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ORDOVICIAN OF ÖLAND

Guide to Excursion 3

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Introduction

Öland is situated on the western margin of the Russian Platform. The Precambrian crystalline basement and its Cambrian and Lower-Middle Ordovician sedimentary cover dip weakly to the east. As a result, the earliest beds on the island, topmost Lower Cambrian sandstone (accessible only at the beach of Mörbylånga), are exposed in the west, and the youngest beds (Middle Ordovician Lower Dalby Limestone) in the east. The sedimentary sequence continues on the sea floor east of Öland, and some of it can be reconstructed from erratic boulders which were transported westward and deposited on the island by a differential movement of the Pleistocene land ice.

For a correlation table of the Ordovician sequence of Öland, see Fig. 4 in the main guide.

Description of the sequence

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Lower Ordovician (Oelandian Series)

The base of the Ordovician. - At the base of the Ordovician there is a break all over the island. The break is smallest in the south, where it comprises two topmost Upper Cambrian subzones and two lower zones of the Lower Tremadocian Dictyonema Shale. Northwards the break increases rapidly, and farthest to the north it comprises the Paradoxissimus and Forchhammeri Stages of the Middle Cambrian and the whole Upper Cambrian.

The Upper Cambrian, developed as a dark, bituminous shale with lenses of bituminous limestone (in Swedish orsten), has the greatest thickness (13.2 m) and is most complete on the southernmost tip of the island, but

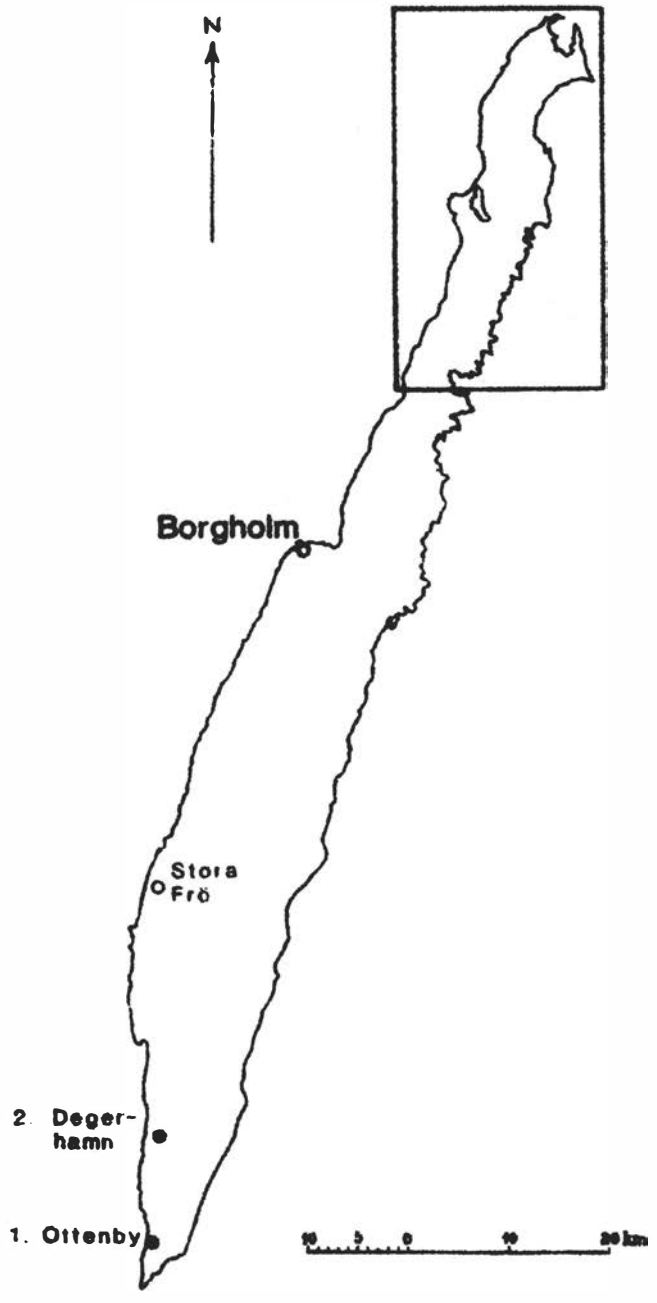

Fig. 1. Map of Öland. Dots show the location of stops on southern Öland. The rectangle indicates the area of the map on Fig. 2.

