SVERIGES GEOLOGISKA UNDERSÖKNING

SER C NR 639 AVHANDLINGAR OCH UPPSATSER ÅRSBOK 63 NR 2

LARS E. FÅHRÆUS

CONODONT ZONES IN THE LUDLOVIAN OF GOTLAND AND A CORRELATION WITH GREAT BRITAIN

STOCKHOLM 1969

SVERIGES GEOLOGISKA UNDERSÖKNING

SER C NR 639 ÅRSBOK 63 NR 2

LARS E. FÅHRÆUS

CONODONT ZONES IN THE LUDLOVIAN OF GOTLAND AND A CORRELATION WITH GREATH BRITAIN

STOCKHOLM 1969

Manuscript received Aug 23th, 1968
Editor: Per H. Lundegårdh

C. DAVIDSONS BOKTRYCKERI AB, VÄXJÖ

CONTENTS

ABSTRACT

Several of Walliser's (1964) condont zones were recognized in the upper Wenlockian and Ludlovian of Gotland, specifically: the *sagitta* Zone, the *ploeckensis* Zone, the *siluricus* Zone, and the *eosteinhornensis* Zone. The *crassa* Zone was tentatively identified. It has not been possible to establish the existence of the *latialatus* Zone and the *crispus* Zone. The zone fossil *Spathognathodus crispus* was found to occur in the *eosteinhornensis* Zone. A comparative study of condont faunas from the late Ludlovian of Gotland, the *Beyrichienkalk,* and the upper Ohesaare Beds of the island of Saarema, Estonia, shows that the Silurian of Gotland reaches very close to the Ludlovian/Pridolian boundary. It was concluded that the Beyrichienkalk most probably is entirely Pridolian in age. The condonts from the upper Ohesaare Beds indicate a very late Pridolian or early Gedinnian age. The Sundre Beds, the Hamra Beds, and the Burgsvik Beds are correlated with the Whitcliffian Stage; the Eke Beds and high levels in the upper Hemse Beds with the Leintwardinian; the lower part of the upper Hemse Beds with the Bringewoodian; the middle Hemse Beds with the Upper Eltonian; the lower Hemse Beds with the Middle and Lower Eltonian; the Klinteberg Beds with the Wenlock Limestone and (?) uppermost Wenlock Shale; the Mulde Beds and the Halla Beds, finally, are correlated with the Wenlock Shale.

INTRODUCTION

Within the Paleozoic conodonts have proven to be excellent index fossils for stratigraphic zonation in many parts of the world and Walliser (1964) has established such a zonation for the Silurian of the Carnic Alps, Austria.

The purpose of the study reported on herein was to test if Walliser's (loc. cit.) conodont zones could be recognized in the Silurian of Gotland. However, it soon became evident that Ludlovian deposits of later age (Fåhræus 1967) than assumed by Hede (1960) do exist on Gotland. The scope of the present paper was therefore restricted to the Ludlovian and a discussion about the correlation with Great Britain was included.

This study is based on spot samples and no continuos section has been sampled. The author is fully aware that this type of sampling can only provide a very rough and limited picture of the chrono-stratigraphic sequence. The mode of sampling is due to the fact that the results of the sampling were meant to serve as a guide for future sampling and that there exist no stratigraphically long ranging sections in Gotland and that it is virtually impossible to trace individual beds over long distances because of rapid changes of lithology and frequent thinning out of beds. However, the initial results clearly established that extensive parts of Hede's (1921 and 1924) topo-stratigraphic units needed careful restudy as to their lateral extent because chrono-stratigraphic bounda-

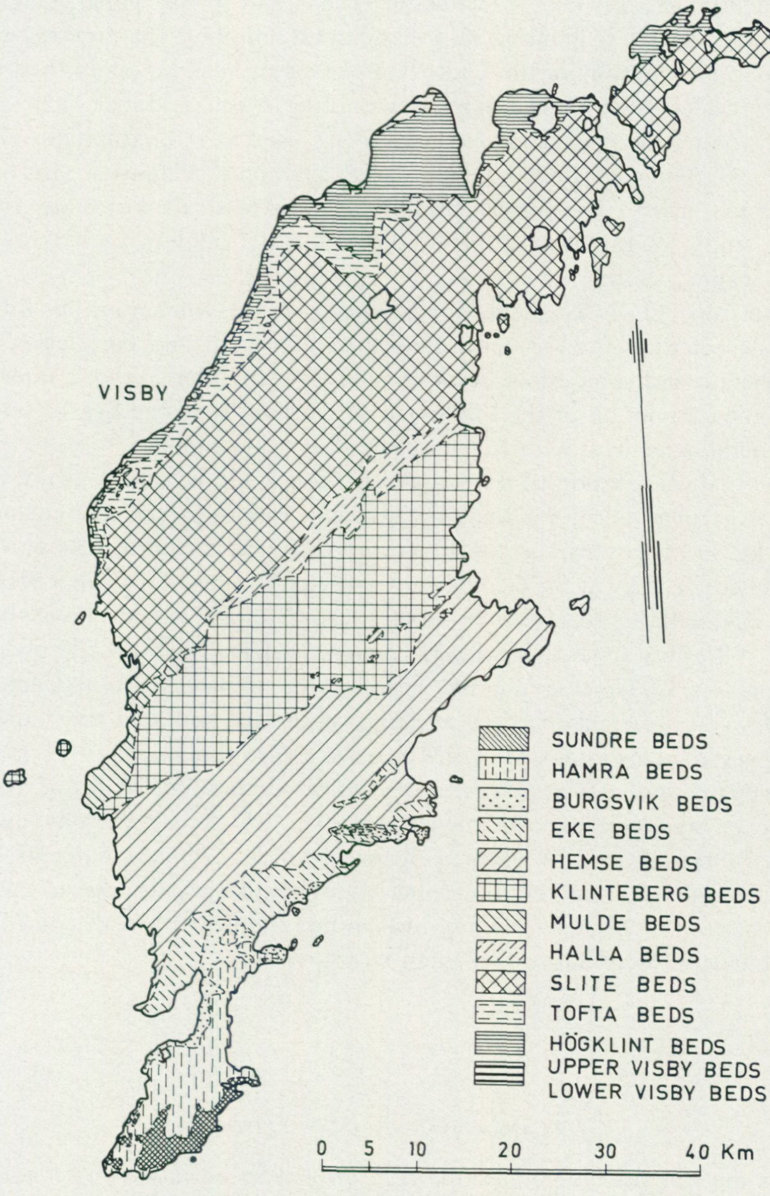


Fig. 1. Geological map of Gotland (from J. E. Hede 1942).

För spridning godkänd den 27/4 1960 i Rikets allmänna kartverk.

ries evidently, as shown by Martinsson (1967) and in this paper, cut across Hede's units. Such a remapping, and very careful sampling, is a necessity before the chrono-stratigraphy of the Ludlovian of Gotland can be established in detail. The results presented in this paper would serve as a guide for such a study.

In this paper the conodonts exclusively are used as stratigraphic tools and only a few comments, necessary for the stratigraphic evaluation, are offered on their taxonomy. The present author does not wish to anticipate a forthcoming study by L. Jeppsson on Ludlovian and Pridolian conodonts from Skåne (Scania), southern Sweden.

Martinsson (1967) has recently published a paper concerning an informal ostracode zonation for the entire Silurian of Gotland and correlations with Great Britain and some other areas outside Sweden. This author's interpretation of the correlation of the Ludlovian of Gotland with the British standard is in general agreement with Martinsson's (loc. cit.) opinion.

The initial preparation of the samples for this study was done at the Geological Survey of Sweden, Stockholm. The study was suggested and encouraged by late Dr. Fritz Brotzen, former Director of the Departement for Research and the Applied Geology at the Geological Survey of Sweden. This paper was written during the first part of the tenure of a Post-Doctoral Fellowship at the University of Western Ontario, London, Canada, wich is gratefully acknowledged. To Professor C. Gordon Winder, head of the Departement of Geology at U.W.O., who provided excellent working conditions and read the manuscript and suggested many linguistic as well as other improvements, the author wishes to convey his sincere thanks. Professor Maurits Lindström, Marburg, read the manuscript and offered constructive criticism which is gratefully acknowledged. Professor O. H. Walliser, Göttingen, kindly offered comments on the identification of some of the conodonts. Many thanks are also due to Professor Alfred Lenz at U.W.O. with whom the author frequently has discussed problems connected with Siluro-Devonian stratigraphy.

SILURIAN CONODONT ZONATION

During the last decade conodonts have proved to be increasingly useful for detailed zonation of Paleozoic marine sedimentary sequences and for precise intercontinental correlation. Most studies have considered Devonian and Ordovician conodont faunas and sequences and until quite recently no attempt had been made to establish a conodont zonation for the Silurian System. However, in a preliminary paper, O. H. Walliser (1962) showed that such a zonation is possible. Walliser divided the Siluran into 7 informal zones which he called *Bereiche* (= realms). These "*Bereiche*" were mainly based on material from a partly Ordovician – Silurian – partly Devonian sequence at Cellon in the Carnic Alps of Austria, close to the Italian border. Walliser's (1964) final report elaborated this zonation into more details and recognized five stages and eleven zones. Walliser also demonstrated that several of his zones could be recognized outside the Carnic Alps. Some of these samples were from graptolite dated sections and aided in a correlation with standard Silurian graptolite zones.

Subsequent work in Europe and especially North America is beginning to reveal that Walliser's zonation has universal application although the extent of the zones not always is the same as in the Carnic Alps. One or more zones would seem to be suppressed or poorly developed in certain areas.

Rexroad and Richard (1965) showed that the Llandoverian and Wenlockian conodont zones exist in the Niagara Gorge section, Canada. Rexroad (1967) recognized the basal Silurian zone, *Bereich* 1, in the Brassfield Formation in the Cincinnati Arch area. Jocelyne Legault *(in press)* found the *eosteinhornensis* Zone in the Stonehouse Formation, at Arisaig, Nova Scotia. Unpublished work by C. Collinson and L.V. Richard, reported in Berry and Boucot *(in press)*, has proved the existence of the Ludlovian conodont zones in central North America. Berry and Boucot (loc. cit.) have incorporated a modification of Walliser's (1962, 1964) conodont zonation in the correlation table of their exhaustive paper on the "Silurian of North America".

