b*.

KÄTTELVIKEN 5. Hamra Beds, unit b. Beds with *Hindeodella snajdri*. *Age*: Ludlovian; Late Whitcliffian or slightly younger.
References: Laufeld & Jeppsson 1976*; Larsson 1979.

KATTHAMMARSVIK 1. Hemse Beds, unit a. *Age*: Early Ludlovian.
References: Laufeld 1974a, b*; Laufeld & Martinsson 1981.

KLASÅRD 1. 633190 164580 (CJ 3105 3107), ca 3800 m SW of Näs church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 152 Burgsvik.
Shore exposure on the bulge of the shore with three shrubby service-trees (*Sorbus*) at the end of the field road. Sample G 71-150 from 10 m N of these trees.
Hemse Beds, Hemse Marl SE part. *Polygnathoides siluricus* Zone. *Age*: Ludlovian; Leintwardinian.
References: Hede 1919:20 line 24–p. 21 line 8, loc. 8; Hede 1942:20, loc. 2c.

KLINTEBERGET 1. Klinteberg Beds, lower-middle parts. Beds with *Hindeodella snajdri*. *Age*: Late Wenlockian.
References: Laufeld 1974a, b*; Larsson 1979; Claesson 1979: Laufeld & Martinsson 1981; Jeppsson 1982.

KLINTEBYS 1. Slite Beds, Slite Siltstone (top) and Halla Beds. Both Beds contain *Hindeodella snajdri* *Age*: Late Wenlockian.
References: Laufeld 1974a, b*; Sivhed 1976:60; Larsson 1979; Bergman 1979, 1980; Laufeld & Martinsson 1981.

KLINTHAGEN 1. 641340 167870 (CK 7000 0975), ca 2700 m NNE of Lärbro church. Topographical map sheet 7J Fårösund SO o. NO. Geological map sheet Aa 171 Kappelshamn.
Old quarry, ca 650 m SSE St. Vikers.
Slite Beds, unit g. Beds with *Kockelella walliseri*. *Age*: Early Wenlockian.
Reference: Hede 1933:43, lines 5–28.

KLOCKAREMYR 1. Tofta Beds. Beds with *Hindeodella sagitta rhenana*. *Age*: Early Wenlockian.
References: Laufeld 1974a, b*; Larsson 1979.

KLUVSTAJN 1. Slite Beds, unit b. *Age*: Early Wenlockian.
References: Laufeld 1974a, b*.

KULLANDS 1. Hemse Beds, Hemse Marl NW part. *Age*: Ludlovian; Bringewoodian or Early Leintwardinian.
References: Laufeld 1974a, b*; Laufeld & Jeppsson 1976; Larsson 1979.

KUPPEN 1. Hemse Beds. The beds immediately above the reference level belong to unit e. A *Polygnathoides siluricus* Zone fauna occurs up to 0.11 m above the reference level, followed by beds with the *Pelekysgnathus dubius* fauna. *Age*: Ludlovian; Leintwardinian.
References: Laufeld 1974a, b*; Larsson 1979; Jeppsson 1982.

KUPPEN 2. Hemse Beds. *Age*: Ludlovian; Leintwardinian.
References: Laufeld 1974a, b*; Kershaw & Riding 1978, Figs. 5, 12; Laufeld & Martinsson 1981; Kershaw 1981; Jeppsson 1982.

LANGHAMMARSHAMMAR 1. Högklint Beds, lower–middle part. Beds with *Kockelella? ranuliformis*. *Age*: Early Wenlockian.
References: Laufeld 1974a, b*.

LANSA 2. 642560 169423 (CK 8645 2075), ca 3000 m W of Fårö church. Topographical map sheet 7J Fårösund SO & NO. Geological map sheet Aa 180 Fårö.

Ditch exposure 0–100 m S of the road, about 400 m SE the crossroads 650 m E of Lansa and 1100 m S of Marpes. Sample G 73–70 from 1 m S of the road.

Slite Beds, unit f, *Rhipidium tenuistriatum* beds. Beds with *Kockelella walliseri*. *Age*: Early Wenlockian.

Reference: Hede 1936, p. 28, line 30–p. 29 line 9.