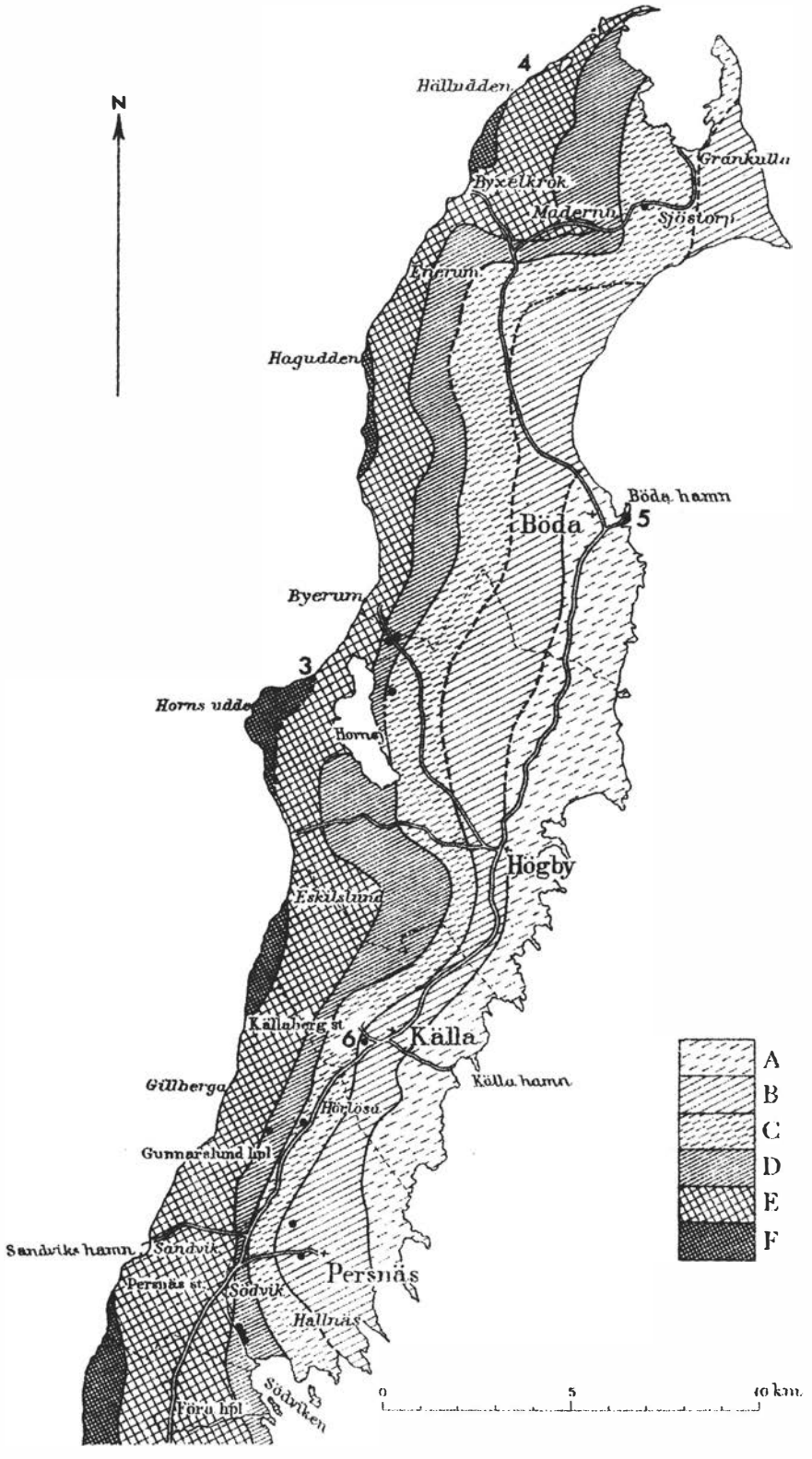

Fig. 2. Geological map of the northernmost part of Öland. After Jaanusson 1960. Dots show the location of important Middle Ordovician localities. Numbers refer to stops in the road-log. A, Lower Dalby Limestone (Kukrusean Stage). B, Källa and Persnäs Limestones (Uhakuan Stage). C. Skärlöv, Seby and Folkeslunda Limestones (Lasnamägian Stage). D, Segerstad Limestone (Aserian Stage). E, Holen Limestone (Kundan Stage). F, Latorp and Lanna Limestones (Billingenian, Hunnebergian and Volkhovian Stages).

the thickness decreases rapidly northwards. Already at Köping, immediately north of Borgholm, the thickness of the Upper Cambrian - represented by a bank of bituminous limestone - is reduced to 0.3 - 1.1 m. At Horns Udde, Upper Cambrian species (Olenus truncatus, O. attenuatus, Agnostus pisiformis) occur associated with Middle Cambrian (Lejopyge laevigata) and Ordovician (Obolus appollinis) species in a condensed conglomeratic bed, only 18 cm thick. The conglomerate was formed during several separate phases (Hadding 1927, 1932). On the northernmost part of Öland (Böda Hamn boring) the whole Upper Cambrian Series is missing; there the Ordovician rests, with a thin (0.2 m) conglomerate at the base, on lower Middle Cambrian.

Dictyonema Shale (Lower Tremadocian Pakerort Stage). - On Öland the isopachytes of the Dictyonema Shale run roughly from south-east to northwest, and not east-west as in the Upper Cambrian (Westergård 1947). The shale is thickest at the southern tip of the island (7.8 m in a bore at Ottenby). It is totally missing along the west coast between Mörbylånga and Borgholm, and poorly developed (at the most 0.2 m) along the same coast north of Borgholm.

In areas where the Dictyonema Shale rests directly on the Upper Cambrian Shale, the location of the boundary between Cambrian and Ordovician is definable only biostratigraphically because the rock of the two divisions is scarcely distinguishable. Geochemically the boundary is recognisable by a much higher vanadium content in the Dictyonema Shale.

The lowermost two Lower Tremadocian zones (the zones of Dictyonema desmograptoides and D. sociale) are not developed on Öland. The most persistent zone appears to be that of Dictyonema norvegica. At Köpings Klint, immediately north of Borgholm, D. norvegica occurs in a thin bed of shale, at the most 5 cm thick, between a conglomerate and a glauconitic shaly rock which belongs to the Upper Tremadocian Ceratopyge Shale. At Horns Udde (Stop 3) a similar shaly, graptolitiferous unit has been reported in places between the conglomerate and the glauconitiferous Ceratopyge Shale, but in most places it is missing.

Ceratopyge Shale (Upper Tremadocian). - The Ceratopyge Shale is developed all over the island except in the immediate vicinity of Mörbylånga where the unit is missing. Otherwise the thickness of the shale does not vary much (2.3 - 2.8 m on southernmost Öland, 1.7 m in the Böda Hamn boring,

0.55 m at Horns Udde). In most areas the unit consists of black shale (Stops 1 and 2), and in places where it overlies the Dictyonema Shale its lower boundary cannot be defined lithologically. In some areas the shale has thin intercalations of glauconite sand, and in some places on the western side of central Öland (Köping, Horns Udde) most of the black shale is replaced by a shaly glauconitic rock. The Ceratopyge Shale is mostly poor in fossils with the exception of the elkaniid inarticulate Broeggeria salteri.

Ceratopyge Limestone (Upper Tremadocian). - The Ceratopyge Limestone is developed only on southern and south-central Öland. North of Köping the limestone is missing and various units of the Hunneberg and Billingen Stages rest on the Ceratopyge Shale. The rock of the unit is a dense calcilutite in the lower part and glauconitic limestone or shale in the upper part. The maximum thickness is 0.6 m (Ottenby, Stop 1). Trilobites form a conspicuous element of the large macrofauna (Ceratopyge forficula, Euloma ornatum, Symphysurus angustatus, Niobe insignis etc.).

Latorp Limestone (Hunneberg and Billingen Stages). - This unit is developed as thin-bedded calcilutites which are mostly glauconitiferous in the lower part and contain numerous discontinuity surfaces. The thickness varies from 1.1 to 2.8 m. On north-western Öland the upper part of the Latorp Limestone is red whereas on southern Öland the rock is grey except for a few red beds. The sequence becomes less complete northwards because the Hunneberg Stage decreases successively to nothing. At Horns Udde (Stop 3) the Hunneberg Stage is only 5-10 cm thick and represented only by the zone of Megistaspis (Ekeraspis) armata (the zone of Megistaspis (Varvaspis) planilimbata is missing). In the Böda Hamn boring the Lower Billingenian zone of Megalaspides (Megalaspides) dalecarlicus rests directly on the Ceratopyge Shale (Tjernvik 1956). Dominant elements in the large macrofauna are asaphid and nileid trilobites.

Lanna Limestone (Volkhov Stage). - On northern and north-central Öland red calcilutites (3.7 m thick in the Böda Hamn boring) form the lower part of the formation, and grey to pale brown calcarenites (2.5 m in the Böda Hamn boring) the upper part. On southern Öland the rock of the lower part of the formation is grey to pale red, and as the limestone of the upper grey part

tends to be fine-grained, these two lithologic subdivisions cannot be distinguished there.

