Fossils from the Ordovician 'Upper Hovin Group' (Caradoc-Ashgill), Trondheim Region, Norway

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The 'Upper Hovin Group' on the downthrown side of the Horg Fault between the Orkla and Gaula rivers contains rocks of both Late Caradoc and Early Ashgill age, determined from fossils from eight localities. The older part of the sequence may represent a shelf to basin transition from a carbonate build-up at the western edge (Kalstad Limestone) to a deeper water equivalent (shale and limestone at Svartsætra) towards the east. Brachiopods and tri-lobites from these limestones indicate a Late Caradoc-Ashgill age, the former and associated conodonts showing clear North American (Chatfieldian) affinities. The siltstone matrix of a limestone-bearing conglomerate near the Gaula river contains brachiopods that do not permit precise age determination, but black shale that underlies it is like the Upper Caradoc 'Dicranograptus Shales' at Gyllan, on the east side of the Gaula river. Brachiopods from the volcanogenic sandstone of the Espehaug boulder, together with similar brachiopods and pelecypod molluscs from an outcrop of identical rock nearby, are of Late Ordovician age.

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Introduction

The rocks of the 'Hovin Group' between the Orkla River at Meldal and the Gaula River at Hovin (Fig. 1) are unique in the Central Norwegian Caledonides for their fossils of both older Ordovician (Arenig-Llanvirn) and younger (Caradoc-Ashgill) ages. Preservation of the fossils here suggests that this area is a remarkably low-strain sector of the Caledonian alloch-thon. The younger rocks ('Upper Hovin Group'), whose fossils are the subject of this paper, have long been considered to occupy the trough of a syncline (the Horg syncline; Vogt 1945), underlain by the the 'Lower Hovin Group' in unfaulted succession on the flanks of this structure. Oftedahl (1979), however, suggested the possibility that three separate thrust sheets may be represented in the area. Walsh (1986) showed that a southeasterly-directed reverse fault (the Horg Fault), separates the older rocks from the younger ones, throwing into question the synclinal structure of these rocks and their stratigraphic integrity. Thus, two very distantly rela-ted sequences of fossiliferous rocks may have been juxtapo-sed by faulting. For these reasons, and others discussed be-low, the names Hovin Group, Lower Hovin Group, and Upper Hovin Group are no longer appropriate. They are used in quotation marks in this paper in the absence of a consensus for a revised and more appropriate nomenclature.

Revision of the traditional stratigraphic classification is also deemed necessary as a result of the finding of geoche-mical and other contrasts in the volcanic assemblages oc-curring both within and beneath the 'Lower Hovin Group' and 'Upper Hovin Group' (Roberts et al. 1984, Furnes et al. 1985). These rocks are now considered to be parts of diffe-rent obducted ophiolites rather than a single unit, the Støren Greenstones of Vogt (1945). The typical Støren Group magmatic rocks to the southeast of the fossiliferous rocks have the composition of mid-ocean ridge basalts (MORB) and are considered to be slightly older than the greenstones of marginal basin origin (Løkken, Grefstadfjell, Vasfjell and Resfjell ophiolites) that both underlie and in part overlie (Ryan et al. 1980) the fossiliferous 'Lower Hovin Group'. Between the fossiliferous 'Upper Hovin Group' and the typi-cal Støren Group is a unit of green sandstone and shale and minor basic volcanic rocks that were mapped by Walsh (1986) who classed them as 'undisputed Lower Hovin Group'. No fossils are known from these rocks to support this identi-fication, nor do the descriptions of any of the rocks match those of the fossiliferous 'Lower Hovin Group' north of the Horg Fault. It thus remains possible that these rocks are of Caradoc age and have no counterparts northwest of the Horg Fault.

