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Cambro-Silurian Stratigraphy of Bornholm

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The Cambro-Silurian geology of the island of Bornholm is in many ways related to that of Scania, Sweden, and as a consequence of the advanced status of the Swedish Cambro-Silurian stratigraphy a revision of the Lower Palaeozoic succession on Bornholm is needed.

The Cambro-Silurian sequence on Bornholm is rather incomplete and the beds are usually thinner than in neighbouring regions. The island was now and then emerged for considerable lengths of time as a result of uplifts. In a few instances Bornholm was submerged while the rest of the Balto-Scandian region was above sea level.

The Cambro-Silurian sediments are preserved in relatively small, in most cases down-faulted areas in the southern part of the island. The exposures are mostly small sections along the streams.

The stratigraphy presented here must be regarded as provisional and an exact correlation with the Scanian succession cannot yet be carried out for all divisions, all the more so because several faunas are still undescribed or need revision. The accompanying tables I–III, drawn by Mrs. R. LARSEN, show the proposed zonal divisions and their correlation with previously used divisions (see also C. POULSEN, 1960).

Cambro-Silurian beds are recorded from a deep boring at Slagelse about 90 km wsw of Copenhagen (SORGENFREI & BUCH, 1964). The core has not yet been investigated in detail, but contains Lower Cambrian sandstone, Upper Cambrian –? Tremadocian alum shale with spindle-shaped pyrite pseudomorphs after barite, at a higher level *Monograptus crispus* (Rastrites Shale) was found. The core shows that the Slagelse sequence is developed predominantly in shaly facies.

Cambrian

The Cambrian System on Bornholm is divided into three series: The Holmia Series (Lower Cambrian), the Paradoxides Series (Middle Cambrian), and the Olenid Series (Upper Cambrian). The Cambrian sedimentation took place in a

relatively shallow sea which was part of what was formerly known as the Atlantic or Acado-Baltic Province. The total thickness of the Cambrian on Bornholm amounts to about 185 m.

Lower Cambrian

Towards the close of the Precambrian the granitic land surface was eroded so as to form the sub-Cambrian peneplain; depressions were filled with arkose-like products of weathering on top of which the continental Neksø Sandstone was deposited.

The Cambrian was initiated by the transgression which resulted in the formation of the Balka Quartzite (HANSEN, 1936). The quartzite, which corresponds to the Scanian Hardeberga Sandstone and subsequent sandstone with *Diplocraterion*, *Skolithos*, a.o., is mostly white or light-grey, at certain levels greenish due to a content of glauconite or black due to organic matter. The basal part of the about 60 m thick Balka Quartzite is conglomeratic. The upper part of the sequence contains shaly, micaceous layers which have yielded remains of a worm resembling the North American *Byronia* (to be published by C. POULSEN in the near future). Organic activity appears from trails and tracks, the most characteristic being those of *Skolithos*, *Diplocraterion*, and *Tigillites*. Ripple marks are common and some bedding planes show traces which may be interpreted as a result of gas bubbles coming from underlying bituminous layers.

The Balka Quartzite is included in the *Mobergella holsti* Zone.

The quartzite is overlain by up to 100 m of predominantly greyish-green siltstone known as the "Green Shales". The basal part of the sequence contains a quartz conglomerate. The bedding is mostly indistinct and the bedding planes irregular, undulating. Tracks and trails are common. The greenish tint of the siltstone is caused by glauconite which gives rise to a brownish coating on weathered surfaces.

The middle part of the siltstone contains small phosphorite concretions with *Orthotheca johnstrupi* HOLM, *Hyolithes nathorsti* JOHNSTRUP, *H. lenticularis* HOLM, *Hyolithellus micans* BILLINGS, and several tubicular fossils of unknown affinities (C. POULSEN Ms). A few species indicate a correlation with the *Holmia torelli* & *Kjerulfia lundgreni* Zone. Thoracic fragments of *Holmia* sp. redeposited in the Middle Cambrian Kalby Clay possibly originated from a level within the siltstone (V. POULSEN, 1965).

The major part of the siltstone sequence is believed to have been deposited in somewhat deeper water, but shallow depths are indicated for the upper part, as the siltstone grades into 3 m of medium-grained sandstone – the Rispebjerg Sandstone – which is assumed to belong to the same zone as the underlying siltstone. Numerous brown round spots in the sandstone are probably caused by weathered pyrite. The upper 40 cm of the sandstone are thoroughly impregnated by black phosphorite.

The eroded upper surface of the Rispebjerg Sandstone indicates a hiatus. The overlying beds belong to the Middle Cambrian Paradoxides paradoxissimus Stage.

Middle Cambrian

The Balto-Scandian region was subjected to repeated changes of sea level during the Middle Cambrian, and consequently the lower part of the sequence on Bornholm is incomplete.

The Middle Cambrian stratigraphy has been discussed by GRÖNWALL (1902), and in part by C. POULSEN (1942), and V. POULSEN (1963).

At Øleaa the Lower Cambrian Rispebjerg Sandstone is overlain by 25 cm of light-grey Exsulans Limestone which is rich in grains of quartz, glauconite, pyrite, and irregular, somewhat rounded pebbles of phosphoritic sandstone. The lithology of these pebbles corresponds to the upper part of the Rispebjerg Sandstone. At Læsaa the Rispebjerg Sandstone is succeeded by about 15 cm of grey clay – the Kalby Clay. The clay was believed to represent the residue of weathered Exsulans Limestone (GRÖNWALL 1902, C. POULSEN 1942), whereas HANSEN (1937) correlated the clay with a level within the Rispebjerg Sandstone at Øleaa.

The presence of *Jincella parva* (LINNARSSON), *Ctenocephalus exsulans* (LINNARSSON), and *Holocephalina* indicates that the Exsulans Limestone belongs to the *Triplagnostus gibbus* Zone of the Paradoxides paradoxissimus Stage. The same species are present in the Kalby Clay, but here as internal moulds consisting of a fine-grained phosphoritic and argillaceous siltstone (V. POULSEN, 1963). This type of preservation is unknown from the Exsulans Limestone. The writer also found a worn cephalic mould of *Ptychagnostus atavus* (TULLBERG), and the clay, which accordingly belongs to the *Tomagnostus fissus – Ptychagnostus atavus* Zone, must have been deposited after a short break in the sedimentation. The well-preserved eocystid plates of calciumcarbonate in the clay show that the Kalby Clay can hardly be regarded as the residue of a decomposed limestone. The deposit, probably due to an insufficient amount of calciumcarbonate was never lithified.

By elutriation of clay samples a number of non-trilobite fossils has been obtained. Worn specimens of *Acrothele* (*Redlichella*) *granulata* LINNARSSON suggest the former presence in the Bornholm area of an unconsolidated deposit corresponding to the *Acrothele granulata* Conglomerate which is the lowermost bed in the Paradoxides paradoxissimus Stage (C. POULSEN, 1942). The present writer believes that several other fossils such as species of *Stenothecopsis* in the same way indicate the former presence of thin, unconsolidated beds from the Lower Cambrian *Strenuella linnarssoni* Zone.