LAUTERSHORNSVIK 2. Högklint Beds, the middle of the three Högklint units on Fårö described by Hede (1936); lower–middle part (Laufeld 1974b). Beds with *Hindeodella sagitta rhenana*. *Age*: Early Wenlockian.

References: Laufeld 1974a, b*.

LAUTERSHORNSVIK 3. Högklint Beds, the upper part of the middle of the three Högklint units on Fårö described by Hede (1936); lower–middle part (Larsson 1979). Beds with *Hindeodella sagitta rhenana*. *Age*: Early Wenlockian.

Reference: Larsson 1979*.

LERBERGET (I need to revisit the locality to be able to refer my locality to those described by Laufeld 1974b).

LEVIDE 3. 635246 164760 (CJ 3440 5143), ca 1200 m SW of Levide church. Topographical map sheet 6I Visby SO. Geological map sheet Aa 164 Hemse.

Exposure in the ditch along the western edge of the small forest, 47 m S of the private road that passes Hagalund, 350 m NE that farm.

Hemse Beds, Hemse Marl NW part. Beds with *Kockelella variabilis*. *Age*: Ludlovian; probably Bringewoodian.

LILLA HALLVARDS 1. Hemse Beds, Hemse Marl NW part. Beds with *Kockelella absidata*. *Age*: Early Ludlovian.

References: Laufeld 1974a, b*; Larsson 1979; Jaeger 1981; Laufeld & Martinsson 1981.

LJUGARN 1. Hemse Beds upper part, probably unit d, in that limestone there is a fissure filling of Hemse Marl, SE part (mapped as fine-grained limestone by Watkins 1975). The latter unit belongs to the *Polygnathoides siluricus* Zone. *Age*: Ludlovian; the fissure filling is Leintwardinian.

References: Laufeld 1974a, b*; Watkins 1975.

LOGGARVE 1. 636574 164813 (CJ 3597 6468), ca 2800 m NE of Klinte church. Topographical map sheet 6I Visby SO. Geological map sheet Aa 160 Klintehamn.

The most westerly roadside section south of the old road from Loggarve towards Hejde, about 400 m E of Loggarve, about 25 m E of the forest edge.

Reference level: The Mulde–Klinteberg boundary.

Mulde Beds, topmost part (about 0.1 m) and *Klinteberg Beds* (about 2.5 m), lowermost part. In the Mulde Beds occurs *Hindeodella snajdri*. *Age*: Late Wenlockian.

References: Hede 1927a:37 line 14 (to the area in general) and p. 38 lines 15–16 (to the area in general); Jeppsson 1982.

LUKSE 1. Hemse Beds, Hemse Marl NW part. *Age*: Ludlovian; probably Bringewoodian or Leintwardinian.

References: Laufeld 1974a, b*; Larsson 1979.

MARTILLE 7. 638472 164371 (CJ 3298 8390), ca 4150 m (W)NW of Stenkumla church. Topographical map sheet 6I Visby NO. Geological map sheet Aa 183 Visby & Lummelunda.

20 m E of road 140 and 20 m N of the private road to Martille; the bedrock occurs 0.5 m below the surface.

Slite Beds, unit d. Beds with *Hindeodella sagitta rhenana*. *Age*: Early Wenlockian.

Reference: Hede 1940:49, lines 9–10.

MILLKLINT 1. Hemse Beds, unit e, i.e. Millklint Limestone. *Polygnathoides siluricus* Zone. *Age*: Ludlovian; Leintwardinian.

References: Laufeld 1974b*; Jeppsson 1969, Figs. 1A–F, 2A–F, 1972, Fig. 1A(tr), B, Pl. 1:25–30, 1974; Larsson 1979.

MILLKLINT 3. Hemse Beds, unit e, i.e. Millklint Limestone. *Polygnathoides siluricus* Zone. *Age*: Ludlovian; Leintwardinian.

References: Laufeld 1974a,b*; Jeppsson 1974:7; Laufeld & Jeppsson 1976.

MILLKLINTDALEN 2. Hemse Beds, unit e, i.e. Millklint Limestone. *Age*: Ludlovian, Late Leintwardinian.

References: Laufeld 1974a, b*; Laufeld & Jeppsson 1976.