In this paper we report the results of our re-study of fos-sils from older collections, including those first found in the area by Brøgger (1875, 1877). Several fossil localities were discovered and collections made from these during a pale-ontological reconnaissance by Neuman, Bruton, and co-wor-kers in 1970 and 1980. The fossils of the 'Upper Hovin Group' are less well preserved and less abundant than those from the 'Lower Hovin Group' (Arenig-Llanvirn age) that were treat-ed in two previous papers (Neuman & Bruton 1974, 1989). Many features that permit confident generic and specific identification of the fossils from the 'Lower Hovin Group' are not present in specimens from the 'Upper Hovin Group'. This
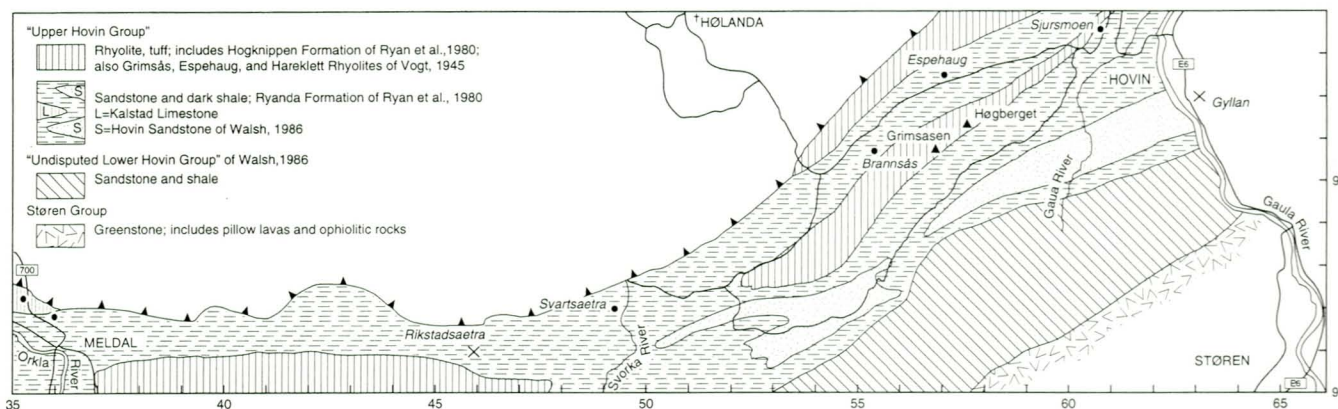
Fig. 1. Generalized geologic map of the 'Upper Hovin Group' between the Orkla and Gaula rivers, Sør-Trøndelag showing the location of 'Upper Hovin Group' fossil localities. Sources: west of grid line 38, Ryan et al. (1980); between grid lines 38 and 60, Walsh (1986); between grid line 60 and the Gaula River, Bruton & Bockelie (1982). The barbed heavy line shows the trace of the Horg Fault of Walsh (1986) along which the 'Lower Hovin Group' is juxtaposed against the 'Upper Hovin Group'.

The other geologic boundaries are presumed to be unfaulted. The six points marked • are the sources of brachiopods and other fossils treated in this paper; two points marked X are other fossiliferous occurrences mentioned here. Summits indicated by a triangle. Planimetry from Norwegian Mapping Authority 1:50,000- scale topographic maps, 1992 editions: Løkken (1521 III), Hølonda (1521 II), Støren (1621 III). WGS84 grid tics at 1 km.

is indicated by the open nomenclature used here.

The introductory part of this report and the descriptive notes on the brachiopods from six principal localities (Fig. 1), are by Neuman. These are supplemented by notes on the trilobites from the Meldal A locality by Bruton, and on the pelecypod molluscs from the Brannsås locality by John Pojeta, Jr. Conodonts from limestone at the Svartsætra locality are described by Bergström (1997).

Specimens dealt with in this paper are from several sources. The principal, previously described collection was taken from the large boulder near the Espehaug farm, the site of Brøgger's original discovery. Specimens from this collection that were described and illustrated by Reed (in Kiær 1932) were enhanced by decalcification and matrix removal, and are reassessed in the light of the discovery of identical rocks and fossils at the Brannsås locality nearby.