The biostratigraphy of the Lanna Limestone has not been studied in detail. On northern Öland the base of the formation is in the zone of Megistaspis (Megistaspis) lata and the grey, calcarenitic subdivision belongs to the zone of Megistaspis (Megistaspis) limbata limbata (= the zone of Asaphus (Asaphus) lepidurus). For fauna see Stop 4.

Holen Limestone (Kunda Stage). - On northern Öland the whole formation consists of calcarenites. In the north-western part of the island a distinctive thin oolitic limestone is developed at the very base of the unit. Farther to the south, in Persnäs parish, the oolitic horizon is no longer developed (Bohlin 1949), and it is not present in the Böda Hamn core to the east. In the northernmost part of the island (at Norra Udden and up to a kilometre southwards) the rock of the whole formation is grey. Somewhat to the south the rock of the Gigas and Obtusicauda zones changes to red, and farther southwards (in the Föra parish) even the middle and upper parts of the "Raniceps" zone are red. Grey calcarenites are mostly rich in fossils of various groups, both vagile and sedentary (Fig. 5; Stop 4). Red calcarenites also tend to be fairly richly fossiliferous, but faunal diversity is low and the commonest groups are trilobites and cephalopods. The thickness of the Holen Limestone on northern Öland is 7.6 m (Böda Hamn boring).

The equivalent beds on southern Öland have not yet been studied, neither biostratigraphically nor lithologically. They form a fairly monotonous limestone sequence, grey in the lower part and red in the upper part. A distinctive bank crowded with the diploporite cystoid Sphaeronites is generally developed in the lower half of the formation (Stop 2) but its level relative to the biostratigraphic classification is uncertain. A similar Sphaeronites bank, at about the same level, is known also from Kinnekulle.

In the uppermost beds of the Holen Limestone Megistaspis (Megistaspidella gigas occurs all over the island.

Middle Ordovician (Viruan Series)

Middle Ordovician limestones are poorly exposed on Öland, and some of the best natural shore exposures (at Segerstad Lighthouse and Folkeslunda Sjöbodar) are not accessible by bus. Previously the Middle Ordovician was exposed in numerous shallow quarries and drainage ditches but practically all these are now overgrown.

Segerstad, Skärlöv and Seby Limestones. - The Segerstad Limestone consists of fairly thick bedded red calcarenites which lithologically cannot be distinguished from the underlying Kundan beds of the zone of Megistaspis (Megistaspidella) gigas. The boundary, however, can be easily localised faunally because the lowermost Segerstad beds abound in large pygidia of Asaphus (Neoasaphus) platyurus. At several levels of the Segerstad Limestone furrowed surfaces have been observed (possibly mud cracks) and in one case such a surface has been found to be encrusted by a stromatolitic algal mat (Gammalsby boring, 11.23 m; V. Jaanusson, unpublished). The thickness of the Segerstad Limestone varies from 2.7 m in the south to 5.1 m in the north.

The Skärlöv Limestone consists predominantly of a soft, finely nodular, red, argillaceous limestone (2.0 m in the north and 1.4 m in the south) which is very poorly exposed.

The Seby Limestone comprises a few beds of variegated red and grey limestone. However, in addition to being lithologically distinctive, it comprises two of Holm's lituitid zones, the zones of Trilacinoceras discors and Lituites lituus, and contains also other characteristic cephalopod and hyolithid species (Jaanusson 1960).

Folkeslunda Limestone. - This formation consists of grey calcarenites (2.8 - 2.9 m thick) and is mostly rich in macrofossils. From Folkeslunda Sjöbodar the following estimate of the quantitative composition of the large macrofauna is available (N = 101; V. Jaanusson in 1953, unpublished): Illaenus chiron Holm 28 %, other trilobites 28 %, Cephalopoda 29 %, Gastropoda 24 %, Brachiopoda 1 %, Hyolithida 1 %. The formation belongs to Holm's zone of Lituites perfectus. Other common trilobites are Plectasaphus plicicostis (Törnq.), Pseudoasaphus aciculatus (Angelin) and Pseudobasilicus

brachyrachis (Törnq.).

Furudal, Källa and Persnäs Limestones (Uhakuan Stage). - Beds of Uhakuan age are developed differently on southern and northern Öland. On southern Öland the whole Uhakuan sequence consists of thick bedded to finely nodular, grey calcilutites, the Furudal Formation. This formation, a part of which is well exposed along the shore immediately north of Gräsgårds Hamn, forms the youngest bed-rock on southern Öland. The calcilutites are poor in macrofossils. Nileus is the commonest trilobite, associated with occasional Ancistroceras conchs.

On northern Öland a wedge of the Furudal calcilutite, the Källa Limestone (Stop 6), occupies the basal 2 m of the Uhakuan sequence (total thickness 7.4 m). There the main upper part of the Uhakuan beds, the Persnäs Topoformation, is composed of calcarenites. Strangely enough, these calcarenites tend to be poor in macrofossils, especially in comparison with the overlying Dalby Limestone, which is fairly rich in fossils, but so similar to the Persnäs Limestone lithologically that the boundary between these two units can be based only on faunal criteria. The most conspicuous fossil in the Persnäs Limestone is a Heliocrinites, a rhombiferan cystoid, which occasionally has a mass-occurrence in a bed or two.

Dalby Limestone. - Only the lower part of the Dalby Limestone (maximum known thickness 6 m) is exposed on Öland, and it forms the youngest bed-rock of the island. The rock is a grey calcarenite, commonly somewhat nodular. On Öland the Dalby Limestone is defined in a topostratigraphic sense because it cannot be distinguished lithologically from the underlying Persnäs Limestone. For fauna see Stop 5.

The upper Viruan and Harjuan erratic boulders

Numerous erratic boulders of upper Viruan and Harjuan age were deposited on Öland by a differential movement of the Pleistocene land ice. The boulders are probably derived from the submarine bed-rock east of the island (Andersson 1893). The boulders are concentrated to certain limited areas: to a narrow belt along the east coast between Stenåsa and As, and to a further two

very small areas, viz. immediately west of Eriksöre and at Borgholm (Andersson 1893). The following succession can be reconstructed: Upper Dalby Limestone, Gräsgård Siltstone ("Macrourus Limestone"), Green and Red Tretaspis Limestone, and "Limestone with Leptaena schmidti" (Andersson 1893). In addition, there are numerous boulders of a hard, dense, mostly finely nodular calcilutite, occasionally crowded with the calcareous alga Palaeoporella but otherwise very poor in fossils. These calcilutite boulders may be derived from Slandrom or Upper Östersjö equivalents, or both. Two of the subdivisions recognised in boulders have frequently been referred to in the literature and require some comments.