There is no evidence of sedimentation during the Eccaparadoxides oelandicus Stage.

The transgression responsible for the deposition of the Kalby Clay was of short duration. Following a short break in the sedimentation 5 cm of a pyritic conglomerate with pebbles of phosphoritic sandstone were formed. Another hiatus followed, and during this interruption the erosion removed the remaining undisturbed parts of the *Strenuella linnarssoni* Zone beds, the rests of the *Acrothele granulata* Conglomerate, and in most places the Kalby Clay and the overlying conglomerate with pyrite.

When the subsequent transgression took place at the time of the upper part of the *Tomagnostus fissus – Ptychagnostus atavus* Zone, the environment had

TABLE I: THE CAMBRIAN OF BORNHOLM

SERIES		STAGES	ZONES	LITHOLOGIC DIVISIONS
UPPER	OLENID SERIES		ACEROCARE	ALUM SHALE WITH ANTHRACONITE LENSES
			PELTURA SCARABAEOIDES	
			PELTURA MINOR	
			PROTOPELTURA PRAECURSOR	
			LEPTOPLASTUS	
			PARABOLINA SPINULOSA & ORUSIA LENTICULARIS	
			HOMAGNOSTUS OBESUS & OLENUS	
			AGNOSTUS PISIFORMIS	
MIDDLE	PARADOXIDES SERIES	PARADOXIDES FORCHHAMMERI	LEJOPYGE LAEVIGATA	
			JINCELLA BRACHYMETOPA	ANDRARUM LIMESTONE
			TRIPLAGNOSTUS LUNDGRENI & GONIAGNOSTUS NATHORSTI	ANTHRACONITE PHOSPHORITE CONGLOMERATE
		PARADOXIDES PARADOXISSIMUS	PTYCHAGNOSTUS PUNCTUOSUS	LOWER ALUM SHALE
			HYPAGNOSTUS PARVIFRONS	
			TOMAGNOSTUS FISSUS & PTYCHAGNOSTUS ATAVUS	KALBY CLAY
			TRIPLAGNOSTUS GIBBUS	EXSULANS LIMESTONE
		ECCAPARADOXIDES OELANDICUS	"PARADOXIDES" PINUS	
			ECCAPARADOXIDES INSULARIS	
LOWER	HOLMIA SERIES		STRENUELLA LINNARSSONI	
			HOLMIA KJERULFI	
			HOLMIA TORELLI & KJERULFIA LUNDGRENI	RISPEBJERG SANDSTONE
				SILTSTONE ("GREEN SHALES")
			MOBERGELLA HOLSTI	BALKA QUARTZITE

changed, and abruptly, without any transition, alum shales were deposited. The stable conditions then persisted throughout the remaining part of the Paradoxides paradoxissimus Stage. The lower alum shale, in which fossils are rare and imperfectly preserved, is 0.8 m thick at Øleaa, 1.40 m at Læsaa. The agnostids from this shale indicate that the *Hypagnostus parvifrons* Zone as well as the *Ptychagnostus punctuosus* Zone are developed.

The Paradoxides forchhammeri Stage as defined below is initiated by a break in the sedimentation, and the lower alum shale at Læsaa is overlain by about 20 cm of rather fine-grained anthraconite forming a continuous stratum, of which the lower part is a conglomerate with reworked round phosphorite concretions in an anthraconite matrix. The anthraconite is occasionally succeeded by a thin transition bed to the Andrarum Limestone. In other instances the boundary between the anthraconite and the limestone is very sharp. The same sequence is found at Øleaa, but here the conglomeratic part is more poorly developed, and the overlying anthraconite is more coarsely crystalline. It is separated from the Andrarum Limestone by 1–3 cm of alum shale.

Fossils have been found in the anthraconite and in the matrix of the conglomerate and both have previously been assigned to the *Paradoxides davidis* Zone (sensu TULLBERG, 1882). This zone has been replaced by the *Ptychagnostus punctuosus* Zone (B4) which is equivalent to TULLBERG's zones of *P. davidis* and *Bailiella aequalis* (WESTERGÅRD 1944, p. 25). Accordingly, the conglomerate and the anthraconite have been referred to the uppermost part of the Paradoxides paradoxissimus Stage, but the present writer provisionally refer both to the *Triplagnostus lundgreni – Goniagnostus nathorsti* Zone (C1) of the Par. forchhammeri Stage. This part of the sequence appears to contain a transition fauna. The stratigraphic delimitations of *Paradoxides davidis* SALTER have not yet been properly fixed, and more attention should be paid to the agnostids.

The presence of *Triplagnostus lundgreni* (TULLBERG), *Goniagnostus nathorsti* (BRÖGGER), and others show that the beds in question may be referred to the Par. forchhammeri Stage. *Jincella brachymetopa* (ANGELIN) occurs in the transition bed between the anthraconite and the Andrarum Limestone, and the conglomerate/anthraconite bed may apparently be compared to the Scanian Hyolithes Limestone. Hyolithids are also fairly common in the matrix of the conglomerate and in the overlying anthraconite.

Ptychagnostus punctuosus (ANGELIN) is a prominent member of the assemblage in the anthraconite. In Sweden this species is not known from the Par. forchhammeri Stage, but on the other hand *Goniagnostus nathorsti* is not recorded from the Par. paradoxissimus Stage in Southern Sweden (WESTERGÅRD 1946, pp. 8–9). On Bornholm they occur together, and in view of the transitional nature of the fauna the writer believes that *Ptychagnostus punctuosus* may have survived for a while in places. A transition fauna is also found in a thin stratum of anthraconite fused with the Andrarum Limestone at Kiviks-Esperöd (WESTERGÅRD 1946, p. 9). Two boulders found just north of Gislövshammar consist of Andrarum Limestone united with anthraconite rich in *Ptychagnostus punctuosus* and other species characteristic of zone B4. WESTERGÅRD (1946, p. 11) concluded that the zone C1 must be absent at some places in the neighbourhood of Gislövshammar. Another possibility is that *Ptychagnostus punctuosus* did survive into zone C1. Finally, the transition bed – a fragment limestone with a

mixed assemblage found in places at Læsaa – makes the absence of zone C1 unlikely. However, this question cannot be definitely settled until the transition between the Par. paradoxissimus Stage and the Par. forchhammeri Stage has been thoroughly analysed.

The Andrarum Limestone is 0.85 m thick at Læsaa, 0.55–0.85 m at Øleaa. It is a bituminous, greyish-black limestone composed of dark and more light-coloured layers which are delimited by undulating bedding planes. It varies from a dense limestone to a crystalline anthraconite-like rock. The limestone is highly fossiliferous, and among the numerous trilobite species, mention may be made of the following: *Centropleura loveni* (ANGELIN), *Paradoxides forchhammeri* ANGELIN, *Jincella brachymetopa* (ANGELIN), *J. holometopa* (ANGELIN), *Anomocare laeve* ANGELIN, *Anomocarina excavata* (ANGELIN), and *Phalagnostus glandiformis* (ANGELIN).