In Europe research on Silurian conodont faunas verifying Walliser's zonation has been less extensive and so far exclusively concentrated to Great Britain. Walliser (1966) proved the existence of the *eosteinhornensis* Zone in the Ludlow Bone Bed at the type section at Ludford Corner, Ludlow, and showed that the *eosteinhornensis* Zone is developed in the Upper Whitcliffian at Ludlow and in the Woolhope inlier at Herefordshire. Collinson and Druce (1966) identified the *eosteinhornensis* Zone in the Upper Whitcliffe Flags at Diddleburg, Shropshire. Brooks and Druce (1965) identified the *celloni* Zone in a conglomeratic limestone at Malvern Hills. Rhodes (1953) described conodonts from the Aymestry Limestone in Shropshire and the Sedgley Limestone in South Staffordshire. Evidence presented by this author (p. 26), strongly suggests that Rhodes (loc. cit.) conodont faunas belong in the *siluricus* Zone. This is also corroborated by the occurrence of *Kockelella variabilis* in these beds (Rhodes and Newall 1963). *K. variabilis* is restricted to the *crassa, ploeckensis,* and *siluricus* Zones (Walliser 1964, p. 40). Recently Austin and Basset (1967) have described a *sagitta* Zone conodont fauna from the Wenlockian of the Usk inlier, Monmouthsire.

These data are partly summarized in Table 2 and compared with the present author's concept of the Ludlovian conodont zonation of Gotland.

COLLECTING LOCALITIES AND COMPOSITION AND AGE OF THE CONODONT FAUNAS

For a brief but excellent summary about the bedrock geology of Gotland see Hede 1960, pp. 44–52.

Conodonts are scarce in the Silurian of Gotland, with exception of some outstanding horizons, *i. a.* in the Högklint Beds and middle and upper Hemse Beds, the yield is fairly low and usually less than twenty specimens *per* dissolved kilogramme of sample. The preservation as a rule is very good and the colour varies from light (predominantly) to dark amber.

Several samples are from localities previously sampled by Hede (1960 *in* Regnéll and Hede) who has provided extensive lists of the macrofaunas and by Martinsson (1962) who has studied the ostracode faunas. Whenever possible Martinsson's and Hede's localities are quoted below in abbreviated form (R and H – Regnéll and Hede 1960; and A M – Martinsson 1962) immediately after the present author's sample location.

To avoid repetition of lengthy fauna lists the conodonts encountered from each sample are summarized in Table 1.

The topographical maps referred to below have the scale 1:50 000.

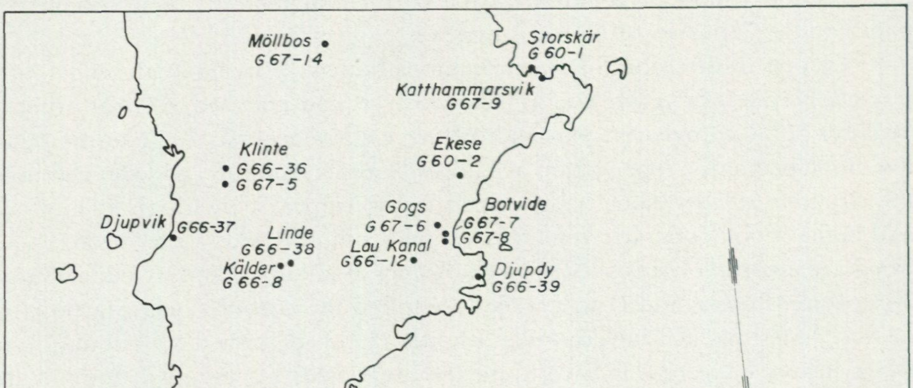


Fig. 2. Map of southern Gotland showing the collecting localities with code names und numbers.

Halla Beds

G67-14, Möllbos; R and H p. 67, loc. 20; AM p. 53
About 2.4 kilometres NNW of the church of Viklau there is a small exposure along the rivulet about 200 metres downstream from the old mill pond at the abandoned watermill of Möllbos. Topographical sheet *6I Visby SO.*

About 6 kilogrammes of a dense, light greyish-brown and sligthly argillaceous limestone were dissolved.

The conodont yield was low and the recovered fauna is small and incomplete with only seventeen identifiable specimens. However, three of the identified species are of considerable stratigraphic value viz: *Ozarkodina edithae, Plectospathodus extensus, and Spathognathodus sagitta bohemicus.*

S. sagitta is the index fossil of the *sagitta* Zone, which according to Walliser (1964, p. 97) spans the graptolite zones of *Monograptus testis, M. deubeli, M. ludensis,* and the lower part of the zone of *M. nilssoni.* This author has also found typical specimens of *S. sagitta* in layers at the top of the Högklint Beds, northern Gotland, which Martinsson (1967) correlates with the zone of *Monograptus riccartonensis,* which considerably extends the known range of the *sagitta* Zone.

Prior to this study *S. sagitta bohemicus* has only been reported from Bohemia and the Welsh Borderlands. In Bohemia the subspecies occurs at Jikonice and Ladenice. At the former locality it was found in beds belonging to the lower part of the *nilssoni* Zone (Walliser 1964, p. 83), whereas at the latter locality it occurs in the zone of *M. testis* together with a.o. *O. edithae* and *P. extensus,* of which the former is, so far known, entirely restricted to the *sagitta* Zone (*sensu* Walliser 1964). *P. extensus* has in Europe not been reported from beds older than the zone of *M. testis* (Walliser 1964, table 2, pt. 3). In the Cellon section *P. extensus* begins to occur at the base of the *crassa* Zone (Walliser 1964, table 2, pt. 2).

Mulde Beds

G66-37, Djupvik
At the harbour of the fishing village of Djupvik (Djauvik) in the parish of Eksta. Topographical sheet *6I Visby SO.*

During deepening excavations of the harbour a large quantity of limestone was dumped on the shore. The sample was collected from this material. About 6 kilogrammes of an argillaceous fine-grained, slightly yellowish grey limestone were digested.

The conodont fauna is quite rich and varied but unfortunately of very little stratigraphic value and its stratigraphic assignment must be deduced more or less indirectly. *Spathognathodus inclinatus inclinatus* and *Plectospathodus ex-*

tensus both are represented with quite great numbers suggesting that the sample would be from a level high in the *sagitta* Zone. However, the total absence of *Spathognathodus sagitta* suggests that the sample might come from an even younger zone, viz. the *crassa* Zone. This possibility is further emphasized by finds of *Spathognathodus primus* and *Plectospathodus flexuosus* in a sample from the Mulde Beds at Djupvik (L. Jeppsson pers. comm. 1967). These two species have previously not been reported from deposits older than the *siluricus* Zone (Walliser 1964). This author has found the two species in a sample from the middle Hemse Beds where they occur together with the zone fossil *Ancoradella ploeckensis*. *S. primus* has also been found in a sample from the Klinteberg Beds, that is in layers immediately above the Mulde Beds.

The zone fossil *Ozarkodina crassa* seems to occur sporadically and in limited number in the Cellon sequence (Walliser 1964, table 2, pt. 2). Walliser (loc. cit.) dissolved 6 samples from the *crassa* Zone and only found *O. crassa* in two of them, he also found *O. crassa* in one sample from the base of the *ploeckensis* Zone. Walliser identified a total of about 15 specimens of *O. crassa*. No other conodont species is reported by Walliser (1964) as limited to the *crassa* Zone. The *crassa* Zone seems to be so poorly developed even in its type area that it in this author's opinion is highly questionable if it really can be regarded as a zone of its own. The Mulde Beds are therefore tentatively placed in the *sagitta* Zone.

Klinteberg Beds

G66-36, Klinte; R and H p. 75, loc. 33

Road cutting along the main road between Klinte and Hemse, 350 metres SSE of Bönders. Topographical sheet *61 Visby 50*.

G67-5, Klinte

Road cutting about 2 kilometres further SSE of the above locality. Above cited topographical sheet.

The Klinteberg Beds have so far yielded few conodonts. Several samples from a number of localities have been dissolved but only two yielded any conodonts. In both of these samples the limestone is dense and light grey. About 6 kilogrammes of each sample were dissolved.

The occurrence of *Hindeodella equidentata* and *Trichonodella excavata* suggests that the age could be as old as the *sagitta* Zone. The find of *Spathognathodus primus* in sample G67–5 is of considerable stratigraphic value since it is one of the oldest proven occurrences of this species in the Silurian of Gotland. L. Jeppsson has, as previously mentioned, found the species in the Mulde Beds. The Mulde Beds have above tentatively been placed in the *sagitta* Zone. The Klinteberg Beds ar also tentatively referred to this zone.

Hemse Beds

During the course of study it became more and more evident to the present author that the Hemse Beds (*sensu* Hede 1921 and later papers) cover a considerable time stratigraphic span and that sections of different age could be recognized within the region covered by the Hemse Beds. The oldest deposits are found in the west and southwest, with the exception of a strip along the border to the overlying Eke Beds. Successively younger beds are found toward the east and northeast and along the above mentioned strip. The Hemse Beds are one of the largest of Hede's topo-stratigraphical units, both with regard to lateral as well as vertical extent. It has been known for a long time that faunistic communities of presumably different age exist within this unit and attempts have been made to draw boundaries. Hede (1927, p. 24) suggested one younger (western and southwestern parts) and one older faunistic community stating that a tentative boundary could be drawn along the following line: Kvinnegärde–St. Vasstäde–Mullvads–1.5 kilometres SE of the church of Stånga (topographical sheets *5J Hoburgen SO och 5J Hemse SV and 6J Roma SV).* Martinsson (1962, p. 53, 54) also mentions these faunistic communities and generally agrees with Hede's dividing line. Martinsson (1967) recognizes five of his informal ostracode zones within the Hemse Beds. For the purpose of the present paper the author prefers to divide the Hemse Beds into three informal subunits, designated as lower, middle, and upper.