Gräsgård Siltstone is a calcareous siltstone to silty limestone (for lithology see Martna 1955). Boulders of this type are very common and they are also mostly richly fossiliferous. The unit is also known from borings on Gotland and Gotska Sandön where it is an Oandu equivalent. In the boulders on Öland, the silty succession spans a longer time, and includes demonstrably also Keila equivalents which are missing on Gotland and Gotska Sandön. The quantitative composition of the large macrofauna varies, indicating a variable environment. In two boulders at Gräsgårds Kanal the following composition of the large macrofauna was estimated (V. Jaanusson in 1951). Boulder C (N = 70): Brachiopoda (no Sowerbyella) 43 %, Trilobita 23 %, Gastropoda 14 %, Pelecypoda 6 % Bryozoa 14 %. Boulder D (N = 54): Sowerbyella 44 %, other brachiopods 19 %, Trilobita 12 %, Gastropoda 12 %, Pelecypoda 7 %, Bryozoa 4 %, Cyclocrinites 2 %. Toxochasmops extensa is a common trilobite (syn. T. macrourus (Ang.), type locality and horizon in these boulders). The fauna of the Gräsgård Siltstone is diverse but still poorly described.

The term Hulterstad Fauna has been used for a long time as an informal name for the silicified fauna described by Wiman (1907) from boulders referred to as "Limestone with Leptaena schmidti" by Andersson (1893) and as "West Baltic Leptaena Limestone" by Wiman (1907). Both terms are misleading. The form identified as Leptaena (= Eoplectodonta) schmidti is a species of Sampo which has not yet been recorded elsewhere in Sweden. The bedded, chert-bearing limestone, which has yielded the Hulterstad Fauna, is not related lithologically to what formerly has been called "Leptaena Limestone" (= stromatactis-bearing carbonate mounds) in the Siljan district; it is not derived from a carbonate mound. The Hulterstad Fauna contains many species that have not been found elsewhere, and its age is uncertain. It is certainly of Pre-Hirnantian Harjuan age, possibly Pirguan.

Road log

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Stop 1. Ottenby. A natural exposure along the shore of Kalmarsund. The section comprises the Upper Tremadocian Ceratopyge Shale (uppermost part exposed, thickness in a nearby boring 2.3 m; Westergård 1944) and Ceratopyge Limestone, and the Lower Arenigian limestones. The key to the section is shown in Fig. 3.

The cliff at Ottenby is the best exposure of the Ceratopyge Limestone on Öland. It has yielded some 20 trilobite species. The commonest forms are Ceratopyge forficula (Sars), Euloma ornatum Angelin, Orometopus elatifrons (Angelin), Niobe insignis Linnarsson, Niobella obsoleta (Linnarsson), Varvia longicauda Tjernvik, Ottenbyaspis oriens (Moberg and Segerberg), Symphysurus angustatus (Sars and Boeck), and Nileus limbatus Brögger.

Stop 2. Degerhamn. An extensive quarry in Ontikan limestones. The limestone is quarried for the production of cement in the factory about 2 km north-west of the quarry. No biostratigraphic study has been made on the exposed sequence. The top of the section is probably within the lower Valastean Substage, possibly at about the level of the top of the Hälludden section. However, here the rock is poor in identifiable macrofossils and faunal diversity is low. Faunal assemblages appear to be dominated by trilobites whereas sedentary organisms are rare. An exception is the bank crowded with the diploporite cystoid Sphaeronites. A similar Sphaeronites bank is known also from other places on southern Öland (Moberg 1890), but it is not known whether the horizon is always the same.

The following description of the section, prepared for the excursion by H. Mutvei, is based only on a rough macroscopic examination of the rock.

The section was measured on the south-western and eastern walls of the quarry.

