Cambrian and Ordovician fossils from the Hardangervidda Group, Haukelifjell, southern Norway

DAVID L. BRUTON, DAVID A. T. HARPER, IVAR GUNBY & JOHAN NATERSTAD

Bruton, D. L., Harper, D. A. T., Gunby, I. & Naterstad, J. Cambrian and Ordovician fossils from the Hardangervidda Group, Haukelifjell, southern Norway. *Norks Geologisk Tidsskrift,* Vol. 64, pp. 313–324. Oslo 1984. ISSN 0024-196X.

New finds of trilobites and brachiopods are described from two horizons in the autochthonous/parautochthonous Hardangervidda Group. The occurrence of the trilobites *Lejopyge armata* (Linnarsson) and *Andrarina costata* (Angelin) indicates, for the first time, a late mid-Cambrian (*Lejopyge laevigata* Zone) age for part of the 'Alum Shale' (Bjørno Member of the Låven Formation) on Hardangervidda. Brachiopods from the younger Bjørnaskalle Formation include orthides, a clitambonitide and *Antigonambonites* of the *planus* species group of Öpik and are indicative of a late Arenig – early Llanvirn age. Both faunas indicate the most westerly known extension of Cambrian and Ordovician rocks on the Baltic platform. But whilst the uniformity of the 'Alum Shale' facies across the platform is confirmed, the upper Arenig-lower Llanvirn rocks differ from coeval strata elsewhere in the autochthon.

D. L. Bruton, Paleontologisk Museum, Sars Gate 1, Oslo 5, Norway.
D. A. T. Harper, Department of Geology, The University, Dundee DD1 4HN, Scotland. Present address: Department of Geology, University College, Galway, Ireland.
I. Gunby, Institutt for Geology, University of Oslo, Blindern, Oslo 3, Norway.
J. Naterstad, Norges geologiske undersøkelse, Oslokontoret, Drammensveien 230, 0277 Oslo 2, Norway.

Fossils are rare in the deformed rocks of the Scandinavian Caledonides, but where present they provide important constraints on developmental models for the fold belt. Two recently discovered shelly faunas are reported, herein, from the autochthonous metasedimentary rocks of the Hardangervidda Group, Haukelifjell, on Hardangervidda (Fig. 1). Cambrian trilobites have been collected from the basal part of the Låven Formation, whilst the Ordovician brachiopods are from the Bjørnaskalle Formation.

The stratigraphy of the Hardangervidda Group has been described recently (Andresen 1978) and an important fossil find has been reported from these rocks (Andresen 1974). That fauna, from two localities near Kvennsjøen, lies within a crystalline limestone downfolded into the underlying blue quartzite; it includes the brachiopod *Orthis* of the *calliframma* [sic] type, the trilobite *Ptychopyge* sp., a planispire gastropod and the actinoceroid cephalopod *Ormoceras?* sp. It is probable that a horizon equivalent to that of the Bjørnaskalle Formation is represented. Since *Orthambonites calligramma* is considered to be a typical member of the genus *Orthambonites* (see Bassett 1981, p. 652), Andresen's record of *Orthis* of the *calligramma* type probably refers to a species similar or conspecific with orthid gen. et sp. 1, herein.

Although this new brachiopod material is not well preserved and some specimens have suffered intense tectonic deformation, the trilobites have undergone less distortion and are relatively well preserved. The trilobites indicate a correlation of the base of the Bjørno Member of the Låven Formation with the uppermost zone of the Middle Cambrian, whilst the brachiopod fauna suggests a correlation of the Bjørnaskalle Formation with the upper part of the Lower Ordovician (high Arenig – low Llanvirn). These faunas therefore provide a means of correlation of parts of the Hardangervidda Group with coeval sequences elsewhere on the Baltic platform. And although further evidence is provided of the lateral persistence of the 'Alum Shale' facies in the Norden area (Martinsson 1974), at least patterns of sedimentary facies in the lower Ordovician are markedly different from those elsewhere in the autochthon (Bruton & Harper in press).

The faunal province affinities of the Hardangervidda assemblages are with the Baltic and therefore provide the minimum westward extension of this province; further evidence from more fossil occurrences is necessary in order to describe in detail the western margin of the Baltic province and its associated biofacies. It is hoped that this paper may provide a further stimulus to researchers to sustain the search for

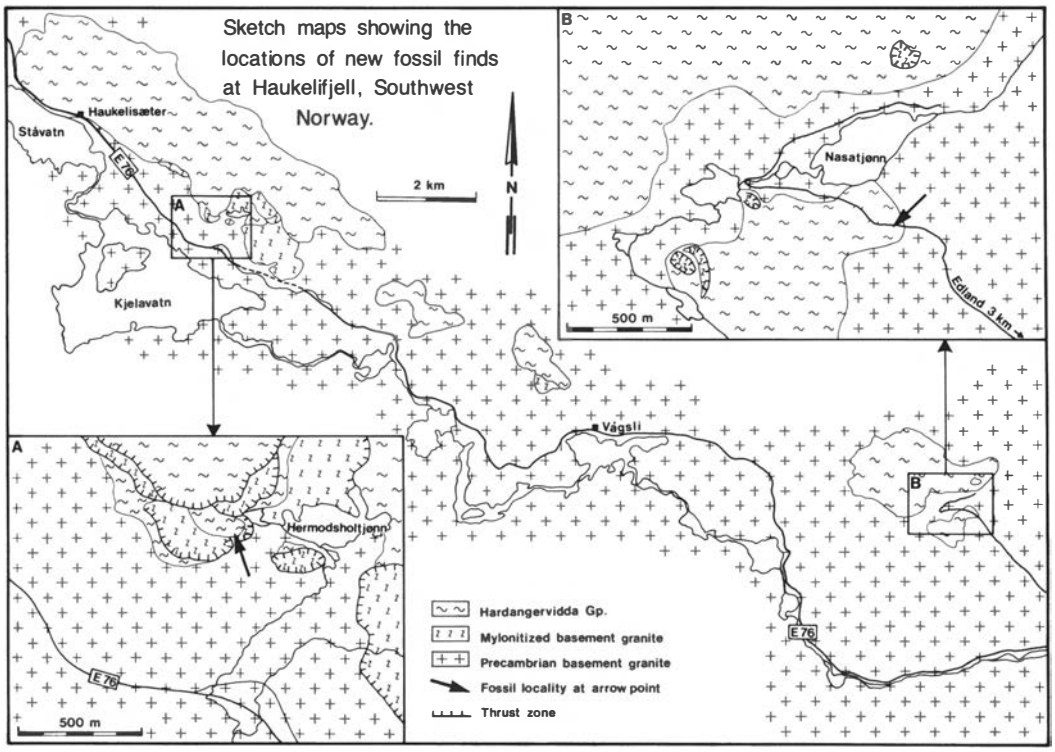


Fig. 1. Locality map showing position of Ordovician brachiopod find (A) and Cambrian trilobite find (B).

fossils in the uncompromising rocks of the mountain belt.