The present knowledge of the microfaunas as well as the macrofaunas does not allow precise outlining of the lateral extent of these subunits. Hence, only vague boundaries are defined. The upper Hemse Beds can be seen in the outcrops east and northeast of an arbitrarily drawn, N-S oriented, line through the church of Stånga and a strip of undetermined width along the border to the overlying Eke Beds. The middle Hemse Beds occur in an undefined area centered around the church of Linde. The remaining areas in the west and southwest expose the lower Hemse Beds.

Martinsson (1967, Fig. 1) already has published a map showing tentative and provisional boundaries of his informal ostracode zones. This author's few conodont samples readily could be framed within these fauna zones. However, as will be shown further in this paper, some results of the conodont studies do not agree with Martinsson's results which are based almost exclusively on material from the marly facies of the deposits.

Lower Hemse Beds

The lower Hemse Beds have failed to yield conodonts.

Middle Hemse Beds

G66-8, Kälder
Abandoned quarry about 100 metres NNW of Kälder, at the western end of the limestone hill Lindeberget, in the parish of Linde. The sample is from the upper part of the quarry wall. Topographical sheet *6J Roma SV* .

About 6 kilogrammes of a light grey dense limestone, very rich in crinoids, bryozoans, stromatoporoids, and corals, were dissolved.

G66-38, Linde; A M p. 54
About 1.5 metres above the base of the limestone cliff immediately NW of the church of Linde. Topographical sheet *6J Roma SV*.

About 4 kilogrammes of a light grey fine grained limestone were dissolved.

The conodont faunas found in both samples are quite rich and varied. The zone fossil *Ancoradella ploeckensis* is present in both samples. Prior to this paper *A. ploeckensis* has in Europe only been reported from the Cellon sequence (Walliser 1964, table 1). Walliser (loc. cit.) also states that the *ploeckensis* Zone is transitional with the *crassa* Zone and that it in the top extends into the *siluricus* Zone. The zone fossil *Ozarkodina crassa* has been found in sample G66–38 thus suggesting that the sample may be from the base of the *ploeckensis* Zone.

Upper Hemse Beds

G67-6, Gogs; R and H p. 79, loc. 41; A M p. 57
Small exposure along a ditch NNW of Gogs farmhouse in the parish of Lau. Topographical sheet *6J Roma SV*, on which the location is misspelled *Goks*.

About 6 kilogrammes of a dense light bluish-grey, very fossiliferous, flaggy limestone were dissolved.

G67-7, Botvide; R and H p. 80, loc. 42; A M p. 57
Road cut in the hill of Lau Backer immidiately SSW of Botvide farmhouse. At this locality a good section exposes the upper Hemse Beds/Eke Beds boundary. The sample is from the top of the upper Hemse Beds. Topographical sheet *6J Roma SV*.

About 6 kilogrammes of a fine grained reddish, slightly argillaceous, limestone were dissolved.

G66-12, Lau Kanal; A M p. 57
About 1.7 kilometres SW of the church of Lau there is a channel (Lau Kanal) with extensive outcrops of upper Hemse Beds and lower Eke Beds. The sample is from the central part of a 3 decimetres thick bed of blue-grey marly limestone (layer b in Hede 1925, p. 38). The sample is taken about 1 decimetre below the base of the Eke Beds. Topographical sheet *6J Roma SV*. About 2 kilogrammes were dissolved.

G60-2, Ekese
The small limestone hill south of Ekese (Aikse) farm in the parish of Ardre. About 2.1 kilometres S40°W of the church of Ardre. Topographical sheet *6J Roma SV.*

About 4 kilogrammes of a slightly reddish greyish white limestone were dissolved.

G67-8, Katthammarsvik; R and H p. 77, loc. 37
At the shoreline immediately east of the pier of the small harbour of Katthammarsvik in the parish of Östergarn. Topographical sheet *6J Roma SO*. About 6 kilogrammes of a light grey fine grained limestone were dissolved.

G60-7, Storskär
At the northern shore of the small peninsula bordering the western part of the bay of Katthammarsvik in the parish of Gammelgarn. Topographical sheet *6J Roma SO*.

About 4 kilogrammes of a dense grey to brownish grey slightly marly limestone were dissolved.

All of these samples from the upper Hemse Beds are considered by this author to belong in the *siluricus* Zone. A single specimen of the zone fossil *Polygnathoides siluricus* was found in one sample, viz. sample G60-2; unfortunately no other conodonts were found in this sample. However, *P. siluricus* has been found by L. Jeppsson (reported in Martinsson 1967, p. 372) in a sample from the Gogs locality.

The *siluricus* Zone fauna is on Gotland characterized by the following species: *Neoprioniodus bicurvatus, Ozarkodina typica typica, Plectospathodus extensus, P. flexuosus,* and *Spathognathodus primus*. The first two species are reported for the first time on Gotland. *S. primus* is a very common species in this zone and quite often it dominates the fauna. *Trichonodella symmetrica* also makes its first appearance on Gotland in the *siluricus* Zone.

The conodont fauna from the Gogs locality is extremely rich, varied and well preserved, and can probably serve as a model for the *siluricus* Zone fauna but with the obvious drawback that it lacks the zone fossil and contains two forms, viz. *Spathognathodus* n. sp. A and *Hindeodella* n. sp. A, of wich the former so far only has been reported from this locality.

It is above stated that all these samples from the upper Hemse Beds are considered to belong to the *siluricus* Zone. However, there is one possible exception, namely the sample from the Storskär locality, which a.o. contained *Ligonodina elegans,* a species which has not been found in any other sample from Gotland. The species, however, is very common in the *Beyrichienkalk* in a form which appears to be much more advanced than the Storskär specimens. The Storskär sample also contains forms of *Lonchodina walliseri* which are highly assymetrical and quite close to *Lonchodina detorta,* a form which in Gotland is encountered for the first time in the Hamra Beds. It is also interesting to note that the associated *Spathognathodus primus* specimens are quite close to the typical *S. frankenwaldensis* outline with its enlarged anterior denticles and tapering posterior process.

Eke Beds

G67-8, Botvide; R and H p. 80, loc. 42; A M p. 57

The same locality as sample G67–7. The sample is from the base of the Eke Beds.

About 6 kilogrammes of light brownish-grey fine-grained limestone were dissolved.

G66-39, Djupdy

A small fishing village in the parish of När at the eastern shore of the Hammaren peninsula. Topographical sheet *6J Roma SO.*

About 6 kilogrammes of brownish grey slightly marly and fine-grained limestone were dissolved.

The two conodont faunas from the Eke Beds have essentially the same composition as the faunas from the upper Hemse Beds and they most probably belong in the *siluricus* Zone.

Burgsvik Beds

The slightly calcareous sandstone which comprises the main part of the Burgsvik Beds has not been searched for conodonts. The samples yielding conodonts are from the upper oolitic part and the overlying finely oolitic limestone immediately below the base of the Hamra Beds.

G66-43, Uddvide; R and H p. 83, loc. 46
The abandoned sandstone quarry east of the main road about 200 metres SSE of Uddvide in the parish of Grötlingbo. Topographical sheet *5I Hoburgen NO och 5J Hemse NV*.

About 6 kilogrammes of light bluish grey oolitic limestone were dissolved.

G66-44, Uddvide; R and H p. 83, loc. 46
The same locality as G66–43. The sample is from the limestone immediately below the base of the Hamra Beds.

About 6 kilogrammes of grey finely oolitic limestone were dissolved.

G67-15, Rovalds
Small abandoned sandstone quarry about 600 metres N65°E of Rovalds and about 400 metres west of the southwest shore of the bay of Gansviken in the parish of Grötlingbo. Above cited topographical sheet. The sample was collected from the sligthly oolitic limestone immediately below the base of the Hamra Beds. About 6 kilogrammes were dissolved.

All three samples yielded the zone fossil *Spathognathodus steinhornensis eosteinhornensis* and hence belong in the *eosteinhornensis* Zone. This zonal assignation is also supported by the presence of *Ozarkodina typica denkmanni* which according to Walliser (1964, p. 61) makes its first appearance in the *eosteinhornensis* Zone.

Hamra Beds

G67-16, Kettelvik
The southern part of the cliff exposure along the bay of Kettelvik. Topographical sheet *5I Hoburgen SO och 5J Hemse SV*. The sample is from a level 1.5 metres above the base of the Hamra Beds.

About 6 kilogrammes of light bluish grey slightly marly limestone were dissolved.