MÖLLBOS 1. Halla Beds, unit b. Beds with *Hindeodella snajdri*. *Age*: Late Wenlockian.

References: Laufeld 1974a, b*; Laufeld & Jeppsson 1976; Larsson 1979; Claesson 1979; Laufeld & Martinsson 1981; Stridsberg 1981a, b; Liljedahl 1981, 1983.

MÖLNER 1. Mulde Beds, upper part. Strata with *Hindeodella snajdri*. *Age*: Late Wenlockian.

References: Laufeld 1974a, b*; Larsson 1979.

NYGÅRDSBÄCKPROFILEN 1. 638880 164417 (CJ 3374 8794), ca 2970 m NW of Västerhejde church. Topographical map sheet 6I Visby NO. Geological map sheet Aa 183 Visby & Lummelunda.

Brook section at the mouth of Nygårdsbäcken (bäcken = the brook) and shore section SW of it. My samples are taken 5 to 10 m from the ravine.

Lower Visby Beds, upper part (at least 2.3 m exposed), and *Upper Visby Beds*. *Age*: Earliest Wenlockian.

References: Hedström 1910:1463, 1474; Hede 1940:13; Jeppsson 1982.

NYMÅNETORP 1. Högklint Beds, unit b, upper part. Beds with *Hindeodella sagitta rhenana*. *Age*: Early Wenlockian.

References: Laufeld 1974a, b*; Laufeld & Martinsson 1981:6.

OIVIDE 1. Slite Beds, unit f, i.e. *Rhipidium tenuistriatum* Beds. Strata with *Kockelella walliseri*. *Age*: Early Wenlockian.

References: Laufeld 1974a, b*; Larsson 1979; Jeppsson 1982.

ÖSTERGARNSHOLM 1. Hemse Beds, unit d?. *Age*: Ludlovian; Leintwardinian.

References: Laufeld 1974a, b*; Larsson 1979.

ÖSTERGARNSHOLM 2. Hemse Beds, unit d?. *Age*: Ludlovian; Leintwardinian.

References: Laufeld 1974a, b*; Larsson 1979.

ÖSTERGARNSHOLM 3. Hemse Beds, unit d?. *Age*: Ludlovian; Leintwardinian.

The locality will be described by Björn Sundquist.

ÖVERBURGE 1. 635215 165146 (CJ 3820 5085), ca 1680 m NW of Fardhem church. Topographical map sheet 6J Roma SV. Geological map sheet Aa 164 Hemse.

Exposure on the eastern side of the ditch, 10 m S of the ditch and road intersection 300 m NW Överburge.

Hemse Beds, Hemse Marl NW part. Beds with *Kockelella variabilis*. *Age*: Ludlovian; Bringewoodian or Leintwardinian.

RANGSARVE 1. Hemse Beds, upper part. Beds with *Polygnathoides siluricus*. *Age*: Ludlovian; Leintwardinian.

References: Laufeld 1974a, b*; Laufeld & Jeppson 1976; Larsson 1979; Claesson 1979; Laufeld & Martinsson 1981.

RONEHAMN 3. 634152 166181 (CJ 478 393), ca 4800 m SSE Ronehamn church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 156 Ronehamn.

Excavation 500 m WSW the harbour of Ronehamn.

Eke Beds, uppermost part. *Age*: Ludlovian; Whitcliffian.

Reference: Jeppson 1974:11, 12, 13.

RONNINGS 1. Eke Beds, upper part. *Age*: Ludlovian; Whitcliffian.

References: Laufeld 1974a, b*; Larsson 1979: Jeppsson 1982.

RÖNNKLINT 1. 641175 165700 (CK 4828 0984), ca 3750 m N (and slightly W) of Lummelunda church. Topographical map sheet 7J Fårösund SV & NV. Geological map sheet Aa 183 Visby & Lummelunda.

Cliff section in the channel down the cliff face just south of the reef that forms Rönnklint.

Reference level: The bentonite level about 6 m above base of section (= about 8 m above sealevel). There is another major bentonite 2.50 m higher up, and a thick limestone bed 3.5 m further up.

Lower Visby Beds, Upper Visby Beds, and *Högklint Beds*. The main part of the Lower Visby Beds contains the *Pterospathognathus amorphognathoides* Zone. *Age*: The age of the strata exposed is Llandoverian, late Telychian (C6), and Early Wenlockian. The Lower Visby Beds span the boundary between the Llandoverian and the Wenlockian.