The Hølonda area was the focus of intensive work by Johan Kiær, the results of which were summarized in a posthumous report (Kiær 1932), that included a detailed description of the limestone at Meldal together with his description of its corals. That report also included contributions from several leading paleontologists on various elements of the faunas from throughout the area.

This paper reports the results of the work of several people that began with a field trip with the late Professor Trygve Strand in 1970 when Neuman and Bruton were introduced to the area. Most of the fossils reported on here resulted from a more thorough paleontological search by Neuman, Bruton, B. G. T. Wandås, and Greta G. Lydecker in June and July, 1980.

Many fossil localities are shown on the 1:50,000 geologic map-sheet Hølonda (Chaloupsky 1977) and most of these were examined for brachiopods by Neuman. Specimens from one of these (Lundsætra) were identified by V. Havlíček

as Sowerbyella (Sowerbyella) sp. and illustrated by Chaloupsky (1970).

Biostratigraphy and biogeography

Nearly 300 specimens of brachiopods are assigned to 25 genera with various degrees of confidence, the remainder not being identified. Three genera of trilobites are identified but not assigned to species, whilst two of the five pelecypod molluscs can be compared with previously known species. Conodonts extracted from limestone at Svartsætra provide invaluable information on the age and environmental setting of those rocks (Bergström 1997).

The assemblage at each locality is notably different from the others. In the Kalstad Limestone at the Meldal A locality, Plectorthis is dominant, but possible congeners are rare and of uncertain identity elsewhere in the 'Upper Hovin Group'. Abundant but poorly preserved Catazyga specimens occur in a tuff that overlies the Kalstad Limestone, and a few better preserved specimens of Catazyga were obtained from sandstone of the Espehaug boulder. The Svartsætra assemblage is represented by more than twenty specimens of three genera (Glyptorthis, Paucicrura, and Leptaena) that are absent or of uncertain identity at the other localities. The Espehaug/-Brannsås assemblage is notable for its relatively high diversity for so small a number of specimens: (42) representing 20 taxa, among them Schizophorella, Catazyga, and Protatrypa? that indicate a probable Ashgill age. Distinction between Caradoc and Ashgill ages is not possible from the small assemblage from the Sjursmoen locality that includes the only specimen of Platystrophia encountered in this study.

Most of the brachiopod taxa are common components of assemblages of Mid to Late Caradoc and Early Ashgill age in the Appalachian-Caledonide orogen in northeastern

LOCALITY	Meldal A	Svartsætra	Espehaug/ Brannsås	Sjursmoen
GENERIC NAME				
Glyptorthis	—	22	—	—
Skenidioides	—	4	—	—
Nicolella?	—	—	1	—
Sulevorthis?	—	—	1	—
Hesperorthis?	—	—	2	—
Plaesiomys?	—	—	1	—
Plectorthis	95	—	?2	?4
Platystrophia	—	—	—	1
Schizophorella	—	—	5	—
orthid indet.	—	—	7	—
Dalmanella	8	—	—	—
Onniella?	—	—	1	—
Paucicrura	—	28	—	—
dalmanellid indet.	—	—	1	17+
Hirnantia?	—	—	3	1
Triplesia	—	1	—	—
Oxoplecia	—	3	—	—
Sowerbyella	3	*>100	6	8
Ptychoglyptus?	—	—	2	—
Rafinesquina	7	3	1	—
Kjaerina?	—	—	1	—
Leptaena	—	23	—	—
Camerella?	—	—	1	—
Parastrophina	—	—	1	—
zygospirinid indet.	—	—	1	—
Rhynchotrema?	—	—	3	1
Catazyga	†> 50	—	12	—
Protatrypa?	—	—	1	—

* - Includes Lundsætra locality of Chaloupsky,1970.