G67-7, Majstre
From a ditch c. 500 metres northwest of the lighthouse of Hoburg. Immediately northwest of M in Majstre on above cited topographical sheet. This conodont fauna has been described by the author in a preliminary note (Fåhræus 1967). The identification of the species *Spathognathodus crispus* is now confirmed. The zone fossil of the *crispus* Zone thus occurs in beds which overlie

Conodont species / Stratigraphic unit and sample number	Halls Beds	Mulde Beds	Klinteberg Beds		Middle Hemse Beds		Upper Hemse Beds					
	067-14	066-37	066-36	067-5	066-8	066-38	067-6	067-7	066-12	060-2	067-9	060-1
Ancoradella ploeckensis Walliser 1964					1	2						
Distomodus suberectus Rhodes 1953							3					
Distomodus sp.							3	5				
Hindeodella equidentata Rhodes 1953	1	14	1		3	9	33	8(2)	2		2	(1)
Hindeodella priscilla Stauffer 1938												
Hindeodella n. sp. A							4					
Hindeodella spp.	1						1					
Ligonodina elegans Walliser 1964												3(1)
Ligonodina salopia Rhodes 1953											1	
Ligonodina silurica Branson and Mehl 1933					1	2						
Ligonodina spp.					5	2	7	1			21	
Lonchodina detorta Walliser 1964												
Lonchodina greilingi Walliser 1957								1			8	
Lonchodina walliseri Ziegler 1960											4	6
Lonchodina spp.												
Neoprioniodus bicurvatus (Branson and Mehl 1933)						(1)	4	2	1		3	
Neoprioniodus excavatus (Branson and Mehl 1933)		13			2		12(2)					
Neoprioniodus multiformis Walliser 1964	2				3	6	3	(1)			12	
Neoprioniodus pronoides Walliser 1960												
Neoprioniodus spp.		1			1			2(1)				
Ozarkodina crassa Walliser 1964						1						
Ozarkodina edithae Walliser 1964	2											
Ozarkodina jaegeri Walliser 1964						5						
Ozarkodina media Walliser 1957		16			1(1)	4(1)	1(1)	2	1		(1)	
Ozarkodina ertuormis Walliser 1964												
Ozarkodina typica denckmanni Ziegler 1956												
Ozarkodina typica typica Branson and Mehl 1933							17	7	1		10	
Ozarkodina spp.	1	3				2	6	2				1
Panderodus spp.	1	41		1	8	56	43	16	6		82	
Plectospathodus alternatus Walliser 1964												
Plectospathodus extensus Rhodes 1953	3	15			5	5	25	4			6	
Plectospathodus flexuosus Branson and Mehl 1933					1		9	3	1		19	1
Plectospathodus spp.												
Polygnathoides siluricus Branson and Mehl 1933										1		
Spathognathodus crispus Walliser 1964												
Spathognathodus cf. *frankenwaldensis* Bischoff and Sanneman 1958												
Spathognathodus inclinatus inclinatus (Rhodes 1953)	1	5			3(1)	2	14	5(9)				
Spathognathodus primus (Branson and Mehl 1933)				3	26	6	49	45			68	3
Spathognathodus sagitta bohemicus Walliser 1964	2											
Spathognathodus steinhornensis eosteinhornensis Walliser 1964												
Spathognathodus steinhornensis remscheidensis Ziegler 1960												
Spathognathodus steinhornensis ssp. indet. Ziegler 1956												
Spathognathodus n. sp. A							5					
Spathognathodus spp.	3					2						
Synprioniodina silurica Walliser 1964					2	2(1)						
Trichonodella excavata (Branson and Mehl 1933)	5		1	1	3	5	7				12	
Trichonodella inconstans Walliser 1957					(1)		(1)					1
Trichonodella symmetrica (Branson and Mehl 1933)								2				1
Trichonodella spp.								1			4	

Eke Beds		Burgsvik Beds			Hamra Beds			Sundre Beds		Beyrichienkalk	Ohesaare Beds	Stratigraphic unit and sample number / Conodont species
067–8	066–39	066–43	066–44	067–15	067–16	066–7	066–41	066–42	067–2			
												Ancoradella ploeckensis Walliser 1964
												Distomodus suberectus Rhodes 1953
												Distomodus sp.
5	4				1	3	5	1	5		6	*Hindeodella equidentata* Rhodes 1953
										3	18	*Hindeodella priscilla* Stauffer 1938
						2						*Hindeodella* n. sp. A
												Hindeodella spp.
						(1)				12	37	*Ligonodina elegans* Walliser 1964
1	2		1			3		1	1			*Ligonodina salopia* Rhodes 1953
								4		(1)	(2)	*Ligonodina silurica* Branson and Mehl 1933
1			4			1		1	(2)	3	3	*Ligonodina* spp.
					1					2	14	*Lonchodina detorta* Walliser 1964
										1		*Lonchodina greilingi* Walliser 1957
				1					1(1)			*Lonchodina valliseri* Ziegler 1960
				1	1			1				*Lonchodina* spp.
2	1				1	2		4	2	1	14	*Neoprioniodus bicurvatus* (Branson and Mehl 1933)
						5		(1)	1			*Neoprioniodus excavatus* (Branson and Mehl 1933)
3					1		2		1			*Neoprioniodus multiformis* Walliser 1964
										9	24	*Neoprioniodus pronoides* Walliser 1960
					(1)	1						*Neoprioniodus* spp.
												Ozarkodina crassa Walliser 1964
												Ozarkodina edithae Walliser 1964
						(1)						*Ozarkodina jaegeri* Walliser 1964
	1					6		3			2	*Ozarkodina media* Walliser 1957
											3	*Ozarkodina ertuormis* Walliser 1964
			5					4		2	9	*Ozarkordina typica denckmanni* Ziegler 1956
3						1	1(1)		1	1	9	*Ozarkordina typica typica* Branson and Mehl 1933
2			(1)		(1)			1(3)	5			*Ozarkordina* spp.
44			4	3	10	23	6	75	6		4	*Panderodus* spp.
								(1)	2		8	*Plectospathodus alternatus* Walliser 1964
12	1		2		3	3		3	2			*Plectospathodus extensus* Rhodes 1953
1	2(1)					2		3			18	*Plectospathodus flexuosus* Branson and Mehl 1933
								1				*Plectospathodus* spp.
												Polygnathoides siluricus Branson and Mehl 1933
						2						*Spathognathodus crispus* Walliser 1964
											23	*Spathognathodus* cf. *frankenwaldensis* Bischoff and Sanneman 1958
12	1					9	4		3			*Spathognathodus inclinatus inclinatus* (Rhodes 1953)
4					5	3		9			4(1)	*Spathognathodus primus* (Branson and Mehl 1933)
												Spathognathodus sagitta bohemicus Walliser 1964
		1	5(1)	3					5	23		*Spathognathodus steinhornensis eosteinhornensis* Walliser 1964
											35	*Spathognathodus steinhornensis remscheidensis* Ziegler 1960
											2	*Spathognathodus steinhornensis* ssp. indet. Ziegler 1956
												Spathognathodus n. sp. A
						(1)	1	1			8	*Spathognathodus* spp.
	1		1						1			*Synprioniodina silurica* Walliser 1964
5	1					6		2	2		2	*Trichonodella excavata* (Branson and Mehl 1933)
										10	14	*Trichonodella inconstans* Walliser 1957
	1				1				1		2	*Trichonodella symmetrica* (Branson and Mehl 1933)
											3	*Trichonodella* spp.

Table 1

and underlie beds which belong in the *eosteinhornensis* Zone. It can be concluded that the *crispus* Zone is not developed in Gotland as a zone older than the *eosteinhornensis* Zone. In the present paper a few other modifications of the author's 1967 species determinations have been made. The most important changes are the following: one specimen of *Hindeodella equidentata* and the specimen questionably referred to Gen. et sp. n. are placed in *Hindeodella* n. sp. A; the specimen referred to *Plectospathodus alternatus* is placed in *P. extensus*.

G66-41, Hoburg; R and H p. 84, loc. 47
The sample is from a level 1.5 metres above the base, on the western side, of the small limestone hill called *Hoburgs-gubben* close to the southwesternmost point of Gotland. Topographical sheet *5I Hoburgen SO och 5J Hemse SV*.

None of these sample yielded a conodont fauna which allows a direct zonal assignation. However, their stratigraphic position in between beds yielding definite *eosteinhornensis* Zone faunas makes an assignation to that zone warranted.

Sundre Beds

G66-42, Juves; A M p. 59
The top of the limestone cliff about 300 metres SSW of Juves' farm in the parish of Sundre. Topographical sheet *5I Hoburgen SO och 5J Hemse SV*.

The sample is from the uppermost part of the Sundre Beds. The conodont fauna has previously been described (Fåhræus 1967); three specimens referred to Gen. et sp. n. are herein tentatively referred to *Ozarkodina* sp. The four specimens referred to *Ozarkodina typica* ssp. aff. *O. typica denckmanni* are now regarded as good representatives of the subspecies *denckmanni* although the evolutionary step they represent does not have the typical difference in height of the denticulation on the blades. The specimens of *O. typica denckmanni* found in the Ludlovian of Gotland closely resembles a specimen illustrated by Walliser (1964, pl. 26, fig. 10).

G67-2, Hoburg; R and H p. 84, loc. 47; A M p. 59
The western cliff of the Storburg, on southeastern side, about 1.5 metres below the uppermost beds. Above cited topographical sheet.

About 6 kilogrammes of a marly reddish thin bedded limestone were dissolved.

This sample yielded a conodont fauna which has few individuals but a relatively large number of species. *Ozarkodina typica denckmanni* and *Spathognathodus steinhornensis eosteinhornensis* have a.o. been identified, establishing that this sample belongs in the *eosteinhornensis* Zone. *Plectospathodus alternatus*, a species which becomes quite common in the Gedinnian, also occurs in this sample.

CONODONT FAUNAS FROM THE *BEYRICHIENKALK* AND THE OHESAARE BEDS AND THEIR RELATION TO THE LATE LUDLOVIAN FAUNAS OF GOTLAND

Through the courtesy of Drs. A. Martinsson and T. Ørvig, who provided the author with material from the *Beyrichienkalk* and the Ohesaare Beds respectively, it has been possible to make this comparative study.

The *Beyrichienkalk* and its ostracode fauna has recently been discussed by Martinsson (see *i.a.* 1963a, 1963b, 1963c, and 1965). The *Beyrichienkalk* is, as presently known, entirely submarine and crops out on the floor of the Baltic Sea. Martinsson (i.a. 1967) believes that the *Beyrichienkalk* is a facies equivalent of the slightly less argillaceous Estonian Ohesaare Beds and that it has its northwestern limit in the upper part of the Hoburg Bank south south-east of Gotland. This concept, however, has not been proven by actual samples from *in situ* beds but is inferred by Martinsson (1965) from a rich occurrence of *Beyrichienkalk* erratics on top of the Hoburg Bank. Martinsson (1967, p. 379) concludes that "the upper range of the *Beyrichienkalk* fauna is to be found inconsiderably below or at the *eosteinhornensis* – *woschmidti* boundary". The base of the *woschmidti* Zone coincides with the base of the *uniformis* Zone, wich more and more among stratigraphers has come to denote the base of the Devonian System.