Stratigraphy and locality data

The stratigraphy of the Hardangervidda Group is summarised in Fig. 2 and follows closely that of Andresen (1978). The new fossils have been collected from two localities. Middle Cambrian trilobites have been collected from near the base of the Bjørno Member of the Låven Formation at Nasatjønn whilst Lower Ordovician brachiopods, bryozoans and trilobites dominate a fauna collected from the Bjørnaskalle Formation at Hermodsholtjønn.

Nasatjønn

The trilobites were collected from a black carbonaceous shale, presumably the Alum Shale, in a road cutting about 4 km from Edland (Grid Ref. of locality MM163 256 see also Fig. 1). The rocks crop out in a down-faulted outlier of autochthonous Cambrian-Ordovician meta-sedimentary rocks; the succession here is disturbed by faults but is presumed continuous. The fauna, which indicates a late Mid-Cambrian age for this part of the sequence, occurs a few metres above the local basal quartzite (Haremo pers. comm. 10 Oct. 1984). Although within the outlier thrust zones and imbricate basement slices occur, the rocks are locally less deformed than those at Hermodsholtjønn. Moreover, whilst the rocks are intensely folded, with axes trending NW-SE, the late Caledonian crenulation cleavage, which dips SE and is common as far SE as Haukelisæter, is not developed at Nasatjønn.

Hermodsholtjønn

The shelly fauna was collected from fallen blocks of calcareous sandstone immediately below exposures of this unit, 3.5 km SE of Haukelisæter (Grid Ref. for the locality MM 016 314; see also Fig. 1). These rocks overlie quartzites, whilst phyllites occur both above and below. This sequence has been folded about axes which trend

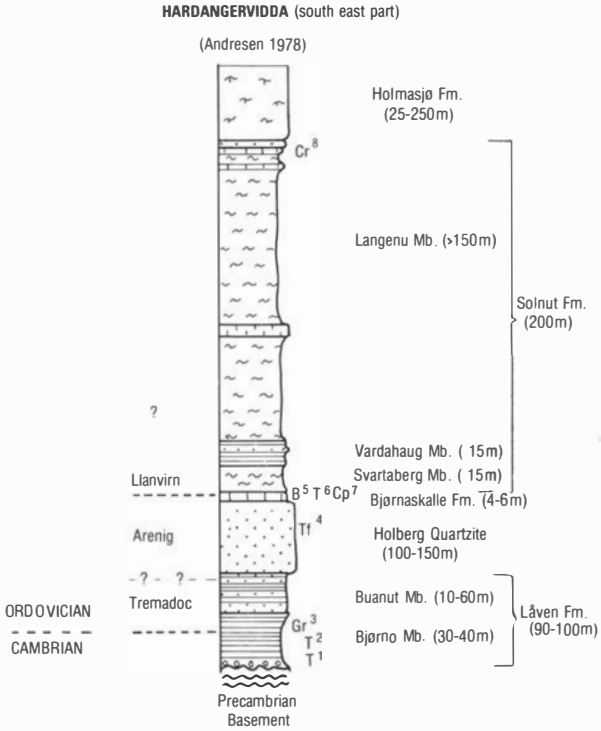


Fig. 2. The Stratigraphy of the Hardangervidda Group and location of fossils in the section on Hardangervidda. Modified from Andresen (1978). Footnotes: T = trilobite, Gr = graptolite, Tf = trace fossil, B = brachiopod, Cp = cephalopod, Cr = crinoid stem. 1. Lower Cambrian fauna recorded from basal conglomerate at Ustaoset (Størmer 1925). 2. Late Middle Cambrian trilobites described herein. 3. *Dictyonema flabelliforme* at several localities (Dahll 1861, Rekstad 1905, Størmer 1941, Andresen 1974, Erdtmann 1982). 4. 'Tube-like' structures (Andresen 1978). 5–7. Brachiopod, trilobite and cephalopod faunas consistent with a late Arenig-early Llanvirn age for the formation and suggest correlation with the 'Orthoceras Limestone' of the Oslo Region (Andresen 1974, also this paper). 8. Crinoid stems, Middle Ordovician or younger (Bockelie *in* Andresen 1978).

NW-SE, whilst the quartzite and calcareous sandstone is surrounded by slices of highly tectonised gneiss which is separated from the typical basement rocks by black shale. The extent of the thrusting is not known but the tectonised gneiss is considered to be of local origin.

The fossils, although commonly highly deformed, indicate a correlation with the high Lower Ordovician for the Bjørnaskalle Formation. Fossils have recently been described from a stratigraphically similar level, by Andresen (1974), farther north on Hardangervidda.