References: Hede 1940:13, lines 16–17; Brood 1982:18–19, 24–25.

SIGVALDE 2. 636070 166462 (CJ 5195 5833), ca 2680 m ENE of Etelhem church. Topographical map sheet 6J Roma SV. Geological map sheet AA 156 Ronehamn.

Inland cliff section ca 470 m E of the eastern end of Sigvalde träsk and just south of the road. For a photograph of the locality, see Munthe 1910, Fig. 26 or Hede 1925b, Fig. 10.

Hemse Beds, lower-middle part (probably unit c and perhaps both that and unit d). *Age*: Ludlovian, probably early.

Reference level: The upper limit of the *Ilionia* limestone as drawn in Munthe 1910, Fig. 26 (= Hede 1925b, Fig. 10).

Reference point: The fissure visible 3 cm from the left margin of the photograph in Munthe 1910, Fig. 26 and Hede 1925b, Fig. 10.

References: Munthe 1910:1432, Fig. 26; Hede 1925b:16, line 21–31, Fig. 10; Martinsson 1962:56, the second locality mentioned under Sigvalde.

SIMUNDS 1. Slite Beds, unit g. The lowermost beds contain *Kockelella walliseri*. *Age*: Early Wenlockian.

Reference: Laufeld & Martinsson 1981:6*.

SION 1. Slite Beds, unit f, i.e. *Rhipidium tenuistriatum* Beds. Beds with *Kockelella walliseri*. *Age*: Early Wenlockian.

References: Laufeld 1974a, b*.

SLITEBROTTET 1. Slite Beds, Slite Marl and Slite g. *Age*: Wenlockian.

References: Walmsley 1965:469, Pl. 62:23–27, 33–35; Laufeld 1974a, b*; Walmsley & Boucot 1975:65, Pl. 3:9–11; Eisenack 1975, Fig. 18; Larsson 1979.

SLITEBROTTET 2. Slite Beds, Slite Marl, i.a. the parts corresponding to the Slite f. Beds with *Kockelella walliseri*. *Age*: Early Wenlockian.

References: Laufeld 1974a, b*; Claesson 1979.

SNAUVALDS 1. Hemse Beds, Hemse Marl NW part. *Age*: Ludlovian; Bringewoodian or, more probably, Early Leintwardinian.

References: Laufeld 1974a, b*; Larsson 1979.

SNODER 3. 634805 164490 (CJ 3135 4725), ca 2500 m NO of Silte church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet 164 Hemse.

Low (about 1.5 m) section from the bottom of a small ditch down to below the waterlevel in the Snoder-a drainage ditch, 5 m S of the ditch and road intersection, on the private road between Snausarve and Snoder.

Hemse Beds, Hemse Marl NW. Beds with *Kockelella variabilis*? *Age*: Ludlovian; Bringewoodian or Early Leintwardinian.

References: Hede 1927b:26, line 29–p. 27, line 5 (list of over 50 taxa of macrofossils and ostracodes based on excavated material from this locality and others); Mori 1970:23, loc. 131 (excavated material from the ditch); Jeppsson 1982.

SOJVIDE 1. Slite Beds, unit f, i.e. *Rhipidium tenuistriatum* Beds. Beds with *Kockelella walliseri*. *Age*: Early Wenlockian.

Reference: Larsson 1979*.

STORA MYRE 1. Slite Beds, unit d. Beds with *Kockelella walliseri*? *Age*: Early Wenlockian.

References: Laufeld 1974a, b*; Larsson 1979.

STORBURG 1. Hamra and Sundre Beds. *Age*: Latest Ludlovian.

References: Laufeld 1974a, b*; Larsson 1979.

STRANDS 1. Hamra Beds, unit b. Beds with *Hindeodella snajdri crispa*. *Age*: Latest Ludlovian.

References: Laufeld 1974a, b*; Larsson 1979.

SUTARVE 2. Klinteberg Beds, unit f, top. *Age*: Early Ludlovian.

References: Laufeld 1974a, b*; Laufeld & Jeppsson 1976.