The Estonian Ohesaare Beds, well known for their very rich fish faunas, crop out on the Sôrve Peninsula on the island Saarema. The Department of Paleozoology of the Swedish Museum of Natural History (Naturhistoriska Riksmuseet) has a large collection of samples from Ohesaare collected and subsequently described by Hoppe in 1931. The sample processed for study of the conodont fauna is from the middle fish horizon.

Kaljo and Sarv (1966) are of the same opinion as Martinsson (1967), that the *Beyrichienkalk* in its main part is a facies equivalent of the Ohesaare Beds, but suggest a correlation with the Ludlow Bone Bed and the Downton Castle Sandstone.

Gross (1967), who recently has revised the acanthodian fish fauna of the Ohesaare Beds and the *Beyrichienkalk*, correlates the former with the Whitcliffian and the latter with the Ludlow Bone Bed and basal Downtonian.

The herein reported conodont faunas do not speak unequivocally in favour of either Gross (loc. cit.), or Martinsson's (1967) and Kaljo's and Sarv's (1960) concept about the relation between the *Beyrichienkalk* and the Ohesaare Beds.

Three *Beyrichienkalk* erratics (total weight c. 2 kilogrammes) were dissolved and searched for conodonts. They were collected by Dr. A. Martinsson along the Polish shore at Miezyzdroje, about 20 kilometres east of the mouth of the river Oder. The three erratics were kept apart during extraction of the conodonts but are herein accounted for in bulk.

Walliser (1964, table 2. pt. 3) has described conodont faunas from *Beyrichienkalk* erratics (eleven samples) and beside the species listed by this author in Table 2 Walliser also identified the following: *Hindeodella equidentata, Icriodus woschmidti, Neoprioniodus excavatus, Ozarkodina media, O. typica typica, Plectospathodus alternatus, P. extensus,* and *Spathognathodus primus.* The Gedinnian zone fossil *I. woschmidti* was found in one sample and there together with *Spathognathodus steinhornensis eosteinhornensis* suggesting an overlap between the *eosteinhornensis* Zone and the *woschmidti* Zone. However, the *Beyrichienkalk* seems to be essentially within the upper part of the *eosteinhornensis* Zone.

The *Beyrichienkalk* conodont fauna is dominated and characterized by the following species: *Ligonodina elegans, Lonchodina greilingi, Neoprioniodus pronoides, Spathognathodus steinhornensis eosteinhornensis,* and *Trichonodella inconstans.*

Of all species reported from the *Beyrichienkalk* only one, viz. *Hindeodella priscilla,* has not been found in the Ludlovian of Gotland, but other evidence clearly indicates that the *Beyrichienkalk* is younger than any known deposit on Gotland. Very few and small specimens of *S. steinhornensis eosteinhornensis* have been found in the late Ludlovian of Gotland whereas in the *Beyrichienkalk* this subspecies is quite large and well defined and usually occurs in great number. Of the species *Ligonodina elegans,* which occur in great number in the *Beyrichienkalk,* only one specimen has been found in the Gotland samples.

Jocelyne Legault *(in press)* has recently described conodont faunas from the Stonehouse Formation, Arisaig, Nova Scotia. Legault reports occurrence of the following species (number of specimens within brackets): *Ligonodina elegans* (400), *Lonchodina detorta* (64), *L. greilingi* (190), *Lonchodina* sp. indet (? = *Trichonodella inconstans)* (32), *Neoprioniodus* n. sp. a (? = N. *pronoides)* (188), *Neoprioniodus* n. sp. b (? = N. *pronoides)* (32), *Ozarkodina typica denckmanni* (52), O. cf. *jaegeri* (18), *Spathognathodus steinhornensis eosteinhornensis* (339), and *Trichonodella inconstans* (309).

Legault (loc. cit.) also states that the conodont fauna seems to be of essentially the same composition throughout the Stonehouse Formation. However Legault did not sample the uppermost part of the Stonehouse Formation exposed in Pictou County, west of Arisaig, which Boucot (1960) consider to be lower Gedinnian in age.

This fauna is clearly dominated by the same species as the *Beyrichienkalk*. The differences between the Stonehouse fauna and the *Beyrichienkalk* fauna seem unconsequential and it is tentatively concluded that the two are correlative.

Copeland (1964, p. 8) correlates the Stonehouse Formation with the *Beyrichienkalk*. Martinsson (1963a) has restricted the extent of the *Beyrichienkalk* to the part containing the ostracode fauna of *Sleia kochi, Macrypsilon salterianum, Hemsiella maccoyiana, Berolinella steusloffi, Nodibeyrichia tuberculata, N. gedanensis, (N. pustulosa), Frostiella pliculata, F. cornuta, Kloedenia leptosoma, K. wilckensiana, and Amygdalella subclusa*. This fauna characterizes Martinsson's (1967) uppermost informal ostracode zone. Martinsson (loc. cit.) correlates only the upper half (with exception of the lower Gerdinnian uppermost layers) of the Stonehouse Formation with this uppermost zone. The lower part of the Stonehouse Fm. is correlated with "low levels in the Downton Castle Sandstone" (Martinsson 1967, p. 372, fig. 3). The present knowledge of the *Beyrichienkalk* and Stonehouse Fm. conodont faunas does not allow such a precise correlation and it can only be concluded that both faunas are typically Pridolian.

It can be summarized that the late Ludlovian conodont faunas from Gotland suggest that the Silurian deposits of Gotland reach very close to the Ludlovian/Pridolian boundary.

Three kilogrammes of rock sample from the Ohesaare Beds were dissolved and yielded a very rich and varied fauna. All but three of the identified species have been met with in the Gotland samples and/or the *Beyrichienkalk* samples, specifically *Spathognathodus* cf. *frankenwaldensis, S. steinhornensis remscheidensis* and *S. steinhornensis* ssp. indet.

The subspecies *S. steinhornensis remscheidensis* occurs according to Walliser (1964 p. 87) in the Gedinnian *woschmidti* Zone, thus indicating that the upper part of the Ohesaare Beds could be Gedinnian in age. Walliser (1964, p. 84) states that it is difficult to distinguish forms belonging in the subspecies *S. steinhornensis remscheidensis* from forms belonging in *S. steinhornensis eosteinhornensis* and that the separation of the two is purely arbitrary. The author has compared his specimens of the *remscheidensis* form with the specimens of the *eosteinhornensis* form which were obtained from the *Beyrichienkalk* and they definitely fall into two different form groups. The species *Spathognathodus canadensis* described by Walliser (1960) from the Sutherland River Formation in arctic Canada is by Walliser (1964) considered a junior synonym of *S. steinhornensis remscheidensis*. Walliser (1960), in his description of *S. canadensis*, stresses the unequal size of the laterally flattened denticles, one larger denticle always being present above the basal cavity. Walliser (loc. cit.) also states that the basal line of the denticles always is slightly sigmoidal and that the aboral margin always is higher in the anterior part than in the posterior part. Walliser's description (loc. cit.) of *S. canadensis* fits the author's *remscheidensis* forms to the point. The author regards his specimens of *S. steinhornensis remscheidensis* as typical and well within the limits of the subspecies. However, if regarded to be within the *eosteinhornensis* form group they are certainly much more advanced and consequently younger than the form group in the *Beyrichienkalk*.

A very late Pridolian or early Gedinnian age for the Ohesaare Beds sample is further emphasized by the identification of *S.* cf. *frankenwaldensis*. This species was described by Bischoff and Sannemann (1958) on material which they questionably referred to the Siegenian. Since then it has a.o. been reported from the Emsian in North America (Clark and Ethington 1966). A similar species, *S. exiguus*, [the specimens referred by Clark and Ethington (loc. cit.) to *S. frankenwaldensis* most probably belong in this species] has been reported by Philip (1966) from the Murrindale limestone, McLaren Ridge, Australia. Philip (loc. cit.) also reports on a subspecies, *S. steinhornensis buchanensis*, which he divides into two form groups one of which with the typically enlarged anterior denticles of the *frankenwaldensis* type. Philip (loc. cit.) regards his forms to be of Lower Emsian age. The form group represented by *S. frankenwaldensis* seems to be entirely post – Pridolian in age.

Walliser (1964, p. 80, 81) clearly demonstrates that the "*frankenwaldensis*" type evolves from *Spathognathodus primus* and states that it is not fully evolved until Lower Devonian.

The finds of *S.* cf. *frankenwaldensis* also seems to sustain an age assignation of Lower Gedinnian to the upper part of the Ohesaare Beds.

Ziegler (1960, 1962) has described a lower Gedinnian conodont fauna from the base of the Hüinghäuser Beds at Utenrüden, Germany, which is quite similar to the fauna from the Ohesaare Beds. Only a few of the species identified by Ziegler (1960) have not been found in the samples studied by the author and reported on herein. Two of these species are *Icriodus woschmidti* and *Lonchodina cristagalli*. Both of these species are not known from beds older than the Gedinnian. *L. cristagalli* has so far only been found at the type locality at Hüinghäuser, where it occurs in four of Ziegler's (1960) nine samples, and in the Cellon sequence where Walliser (1964, table 2, pt. 2) found the species in one sample from the base of the *woschmidti* Zone. The zone fossil *I. woschmidti*, on the other hand, is much more common and it is the absence of this species in the Ohesaare Beds sample which prompts this author to consider the age of the Ohesaare Beds conodonts in some details although negative evidence as a rule is not very reliable.

The following two species identified by Ziegler (1960) are especially significant: *Spathognathodus* cf. *canadensis* and *S. steinhornensis remscheidensis*. Ziegler (loc. cit.) is of the opinion that *S. canadensis* is related to *S. steinhornensis remscheidensis* but an earlier evolved form *S. cf. canadensis* is considered to be an intermediate form. The author has found a few *remscheidensis* specimens which show some resemblance to some of Ziegler's (loc. cit.) figured specimens but also several which are quite close to specimens figured by Ziegler as *S.* cf. *canadensis*.