Ontikan Subseries

Light buff to red, mostly thick bedded, coarse grained limestone ..... 2.0 m+

Grey limestone crowded with Sphaeronites ..... 0.2 m

Mostly grey, thick bedded, coarse grained limestone ..... 0.6 m

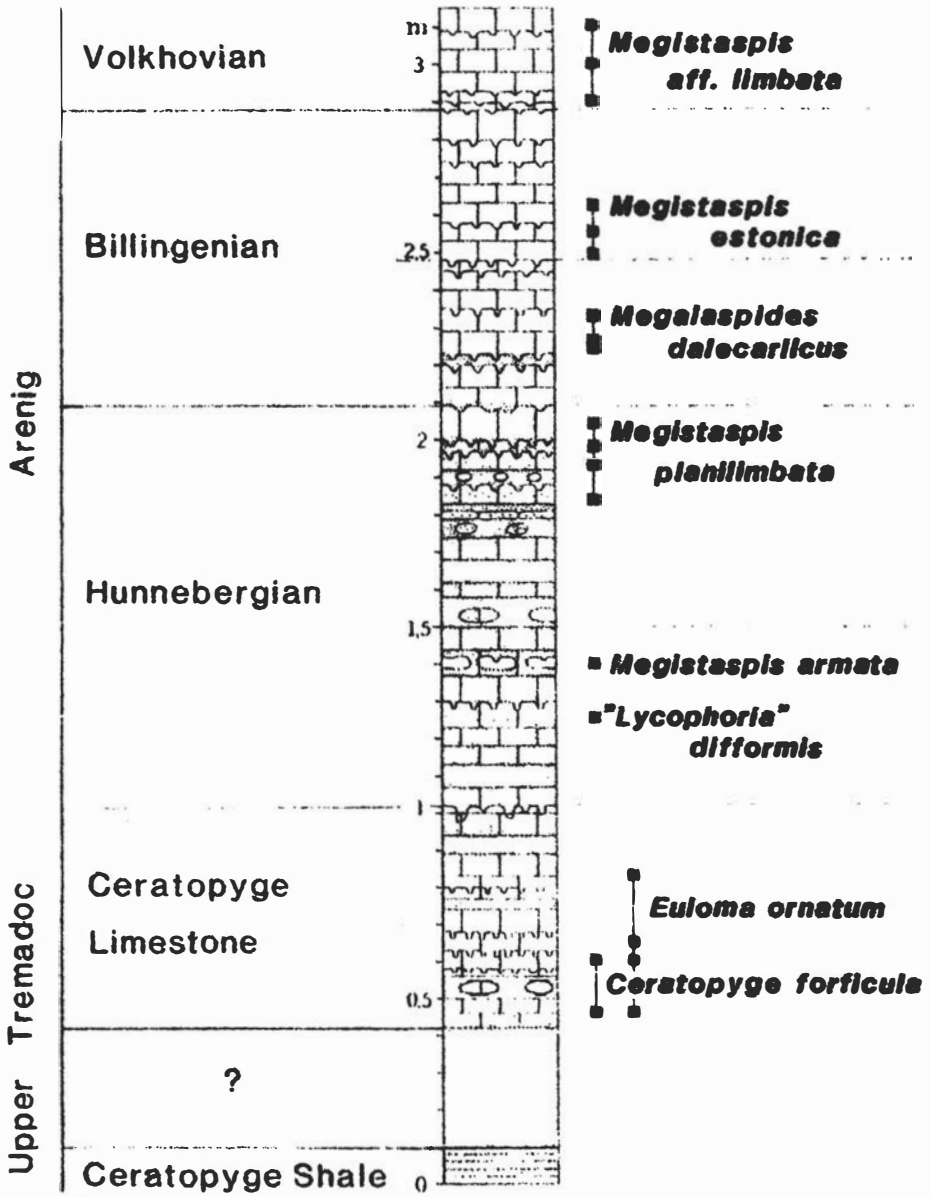

Fig. 3. Section through the uppermost Tremadocian and lower Arenigian sequence in the coastal cliff at Ottenby. After Tjernvik 1956.

Predominantly buff-coloured, thick bedded, coarse grained limestone. In the uppermost 0.5 m several bedding planes are encrusted by a haematite mineralisation ..... 3.3 m

Grey to light brown, thick bedded, mostly fine grained limestone. Bedding planes are often covered by glauconitic or limonitic films. The upper boundary poorly defined lithologically ..... 2.5 m

Thick bedded glauconitiferous limestone. The unit terminates upwards with a bed of shaly glauconitic rock and glauconite sand ..... 0.9 m

Tremadocian Subseries ?

Glauconite sand and thin bedded limestone rich in glauconite. Uppermost 0.08 m is a black shale with lenses of glauconitiferous limestone. The allocation of this unit is difficult without a biostratigraphic study. In comparison to the Ottenby section this interval appears to be condensed and probably with breaks ..... 0.6 m

Tremadocian Subseries

Ceratopyge Shale. Black alum shale with occasional limestone lenses ..... 2.8 m

Dictyonema Shale (zone of D. norvegicum). Black shale as above. The Ceratopyge and Dictyonema Shale cannot be differentiated lithologically, and the thicknesses given here are based on previous reports on the alum shale at Degerhamn (Westergård 1944) ..... 1 m+

Stop 3. Horns Udde. The coastal cliff at Cape Horn is formed of the Lower Ordovician Hunnebergian, Billingenian and Volkhovian limestones. At the base of the cliff also the Ordovician basal conglomerate is occasionally accessible, but often it is covered by beach shingle. The conglomerate is overlain by 0.55 m Upper Tremadocian Ceratopyge Shale which at this locality is particularly rich in glauconite.

The section in the north-eastern part of the cliff, 1.5 km from Cape Horn, exhibits sedimentary folds in the Billingenian limestones. These structures were described and analysed in detail by Lindström (1963). The Billingenian sequence consists of thin bedded limestone with soft, argillaceous intercalations ("marl"), and includes numerous successive discontinuity surfaces (hardgrounds). The horizontal bedding is in places deformed into low folds. According to Lindström,a lithified limestone bed which rested on a layer of "marl" was apt to glide and deform into anticlines which rose from the otherwise level sea floor up to 20 cm. The folds were rarely destroyed mechanically which indicates tranquil bottom conditions. The fold crests became chemically corroded. According to Lindström, the abundance of preserved fold structures indicates that the sea was relatively deep.

Stop 4. Hälludden. This locality is a long natural outcrop along the shore north of Byxelkrok. The lower boundary of the Lanna Limestone ("Blommiga bladet") is situated just below water level c. 1 km north of Byxelkrok (Bohlin 1949), and from that point northwards the limestone beds which are exposed at the water's edge become gradually younger, reaching lower Valastean at the northern end of the exposure (Fig. 4). The name Hälludden refers really only to the northern part of the locality, approximately from the southern end of the cliff in the Hunderumian beds northward, but among geologists usually the whole extent of the outcrop is termed Hälludden.

Landward the outcrop is bordered by an extensive area with numerous well defined beach ridges composed of shingle. Linnaeus (1745) coined the name Neptunii åkrar (the fields of Neptune) for this particular accumulation of beach ridges at Hälludden, and this name has gained general usage. He also commented on fossils from the exposures along the shore, especially the abundance of orthoconic cephalopods ("Ölandsspikar"), and figured a pygidium of Megistaspis (Megistaspis) limbata.

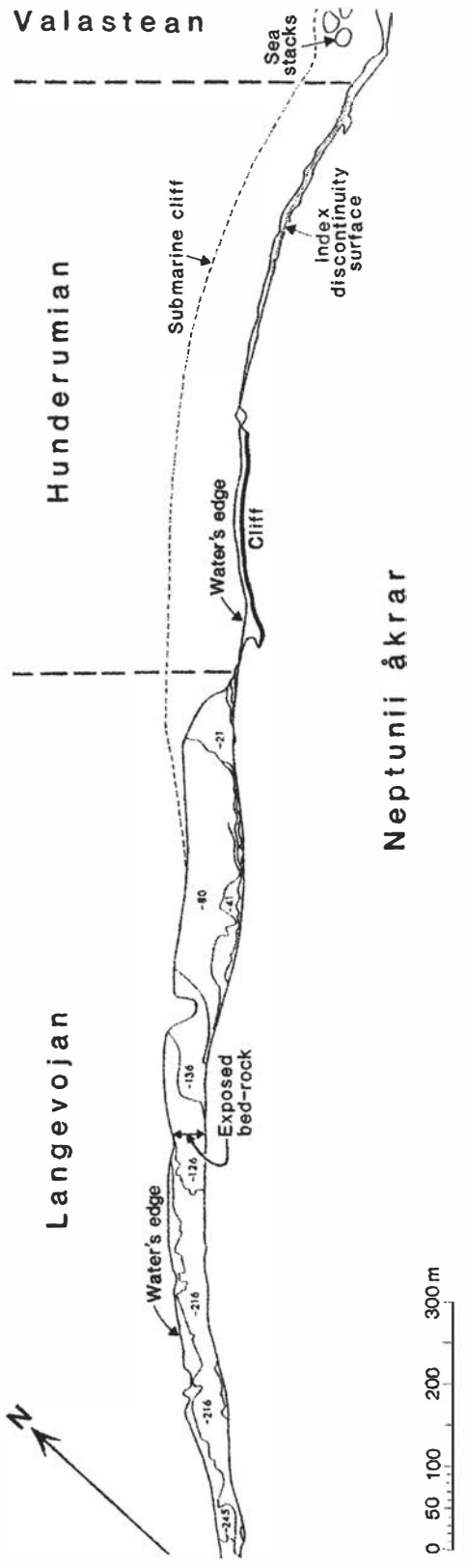

Fig. 4. Map of the Hälludden exposure. H. Mutvei in 1948, original. Landward the bed-rock is covered by shingle, accumulated into beach-ridges (Neptunii åkrar). At water's edge the succession becomes gradually younger to the north-east. The stratigraphic boundaries (coarse dashed lines) refer to the points where the boundary emerges at water's edge.