The Andrarum Limestone is overlain by about 26 m of uniform alum shale ("upper alum shale") ranging from late Middle Cambrian into early Ordovician (Tremadocian). The Middle Cambrian part of this alum shale is about 2 m thick and belongs entirely to the *Lejopyge laevigata* Zone. The index fossil is rare. Coarsely crystalline anthraconite lenses up to 50 cm in diameter are found just above the Andrarum Limestone.

Upper Cambrian

The Upper Cambrian seems to be completely developed and is represented by monotonous alum shale in a thickness of about 21 m. Large anthraconite lenses (diameter up to 1,5 m) are concentrated in layers. The fauna (C. POULSEN, 1923) is dominated by the olenid genera: *Olenus*, *Parabolina*, *Leptoplastus*, *Eurycare*, *Ctenopyge*, *Sphaerophthalmus*, and *Peltura*. *Orusia* (restricted to one level) and *Broeggeria* are the dominating brachiopods.

The position of the Middle-Upper Cambrian boundary has been much discussed as no hiatus appears to be present within the alum shale. In general the boundary has been set at the first apperance of *Agnostus pisiformis* (WAHLENBERG) and this species is now known to be associated with an olenid (*Olenus alpha* HENNINGSMOEN, 1957). Accordingly, this boundary seems well chosen.

On Bornholm the number of olenid species is smaller than in other parts of Scandinavia, but this is possibly due to the limited number of exposures. In accordance with HENNINGSMOEN (1957) the Upper Cambrian of Bornholm is here divided into eight zones. From the uppermost level with olenids *Parabolina acanthura* ANGELIN is recorded and this species belongs to the upper subzone of the *Acerocare* Zone. The presence of the lower subzones of the *Acerocare* Zone has not been ascertained, but they are probably represented as there is no lithological evidence of breaks in the sedimentation. In this connection it must be noted that the fossils in the alum shale are concentrated in very thin layers separated by thick, unfossiliferous sections.

The *Parabolina acanthura* layers are followed by 2 m of unfossiliferous alum shale arbitrarily referred to the Olenid Series.

Ordovician

A survey of the Ordovician stratigraphy of Bornholm was presented by C. POULSEN (1936).

In a large part of Scandinavia the Ordovician is entirely dominated by shales with graptolites and limestones with trilobites. The stratigraphic divisions of the Scandinavian and Baltic Ordovician have been revised and changed considerably within the last few years. Especially JAANUSSON has advocated the necessity of distinguishing between chrono-stratigraphic, litho-stratigraphic, and bio-stratigraphic units, and many units have now been defined and named in accordance with current stratigraphical nomenclature.

The ultimate aim in the chrono-stratigraphic classification of the sequence would be the applicability of stage names common to both the shelly and the graptolitic facies (JAANUSSON 1960, p. 297). As further stated the unconditional use of terms of stage category common to both facies is possible only if the boundaries of the graptolite zones coincide with the units of the shelly sequence. If the boundaries do not coincide, the subdivisions defined in each facies can be roughly correlated, but a name defined to cover one facies would be of little practical use with regard to the other facies.

THORSLUND (1948) and later JAANUSSON stressed the improbability that the graptolite succession should coincide in detail with the shelly facies, and it is known that faunal units of different facies may overlap.

At present it has been found useful to apply names of the stage category separately to sequences with graptolitic and shelly facies. This procedure is not regarded necessary at the series level, since chronostratigraphic units of that size make correlations reasonably exact so as to be usable in practice.

Another hazard in correlation is the assumption that the boundary level between a zone with a shelly fauna lacking distinctive graptoloids and an underlying or overlying graptolite zone corresponds to the upper or lower boundary, respectively, of that graptolite zone (JAANUSSON 1960, p. 298).

So far the majority of formally named stages is defined in shelly facies. Table II shows the shelly facies stages with the following exceptions: The previously used terms Dictyonema Shale and Ceratopyge Limestone & Shale are on account of insufficient knowledge maintained; in the Harju Series the graptolitic facies stages Vasagaardian and Jerrestadian are relevant for the shaly sequence on Bornholm. The Tommarp Stage was introduced by JAANUSSON (1963, p. 132) for the division known as the Dalmanitina beds in Sweden and Poland. These beds were for many years interpreted as the basal transgressive sediments of the Silurian (HOLM and TROEDSSON), but is now believed to be of Upper Ordovician age in agreement with the original conception (LINNARSSON, 1869).

The zones listed in table II are the ones commonly used, but only in the Volkhov, Kunda, and Jerrestad Stages are graptolite zones as well as trilobite zones shown. Zones not developed on Bornholm are also listed to show the extent of the sedimentary breaks.

The Ordovician on Bornholm comprises parts of the Oeland, Viru, and Harju Series, and the total thickness of the developed parts amounts to about 24 m.

TABLE II: THE ORDOVICIAN OF BORNHOLM

SERIES		STAGES (MAINLY SHELLY FACIES)	ZONES		LITHOLOGIC DIVISIONS
UPPER	HARJU	TOMMARP	BRONGNIARTELLA PLATYNOTA		?
			DALMANITINA MUCRONATA		
			DALMANITINA OLINI		
		JERRESTAD	DICELLOGRAPTUS ANCEPS	STAUROCEPHALUS CLAVIFRONS	JERRESTAD FORMATION (BROWN TRETASPIS SHALE)
			DICELLOGRAPTUS COMPLANATUS	EODINDYMENE PULCHRA	
		VASAGAARD	PLEUROGRAPTUS LINEARIS		DICELLOGRAPTUS SHALE
MIDDLE	VIRU	OANDU KEILA	DICRANOGRAPTUS CLINGANI		? DICELLOGRAPTUS SHALE
		JÕHVI IDAVERE KUKRUSE	DIPLOGRAPTUS MULTIDENS		
			NEMAGRAPTUS GRACILIS		
		UHAKU	GLYPTOGRAPTUS TERETIUSCULUS		
		LASNAMÄGI	DIDYMOGRAPTUS MURCHISONI		
		ASERI			
LOWER	OELAND	KUNDA	DIDYMOGRAPTUS BIFIDUS	MEGISTASPIS GIGAS	
				MEGISTASPIS OBTUSICAUDA	
				ASAPHUS RANICEPS	
				ASAPHUS EXPANSUS	
		VOLKHOV	----?----	ASAPHUS LEPIDURUS	KOMSTAD LIMESTONE
			DIDYMOGRAPTUS HIRUNDO	?	
				MEGISTASPIS LATA	
				CYCLOPYGE STIGMATA	SKELBRO LIMESTONE
		LATORP	PHYLLOGR. ANGUSTIFOLIUS ELONGATUS		
			PHYLLOGRAPTUS DENSUS		
			DIDYMOGRAPTUS BALTICUS		
			TETRAGRAPTUS PHYLLOGRAPTOIDES		
			?		
		CERATOPYGE LIMESTONE AND SHALE	APATOKEPHALUS SERRATUS		
			"SHUMARDIA"		
			CERATOCARIS ? SCANICA BEDS		
		DICTYONEMA SHALE	DICTYONEMA NORVEGICUM & BRYOGRAPTUS KJERULFI		
			ADELOGRAPTUS HUNNEBERGENSIS & CLONOGRAPTUS TENELLUS		DICTYONEMA SHALE
			DICTYONEMA FLABELLIFORME		
			DICTYONEMA SOCIALE		
			DICTYONEMA DESMOGRAPTOIDES		

Oelandian

The Oeland Series on Bornholm comprises the Dictyonema Shale and two limestone formations: Skelbro Limestone and Komstad Limestone which were formerly known as "Orthoceras limestone".