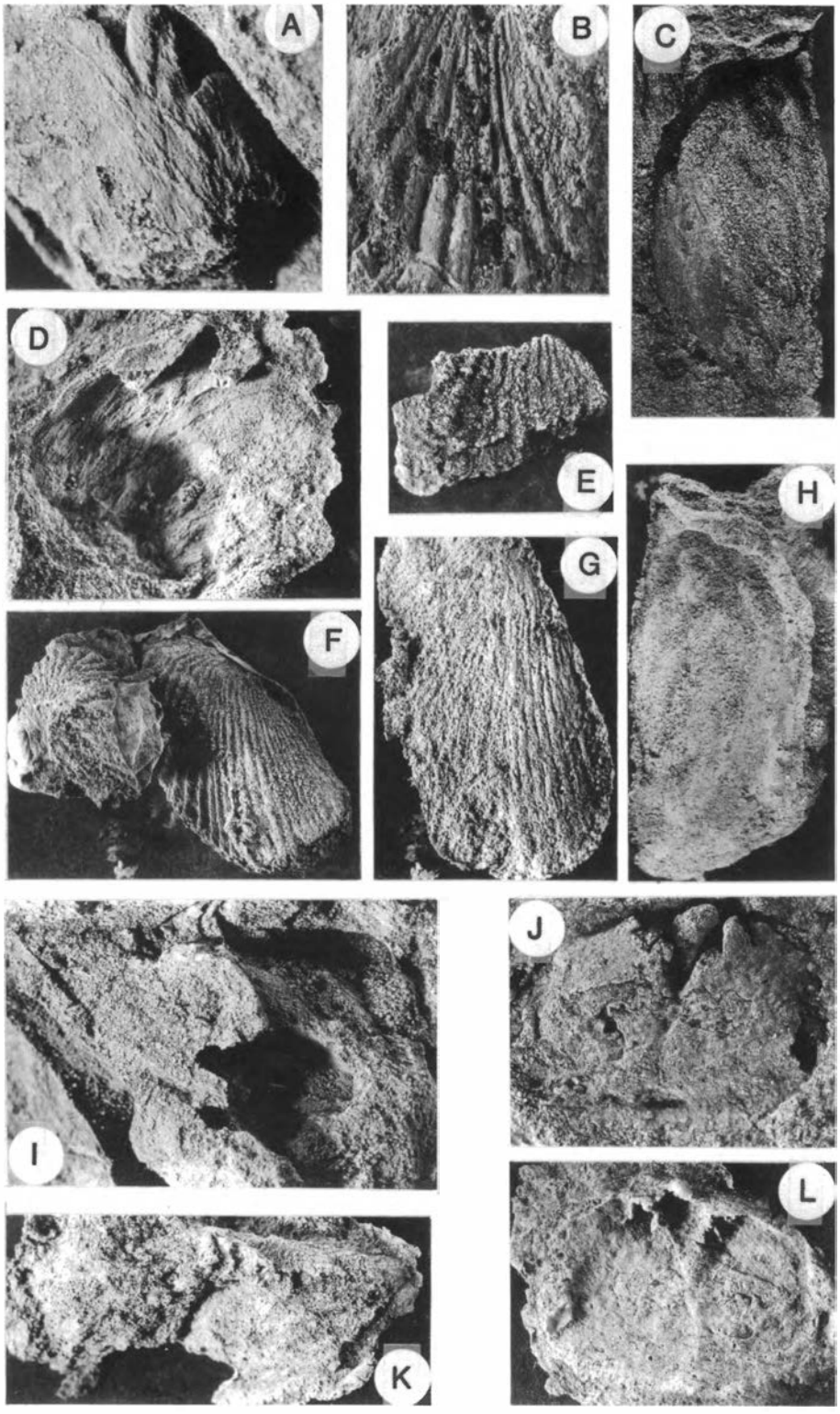
Significance of the faunas

The Cambrian trilobites

Until now, only the age of the top of the 'Alum Shale' succession on Hardangervidda has been known from the occurrence of the Tremadoc dendroid *Dictyonema flabelliforme* (Dahll 1861, Brøgger 1893, Rekstad 1905, Størmer 1941). The present record of *Lejopyge armata* (short spine form) and of *Andrarina costata* from a level a few metres above the local Precambrian basement indicates that here the Bjørno Member of the Låven Formation belongs to the topmost zone (1dß, *Lejopyge laevigata* Zone) of the Middle Cambrian. This same zone is represented on Bornholm (but not Gotland), in all districts of southern and central Sweden (Martinsson 1974), in the Oslo Region (Strand 1929, Henningsmoen *in* Strand & Henningsmoen 1960) and in various districts along the Caledonian front west of Lake Mjøsa, including Etnedal (Brøgger 1876) and to the east in Rendalen (Strand 1929, p. 326). Study of material from these areas confirms the identification of the present specimens which are figured and discussed along with better preserved comparative material. The zone has so far not been identified along the Caledonian front from Jämtland and northwards.

The Ordovician brachiopods

The age of the Bjørnaskalle Formation is based principally on the occurrence of the *Antigonambonites* of the *planus* species group. The genus *Antigonambonites* is restricted to rocks of B_{II} and B_{III} age (the Volkhov and Kunda stages of the Öland Series in the Baltic terminology). The *planus* species group is further restricted to the higher B_{II} strata and the lowest part of B_{III} (Öpik 1934, p. 73). These rocks are equivalent to the Upper Arenig and lowest Llanvirn of the standard British Ordovician succession. *Antigonambonites* is an important element of the Öland faunas of the Baltic province. An unnamed species of *Antigonambonites* has been described from the late Arenig rocks of Virgin Arm, Newfoundland which contain a diverse brachiopod fauna (Neuman 1976) currently assigned to the adjacent peri-insular Celtic province (Neuman 1976, Neuman & Bates 1978, Bruton & Harper 1984). Neuman (1976, p. 28) indicated his species may belong to the *maekulaensis* species group; however, it could not be compared with any members of that group. Moreover, denticles


A
B
C
D
E
F
G
H
I
J
K
L

which characterise the hinge line of the Baltic members of the genus are not reported for the Canadian form.

The remaining elements of the brachiopod fauna are not in themselves definitive but, taken together, are compatible with a late early Ordovician age and a position within the Baltic province.

Systematic palaeontology

All figured and additional material has been deposited in the Paleontologisk Museum, Oslo (hereafter abbreviated PMO). Prepared specimens were first coated with a matt black preparation and then ammonium chloride sublimate before photography. Because the material is deformed, measurements are not given in the discussion of taxa. The magnifications given on the figure explanations are accurate to within 5 %.

Brachiopoda

David A. T. Harper

Although the majority of the specimens assigned to the Brachiopoda are broken, poorly preserved and have suffered some tectonic deformation, at least six different forms are present in the sample of about 30 valves studied. Therefore the relatively high diversity of the present small sample suggests that further collecting may markedly increase the multiformity of the brachiopod fauna.

Order ORTHIDA Schuchert and Cooper, 1932
Suborder ORTHIDINA Schuchert and Cooper, 1932

Superfamily ORTHACEA Woodward, 1852
Family ORTHIDAE Woodward, 1852

Three separate species are assigned here. However, due to the poor preservation and incomplete nature of the material, firm generic placements are not possible.

Orthid gen. et sp. indet. 1

Fig. 3 A, B, D, E; Fig. 4C

Remarks. – Approximately ten specimens are assigned to this species. Before distortion the valves appear to have been ventribiconvex with elongate, rounded subquadrate outlines. The external ornament comprises coarse costae with wavelengths of about 1 mm medianly at the 10 mm growth stage. A fine radial ornament of capillae is developed on the ribs and in the interspaces; both the ribs and interspaces have evenly rounded profiles. A fine concentric ornament is occasionally preserved. The ventral interarea is relatively long, flat and anacline whilst the delthyrium is wide and open. The strong teeth bear denticles on their dorsal faces, which may indicate the individual (Fig. 3A, D) to be gerontic, and are supported by thin dental plates which converge towards the floor of the valve. The ventral muscle scar is elongately oval and is confined to the umbonal cavity.