† - Berg Farm locality

Table 1. Brachiopod genera from the 'Upper Hovin Group listed in systematic order. For map of localities see Figure 1

North America and the British Isles, and in coeval rocks of the Baltic platform - the North American and North European biogeographic provinces of Williams (1973). The wide distribution of carbonate rocks with similar fossils appears to indicate a brief interval of anomalously warm climate (Spjeldnæs 1978; Jaanusson 1979) at a time when the width of the Iapetus ocean had decreased from its Late Cambrian-Early Ordovician maximum (Torsvik et al. 1991).

A Caradoc age of limestone at the Svartsætra locality is indicated by the conodonts (Bergström 1997). The Late Caradoc age of the graptolites from the 'Dicranograptus Shales' in the Gaula River valley (Gyllan locality of Fig. 1) was confirmed by S. H. Williams (in Bruton & Bockelie 1982), following a similar determination by Hadding (in Kiær 1932). This shale is presumed to underlie the probable Ashgill-age sandstone at the Espehaug-Brannsås localities. In a sequence of roadside exposures, brachiopod-bearing conglomeratic

siltstone of the Sjursmoen locality overlies similar black shale that has not yet yielded graptolites, but the brachiopods from this locality do not permit distinction between Caradoc and Ashgill ages.

Specimens of *Schizophorella* from the Espehaug-Brannsås localities are identified with confidence because deformation did not obliterate their distinctive morphology. Although the genus has a very wide geographic range, its known age range is limited to the Ashgill. *S. fallax fallax* (Salter), the type species of the genus from Pomeroy, Co. Tyrone, Ireland (Cocks 1978) is of Cautleyan age; *S. fallax alta* Harper from the Girvan area of SW Scotland is from rocks of Rawthyean age (Harper 1984). Almost all other reported occurrences, all of Ashgill age, are in continental margin settings; these include: the Cautleyan-Hirnantian rocks of N Wales (Hiller 1980); the Montagne Noir, France (Dreyfuss 1948); and NE Spain (Villas-Pedruelo 1985). Although not previously reported in North America, the collection at the U.S. National Museum of Natural History contains one specimen of a ventral valve from the Whitehead Formation at «Grand Coupé,» collected by C. H. Kindle, and one specimen of each valve in Neuman's collections from the lower part of the Ashgill-age sequence along the East Branch of the Penobscot River in northern Maine (Neuman 1980). Baltic platform occurrences include *S. estonica* (Rõõmusoks 1964) from the Pirgu Stage of northern Estonia, and an unpublished occurrence in the Boda Limestone of the Siljan district (Jaanusson, pers. comm.).

Catazyga is less distinctive than *Schizophorella* but the several specimens from the Espehaug and Brannsås localities are consistent in supporting its identification there; identification of the deformed specimens from the tuff above the Kalstad Limestone is less certain. *Catazyga* is largely restricted to rocks of Ashgill age but two species of Late Caradoc age are known: *C. uphami* Winchell & Schuchert, 1892 from Minnesota and Kentucky on the Laurentian platform (Copper 1977), and *C. arcana* Williams, 1962 from the Girvan district of Scotland. *Catazyga* is nearly pandemic in distribution, and in some North American Upper Ordovician rocks it commonly forms coquinoid shell beds.

These brachiopods indicate an Early Ashgill age for a part of the 'Upper Hovin Group , but there is little basis for extrapolating this age determination to rocks that lie beyond the outcrop that contains the fossils. On Chaloupsky's (1973) geologic map the fossiliferous rocks near Brannsås were shown to belong to the Upper Ordovician? 'Lower Sandå Group that is mapped as lying in a narrow synclinal belt; both flanks of this structure are shown to include a unit of rhyolite and rhyolite tuff that is classed as the Middle Ordovician Krokstad Group. The brachiopod assemblage from the matrix of a conglomerate at the Sjursmoen locality, mapped as belonging to the same structure and the same unit as the fossiliferous rocks at Brannsås, may also be of Ashgill age, but the age of the Sjursmoen brachiopods remains equivocal. Although black shale beneath the conglo-

merate is like that of the 'Dicranograptus Shale', 3km to the southeast, graptolites have not yet been found in it.