Dictyonema Shale

The fauna of the Dictyonema Shale was described by C. POULSEN (1922). The black alum shale is 2.5 m thick. The lower part (1.95 m) strongly resembles the alum shale of the underlying Olenid Series and there is no lithological evidence of a hiatus in this sequence. The Cambrian- Ordovician boundary is set at the first appearance of *Dictyonema*. The upper part of the shale (0.58 m) is distinguished by numerous small nodules and concretions of anthraconite, phosphorite, and pyrite. This part contains specimens of *Clonograptus tenellus* (LINNARSSON) and *Adelograptus hunnebergensis* (MOBERG). The uppermost part (5 cm) is thoroughly impregnated by phosphorite and is overlain by a conglomerate which is included in the Skelbro Limestone (see below).

It is safe to conclude that the *Dictyonema norvegicum – Bryograptus kjerulfi* Zone is absent and that the regression and precipitation of phosphorite set in at the time of the *Adelograptus hunnebergensis – Clonograptus tenellus* Zone. The lowermost three zones are supposed to be developed and a revision of specimens of *Dictyonema* would very likely reveal the occurrence of *Dictyonema desmograptoides* HAHN and *D. socialis* (SALTER), in fact these species have been identified by TJERNVIK (1958) in material from Læsaa kept at the museum of the Palaeontological Institution in Lund. *Broeggeria salteri* (HOLL) is commonly occurring throughout the Dictyonema Shale; a few specimens of *Lingulella* and *Acrotreta* have been found in the *Adelograptus hunnebergensis – Clonograptus tenellus* Zone.

Skelbro Limestone

The Skelbro Limestone is part of what was formerly known as the "Orthoceras limestone". This term has been used for different sequences of Swedish limestones of Ontikan and Lower Viruan age. New formational names have now been established for these limestone sequences.

C. POULSEN (1936) divided the "Orthoceras limestone" on Bornholm into three units: (in ascending order) Umbonata limestone, Limbata limestone, and lower Asaphus series. The Umbonata limestone was named after the commonly occurring species of *Cyclopyge* which supposedly was identical with *C. umbonata* from Fågelsång, Scania. The assemblage of trilobites was considered transitional between the Planilimbata and Limbata limestones (C. POULSEN 1936, p. 50, and REGNÉLL 1960, p. 19). A revision (V. POULSEN, 1965) has shown that the specimens of *Cyclopyge* belong to a new species *C. stigmata*. The transitional nature of the trilobite assemblage has been confirmed and in view of the presence of *Megistaspis* (*Megistaspis*) a separate zone – the *Cyclopyge stigmata* Zone – was established as the oldest unit within the Volkhov Stage rather than as the youngest unit within the Latorp Stage.

The *Cyclopyge stigmata* Zone is without any known equivalents, although the upper part of the Lower Didymograptus beds at Heramb, Norway, may contain several trilobite species from this zone. It is possible that future work will show that the *C. stigmata* Zone preferably should be regarded as a subzone within the *Megistaspis lata* Zone, but for the time being it is maintained as a separate unit.

Other important species in the Skelbro Limestone are: *Geragnostus danicus* POULSEN, *Paraptychopyge* sp., *Niobella imparilimbata* (BOHLIN), *Nileus exarmatus* TJERNVIK, *Raymondaspis limbata* (ANGELIN), *Harpides nodorugosus* POULSEN, *Trinucleoides praecursor* POULSEN, and *Ampyx glaber* POULSEN.

The lithology of the Skelbro Limestone is rather distinctive. The limestone is light-grey, glauconitic, and contains numerous reworked phosphorite pebbles, or rather pebbles of phosphorite-impregnated Dictyonema Shale. Some layers within the limestone are composed of calcisiltite, but calcilutite is predominant. This unit, which is about 42 cm thick, has been named the Skelbro Limestone Formation (V. POULSEN, 1965). Several discontinuity surfaces are present, and the Skelbro Limestone is delimited from the Komstad Limestone by such a surface. The random orientation of the fossils in the individual layers indicates swift deposition of the sediment as mud flows.

The lower part (12–15 cm) of the Skelbro Limestone consists of a conglomerate with numerous angular pebbles of phosphorite-impregnated Dictyonema Shale in a glauconitic, grey limestone matrix. The conglomerate is delimited from the limestone by a discontinuity surface of the same kind as the one forming the upper boundary of the Skelbro Limestone. In the conglomerate specimens of *Broeggeria*, which is of limited stratigraphic significance, have been found, and this part of the sequence is arbitrarily incorporated in the Skelbro Limestone.

C. POULSEN (1936) pointed out that there is a considerable break in the sedimentation comprising the Ceratopyge beds, the Latorpian limestones, or the Lower Didymograptus Shale, and this view has been confirmed by the present writer's studies.

Komstad Limestone

The Komstad Formation was introduced by JAANUSSON (1960, p. 300) for the Scanian limestones between the Lower and Upper Didymograptus Shale. The main part of the formation probably belongs to the *Asaphus lepidurus* Zone (Langevoj Substage), while the uppermost part very likely belongs to the *Asaphus expansus* Zone (Hunderum Substage of the Kunda Stage). The Komstad Formation apparently has the same range on Bornholm, where the "Limbata" limestone in the strict sense seems to be absent. The limestone contains *Megistaspis* (*Megistaspis*) *limbata* s. str. which is restricted to the *Asaphus lepidurus* Zone (see JAANUSSON, 1956). The Swedish "Limbata" limestones have not yet been completely divided into zones as the faunal succession is not yet studied in detail. The present writer has had the opportunity to study the material collected by TJERNVIK, and it appears that the "Limbata" assemblage differs strongly from that of the Komstad Limestone which contains *Nileus armadillo* (DALMAN), *Symphysurus* (*S.*) *palpebrosus* (DALMAN), *Cyrto-*

metopus clavifrons (ANGELIN), species of *Megistaspis*, illaenids and others. *Ptychopyge applanata* ANGELIN was recorded from the upper part of the limestone sequence. However, ANGELIN's holotype of *Pt. applanata* is lost and no other specimens resembling his drawing of the holotype have been found. The specific name is to be regarded as a nomen nudum.

The Komstad Limestone on Bornholm is about 4.5 m thick and of a dark grey colour. The lower part, which is 1 m thick, consists of rather uniform limestone beds followed by 80 cm of thin-bedded limestone with few cm of shaly strata separating the individual limestone beds. The upper part (2.8 m) is a thick-bedded limestone.

After the deposition of the Komstad Limestone a considerable hiatus followed as the rest of the Kunda Stage limestones or the Upper Didymograptus Shale (including the *Didymograptus murchisoni* Zone) are absent (C. POULSEN, 1936).