The ornament and shape of the valves together with the features of the ventral interior suggest an assignation to either *Orthambonites* (s.s.) Pander or *Paralenorthis*. Havlíček & Branisa (1980, p. 16) considered that the anteriorly divergent proximal parts of the ventral vascula media of species which they placed in the latter require separate generic status from Pander's genus. Sufficient detail of the vascular markings of the Hardangervidda species is lacking and thus a generic placement of this material based on such criteria is not presently possible.

Orthid gen. et sp. indet. 2

Fig. 3F

Remarks. – Two specimens are included in this category. In contrast to the previous form, the

Fig. 3. Orthid gen. et sp. indet. 1: A, D. Internal mould and latex cast of pedicle valve, PMO 111.405, ×2. B. External mould of pedicle valve, PMO 111.486, ×2. E. External mould of brachial valve, PMO 111.487, ×2.
Orthid gen. et sp. indet. 2: F. Latex cast of external mould of brachial valve and adjacent, smaller pedicle (?) valve, PMO 111.488, ×2.
Orthid gen. et sp. indet. 3: G. Latex cast of external mould of pedicle (?) valve, PMO 111.489, ×2.
Antigonambonites of the *planus* species group, Öpik 1934: I, K. Internal mould and latex cast of brachial valve, PMO 111.490, ×2. J, L. Internal mould and latex cast of pedicle valve, PMO 111.491, ×2.
Clitambonitid indet.: C, H. Internal mould and latex cast of pedicle valve, PMO 111.492, ×2.
All P. Haremo Coll.

radial ornament is characterised by angular profiles whilst the wavelengths of ribs, medianly at the 10 mm growth stage, are less than 0.5 mm. A concentric ornament of fine but well-defined concentric growth lines is well developed. Due to severe distortion of the specimens, little can be confidently noted regarding the shape of the valves; the brachial valve, however possesses a well-marked sulcus.

The ornament of this species is similar to that of species of *Panderina* Schuchert & Cooper, 1931 which are present in rocks of B_I and B_{II} age in the eastern Baltic (see e.g. Rubel 1961). Much more information regarding this form is needed before a confident generic assignement can be made.

Orthid gen. et sp. indet. 3

Fig. 3G

Remarks. – The third species of orthid is represented by four poorly preserved valve exteriors which have all suffered tectonic deformation. Nevertheless the ornament of this form consists of rounded costae and costellae which number about 5 per 2 mm at the 10 mm growth stage medianly and have wavelengths of 0.5 mm at the same position on the valve. The concentric ornament is restricted to rarely thickened growth lines. The ornament of this species clearly differs from those of the previous two, but the inadequacy of the material prevents further comment.

Suborder *Clitambonitidina* Öpik, 1934

Two distinct forms of this suborder are present. Specimens of *Antigonambonites* of the *planus* species group are relatively well preserved and permit a confident correlation of the Bjørnaskalle Formation with the high Lower Ordovician of the eastern Baltic. Only one deformed specimen of the second form is available for study; however it is sufficiently distinct as not to be confused with the *Antigonambonites*.

Clitambonitidinid indet.

Fig. 3C, H

Remarks. – The pedicle valve is large and apparently flat although the somewhat elongate outline probably reflects tectonic strain. It is not certain how the relatively short spondylium is supported although there are indications of lateral septa; this may suggest the presence of a spondylium triplex, a feature characteristic of the gonambonitacean brachiopods.

Superfamily GONAMBONITACEA Schuchert and Cooper, 1931
Family GONAMBONITIDAE Schuchert and Cooper, 1931
Subfamily GONAMBONITINAE Schuchert and Cooper, 1931

Genus *Antigonambonites* Öpik, 1934

Type species. – By original designation, *Gonambonites plana* Pander, 1830; from the Lower Ordovician of Estonia.

Antigonambonites of the *planus* species group, Öpik, 1934

Fig. 3I–L; Fig. 4A, B, D, G

Remarks. – Ten valves are assigned to this form and although the majority are broken a few are relatively well preserved. The valves are subpyramidal in shape with an alate hinge line. The brachial valve is essentially flat whilst the pedicle valve is resupinate; the ornament is of fine costae and costellae numbering about five per 2 mm medianly at the 10 mm growth stage, cancellated by fine well-marked concentric growth lines. Ventral interarea long, apsacline with the delthyrium covered by convex pseudodeltidium. The hinge line is denticulate whilst the spondylium triplex is supported laterally by at least two pairs of septa. The teeth are small and other features of the ventral interior are unclear. The dorsal interior possesses a simple cardinal process which is thickened posteriorly adjacent to the minute, convex chilidium. The socket ridges are widely divergent and extend anteriorly from a pair of swollen ridges which mark the margins of the notothyrium. The dorsal interarea is short, flat and anacline whilst the dorsal musculature is feebly impressed.

Öpik (1934, p. 148) considered the members of *Antigonambonites* in terms of three species groups (see also Neuman 1976, p. 28). The Hardangervidda specimens are most similar to those of Öpik's *planus* group in that they have strophomenoid profiles and a feebly impressed dorsal musculature. The *planus* species group comprises *planus* itself and *A. costatus* Öpik, 1934; the