Walliser (1960) described a conodont fauna from the Sutherland River Formation on Devon Island in the Canadian Arctic Archipelago. Walliser (1964, p. 87) regards this fauna as basal Gedinnian since it contains *S. canadensis* (= *S. steinhornensis remscheidensis*). *Icriodus woschmidti* was not found. However, Walliser (loc. cit.) does not rule out the possibility that *S. canadensis* is an extreme form of the *eosteinhornensis* group since one *Spathognathodus* specimen was found with typical *eosteinhornensis* denticulation, that is rounded and of subequal size. No such specimen has been found in the Ohesaare Beds sample. According to Berry and Boucot (*in press*) a lower Gedinnian age of at least part of the Sutherland River Formation is supported by finds of certain brachiopods. All conodonts identified in the Sutherland River fauna, except one which probably represents an intermediate stage between *Spathognathodus inclinatus inclinatus* and the (?) Siegenian *Spathognathodus wurmi* Bischoff and Sannemann 1958 (Walliser 1960, p. 35), have been found in the Ohesaare Beds sample.

The evidence presented by Walliser's (1960) and Ziegler's (1960, 1962) conodont faunas seem to be consistent with a very late Pridolian or basal Gedinnian age for the Ohesaare Beds sample.

Summarizing the above discussion about the conodont faunas compared herein we can conclude that the Ohesaare Beds fauna clearly is the youngest and the late Ludlovian fauna of Gotland the oldest. The differences between the three faunas have been shown to be quite small. The age difference between the Pridolian *Beyrichienkalk* and the Ludlovian Sundre Beds can be considered to be relatively minor and the Sundre Beds are then believed to extend very close to the Ludlovian/Pridolian boundary. The upper part of the Ohesaare Beds most probably is basal Gedinnian or latest Pridoli in age. The conodont fauna of the Ohesaare Beds has a definitely younger aspect than the *Beyrichienkalk* fauna.

CORRELATION WITH THE BRITISH STANDARD LUDLOVIAN

The correlation offered is based upon Walliser's (1964) correlation of his conodont zones with graptolite zones outside the Carnic Alps as well as all available information about Silurian conodont faunas in Britain and elsewhere. Naturally chronostratigraphic evidence presented by other fossil groups in the Ludlovian of Gotland have been taken into consideration. The following discussion is offered as comments to Table 2 which outlines the author's concept of the correlation.

Series	Subseries units	British graptolite zones	German graptolite zones	Gotland topostratigraphical units	CONODONT ZONATION: GOTLAND	CONODONT ZONATION: CARNIC ALPS	CONODONT ZONATION: NORTH AMERICA	CONODONT ZONATION: GREAT BRITAIN
PRIDOLI	Downton		transgrediens			eosteinhornensis crispus latialatus	eosteinhornensis	
LUDLOW	Ludlow Bone Bed							eosteinhornensis
	Whitcliffe		fritschi linearis	Sundre Beds Hamra Beds Burgsvik Beds	eosteinhornensis	siluricus		
	Leintwardine	M. leintwardinensis leintwardinensis leintwardinensis	leintwardinensis	Eke Beds Upper Hemse Beds	siluricus		latialatus-crispus	siluricus
	Bringewood	M. leintwardinensis						
	Upper Elton	incipiens	chimaera	Middle Hemse Beds	ploeckensis	ploeckensis	siluricus	
	Middle & Lower Elton	nilssoni-scanicus	nilssoni (colonus)	Lower Hemse Beds	?crassa	crassa	crassa-ploeckensis	
WENLOCK	Wenlock Limestone	ludensis	ludensis	Klinteberg Beds		sagitta	sagitta	sagitta
	Wenlock Shale	lundgreni ellesi	deubeli dubius-nassa testis radians	Mulde Beds Halla Beds Slite Beds	sagitta	patula	patula	

Table 2

Mulde Beds and Halla Beds

According to Martinsson (1967, p. 365) the Mulde Beds are to be regarded as a marly facies equivalent to the lower part of the Halla Beds. The two conodont faunas from these two units, identified herein, comprise far too little material to even comment on Martinsson's (loc. cit.) conclusions based on extensive ostracode studies. However, the two faunas described represent different time levels and if the above (p. 10) mentioned find by L. Jeppsson of *S. primus* and *P. flexuosus* is taken into consideration the difference is even more pronounced. Hede (1924) originally considered the Halla Beds to be older than the Mulde Beds and this interpretation is corroborated by the conodont faunas and followed herein.

Monograptus dubius and *Gothograptus nassa* frequently occur together in the Mulde Beds (see Hede 1942, p. 18). Jaeger (1964) regarded this co-occurrence of considerable stratigraphic importance and introduced an *interregnum* called *dubius-nassa* between his zones of *Monograptus deubeli* and *M. testis*. This *interregnum* is correlated with the upper part of the zone of *Cyrtograptus lundgreni*, a correlation already assumed by Hede (1942, p. 20) for the Mulde Beds and followed herein.

Klinteberg Beds

The Klinteberg Beds have provided little evidence for a close correlation with British Ludlovian deposits. According to Martinsson (1967, p. 360, fig. 2) the basal part of the Klinteberg Beds is correlative with the upper part of the Halla Beds and the Mulde Beds and the remainder to the lower half of the Hemse Beds. Martinsson (1967) does not clarify his reasons for this equation. Martinsson (loc. cit., p. 366), however, stresses a find of *Gothograptus nassa* by Dr. S. Laufeld very high in the Mulde Beds or within the basal part of the Klinteberg Beds; he also mentions the range of *G. nassa* as interpreted by Jaeger (1964), viz. from low levels in the *testis* Zone into the "*vulgaris*" *(ludensis)* Zone". However, this species repeatedly has been reported from the *nilssoni-scanicus* Zone (Moberg and Törnquist 1909, Boswell 1928, and Rickards 1967).

Table showing the stratigraphic units referred to in the present paper and their correlation. The common base of the *uniformis* Zone and the *woschmidti* Zone is regarded by this author as the base of the Devonian System. Pridoli is used as a series name in accordance with Berry & Boucot *(in press)*. The following references have a. o. been used for the compilation of the table: column 3) Rickards 1967 and Warren, Rickards, & Holland 1966; 4) Jaeger 1964; 5) Hede 1921 and 1924; Walliser 1964; 8) Berry & Boucot *in press*. The conodont zones in the Carnic Alps and North America are *only* correlated with the German and British graptolite zones in accordance with Walliser (1964) and Berry & Boucot *(in press)* respectively.

Martinsson (1967) also places the lower part of the Klinteberg Beds in his fauna zone of *Prisculella garnielloides* and *Calcaribeyrichia duplicicalcarata*. However these two species have so far only been reported to occur in the outcrops of the Halla Beds along the shore between Bryggan and Gothemshammar (Martinsson 1966) on the east coast of Gotland.

The correlation offered herein follows Hede (*i.a.* 1921) in assuming that the Klinteberg Beds are older than the lower Hemse Beds and younger than the Mulde Beds, both of which can be correlated with the British standard.

Lower Hemse Beds

Several finds of *Monograptus nilssoni, M. varians, M. chimaera,* and *Pristiograptus bohemicus* (see Hede 1942) have been made in this area which suggest a correlation with the Lower and Middle Elton.

Middle Hemse Beds

These beds have yielded two conodont faunas which belong in the *ploeckensis* Zone. The lower boundary of this zone has not yet been determined in terms of graptolite zones. Upwards the *ploeckensis* Zone continues into the lower half of the zone of *M. leintwardinensis* (Walliser 1964, p. 94, fig. 10). However, this boundary was arbitrarily drawn by Walliser (1964, p. 97) and not proved with graptolites.

One sample yielded the zone fossil of the *crassa* Zone, viz. *Ozarkodina crassa,* indicating the lower part of the *ploeckensis* Zone. Furthermore one *siluricus* Zone fauna (see below) closely resembles Upper Bringewoodian and Lower Leintwardinian conodont faunas in Britain. It is therefore believed that the middle Hemse Beds tentatively can be correlated with the Upper Elton Beds.

Upper Hemse Beds and Eke Beds

Several localities in these beds have yielded conodont faunas which most probably belong in the *siluricus* Zone. One of the localities, viz. Gogs, has yielded a conodont fauna which is almost identical with conodont faunas described by Rhodes (1953) from the Aymestry Limestone and the Sedgley Limestone. The Aymestry Limestone near Shelderton Rock, Shropshire where Rhodes (loc. cit.) sampled is considered to be Upper Bringewoodian in age (Rhodes and Newall, 1963) and so is the part of the Sedgley Limestone sampled at Beacon Hill, south Staffordshire (Rhodes pers. comm. 1968). Squirrell and Tucker (1960) have reported the following conodonts from the Lower Bodenham Beds of the Woolhope inlier, Herefordshire: distacodid conodonts, *Distomodus curvatus,* *Ozarkodina typica typica, Ozarkodina* sp. *Plectospathodus* sp., *Spathognathodus primus, Spathognathodus* sp, *Trichonodella* cf. *aboroflexa* (= *T.* cf. *excavata),* and *T. symmetrica.* These conodonts suggest that the Lower Bodenham Beds, which Squirrell and Tucker (loc. cit.) correlate with the Lower Leintwardine Beds, are within the *siluricus* Zone.

Conodont faunas from the Eke Beds have not shown any considerable difference from the upper Hemse Beds faunas and are therefore also believed to be within the *siluricus* Zone.

The upper boundary of the *siluricus* Zone is on Gotland developed at the top of the Eke Beds or within the Burgsvik Beds. The Eke Beds and the upper Hemse Beds are teatatively correlated with the Leintwardinian and the Bringewoodian.