Viruan – Harjuan

The Viruan and Lower Harjuan on Bornholm consist of a sequence of graptolite shales – the Dicellograptus Shale – which was previously divided into Lower Dicellograptus Shale, comprising the zones of *Glyptograptus teretiusculus* and *Nemagraptus gracilis*, and Middle Dicellograptus Shale comprising the zones of *Diplograptus multidens*, *Dicranograptus clingani*, and *Pleurograptus linearis*.

Beds from the Harjuan *Eodindymene pulchra* Zone (KIELAN 1959, to replace the *Tretaspis granulata* Zone) in Scania have been termed the Upper Dicellograptus Shale, but on Bornholm they are usually known as the Tretaspis Shale (formerly Trinucleus Shale). The divisions Lower, Middle, and Upper Dicellograptus Shale serve no practical purpose and are partly misleading. The Tretaspis Shale is lithologically distinct from the underlying sequence, but there are no important lithologic differences between the Lower and Middle Dicellograptus Shale, and also the graptolite succession fails to show a radical change that may justify a distinction between Lower and Middle Dicellograptus Shale. NILSSON (1960, p. 223) discussed the graptolite assemblage from a boring through the Viruan in the Fågelsång district and concluded that the fauna of the *Diplograptus multidens* Zone represented a transition between that of the *Nemagraptus gracilis* Zone and that of the *Dicranograptus clingani* Zone. Accordingly, the conditions are similar to those of the transition beds in Great Britain and also previously recorded from the beds at Sularp by NILSSON.

The present writer agrees with JAANUSSON with regard to the use of the British Ordovician standard graptolite zones for the Viruan of Scandinavia and also accepts that the *Glyptograptus teretiusculus* Zone should replace the zones of *Glossograptus hincksi* and *Climacograptus haddingi*. HADDING's zones of *Diplograptus molestus* ("*rugosus*") and *Amplexograptus vasae* were based on isolated occurrences of these species which have a larger vertical range. These two zones are replaced by the *Diplograptus multidens* Zone. The *Climacograptus styloideus* Zone of HADDING is replaced by the *Pleurograptus linearis* Zone of the British standard.

It is suggested here that, as a provisional arrangement, the shale sequence

between the *Didymograptus murchisoni* Zone and the *Eodindymene pulchra* Zone simply should be named the Dicellograptus Shale. The shale is still insufficiently known, and, accordingly, a formal name is not proposed for this sequence in Scania and on Bornholm.

Dicellograptus Shale

The break in sedimentation following the Komstad Limestone lasted until the time of the *Nemagraptus gracilis* Zone. The thickness of the total sequence of Dicellograptus Shale including the layers of bentonite (metabentonite) amounts to about 12 m.

On Bornholm the sequence representing the *Nemagraptus gracilis* Zone is initiated by an up to 30 cm thick conglomerate with black pebbles of phosphorite-impregnated shale with small lenticular phosphorite and pyrite concretions. No diagnostic fossils have been found in this conglomerate. It is succeeded by about 1.5 m of alternating dark-grey shale and light-grey metabentonite. There are at least three bentonite layers totalling about 1 m in thickness. The bentonite, which was described by GRY (1948), consists mainly of illite with scattered quartz and biotite. This sequence is followed by 5 cm of phosphoritic conglomerate and then 60 cm of dark shales resembling the alum shale, but with a considerably smaller content of bituminous matter. *Diplograptus toernquisti* HADDING has been found in the dark shale making an assignment of this shale to the *Nemagraptus gracilis* Zone possible (C. POULSEN 1936, p. 54).

The *Diplograptus multidens* Zone is about 4.7 m in thickness. Fossils are rare in the lower part, more abundant in the upper part. Among the graptolites *Diplograptus molestus* THORSLUND and *Amplexograptus vasae* TULLBERG may be mentioned.

The *Dicranograptus clingani* Zone, which is not lithologically delimited from the underlying zone, is about 1.7 m thick and is rich in graptolite specimens (the zonal fossil and others).

The Harjuan *Pleurograptus linearis* Zone (3 m) contains *Climacograptus styloideus* LAPWORTH and others. JAANUSSON (1963, p. 135) established the Vasagaard Stage for this zone which is well-exposed in a section at Vasagaard, Læsaa.

The brachiopod *Paterula portlocki* (GEINITZ) is abundantly occurring throughout the Dicellograptus Shale.

Five bentonite layers have been recognized in the upper three zones of the Dicellograptus Shale. The average thickness of the layers are from 1–2 cm. It is very likely that several bentonite layers on account of negligible thickness have been overlooked, and this may explain why attempts to make a correlation with the Swedish bentonites have been unsuccessful.

GRY (1948, p. 371) reported a 2 cm thick zone of weathering at the top of the *Dicranograptus clingani* Zone at Vasagaard. The present writer is of the opinion that the weathered zone may possibly indicate a break in the sedimentation which in a way is to be expected, as the Viruan/Harjuan boundary is marked by a hiatus in Scania (Fågelsång), Västergötland, Östergötland, Gotland (the File Haidar boring), and parts of the Oslo region (see JAANUSSON 1963, pp. 135–137).

Jerrestad Formation (Tretaspis Shale)

The youngest known Ordovician deposits on Bornholm are the Tretaspis Shale which comprises the *Eodindymene pulchra* Zone and part of the *Staurocephalus clavifrons* Zone. The name of this unit is then in agreement with OLIN (1906). More rarely the shale has been named the Upper Dicellograptus Shale. This term is misleading, as the use of it for the Scanian sequence was restricted to the *Eodindymene pulchra* Zone (formerly called the *Tretaspis granulata* Zone). Furthermore the graptolites are scarce apart from in few subordinate strata, whereas trilobites are fairly common. The boundary between the *Eodindymene pulchra* Zone and the *Staurocephalus clavifrons* Zone has not yet been recognized in the sections on Bornholm.

The term *Eodindymene pulchra* Zone may preferably be used in Scania and on Bornholm to replace the *Tretaspis granulata* Zone (W. Scania, Bornholm) and the "*Niobe*" *lata* – *Lonchodomas portlocki* [syn. *Lonchodomas tetragonus* (ANGELIN)] Zone (S. E. Scania). This is a result of an analysis of the geographical and vertical distribution of some Harjuan trilobites, made by KIELAN (1959).

The trilobite species from the Tretaspis Shale were listed by RAVN (1899), and in part revised by KIELAN (1959). Among the species are: *Pseudosphaerexochus laticeps* LINNARSSON, *Liocnemis recurvus* LINNARSSON, *Dindymene ornata* LINNARSSON, *D. longicaudata* KIELAN, *Raphiophorus gratus* (BARRANDE), *Lonchodomas portlocki* (BARRANDE) (= "*Ampyx tetragonus*"), *Tretaspis granulata* (WAHLENBERG), *Amphitryon radians* (BARRANDE), *Phillipsinella parabola* (BARRANDE), *Opsimasaphus jaanussoni* KIELAN (= "*Asaphus nobilis*"), *Trinodus tardus* (BARRANDE), *Panderia megalophthalma* LINNARSSON, *Zdicella bornholmiensis* KIELAN, *Diacanthaspis decacantha* (ANGELIN), *Staurocephalus clavifrons* ANGELIN, *Microparia speciosa* HAWLE & CORDA, *Zbirovia longifrons* (OLIN), *Ceraurinella intermedia* (KIELAN), *Oedicybele kingi* WHITTINGTON, *Dionide subrotundata* KIELAN. Among the non-trilobite species are: the brachipod *Christiania tenuicincta* (M'COY) and the nautiloid cephalopod *Discoceras* sp.