Gerhard Holm collected at Hälludden during many years, not least cephalopods and graptolites. Bohlin (1949) published a general description of the locality. Extensive field work was carried out in 1948-1950 (Project Hälludden; V. Jaanusson, B. Kurtén, J. Martna, H. Mutvei), including bed-by-bed quantitative estimates of the composition of large macrofauna (Figs. 5-6). Based on the material collected in the course of this field work the following groups have been described: illaenid trilobites (Jaanusson 1957), graptolites (Skevington 1963, 1965a), "chitinous" hydroids (Skevington 1965b), and chitinozoans (Grahn 1982). The fauna, however, is rich and diverse, and much detailed taxonomic work remains to be done. A preliminary range log of selected, common trilobites and brachiopods is given in Fig. 7.

The exposure extends as a narrow strip along the coast for several kilometres (Fig. 4). The index horizons used for determining the levels of individual beds within the sequence are the top of the oolitic bed (O) at the base of the Hunderumian Substage, and a conspicuous, smooth discontinuity surface (D) in the basal Valastean Substage. The levels above D are designated as + D, and those between D and the upper surface of O as - D or, exceptionally, as + (from O upwards); the levels below the upper surface of O are designated as - (minus), without any letter. The boundary between the Langevojan and Hunderumian Substages is at the base of the oolitic bed, and that between the Hunderumian and Valastean Substages is apparently at about - 30 D, that is, about 30 cm below the index discontinuity surface.
The section is as follows:

Holen Limestone (Kunda Stage) 3.4 m

Valastean Substage (Zone of Asaphus (Asaphus) "raniceps") 1.5 m +

Micritic to sparitic calcarenite, grey and thin bedded (thickness of individual beds 2-4 cm), and with scattered glauconite grains. Two discontinuity surfaces, 55 and 90 cm above the base ..... 1.2 m +

Discontinuity surface, almost perfectly smooth, with a dark mineralisation and abundant organic borings, mostly of Trypanites type.

Predominantly micritic calcarenite, grey, thin-bedded, and with scattered chamosite ooids. Discontinuity surfaces 10 and 17 cm below the top ..... 0.3 m

Hunderumian Substage (Zone of Asaphus (Asaphus) expansus) 1.9 m

Predominantly micritic, argillaceous calcarenite, grey and thin-bedded (thickness of individual beds 2-4 cm). The content of glauconite increases downwards, and some of the lowermost beds can almost be classified as calcareous glauconite sand ..... 1.8 m

Somewhat finely nodular, dark, argillaceous limestone with limonitic coatings around skeletal grains and scattered limonitic ooids ..... 0.1 m

Lanna Limestone (Volkhov Stage) 3.2 m +

Langevojan Substage (Zone of Megistaspis (Megistaspis) limbata limbata = z. of Asaphus (Asaphus) lepidurus) 2.2 m

Predominantly sparitic calcarenite, grey and thin-bedded (thickness of individual beds 2-5 cm). The limestone beds have thin argillaceous partings and a moderate content of glauconite ..... 2.2 m

Zonation uncertain (not yet studied in detail)

Micritic calcarenite, pale buff, thin bedded and glauconitiferous ..... 0.8 m

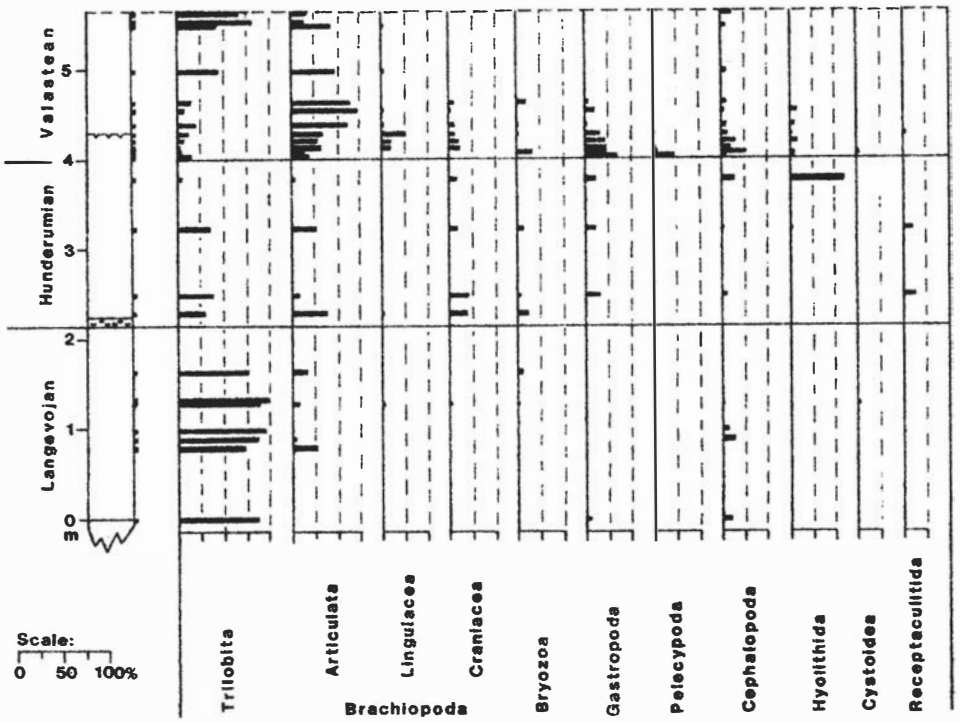

Fig. 5. Composition of the large macrofauna at Hälludden. H. Mutvei, original. For the total number of counted specimens in each sample see Fig. 6.