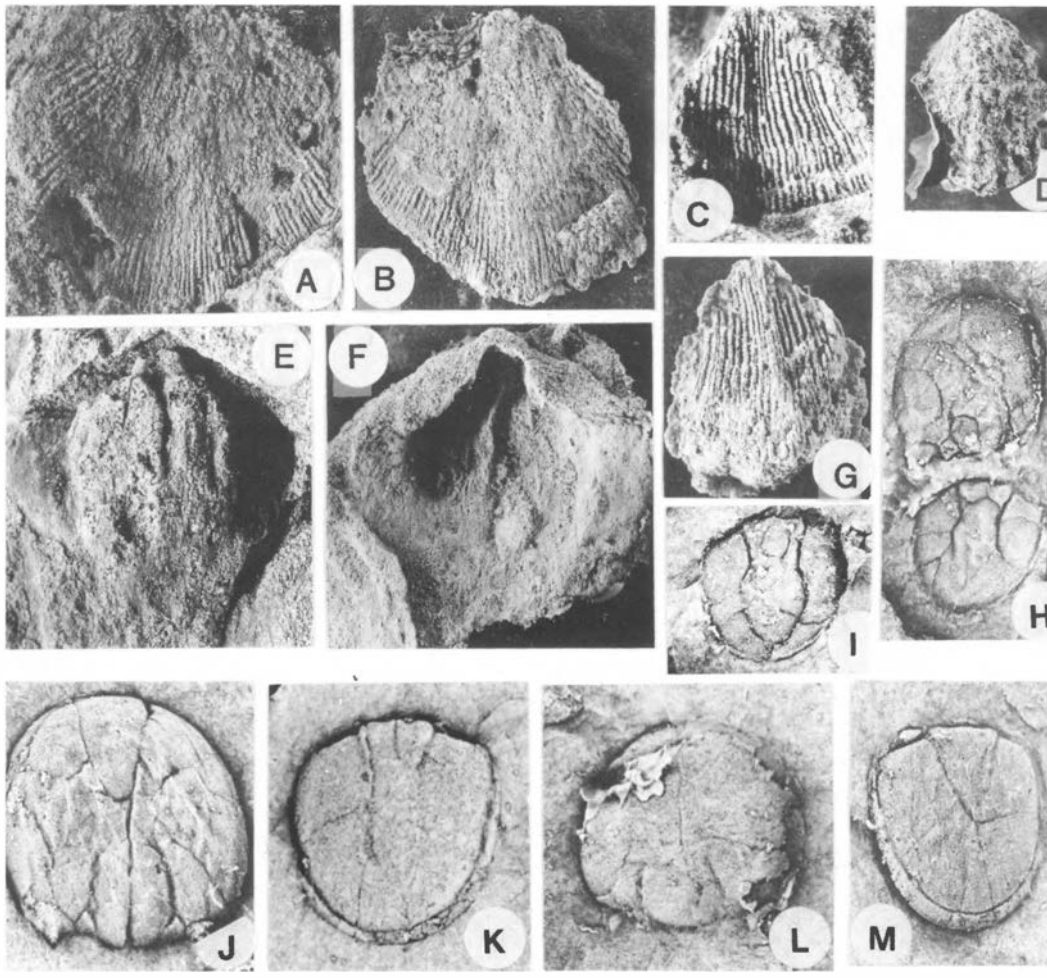
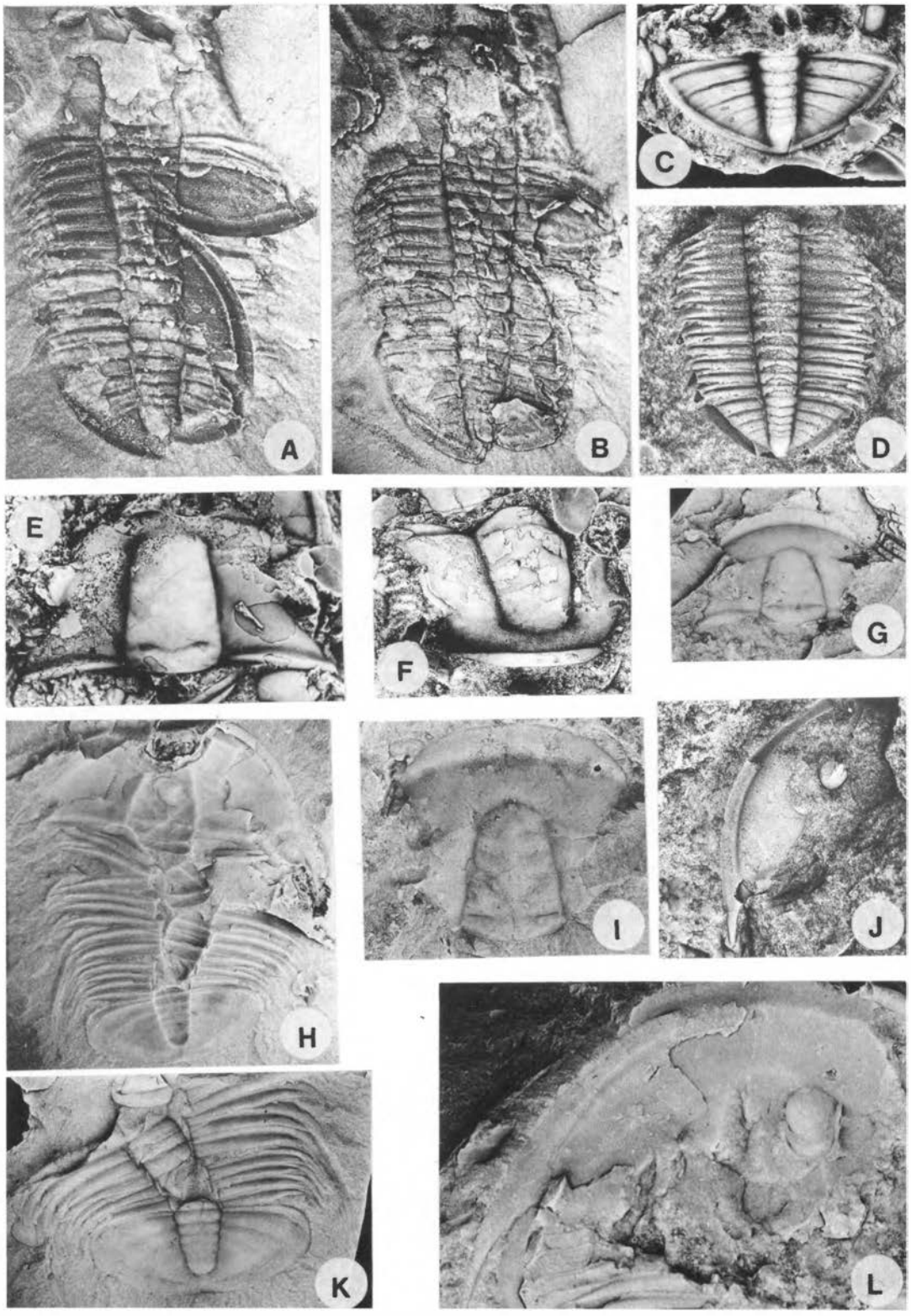


Fig. 4. Antigonambonites of the *planus* species group, Öpik 1934: A, B. External mould and latex cast of pedicle valve, PMO 111.493, C, G. Fragment of external mould and latex cast of indeterminate valve, PMO 111.494, ×2.
Orthid gen. et sp. indet. 1: D. Latex cast of pedicle valve exterior, PMO 111.495, ×2.
Articulate brachiopod indet.: E, F. Internal mould and latex cast of pedicle valve, PMO 111.496, ×2.
All P. Haremo Coll.
H, J–M. *Lejopyge armata* (Linnarsson, 1869). H, complete individual with damaged segments, internal mould. PMO 111.507, ×4. I. pygidium, internal mould. PMO 111.508, ×7. J. cephalon with postero-lateral spines. K. pygidium. PMO 111.506, ×7. L. cephalon. PMO 111.505, ×7. M. pygidium. PMO 111.504, ×5. All specimens latex casts from external moulds. Upper Middle Cambrian, Låven Fm., (Bjørno Mb.), Nasatjønn, Haukelifjell. Coll. D. L. Bruton.