Eodindymene pulchra (OLIN) has not been found and is also rare in Scania where it is only known to occur at Tommarp.

It is not known if the entire *Staurocephalus clavifrons* Zone is developed, as exposures are lacking.

C. POULSEN (1936, pp. 57–58) described *Dicellograptus anceps* var. *bornholmiensis* collected in a diminutive exposure supposedly belonging to the upper part of the Tretaspis Shale and the shale was correlated with the *Dicellograptus anceps* Zone in graptolitic facies and the *Staurocephalus clavifrons* Zone in shelly facies. However, SKOGLUND (1963, p. 36) is of the opinion that *Dicellograptus anceps* var. *bornholmiensis* should be referred to *D. complanatus* LAPWORTH. POULSEN's locality c (1956, p. 56) accordingly must be regarded as belonging to the lower zone.

JAANUSSON (1963, p. 133) established the Jerrestad Stage (typified by sections along the Jerrestad River, S. E. Scania) for the beds between the *Pleurograptus linearis* Zone and the *Dalmanitina olini* Zone. The boundaries of the stage coincide with those of the Jerrestad Formation (JAANUSSON 1963, p. 128) and this term is appropriate also for the Tretaspis Shale on Bornholm. The rock is a shale or mudstone with two subordinate layers of limestone.

The total thickness of the Jerrestad Formation on Bornholm is about 3.15 m.

The lower boundary of the formation is marked by up to 20 cm of yellowish, strongly weathered shale with cavities after weathered pyrite concretions. A hiatus comprising the lower part of the *Eodindymene pulchra* Zone is probably indicated at this level. The weathered zone is followed by 38 cm of rather hard, grey or yellowish-grey mottled shale with irregular brownish-violet spots. This part has yielded a few brachiopods (*Christiania*). Next follows 2.75 m of greyish-brown, soft shale which contains two thin layers of limestone (7 and 3 cm respectively). The described section is situated north of Vasagaard. Most of the fossils collected from the Jerrestad Formation originate from a locality southeast of Vasagaard.

There is no evidence of deposits from the Tommarp Stage and it seems possible that a regression set in at the time of the *Staurocephalus clavifrons* Zone lasting throughout late Harjuan into the Silurian.

Silurian

The Silurian on Bornholm is developed in graptolitic facies and comprises a sequence of shales with a total thickness of about 80 m. It belongs to the Llandovery and lowermost part of the Wenlock Series. For many years two divisions of the shales have been recognized: The Rastrites Shale and the Cyrtograptus Shale.

The fauna of the Rastrites Shale has been described by PEDERSEN (1922), and that of the Cyrtograptus Shale by LAURSEN (1940, 1943).

Table III shows the vertical range of the shale sequence. The terms Lower, Middle, and Upper Silurian are abandoned and replaced by the Llandovery, Wenlock, and Ludlow Series. The Llandovery Series in Dalarna has recently been divided into four stages by WÆRN (1960) and these are relevant also for the sequence on Bornholm.

Rastrites Shale

All graptolite zones with the probable exception of the *Glyptograptus persculptus* Zone and part of the *Akidograptus acuminatus* Zone appear to be developed on Bornholm as there is no lithological evidence of breaks in the sedimentation. The basal part of the Rastrites Shale is nowhere exposed and the writer is of the opinion that the probable hiatus comprising the Tommarp Stage (late Harjuan) may also include the basal part of the Rastrites Shale. The term Rastrites Shale was not well chosen as the genus *Rastrites* itself has not been observed throughout the vertical range of the shale. The sequence is still insufficiently known and no emendation of the name is proposed here. About 50 species are recorded from the Rastrites Shale and among these practically all zonal fossils are present.

PEDERSEN (1922) divided the sequence into six zones: in ascending order the zones of *Akidograptus acuminatus*, *Monograptus acinaces*, *M. triangulatus*, *M. convolutus*, *M. sedgwicki*, and *M. turriculatus*. The Scanian zonation is adopted for the Rastrites Shale in table III. The zones can be correlated with

TABLE III: THE SILURIAN OF BORNHOLM

SERIES	STAGES	ZONES	LITHOLOGIC DIVISIONS
LUDLOW		ÖVED-RAMSÅSA GROUP NOT DIVIDED INTO ZONES	
		?	
		MONOGRAPTUS SCANICUS	
		MONOGRAPTUS NILSSONI	
		? MONOGRAPTUS VULGARIS	
WENLOCK		CYRTOGRAPTUS CARRUTHERSI & MONOGRAPTUS TESTIS	
		CYRTOGRAPTUS RIGIDUS	
		MONOGRAPTUS RICCARTONENSIS	
		CYRTOGRAPTUS MURCHISONI	
LLANDOVERY	KULLATORP	CYRTOGRAPTUS LAPWORTHI	LOWER CYRTOGRAPTUS SHALE (RETIOLITES BEDS)
		MONOGRAPTUS SPIRALIS	
	KLUBBUDDEN	MONOGRAPTUS GRIESTONIENSIS	RASTRITES SHALE
		MONOGRAPTUS CRISPUS	
		MONOGRAPTUS RUNCINATUS	
	SILVBERG	MONOGRAPTUS SEDGWICKI	
		CEPHALOGRAPTUS COMETA	
		PETALOGRAPTUS FOLIUM	
	BOLLERUP	MONOGRAPTUS GREGARIUS	
		MONOGRAPTUS REVOLUTUS	
		RHAPHIDOGRAPTUS EXTENUATUS	
		AKIDOGRAPTUS ACUMINATUS	?
		GLYPTOGRAPTUS PERSCULPTUS	

the British standard, but are modified on certain points (see REGNÉLL & HEDE 1960, p. 28).

The Rastrites Shale is about 30–40 m thick (lower part not exposed). It is dark-grey and has a considerable content of calciumcarbonate in the lowermost exposed part where unfossiliferous limestone beds up to 20 cm thick and lenticular concretions occur. A few bentonite layers up to 2 cm thick have been reported.

Cyrtograptus Shale (Retiolites beds)

The Cyrtograptus Shale in Scania is divided into the Retiolites beds (zones of *Monograptus spiralis*, *Cyrtograptus lapworthi*, and *C. murchisoni*) and the Flemingi beds (zones of *Monograptus riccartonensis*, *Cyrtograptus rigidus*, and *C. carruthersi – Monograptus testis*). Only the Retiolites beds, characterized by *Retiolites geinitzianus* (BARRANDE), are developed on Bornholm. The sequence is in Denmark usually known as the Cyrtograptus Shale, while JOHNSTRUP (1889) used the term Retiolites Shale.