Burgsvik Beds, Hamra Beds and Sundre Beds

Conodont faunas have proven that this sequence, with a possible exception of the sandstone facies of the Burgsvik Beds, belongs in the *eosteinhornensis* Zone. Walliser (1964, p. 94, fig. 10) correlates this zone with the *Monograptus transgrediens* and *M. bouceki* interval in the Bohemian graptolite sequence. In the Cellon sequence Walliser (loc. cit.) has identified two zones, viz. the *crispus* Zone and the *latialatus* Zone, between the *eosteinhornensis* Zone and the *siluricus* Zone. These two zones have not been recognized in the Silurian of Gotland or elsewhere outside the Carnic Alps and since there is no reason to introduce a sedimentary break the *eosteinhornensis* Zone on Gotland is believed to rest conformably on the *siluricus* Zone. In terms of graptolite zones this means that the *siluricus* – *eosteinhornensis* boundary on Gotland is located at the base of, or within, the *Monograptus fritschi linearis* Zone. It has been definitely established (Walliser 1966, Collison and Druce 1966) that the Ludlow Bone Bed and the Upper Whitcliffian belong in the *eosteinhornensis* Zone. It has also been shown above (p. 23) that the late Ludlovian deposits of Gotland extend very close to the Ludlovian/Pridolian boundary, viz. the base of the Ludlow Bone Bed.

The Burgsvik Beds, the Hamra Beds and the Sundre Beds are therefore correlated with the Whitcliffian. No delimitation between Upper and Lower Whitcliffian is made on Gotland.

REFERENCES

AUSTIN, R. L., & BASSETT, M. G., 1967: A *sagitta* zone conodont fauna from the Wenlockian of the Usk inlier, Monmouthshire. *Geol. Mag.* Vol. 104.

BERRY, W. B. N., & BOUCOT, A. J., in press: Silurian of North America. *Geol. Soc. Am. Special Paper.*

BISCHOFF, G., & SANNEMANN, D., 1958: Unterdevonische Conodonten aus dem Frankenwald. *Notizbl. hess. Landesamt. Bodenforsch.* Vol. 86.

BOSWELL, P. G. H., 1928: The Salopian rocks and tectonics of the district south-west of Ruthin (Denbigshire). *Quart. Journ. Soc. London. Vol. 83.*

BOUCOT, A. J., 1960: Lower Gerdinnian brachiopods from Belgium. *Mem. Inst. Géol., Univ. Louvain.* Vol. 21. Louvain.

BROOKS, M., & DRUCE, E. C., 1965: A Llandovery conglomeratic limestone in Gullet Quarry, Malvern Hills, and its conodont fauna. *Geol. Mag.* Vol. 102.

CLARK, D. L., & ETHINGTON, R. L., 1966: Conodonts and biostratigraphy of the Lower and Middle Devonian of Nevada and Utah. *Journ. Pal.* Vol. 40.

COLLINSON, C., & DRUCE, E. C., 1966: Upper Silurian conodonts from Welsh Borderlands (Abstract). *Bull. Am. Ass. Petrol. Geol.* Vol. 50.

COPELAND, M. J., 1964: Canadian fossil Ostracoda: some Silurian species. *Geol. Surv. Canada. Bull.* 117.

FÅHRÆUS, L. E., 1967: Upper Ludlovian deposits of Gotland defined by means of conodonts. *Geol. Fören. Stockholm. Förh.* Vol. 89. Stockholm.

GROSS, W., 1967: Über Thelodontier-Schuppen. *Palaeontographica.* Abt. A. Vol. 127. Stuttgart.

HEDE, J. E., 1921: Gottlands silurstratigrafi. *Sveriges Geologiska Undersökning.* Ser. C. No. 305. Stockholm.

– 1925: Beskrivning av Gotlands silurlager. *In* Munthe, H., Hede, J. E., & von Post, L.: Gotlands geologi. *Sveriges Geologiska Undersökning.* Ser. C. No. 331. Stockholm.

– 1927: Berggrunden (Silursystemet). *In* Munthe, H., Hede, J. E., & von Post, L.: Beskrivning till kartbladet Hemse. *Sveriges Geologiska Undersökning.* Ser. Aa. No. 164. Stockholm.

– 1942: On the correlation of the Silurian of Gotland. *Lunds Geologiska Fältklubb 1892–1942.* Lund.

– 1960: The Silurian of Gotland. *International Geological Congress. XXI Session. Norden* 1960. Sweden, guide-book d.

HOLLAND, C. H., LAWSON, J. D., & WALMSLEY, V. G., 1963: The Silurian rocks of the Ludlow District, Shropshire. *Bull. Brit. Mus. (Nat. Hist.). Geology.* Vol. 8. London.

HOPPE, K.-H., 1931: Die Coelolepiden und Acanthodier der Obersilurs der Insel Oesel. Ihre Paläobiologie und Paläontologie. *Palaeontographica.* Vol. 76. Stuttgart.

JAEGER, H., 1964: Beiträge zur regionalen Geologie Thüringens und angrenzender Gebiete, sowie zu anderen Problemen. *Abh. Dutsch. Akad. Wiss. Berlin.* Klasse für Bergbau, Hüttenwesen und Montangeologie. Jahrgang 1964:2. Berlin.

KALJO, D. & SARV, L. ((Кальо, Д., и Сарв, Л.) 1966: К корреляции верхнесилурийских отложении Прибалтики. *Eesti NVS Teaduste Akadeemia Toimetised,* Vol. 15. Tallin.

LEGAULT, JOCELYNE, in press: The conodont fauna of the Stonehouse Formation, Arisaig, Nova Scotia. *Geol. Surv. Canada. Bull.*

MARTINSSON, A., 1962: Ostracodes of the family *Beyrichiidae* from the Silurian of Gotland. *Bull. Geol. Inst. Univ. Uppsala.* Vol. 41. Uppsala.

– 1963a: *Kloedenia* and related ostracode genera in the Silurian and Devonian of the Baltic area and Britain. *Ibidem.* Vol. 42.

– 1963b: The concealed Silurian of the Baltic area. *Geol. Fören. Stockholm. Förh.* Vol. 84. Stockholm

– 1963c: The geological provenance of net-sinkers found in the wreck of H.M.S. Wasa in Stockholm. *Ibidem.* Vol. 85.

– 1966: Beyrichiacean ostracodes associated with the earliest Silurian vertebrates from Gotland. *Ibidem.* Vol. 88.

– 1967: The succession and correlation of ostracode faunas in the Silurian of Gotland. *Ibidem.* Vol. 89.

MOBERG, J. C., & TÖRNQUIST, S. L., 1909: Retioloidea från Skånes colonusskiffer. *Sveriges Geologiska Undersökning*. Ser. C. No. 213. Stockholm.

PHILIP, G. M., 1966: Lower Devonian conodonts from the Buchan Group, eastern Victoria. *Micropaleontology*. Vol. 12.

REXROAD, C. B., 1967: Stratigraphy and conodont paleontology of the Brassfield (Silurian) in the Cincinnati Arch area. *Geological Survey Indiana. Bull.* 36. Bloomington.

REXROAD, C. B., & RICHARD, L. V., 1965: Zonal conodonts from the Silurian strata of the Niagara Gorge. *Journ. Pal.* Vol. 39.

RHODES, F. H. T., 1953: Some British lower Palaeozoic conodont faunas. *Philos. Transac. Roy. Soc. London*. Ser. B. Vol. 237.

RHODES, F. H. T., & NEWALL, G., 1963: Occurrence of *Kockelella variabilis* in the Aymestry Limestone of Shropshire. *Nature*. Vol. 199. No. 4889.

RICKARDS, R. B., 1967: The Wenlock and Ludlow succession in the Hogwill Fells (north-west Yorkshire and Westmoreland). *Quart. Journ. Geol. Soc. London*. Vol. 123.

SQUIRRELL, H. C., & TUCKER, E. V., 1960: The geology of the Woolhope inlier Herefordshire. *Ibidem*. Vol. 116.

WALLISER, O. H., 1960: Scolecondonts, conodonts, and vertebrates. *In* Boucot, A. J., *et al.*: A late Silurian fauna from the Sutherland River Formation, Devon Island, Canadian arctic archipelago. *Geol. Surv. Canada. Bull.* 65.
– 1962: Conodontenchronologie des Silurs (= Gotlandiums) und des tieferen Devons mit besonderer Berücksichtigung der Formationsgrenze. *Symposiums-Band z. internat. Arbeitstagung Silur/Devon Bonn–Bruxelles 1960*. Stuttgart.
– 1964: Conodonten des Silurs. *Abh. hess. Landesamt. Bodenforsch*. Heft. 41. Wiesbaden.
– 1966: Die Silur/Devon Grenze. Ein Beispiel biostratigrapschicher. Methodik. *N. Jb. Geol. Paläont*. Abh. Vol. 125. Stuttgart.

ZIEGLER, W., 1960: Conodonten aus dem Rheinischen Unterdevon (Gedinnium) des Remscheider Sattles (Rheinisches Schiefergebirge). *Paläont. Zeitschr.* Vol. 34. Stuttgart.
– 1962: Conodonten aus dem Hüinghäuser schichten (Gedinnium) des Remscheider Sattels. *Symposiums-Band der 2. internat. Arbeitstagung über die Silur/Devon Grenze und die Stratigraphie von Silur und Devon. Bonn–Bruxelles 1960*. Stuttgart.

The plates were prepared by Mr. K. Ferringo and the author using facilities provided by the Dept. of Geology at the University of Western Ontario, London, Canada. All specimens, with exception of Pl. I, fig. 4, were lightly coated before photographing. Only a few of the conodont species identified are shown on the plates.

Explanation of Plate I

Fig. 4 X65, other specimens X30

Figs. 1, 2. *Spathognathodus primus* (Branson & Mehl 1933). Lateral views. Fig. 1: sample G67–6; fig. 2: sample G60–1.