latter species has a coarse radial ornament of subangular costae and costellae and a pronounced concentric ornament. *A. planus* (Pander, 1830) is the type species of *Antigonambonites* and the most common fossil in the limestones of B_{II} age in the east Baltic whilst persisting into strata of B_{III} age (Opik 1934, p. 155). The Norwegian material is similar to Pander's species; as far as can be judged the ventral and dorsal interiors of both forms are comparable (see Öpik 1934, pl. 31, figs. 2, 3a–c; pl. 34, figs. 2a, b) and both have fine radial ornaments of costae and costellae cancellated by fine growth lines. Material which may be assigned to the *planus* species group has been documented from the Expansus Shale of the Oslo Region (Öpik 1939); further specimens are present in the collections of the Paleontologisk Museum (Harper, unpublished data). But pending the discovery of more complete and better preserved material of the Har-


A
B
C
D
E
F
G
H
I
J
K
L

dangervidda form and redescription of the Expansus Shale species, a detailed comparison of both is not warranted.

Articulate brachiopod indet.

Fig. 4E, F

Remarks. – One internal mould of a pedicle valve cannot be readily assigned to any described genus of Ordovician brachiopod. The valve has a long flat interarea, anaclinal and with a wide open delthyrium. Both the anterior and lateral profiles are strongly convex and the anterior commissure was probably rectimarginate. Although the teeth are broken, dental plates are absent. A posterior pair of muscle scars are situated on a small thickened callus of shell occupying the posterior part of the umbonal cavity. A median septum separates two large elongate depressions which apparently fade near the mid-valve length.

Information rearding the morphology, noted above, is too sparse to permit confident speculation concerning the precise affinities of this articulate brachiopod. Nonetheless the features of the ventral interior suggest links with the Alimbellidae. Andreeva (1960, p. 292) erected the family to include *Alimbella* Andreeva and *Medesia* Andreeva from the Tremadoc rocks of the Urals. Both she and Biernat (1965, p. H530) considered the alimbellids to be aberrant poranibonitaceans; however, Williams (1974, p. 68) recognised the orthoid features of the family and assigned it, including his new genus *Astraborthis* from the upper Arenig Mytton Flags of the Shelve inlier, to the Orthacea. Although the valve from Hardangervidda is not sulcate, the details of the interarea, the lack of dental plates and the pseudospondylium, though small, have similarities to members of the Alimbellidae.

Trilobita

David L. Bruton

Family AGNOSTIDAE McCoy, 1849
Subfamily PTYCHAGNOSTINAE Kobayashi, 1939

Genus *Lejopyge* Hawle & Corda, 1847

Type species. – *Battus laevigatus* Dalman, 1828, from the *L. laevigata* Zone, Hönsäter, Kinnekulle, Västergötland, Sweden.
Discussion. – Öpik (1979, p. 157–158) used the spelling *Leiopyge,* maintaining that in the translation into Latin from the classical Greek, 'i' (iota) cannot be expressed by 'j', which is unknown in both alphabets. While this is correct, the spelling *Lejopyge* has been used without change since its inception, so there is a strong argument for conservation.

Lejopyge armata (Linnarsson, 1869)

Fig. 4H–M

Discussion. – This form was originally named *Agnostus laevigata* var. *armata,* and Westergård (1946, p. 89) considered it a subspecies of *laevigata.* The two are clearly related, but the presence of postero-lateral spines on the cephalon (Fig. 4J, L) and the pygidium of *L. armata* are characteristic, and I follow Öpik (1979, p. 161) in considering *armata* a separate species because of this spinosity. The pygidial spines are very short and pygidia of the present material (Fig. 4K, M) resemble the two specimens figured by Wester-

Fig. 5. A, B, C–F, J. *Andrarina costata* (Angelin, 1854). A. Dorsal view of part internal mould of moult stage. B. Latex cast of external mould of same specimen. PMO 111.503, ×2. Upper Middle Cambrian, Låven Fm., (Bjørno Mb.), Nasatjønn, Haukelifjell. Coll. P. Haremo. C. Pygidium, dorsal view. PMO 111.502, ×4. Upper Middle Cambrian (1dß), Ringsaker. Coll. S. Skjeseth. D. Thorax of 12 segments and pygidium, dorsal view, internal mould. PMO 26097, ×3.5. Specimen figured by Strand 1929, pl. 2, fig. 7. Upper Middle Cambrian (1dß), Stange. Coll. Th. Kjerulf. E. Cranidium, partly exfoliated, dorsal view. PMO 111.501, ×3. Same horizon and locality as E. Specimen associated with *Lejopyge laevigata.* F. Cranidium, oblique anterior view, latex cast of external mould. PMO 111.500, ×3. Upper Middle Cambrian (1dß), associated with *Lejopyge laevigata,* north west of Auråa, Rendalen. Coll. Getz, 1883. J. Free cheek, dorsal view. PMO 26084, ×4. Specimen figured by Strand 1929, pl. 2, fig. 10. Same horizon and locality as D. Coll. W. C. Brøgger.

G–I, K, L. *Groenwallia microphthalma* (Angelin, 1851). G. Cranidium, dorsal view, flattened in shale. PMO 28792, ×2. Upper Middle Cambrian (= Zone of *Jincella brachymetopa*), Krekling. Coll. W. C. Brøgger 1877. H. Moult stage of complete individual, external mould, flattened in shale. PMO H2658, ×1. Specimen the original of Brøgger 1878, pl. 3, fig. 1. Upper Middle Cambrian, Krekling. Coll. Wille and Brøgger 1877. I. Cranidium, dorsal view, flattened in shale. PMO 28770. K. Moulted pygidium and posterior thoracic segments, dorsal view. PMO 58611, ×1.5. Same locality and collection as G. L. Incomplete cephalon, ventral view, external mould with hypostome. PMO 28627, ×2. Upper Middle Cambrian, Krekling. Coll. Unknown.

gård (1946, pl. 13, figs. 30, 31) from the upper part of the *L. laevigata* Zone in Västergötland. Effacement of the pygidial rachis varies, the rachis of the specimen illustrated as Fig. 4I being well defined posteriorly and resembling the second pygidium figured by Westergård and a variety called *forfex* by Brøgger (1878, pl. 5, fig. 6a). I have examined the latter (PMO 28897), which does not have as deep rachial furrows as Brøgger's illustration suggests (see also remarks by Westergård 1946, p. 88, 89). The specimen is somewhat compressed and appears to have a much wider doublure than material figured herein, and the border lacks the small spines. In my view, Brøgger's variety *forfex* falls within the range of variation known for *Lejopyge laevigata*. The present material of *L. armata* does not seem to have a median node on the rachis which is present on both Swedish and Australian specimens. However, this may be a result of the poor preservation of the Norwegian specimens. The thoracic segments on the only complete individual (Fig. 4H) are not well preserved, but a fulcral spine is visible on the second segment and this is characteristic for *L. armata* and not *L. lejopyge*.