The World's brachiopod assemblages in Late Caradoc-Early Ashgill are rich in pandemic genera (Williams 1973), making faunal provinces much more difficult to recognize than in the Early Ordovician. Paleogeographic maps for the Late Ordovician show northern Europe, North America and Siberia at low latitudes, separated from each other by relatively narrow oceans (Scotese & McKerrow 1990); both probably lay within a tropical to semi-tropical climate realm. The 'Upper Hovin Group has been interpreted to overlie obducted ophiolite fragments and other deformed rocks of the Baltoscandian continental margin where volcanism remained active. The wide variety of penecontemporaneous sedimentary and volcanic rocks can be interpreted to record the range of environments incorporated in this segment of the active margin of the continental plate Baltica. Thus, the Kalstad Limestone and related carbonate rocks seem to record a relatively stable but ephemeral shallow-water platform environment, whereas the dark shale represents sedimentation in deeper water. Both the limestone and the shale are of probable Caradoc age, and both are succeeded by sandstone, conglomerate, and significant amounts of rhyolitic tuff that record renewed volcanic and tectonic activity.

Ten of the twelve brachiopod genera seen in the Kalstad Limestone and the limestone at Svartsætra are present in the considerably richer and better preserved suite from the Craighead Limestone and Kiln Mudstone of the Girvan district, Scotland, (52 genera; Williams 1962), consistent with correlation of these units that was suggested long ago by Kiær (1932) and confirmed by conodonts (Bergström 1997).

Paleontology
Meldal area

The Kalstad Limestone, just north of Meldal at the western end of the area examined for this study (Fig. 1), is a succession of steeply north-dipping, south-facing limestone beds and thin beds of phyllitic argillite in a triangular outcrop area of about 1.35 km². The formation is about 375 m thick. Volcanic rocks of the Løkken Formation abut the limestone on the north; the contact between them is probably the Horg Fault, a northwest-dipping steep reverse fault, upthrown on the north. Beds of tuff that contain coquinoid accumulations of an indeterminate species of Catazyga are intercalated with limestone at the top of the formation. South of the Kalstad outcrop area are sandstones of the Ryanda Formation, probably in upward stratigraphic order (geologic relations interpreted from Kiær 1932; Ryan et al. 1980; Walsh 1986). Where best exposed, in road cuts on the east side of Highway 700, called Bergsbakken in the Kiær (1932) monograph, most limestone beds are thick biostromes. The cuts were made about 1927, and photographs and an interpretive sketch were made shortly thereafer (Kiær 1932, figs. 2-4). These outcrops are the source of specimens of calcareous al-

gae described by Høeg (in Kiær 1932), the corals described by Kiær (in Kiær 1932), and a small number of brachiopods that are discussed in the immediately following paragraphs. The Kalststad Limestone was interpreted to be a local carbonate build-up and breccias derived from it (Opalinsky 1980).

Brachiopods are not common in the Kalstad Limestone. Through the many years of study prior to the publication of Kiær's monograph in 1932, only the few specimens mentioned above had been obtained from the the road cut exposures. Seven taxa were listed by Reed (in Kiær 1932), four of which he described and illustrated, assigning each to a different genus and species. According to specimen labels, Camarella [sic] aemula Salter and Parastrophina simplex Reed were collected in 1927 by Kiær from the Bakkeknausen, just north of the road cut. Specimens labelled Orthorhynchula sp. and Zygospira meldalensis Reed were collected in 1913 by K.O. Bjørlykke from loose blocks at an unspecified locality at Meldal.

Of these, the Camerella (PMO 32979) is more properly referred to as C. cf. C. aemula (Davidson, 1869; fide Cocks 1978). Reed's illustration (Reed in Kiær 1932, pl. 22, fig. 13) depicts the trace of the median septum as longer than I see it, and I find that it is oriented closer to the crest of the median costa than is shown. I consider this incomplete single specimen to be insufficient for confident specific determination.