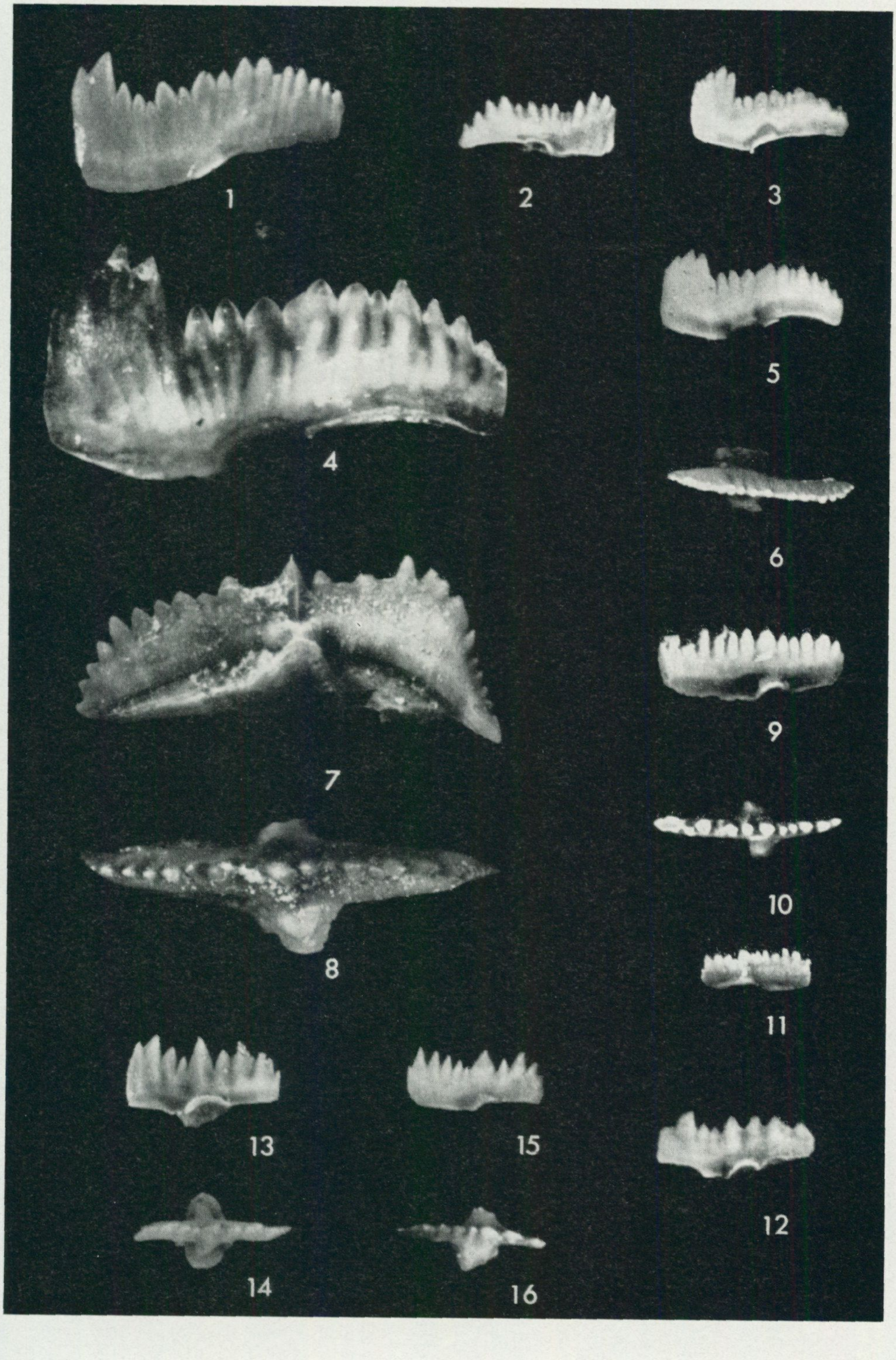
Figs. 3–6. *Spathognathodus* cf. *frankenwaldensis* Bischoff & Sannemann 1958. Lateral and upper views. Figs. 4–6 of the same specimen; fig. 4 is uncoated. Ohesaare Beds sample.

Figs. 7, 8. *Spathognathodus* n. sp. A. Lateral and upper views. Sample G67–6.

Figs. 9–11. *Spathognathodus steinhornensis eosteinhornensis* Walliser 1964. Lateral and upper views. Figs. 9, 10: *Beyrichienkalk* sample; fig. 11: G66–44.

Figs. 12, 15, 16. *Spathognathodus steinhornensis remscheidensis* Ziegler 1960. Lateral and upper views. Ohesaare Beds sample.

Figs. 13, 14. *Spathognathodus steinhornensis* ssp. indet. Lateral and upper views. Ohesaare Beds sample.


1
2
3
4
5
6
7
9
8
10
11
13
15
12
14
16

Explanation of Plate II

X30

Fig. 1. *Hindeodella* n. sp. A. Sample G67–6.

Fig. 2. *Ligonodina elegans* Walliser 1964. Sample G60–1.

Fig. 3. *Ozarkodina typica typica* Branson & Mehl 1933. Sample G67–6.

Fig. 4. *Ozarkodina typica denckmanni* Ziegler 1956. Sample G66–44.

Fig. 5. *Ozarkodina crassa* Walliser 1964. Sample G66–38.

Fig. 6. *Ozarkodina edithae* Walliser 1964. Sample G67–14.

Fig. 7. *Plectospathodus flexuosus* Branson & Mehl 1933. Sample G67–6.

Fig. 8. *Hindeodella priscilla* Stauffer 1938. *Beyrichienkalk* sample.

Figs. 9, 10. *Neoprioniodus bicurvatus* (Branson & Mehl 1933). Sample G67–7.

Fig. 11. *Neoprioniodus pronoides* Walliser 1960. Ohesaare Beds sample.

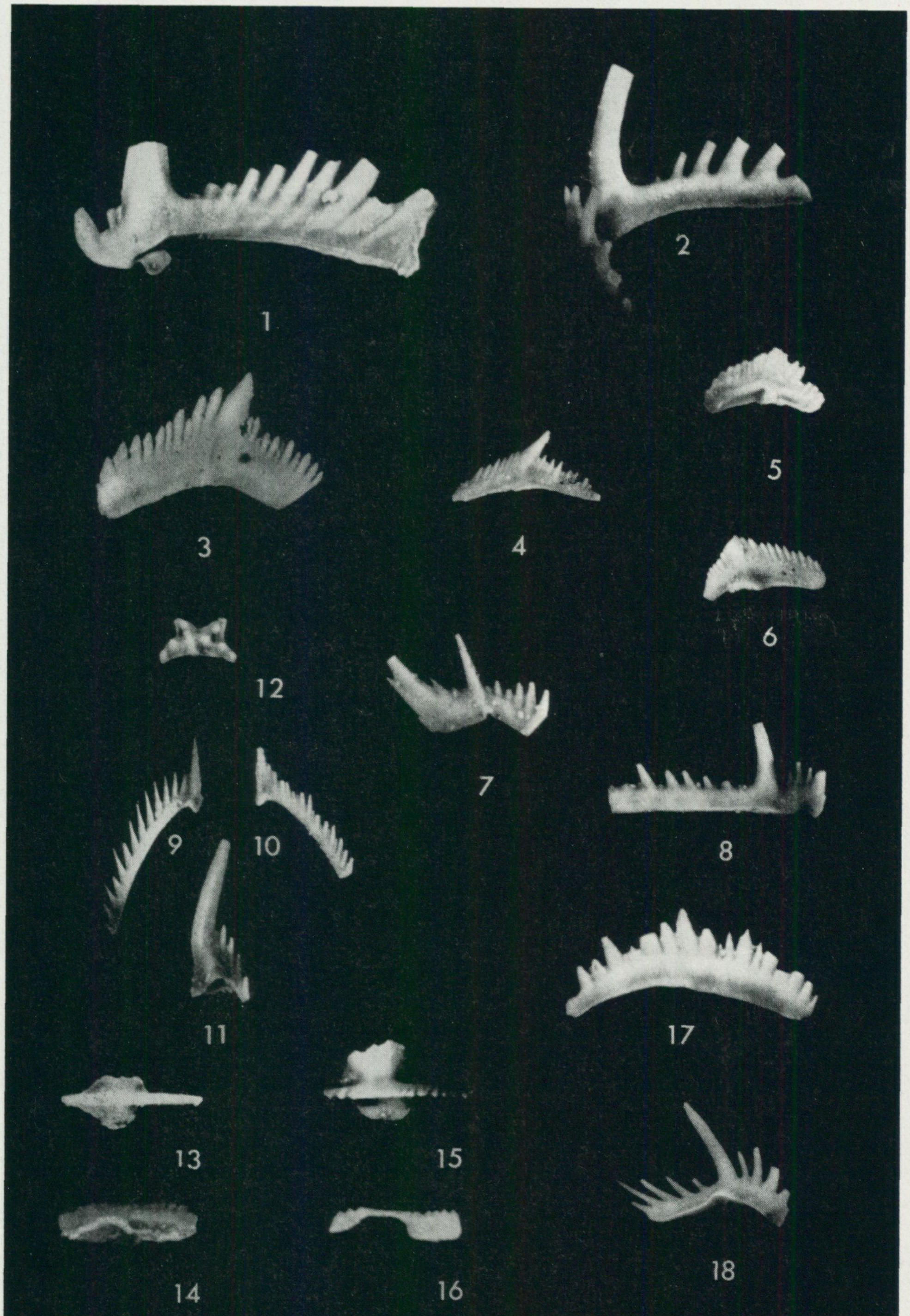
Fig. 12. *Ancoradella ploeckensis* Walliser 1964. Sample G66–38.

Figs. 13, 14. *Spathognathodus crispus* Walliser 1964. Lateral and upper views. G66–7.

Figs. 15, 16. *Spathognathodus sagitta bohemicus* Walliser 1964. Lateral and upper views. Sample G67–14.

Fig. 17. *Spathognathodus inclinatus inclinatus* (Rhodes 1953). Lateral and upper views. Sample G67–7.

Fig. 18. *Ozarkodina ortuformis* Walliser 1964. Ohesaare Beds sample.


1
2
3
4
5
6
12
7
9
10
8
11
17
13
15
14
16
18

PRISKLASS C

Distribution

SVENSKA REPRODUKTIONS AB

FACK, 162 10 VÄLLINGBY 1

Växjö 1969 C. Davidsons Boktryckeri AB

Printed in Sweden