The zonal divisions are as proposed by LAURSEN (1940) with the exception that the *Cyrtograptus grayi* Zone has fallen into disuse and is now included in the *Monograptus spiralis* Zone. No formal name is here introduced for the sequence.

The shale contains monograptid, cyrtograptid, and retiolitid graptolites. Apart from the index fossils a few species may be mentioned: *Stomatograptus grandis* (SUESS) (syn. *S. törnquisti* TULLBERG), *Monograptus cultellus* TÖRNQUIST, *Cyrtograptus grayi* LAPWORTH (*Monograptus spiralis* Zone), *Monograptus vomerinus* (NICHOLSON), *M. dubius* (SUESS), *Barrandeograptus pulchellus* (TULLBERG), and *Retiolites geinitzianus* (BARRANDE). Among the non-graptolite fossils may be mentioned: *Orthoceras* sp., *Ceratiocaris* sp., and *Aptychopsis primus* BARRANDE.

The Cyrtograptus Shale is light-grey. It is characteristic that the graptolite skeletons are in many cases replaced by pyrite and preserved in full relief. A few bentonite layers have been observed. Lenticular septaria of calciumcarbonate are fairly common. The upper part of the Retiolites beds on Bornholm is notably arenaceous and at certain levels even conglomeratic indicating a regression.

Quaternary deposits follow directly on top of the Retiolites beds which thus constitute the youngest known Silurian on the island itself.

? Colonus Shale

In Scania the Cyrtograptus Shale is succeeded by a considerable sequence of micaceous shale – the Colonus Shale of Ludlovian age. The stratigraphy of this shale is not yet known in sufficient detail. The question of the possible presence of Colonus Shale on Bornholm has been discussed by LAURSEN (1943) and ROSENKRANTZ (1944), but no definite conclusions are possible.

Boulders of Colonus Shale are quite common in the Quaternary moraines on the south and north coast of Bornholm and parts of this shale sequence are

very likely developed on the sea bottom outside the island. At the north coast Colonus Shale is also known to occur below the moraine in a small down-faulted area in the Precambrian terrain at Dynddalen, west of Gudhjem, but the occurrence may represent a larger glacier-transported block from outside Bornholm.

DANSK SAMMENDRAG

Kendskabet til den kambrisk-siluriske stratigrafi i Skandinavien er blevet forøget i betydelig grad som følge af de senere års svensk-norske forskningsindsats. Ændringerne berører det biostratigrafiske, lithostratigrafiske og chronostratigrafiske inddelingsgrundlag. De reviderede eller nybeskrevne afdelinger er nu formelt navngivne. Forfatteren har fundet det hensigtsmæssigt at gøre rede for, hvorledes de kambrisk-siluriske dannelser på Bornholm skal indpasses i overensstemmelse med de nye anskuelser.

Skemaerne I–III viser de nugældende inddelinger, hvis betegnelser i højere grad end de tidligere kan gøre krav på international anerkendelse. Aflejringer, som ikke har været revideret, går igen i skemaerne under de hidtidige navne. I en del tilfælde kan nye betegnelser især for skånske dannelser uden videre overføres på de bornholmske. Alle de kambrisk-siluriske zoner er anført for også at vise omfanget af hullerne i lagserien.

Litteraturlisten omfatter et udvalg af klassiske arbejder om Bornholms Kambro-Silur og dertil relevante danske og udenlandske arbejder med stillingtagen til enkeltheder i den bornholmske stratigrafi.

Skemaerne skal her blot kommenteres i det omfang, ændringerne bevirker betydelige afvigelser fra den hidtil gængse opfattelse.

Kambrium

Nedre Kambrium

Undergrænsen for Nedre Kambrium sættes ved overgrænsen af Neksø-sandstenen (K. HANSEN, 1936). Dannelserne omfatter Balka-kvartsit, Grønne Skifre og Rispebjerg-sandsten. Zonerne, hvoraf de to yngste mangler, er især karakteriseret af trilobiter, orme og hyolither.

Mellem-Kambrium

Paradoxides Serien er, bortset fra mangelen af Eccaparadoxides oelandicus Etagen, veludviklet. Aflejringerne er: Exsulans-kalk, Kalby-ler, Nedre Alunskifer, antrakonit med fosforitkonglomerat, Andrarum-kalk og endelig nederste del af Øvre Alunskifer. Flertallet af zonerne er karakteriseret ved indhold af agnostide trilobiter. Antrakoniten med det basale fosforitkonglomerat under Andrarum-kalken hørte før under *Paradoxides davidis* Zonen som yngste enhed i Paradoxides paradoxissimus Etagen. Denne zonebetegnelse er ændret til *Ptychagnostus punctuosus* Zonen (WESTERGÅRD, 1944). Forfatteren til den foreliggende oversigt mener, at antrakoniten muligvis skal jævnføres med den skånske Hyolithes-kalk, som henregnes til Paradoxides forchhammeri Etagen. Antrakonitens trilobiter synes at udgøre en overgangsfauna, og en endelig placering af denne dannelse er endnu ikke mulig.

Øvre Kambrium

Hoveddelen af Øvre Alunskifer tilhører Øvre Kambrium. Zoneinddelingen er hovedsagelig baseret på olenide trilobiter. Den hidtidige *Peltura* Zone er nu opdelt i tre: Zonerne med *Protopeltura praecursor*, *Peltura minor* og *Peltura scarabaeoides*. Alle zoner er tilsyneladende udviklet på Bornholm.

Ordovicium

De ordoviciske aflejringer er i det meste af Skandinavien helt domineret af kalksten med trilobiter eller lerskifre med graptoliter. I skiferafdelinger er zonerne følgelig baseret på graptolit-arter, i kalk på trilobit-arter, og grænserne kan ikke ventes at være sammenfaldende for de to typer af zoner. I skema II vises graptolit- eller trilobitzoner, alt efter hvad der er mest relevant for de bornholmske lag. For enkelte afdelinger er begge slags zoner anført. De chronostratigrafiske enheder Oeland, Viru og Harju Serien foretrækkes frem for Nedre, Mellem og Øvre Ordovicium, som gennem tiden har været forskelligt defineret. Etagerne (stages) i skema II er hovedsagelig karakteriseret i kalkfacies og falder ikke helt sammen med etagerne defineret i lerskiferfacies. Dictyonema-skifer og Ceratopyge-skifer og -kalk er forældede betegnelser, som givetvis vil blive ændret. I Øvre Ordovicium (Harju Serien) er anført etagenavne fra lerskiferfacies; de øvrige anførte etager er defineret i kalkfacies.

De ordoviciske aflejringer på Bornholm inkluderer enheder fra Oeland, Viru og Harju Serien.

Oeland Serien

(Nedre Ordovicium)

Dannelserne omfatter: Dictyonema-skifer, Skelbro-kalk, og Komstad-kalk. Dictyonema-skiferen deles nu i fem zoner, hvoraf de nederste fire er udviklet på Bornholm. Tilstedeværelsen af *Dictyonema desmograptoides* og *D. socialis* er påvist. Undergrænsen for skiferen – og dermed for Ordovicium sættes ved første optræden af *Dictyonema* i alunskiferen. Øverste del af skiferen er fosforitiseret visende en regression, der førte til en sedimentationsafbrydelse omfattende yngste Dictyonema-skifer, Ceratopyge-skifer og -kalk, samt Nedre Didymograptus-skifer (eller i kalkfacies Latorp Etagens »Orthoceratit-kalk«).