The generic identification of ?Parastrophina simplex Reed in Kiær (1932, p. 144; Pl. 22, fig. 11, 11a; PMO 32976) cannot be confirmed because details of its internal features cannot be observed. Release of the specimen from its matrix (Fig. 4, O-Q) shows some features that were not previously noted, such as the low, short median costa in the trough of the ventral sulcus and a corresponding short, shallow depression on the crest of the fold at its front. The traces of short median septa on the exteriors of both valves can now be seen, but they are not apparent in the photographs of this paper because they were covered by ammonium chloride for photography. Several genera of camerellids having little or no radial ornament have been erected since 1932, based largely on internal structures that cannot be seen in this specimen. Reed's species has not been recognized since its introduction, and the name may be considered to apply only to this specimen.

The specimen identified as Orthorhynchula sp. by Reed (in Kiær 1932 (p. 145; Pl. 22, fig. 10; PMO 32959) is unidentifiable and is not dealt with here. Reed's stated his uncertainty (in Kiær 1932, p. 145) by remarking that it «...seems to resemble...» this genus. As he noted, the specimen is broken and deformed, and better referred to as «rhynchonellid, genus indeterminate.»

The specimen identified as Zygospira meldalensis Reed (in Kiær 1932 (p. 144; Pl. 22, fig. 12, 12a; PMO 32961) cannot be located, but a fragment of coarse-grained limestone so labelled bears an external mold of the mid- to anterior portion of what appears to be this specimen. Criteria that might permit confirmation of this generic identification are thus

not available and it is therefore queried. The name has not been used subsequently; it is considered to apply only to this specimen.

Leptellina cf. L. llandeiloensis was reported from the lower part of the limestone by Spjeldnæs (1985); these specimens are not available for study and the occurrence cannot be confirmed.

Meldal A locality

A thin (~1 m) bed of dark-gray phyllitic argillite and siltstone near the middle of the outcrop area of the Kalstad Limestone (Fig. 2) yielded more than one hundred brachiopod specimens belonging to four taxa and nine specimens of trilobites that are assigned to three taxa. The locality (Meldal A locality of this paper) was discovered by P. D. Ryan in the course of mapping (Ryan & Williams, 1980). The fossils occur at a point (GR 350 921) 1.5 km N40W of Meldal Post Office on the steep west wall of the valley on the east side of
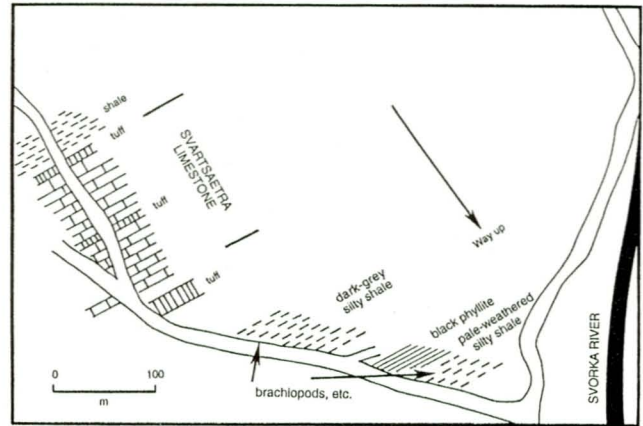
Fig. 3. Geological sketch map along lane leading to the farmhouse Svartsætra, based on field sketch of 1970 by D. L.Bruton modified in 1982 by S. M Bergström; planimetry from Hølonda 1:50,000 scale sheet (1521 II), 1992 edition. North is at top of figure.

which are the road cuts referred to above. The fossiliferous outcrop is a shallow excavation at the side of a trail that follows the 250 m map contour. It is most readily reached /by walking along this trail for about 400 m southwestward from its origin at the western edge of a field west of Highway 700 in the col ~2.0 km north of Meldal (Fig. 2).