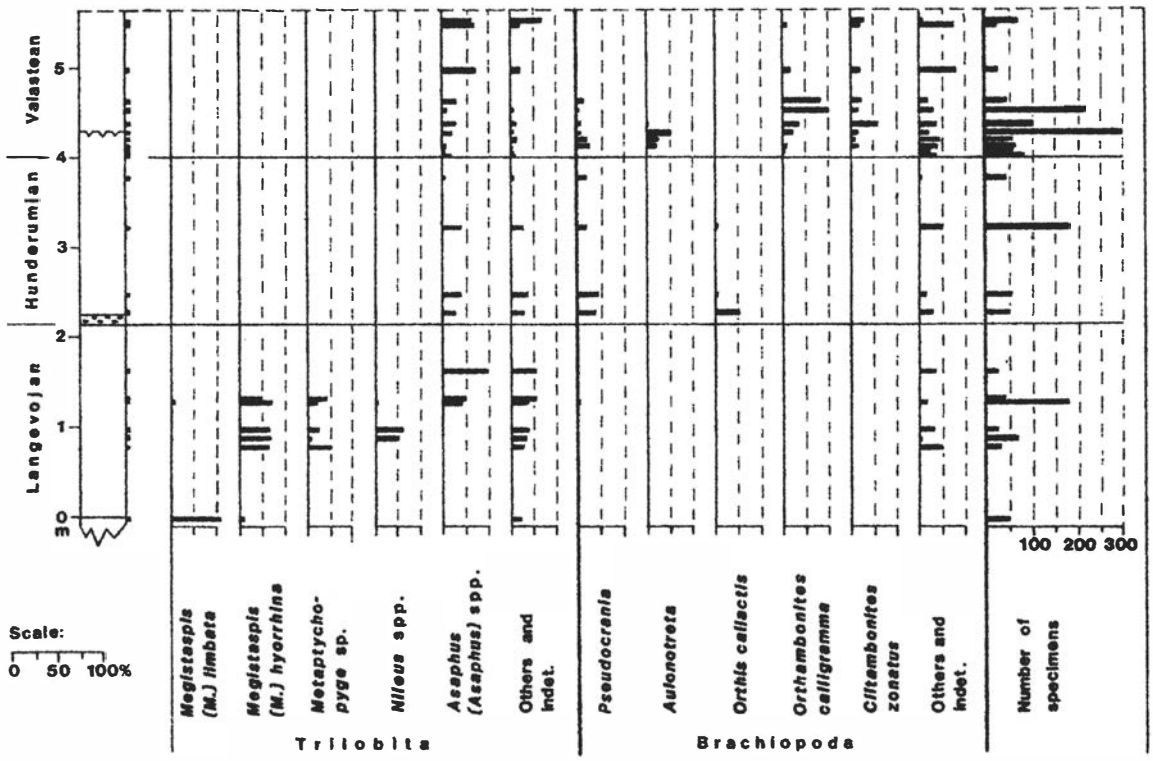

Fig. 6. Relative frequencies of common trilobites and brachiopods in the large macrofauna at Hälludden. H. Mutvei and V. Jaanusson, original. Only those species or genera are shown that form 20 per cent or more of all counted specimens in at least one sample. It was impossible to differentiate species of Asaphus (Asaphus) because pygidial features are not always diagnostic and much counted material was represented by internal moulds. In the identifiable material the subgenus is represented in the Langevojan by A. (A.) lepidurus and in the Valastean by A. (A.) "raniceps" (Fig. 7). In the Hunderumian beds there is, in addition to A. (A.) expansus, at least one further species of the subgenus. Megistaspis (Megistaspis) limbata should read the group of M. (M.) limbata because many of the counted pygidia were not safely identifiable at species level. Metaptychopyge may include more than one species.

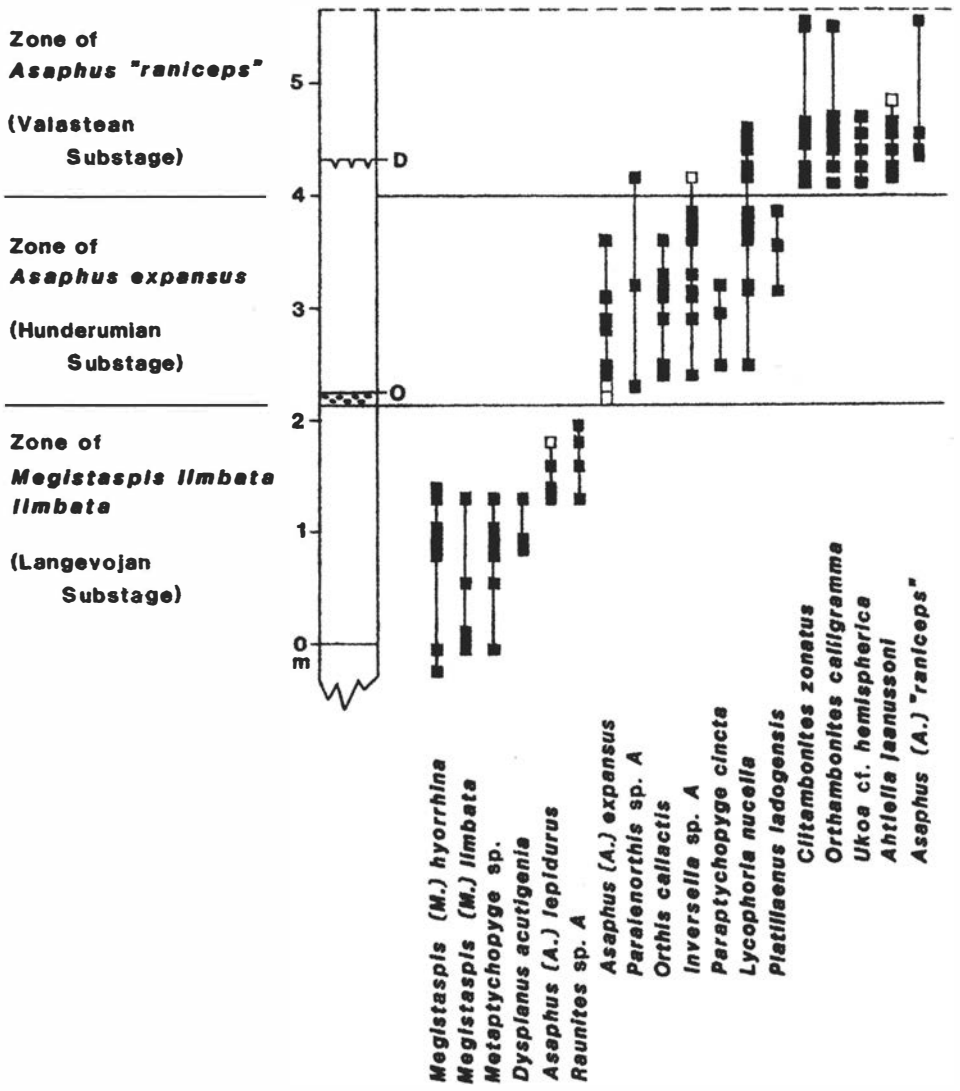

Fig. 7. Vertical range of selected trilobite and articulate brachiopod species at Hälludden. V. Jaanusson and H. Mutvei, original. Only those species are included which have been found at least at three levels. Open rectangles refer to conditional identifications (cf.). D, conspicuous, plane discontinuity surface used as one of the index levels. O, beds with limonitic ooids at the base of the zone of Asaphus (Asaphus) expansus. The zone of Megistaspis (Megistaspis limbata limbata (Tjernvik in Tjernvik & Johansson 1980) appears to be an equivalent to the East Baltic zone of Asaphus (Asaphus) lepidurus. The identification of Megistaspis(M.) hyorrhina is based exclusively on cranidial features; M. (M.) limbata is represented mainly by pygidia and no identification at subspecies level was attempted. Metaptychopyge may include several species. In some of the common brachiopods, such as Antigonambonites and Porambonites, species have not yet been differentiated on Öland. Orthis callactis is the type species of the genus Orthis.