Skelbro-kalken og Komstad-kalken udgør tilsammen, hvad man på Bornholm tidligere kaldte Orthoceratit-kalken. Dette navn, som i Skandinavien har været anvendt om kalksten fra Nedre–Mellem Ordovicium, er stratigrafisk misvisende og er nu helt forladt.

Skelbro-kalken (tidligere betegnet som Umbonata-kalk) rummer en påfaldende blandingsfauna og er blevet etableret som en selvstændig zone i Volkhov Etagen (*Cyclopyge stigmata* Zonen). I kalken inkluderes det underliggende fosforitkonglomerat, som er uden diagnostiske fossiler.

Komstad-kalken (efter Komstad i Skåne) svarer til de tidligere begreber Limbata-kalk og nedre Asaphus-kalk (undertiden betegnet Applanata-kalk). Fossilindholdet viser, at den egentlige »Limbata-kalk« helt mangler på Bornholm, og »Applanata-kalken« har navn efter *Ptychopyge »applanata«*, som nu er »aflivet«. I moderne forstand svarer Komstad-kalken til zonen med *Asaphus lepidurus* samt en del af zonen med *Asaphus expansus*.

Viru og Harju Serien

(Mellem–Øvre Ordovicium)

Dannelserne omfatter: Dicellograptus-skifer (med bentonit) og Jerrestad Formationen (= Tretaspis-skifer).

Efter afsætningen af Komstad-kalken fulgte en sedimentationsafbrydelse omfattende toppen af »Orthoceratit-kalken«, Øvre Didymograptus-skifer, samt nederste zone og en del af næstnederste zone i Dicellograptus-skiferen.

Dicellograptus-skiferen når fra Mellem-Ordovicium ind i Øvre Ordovicium. Skiferen deltes tidligere i Nedre og Mellemste Dicellograptus-skifer, idet Tretaspis-skiferen da opfattedes som Øvre D.-skifer. Tretaspis-skiferen er imidlertid uhyre fattig på graptoliter og desuden lithologisk afvigende, hvorfor betegnelsen Øvre Dicellograptus-skifer er misvisende og bør forlades. I den egentlige Dicellograptus-skifer er der hverken faunistiske eller lithologiske forskelle, som kan berettige opretholdelsen af begreberne Nedre og Mellemste Dicellograptus-skifer, hvorfor

betegnelsen slet og ret bliver Dicellograptus-skifer. Vasagård Etagen omfattende *Pleurograptus linearis* Zonen har navn efter det kendte profil ved Vasagård, Læså.

De tidligere betegnelser: Zonerne med »*Climacograptus rugosus*« (= *Diplograptus molestus* THORSLUND) og *Amplexograptus vasae* er ændret til *Diplograptus multidens* Zonen fra det engelske standardprofil, og på samme måde erstattes betegnelsen *Climacograptus styloideus* Zonen med *Pleurograptus linearis* Zonen. Graptolitfaunaen i *Diplograptus multidens* Zonen viser en jævn overgang fra *Nemagraptus gracilis* Zonen til *Dicranograptus clingani* Zonen.

Jerrestad Formationen (= Tretaspis-skiferen) omfatter to zoner: *Eodindymene pulchra* Zonen og *Staurocephalus clavifrons* Zonen, som begge er udviklet på Bornholm. I den nedre del er fundet *Dicellograptus complanatus* LAPWORTH (ifølge SKOGLUND 1963 = *Dicellograptus anceps* var. *bornholmiensis* POULSEN, 1936) *Eodindymene pulchra* Zonen erstatter *Tretaspis granulata* Zonen, idet denne *Tretaspis*-art har for stor vertikal udbredelse til at være velegnet som zonefossil.

Det yngste Ordovicium (Tommarp Etagen), som andre steder udgøres af Dalmanitina-lagene, er ikke påvist på Bornholm.

Silur

Siluraflejringerne på Bornholm er udviklet som graptolitskifre, som fra gammel tid har været delt i to afdelinger: Rastrites-skiferen og Cyrtograptus-skiferen begge indeholdende bentonit-lag. Disse betegnelser er ikke i overensstemmelse med den moderne nomenklatur, men er bibeholdt her, da aflejringerne endnu ikke er blevet revideret i Skåne og på Bornholm.

Betegnelserne Nedre, Mellem og Øvre Silur er på grund af begrebsforvirringen ved de mange forskellige definitioner helt forladt, og nu omfatter Siluret tre serier: Llandovery, Wenlock og Ludlow Serien. Llandovery Serien er i Dalarna delt i fire etager, som også kan anvendes for den bornholmske lagrække.

Rastrites-skiferen

Glyptograptus persculptus Zonen og det meste af *Akidograptus acuminatus* Zonen synes at mangle på Bornholm. Den nederste del af Rastrites-skiferen er under alle omstændigheder ikke blottet, og forfatteren finder det sandsynligt, at den øvre-ordoviciske sedimentationsafbrydelse rakte ind i Silur. Slægten *Rastrites* er ikke almindelig og er ikke påvist i alle skiferafdelingens lag. Skiferen var tidligere delt i seks zoner, men omfatter nu ti zoner, som med et par modifikationer svarer til den engelske standard.

Cyrtograptus-skiferen

(Retiolites-lagene)

I Skåne falder Cyrtograptus-skiferen i to afdelinger: Retiolites-lagene efter *Retiolites geinitzianus* (BARRANDE) og Flemingi-lagene efter *Monograptus flemingi* (SALTER). På Bornholm er kun Retiolites-lagene udviklet. Afdelingen kaldes i Danmark sædvanligvis Cyrtograptus-skiferen; men betegnelsen Retiolites-skifer anvendtes allerede af JOHNSTRUP i 1889.

Zoneinddelingen er som hidtil – dog med den undtagelse, at *Cyrtograptus grayi* Zonen nu almindeligt inkluderes i *Monograptus spiralis* Zonen.

Kvartær moræne overlejrer direkte Retiolites-lagene, som da udgør det yngste Silur på selve øen.

? Colonus-skifer

Cyrtograptus-skiferen efterfølges i Skåne af mindst 600 meter Colonus-skifer navngivet efter *Monograptus colonus* (BARRANDE). Løse blokke af Colonus-skifer optræder ret almindeligt i morænen på syd- og især nordkysten. Det er da tænkeligt, at dele af Colonus-skiferen findes faststående på havbunden uden for Bornholm.

Colonus-skifer er endvidere påvist under morænen i et lille nedforkastet område i Dynddalen vest for Gudhjem (ROSENKRANTZ, 1944). Der kan dog være tale om istransporteret materiale også i dette tilfælde.

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DGU = Danmarks Geologiske Undersøgelse. Copenhagen.
BGIUU = Bulletin of the Geological Institutions University of Uppsala.
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