Family ANDRARINIDAE Raymond, 1937

Genus *Andrarina* Raymond, 1937

Type species. – *Liostracus costatus* Angelin, 1854, from the uppermost Middle Cambrian Zone of *Lejopyge laevigata,* Hönsäter, Kinnekulle, Västergötland.

Andrarina costata (Angelin, 1854)

Fig. 5A-F, J

Discussion. – Westergård (1948) provided new figures of Swedish material including the originals of Angelin from which a pygidium (Westergård 1948, pl. 3, fig. 23) was chosen as lectotype. Strand (1929) gave a complete description of material from the Zone of *L. laevigata* in the Mjøsa district of Norway. His figured complete thorax and attached pygidium and a free cheek are refigured herein (Fig. 5D, J). Details of the thorax, consisting of 12 segments, the pygidium with narrow, well-defined border and furrowed pleural areas, and the free cheek with short genal spine, are identical with the one new specimen from Hardangervidda (Fig. 5A, B). This specimen, preserved in shale, is of a moult stage in which both free cheeks lie beneath the thorax, that of the left side being inverted. The cranidium, an internal mould, is poorly preserved, but it is possible to distinguish the apparently broad sub-parallel-sided glabella and the long, straight course of the posterior facial suture and broad postocular cheek. This feature and details of the suture are more clearly seen on two uncompressed cranidia (Fig. 5E, F) preserved in limestone (stinkstone), and figured for comparison. Westergård (1948, p. 14) has drawn attention to the similarity between *Andrarina* and the younger olenids, and these similarities extend to details of the occipital furrow, shape of glabella, eye ridges and shape of the pre-glabellar field and border (cf. Figs. 5E, F and species of *Protopeltura* in Henningsmoen 1957, pl. 23). The diverging anterior facial sutures in *Andrarina costata* were thought by Westergård to be essentially a non-olenid feature, though it is clear that the Olenidae as presently interpreted (see Fortey 1974, p. 9–10) include forms with strongly diverging anterior sutures.

Andrarina costata and *Groenwallia microphthalma* (Angelin, 1851) (Fig. 5G, H, I, K, L) were considered by Westergård (1953, p. 31) to be similar and the latter was tentatively assigned to the Andrarinidae. The differences between *Groenwallia* and *Andrarina,* however, were not made clear. The type species of *Groenwallia* (*Liostracus platyrrhinus* Grönwall, 1902) is recorded together with *G. microphthalma* from the *Jincella brachymetopa* Zone (Andrarum Limestone and equivalents) in Sweden, whereas in Norway, *G. microphthalma* is known from Krekling together with *Lejopyge laevigata* and elements of the older zone (Brøgger 1878). There are several complete specimens of *G. microphthalma* in the collections of the Paleontologisk Museum, Oslo, and study of these shows that they are clearly different from *A. costata.* Two specimens (Fig. 5H, K) show a characteristic moulting whereby the thorax is separated into distinct sections with a sinuous axial line. The free cheeks are in place, suggesting that the ventral doublures were attached and the hypostome lies slightly displaced under the glabella. The present material confirms Strand's (1929, p. 354) observation that the thorax possessed 13 segments and the 9th carries a macropleural spine. The glabella tapers more strongly forwards and is more rounded anteriorly than in *A. costata* and there is a broad, concave pre-glabellar field and a flat curved anterior border narrowing towards the anterior corner. On larger, well preserved speci-

mens (Fig. 5I), there is a caecal pattern on the pre-glabellar field. The pygidium of *G. microphthalma* differs from that of *A. costata* in being more rectangular with a smooth to faintly furrowed pleural area and a doublure that is broad anterolaterally, narrowing medially where there is a notch in the posterior border behind the rachis.

The type species of *Groenwallia* has an occipital spine, whereas Swedish material of *G. microphthalma* (cf. Westergård 1953, pl. 7, figs. 13 and 19) has a small node-like swelling. No such node is present on Norwegian material which I have studied, and I do not consider the absence of a spine sufficiently important to exclude *microphthalma* from *Groenwallia*. However, it seems doubtful whether *Groenwallia* should be retained in the Andrarinidae, though like *Andrarina* it possesses several olenid-like features. Certainly the hypostome is olenid-like and was probably attached to a ventral membrane of the cephalon and not the doublure, in a manner similar to those olenids (Balnibarbiinae Fortey, 1974) which have a long pre-glabellar area.

Acknowledgements. – We thank Dr. A. W. Owen and Mr. F. Nikolaisen for reading the manuscript and Jenny Orr for her accurate typing. Bruton acknowledges finance from Norges Almenvitenskapelige Forskningsråd, whilst Harper thanks N.E.R.C., N.A.V.F. and the Paleontologisk Museum, Oslo for financial support.

Manuscript received
October 1984

References

Andreeva, O. N. 1960. *In* Markowskii, B. P. (Ed.) [New species of ancient plants and invertebrates of the U.S.S.R.] 288pp, 73pls., Moscow (in Russian).

Andresen, A. 1974. New fossil finds from the Cambro-Silurian metasediments on Hardangervidda. *Nor. geol. unders. 304,* 55–60.

Andresen, A. 1978. Lithostratigraphy of the authochthonous/parautochthonous Lower Palaeozoic metasediments on Hardangervidda, south Norway. *Nor. geol. unders. 338,* 59–69.

Angelin, N. P. 1851. *Palaeontologia Svecica.* P.I. Inconographia crustaceorum formationis transitionis. Fasc. I. Lundae.

Angelin, N. P. 1854. *Palaeontologia Scandinavica.* P.I. Crustacea formationis transitionis. Fasc. II. Lipsiae [T. O. Weigel] (Lundae).