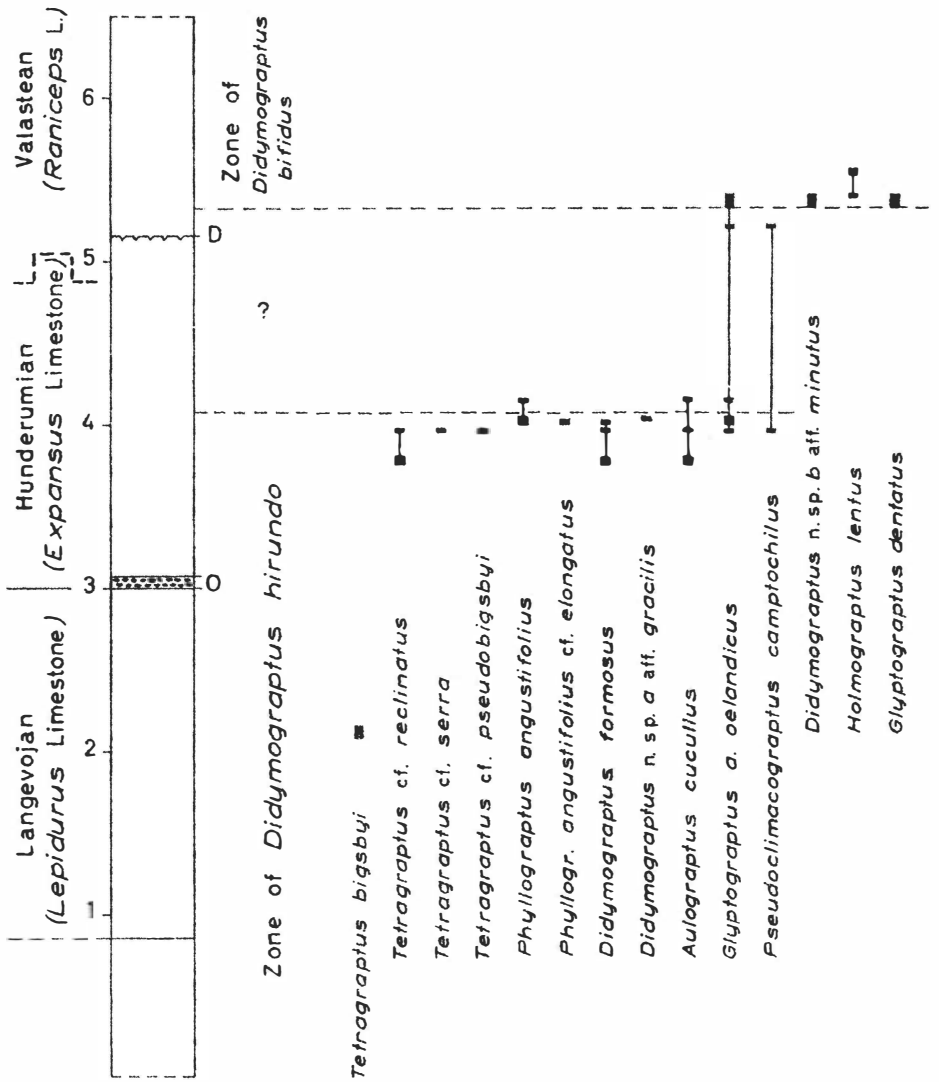

Fig. 8. Vertical range of graptoloid species at Hälludden. After Skevington 1965a. D, index discontinuity surface; O, oolitic bed.

Red calcarenitic calcilutite. The upper boundary is a discontinuity surface with a haematitic mineralisation ..... 0.2 m +

The following points may be of particular interest: (1) Rapid vertical changes in dominance of some macrofossil groups (e.g., hyolithids, receptaculitids and pelecypods; see Fig. 5) in the Hunderumian Substage. (2) Bedding planes abounding in isolated endoceratid siphonal tubes in the Hunderumian and Valastean beds. (3) Discontinuity surfaces in the Valastean Substage. These surfaces have a phosphatic-pyritic mineralisation and formed hardgrounds. Holdfasts of bryozoans can occasionally be found to be attached directly on the surface, and macroscopic borings penetrate both the lithified sediment and skeletal remains.

Stop 5. Böda Hamn. The best locality for the Dalby Limestone on Öland is a natural exposure of a few beds along the shore just west of the old harbour of Böda. Linnaeus (1745) visited the outcrop and described what he called "crystal apples" (=Echinosphaerites). Subsequently, generations of palaeontologists have collected at this place. Now much of the outcrop has become naturally covered and therefore is no longer accessible.

The spectacular fossils at Böda Hamn are cystoids. Echinosphaerites aurantium(Gyllenhaal) is abundant, and in places a whole bed is crowded with its thecae. Heliocrinites granatum (Wahlenberg) and Caryocystites dubia Angelin are also common. The commonest articulate brachiopods are Paucicrura cf. navis (Öpik) and Nicolella demissa (Dalman), probably in that order of relative frequency. Bryozoans form also a quantitatively important component of the macrofauna.

Stop 6. Quarry south-west of Källa church. This is the type locality of the Uhakuan Källa Limestone, a wedge of the Furudal calcilutites. The formerly extensive quarry is now almost completely overgrown. The calcilutite is poor in macrofossils. Systematic crushing of a limestone bed during a long period (V. Jaanusson in 1949) yielded 6 specimens of Nileus, 2 other trilobites, and 2 articulate brachiopods (Leptellina? n.sp.). Despite the very small sample size this probably gives a fairly good indication of the composition of the macrofauna in the Källa Limestone. Some argillaceous bedding planes, however, have been encountered on which small articulate brachiopods (Leptellina? as well as Christiania) were fairly common.

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