SVARVEN 1. Högklint Beds, unit b. Beds with *Hindeodella sagitta rhenana* and *Kockelella*? *ranuliformis*. *Age*: Early Wenlockian.

References: Laufeld 1974a, b*; Larsson 1979.

SYSNE 1. Hemse Beds, unit d? *Age*: Ludlovian; Late Leintwardinian.

Reference: Larsson 1979*.

TJELDERSHOLM 1. Slite Beds, *Pentamerus gothlandicus* Beds, and immediately younger beds (but not *Atrypa reticularis* Beds). *Age*: Late? Wenlockian.

References: Laufeld 1974a, b*; Larsson 1979.

TUTEN 1. 635702 167280 (CJ 5962 5408), ca 3900 m NE of Lau church. Topographical map sheet 6J Roma SV. Geological map sheet Aa 156 Ronehamn.

Blocks on the 'piers' of the 'harbour' at Tuten, excavated when it was deepened.

Hemse Beds, Hemse Marl, SE part. *Polygnathoides siluricus* Zone. *Age*: Ludlovian; Leintwardinian.

UDDVIDE 2. Burgsvik Beds, upper part and Hamra Beds, basal part. *Age*: Ludlovian; Whitcliffian.

References: Laufeld 1974a, b*; Jeppsson 1974:13; Larsson 1975:129.

URGUDE 2. 635021 164333 (CJ 2995 4943), ca 1800 m W of Sproge church. Topographical map sheet 6I Visby SO. Geological map sheet Aa 164 Hemse.

Ditch exposure, 47 m west of the road that runs NNW to St. Norrgårde, in the ditch that runs east-west south of Tjängdarve.

Hemse Beds, Hemse Marl NW part. *Age*: Early Ludlovian.

VAKTÅRD 3. 633370 164594 (CJ 3130 3285), ca 2900 m WSWW of Näs church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 152 Burgsvik.

Shore exposure about 100 metres N of the pier. There are four small former fishing houses at Vaktård, the two middle ones close to each other near the pier. The northern one looks very old. North and northwest of it there are two very small bulges on the shoreline and north of these a very small point. Sample G 71–148 is from the central of these three protusions.

Hemse Beds, Hemse Marl, SE part. *Polygnathoides siluricus* Zone. *Age*: Ludlovian; Leintwardinian.

References: Hede 1919:19 line 11–p. 20 line 23, loc. 7; Hede 1942:20, loc. 3c.

VALE 1. 641185 166046 (CK 5168 0967), ca 1975 m NW of Stenkyrka church. Topographical map sheet 7J Fårösund SV & NV. Geological map sheet Aa 183 Visby & Lummelunda.

Temporary exposure, immediately south of the road from road 149 to Vale, about 700 m from road 149, and slightly closer to the western than the eastern end of the straight part of the road.

Tofta Beds, probably lower part. *Age*: Early Wenlockian.

VALLMYR 1. Klinteberg Beds, unit d. Beds with *Hindeodella snajdri*. *Age:* Wenlockian, very close to the end.

Reference: Larsson 1979*.

VÄSTÖS KLINT 1. Högklint Beds, units b and c. Beds with *Kockelella*? *ranuliformis* and *Hindeodella sagitta rhenana*. *Age*: Early Wenlockian.

References: Laufeld 1974a, b*; Laufeld & Jeppsson 1976; Larsson 1979.

VATTENFALLSPROFILEN 1 (VATTENFALLET). Lower and Upper Visby Beds, and Högklint Beds. Beds with *Pterospathodus pennatus procerus, Kockelella*? *ranuliformis* and *Hindeodella sagitta rhenana*. *Age*: Early Wenlockian.

References: Hedström 1904:93, line 11–p. 96, line 17, 1923b:195, Fig. 2; Hede 1925:15, line 18 from below–p. 16, line 3; Martinsson 1972:128–129; Laufeld 1974b*; Bassett & Cocks 1974:5; Laufeld & Jeppsson 1976; Franzén 1977:223, 226; Larsson 1979; 43 papers *in* Jaanusson, Laufeld & Skoglund 1979 (eds.); Claesson 1979; Bengtson 1981; Jeppsson 1982; Brood 1982:48, Pl. 9:3.