Bassett, M. G. 1981. The Ordovician brachiopods of Cornwall. *Geol. Mag. 118,* 647–664, pls. 1–4.

Biernat, G. 1965. Suborder Syntrophiidina Ulrich & Cooper, 1936. *In* Moore, R. C. (Ed.): *Treatise on invertebrate paleontology, part H, Brachiopoda, H526–H536. Geol.* Soc. Am. & Univ. Kansas Press. Lawrence, Kansas.

Brøgger, W. C. 1876. 'Andrarums-kalk' ved Breidengen i Valders. *Geol. För. i Stockh. Förh. 3,* 1–6.

Brøgger, W. C. 1878. Om Paradoxidesskifrence ved Krekling. *Nyt. Mag. fur Naturv., 24,* 18–80.

Brøgger, W. C. 1893. Lagfølgen pa Hardangervidda og den såkaldte 'højfields-kvarts'. *Nor. geol. unders. 11,* 1–142.

Bruton, D. L. & Harper, D. A. T. in press. Arenig-Llandovery stratigraphy and faunas across the Scandinavian Caledonides. *Geol. Soc. Lond.*

Dahll, T. 1861. Om Telemarkens geologie. *Nyt. Mag. Naturvidensk. 11,* 137–172.

Dalman, J. W. 1828. Nya Svenska Palaeader Årsberättelse om nyart Zoologiske Arbeten och Upptäckter till *Kongl. Vet.-Akad.* 134–135.

Erdtmann, B.-D. 1982. Palaeobiogeography and environments of planktic dictyonemid graptolites during the earliest Ordovician. Pp. 9–27. *In* Bassett, M. G. & Dean, W. T. (Eds). The Cambrian-Ordovician boundary: Sections, fossil distributions, and correlations. 227 pp. *National Museum of Wales, Geological Series 3.*

Fortey, R. A. 1974. The Ordovician trilobites of Spitsbergen I. Olenidae. *Norsk. Polarinst. Skrift. 160,* 1–129.

Grönwall, K. A. 1902. Bornholms Paradoxideslag og deres fauna. *Dan. Geol. Unders. 2(13)* i-xi, 1–23.

Havlíček, V. & Branisa, L. 1980. Ordovician brachiopods of Bolivia. *Rozpr. Cesk. Akad. Ved. 90,* 1–54, pls. 1–6.

Hawle, I. & Corda, A. J. C. 1847. *Prodrom einer Monographie der Böhmischen Trilobiten.* 1–136.

Henningsmoen, G. 1957. The trilobite family Olenidae. *Skr. Norske Vid. Akad. Oslo, 1. Mat.-Nat. Kl. 1957 I,* 1–303.

Kobayashi, T. 1939. On the agnostids (pt. 1). *J. Fac. Sci. Imp. Univ. Tokyo 2,* 5, 60–108.

Linnarsson, J. G. O. 1869. Om Vestergötlands Cambriska och Siluriska aflagringar. *Kongl. Svensk. Vet.-Akad. Förh. 8,* 1–89.

Martinsson, A. 1974. The Cambrian of Norden. *In* Holland, C. H. (Ed.) Cambrian of the British Isles, Norden and Spitsbergen, 185–283.

Neuman, R. B. 1976. Early Ordovician (late Arenig) brachiopods from Virgin Arm, New World Island, Newfoundland. *Bull. Geol. Surv. Canada 261,* 11–61.

Neuman, R. B. & Bates, D. E. B. 1978. Reassessment of Arenig and Llanvirn age (Early Ordovician) brachiopods from Anglesey, north-west Wales. *Palaeontology 21,* 571–613.

Öpik, A. A. 1934. Über Klitamboniten. *Acta Comment. Univ. Tartu. 17,* 1–262, 22 pls.

Öpik, A. A. 1939. Brachiopoden und Ostrakoden aus dem Expansusschiefer Norwegens. *Nor. Geol. Tidsskr. 19,* 117–142, pls. 1–6.

Öpik, A. A. 1979. Middle Cambrian agnostids: Systematics and biostratigraphy. *Bull. Bureau Min. Resources 172,* Vol. 1 (text), Vol. 2 (plates).

Pander, C. H. 1830. *Beiträge zur Geognosie des Russischen Reiches.* 165 pp. 31 pls. St Petersburg.

Raymond, P. E. 1937. Upper Cambrian and Lower Ordovician trilobita and ostracoda from Vermont. *Bull. Geol. Soc. Am. 48,* 1079–1146.

Rekstad, J. 1905. Fra Høifjeldstrøget mellem Haukeli og Hemsedalsfjeldene *Nor. geol. unders. 36,* 1–54.

Rubel, M. P. 1961. [Lower Ordovician brachiopods of the Superfamilies Orthacea, Dalmanellacea and Syntrophiacea of the Eastern Baltic.] *Akad. Nauk. ESSR, Inst. Geol. Trudy 6,* 141–226, pls. 1–27 [in Russian & Estonian].

Schuchert, C. & Cooper, G. A. 1931. Synopsis of the brachiopod genera of the suborders Orthoidea and Pentameroidea, with notes on the Telotremata. *Am. J. Sci. 20,* 265–288, pls. 1–3.

Schuchert, C. & Cooper, G. A. 1932. Brachiopod genera of

the suborders Orthoidea and Pentameroidea. *Peabody Museum Nat. History Mem. 4,* 1–270, pls. A and 1–29.

Størmer, L. 1925. On a Lower Cambrian fauna at Ustaoset. *Fennia 45,* 12–22.

Størmer, L. 1941. Dictyonema shales outside the Oslo Region. *Nor. Geol. Tidsskr. 20,* 161–169.

Strand, T. 1929. The Cambrian beds of the Mjøsen district in Norway. *Nor. Geol. Tidsskr. 10,* 305–366.

Strand, T. & Henningsmoen, G. 1960. Cambro-Silurian stratigraphy. *Nor. geol. unders. 208,* 128–169.

Westergård, A. H. 1946. Agnostidae of the Middle Cambrian of Sweden. *Sver. geol. unders. C 477,* 1–140.

Westergård, A. H. 1948. Non-agnostidean trilobites of the Middle Cambrian of Sweden. *I. Sver. geol. unders. C 498,* 1–32.

Westergård, A. H. 1953. Non-agnostidean trilobites of the Middle Cambrian of Sweden. *III. Sver. geol. unders. C 526,* 1–58.

Williams, A. 1974. Ordovician Brachiopoda from the Shelve district, Shropshire. *Bull. Br. Mus. Nat. Hist. (Geol.)* Suppl. II, 1–163.