The following brachiopods were identified from a sample of about 30 kg collected from this locality by Neuman and Greta G. Lydecker on July 4, 1980:

Plectorthis sp., 95 specimens
Dalmanella sp., 8 specimens
Sowerbyella sp., 3 specimens
Rafinesquina sp., 7 specimens.

This assemblage of brachiopod genera occurs throughout the North Atlantic region in rocks of Caradoc to early Ashgill age, but it does not permit a more precise age assignment. The associated trilobites indicate that an Ashgill age is more likely (see discussion by Bruton, below).

Brachiopods

Plectorthis sp. PMO 141035 - 141042, Fig. 4, A-N. The specimens are internal and external molds of large coarse-ribbed shells whose apparent dorsibiconvex, rectimarginate, transversely semi-elliptical shape and peripherally branched and inserted costellae are unlike those of any described species of the genus. The average large specimens are about one-fourth wider than long (length-16 mm [>7, <27, 13 specimens], width-20 mm [>10, <28], thin-bodied (dorsal thickness-2.8 mm [5 specimens]; ventral thickness-2.1 mm [7 specimens]); their radial ornament consists of about 20 strong costae, anteriorly expanding, and unbranched except in the anterolateral sectors of specimens longer than 10 mm where costellae are added by branching and by insertion; concentric ornament consists of closely spaced growth lines in interspaces throughout the shell, and a few stronger growth lines around the anterolateral margins of larger specimens. Internal features are those characteristic of Plectorthis: in the
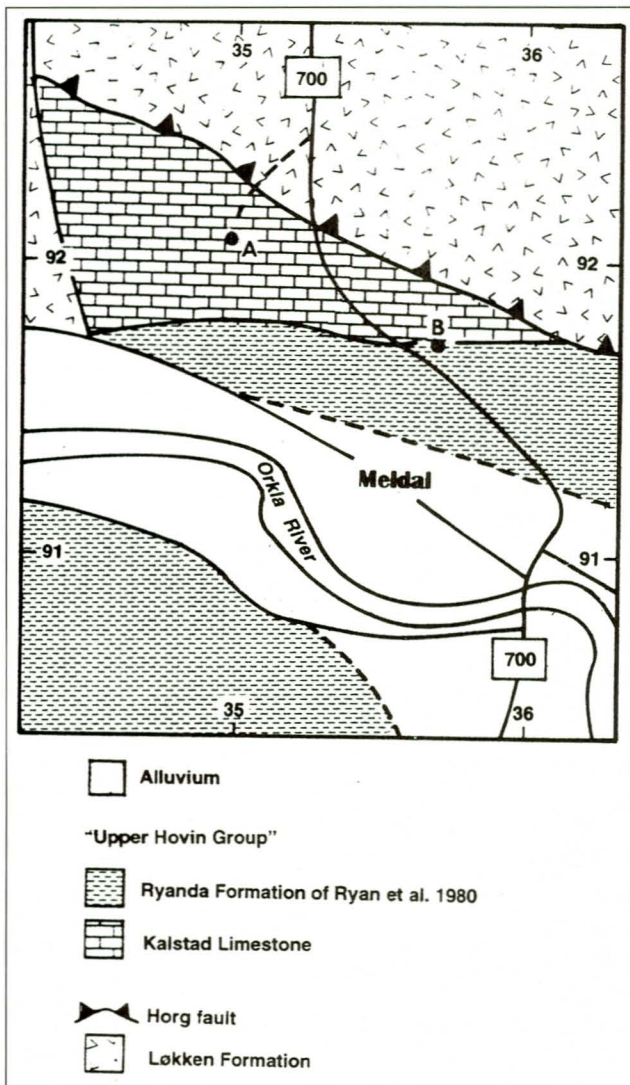

Fig. 2. Geologic map of Meldal and vicinity showing brachiopod collecting localities: A - Meldal A; B - Berg Farm. After Ryan et al. (1980); WGS84 grid tics at 1 km.
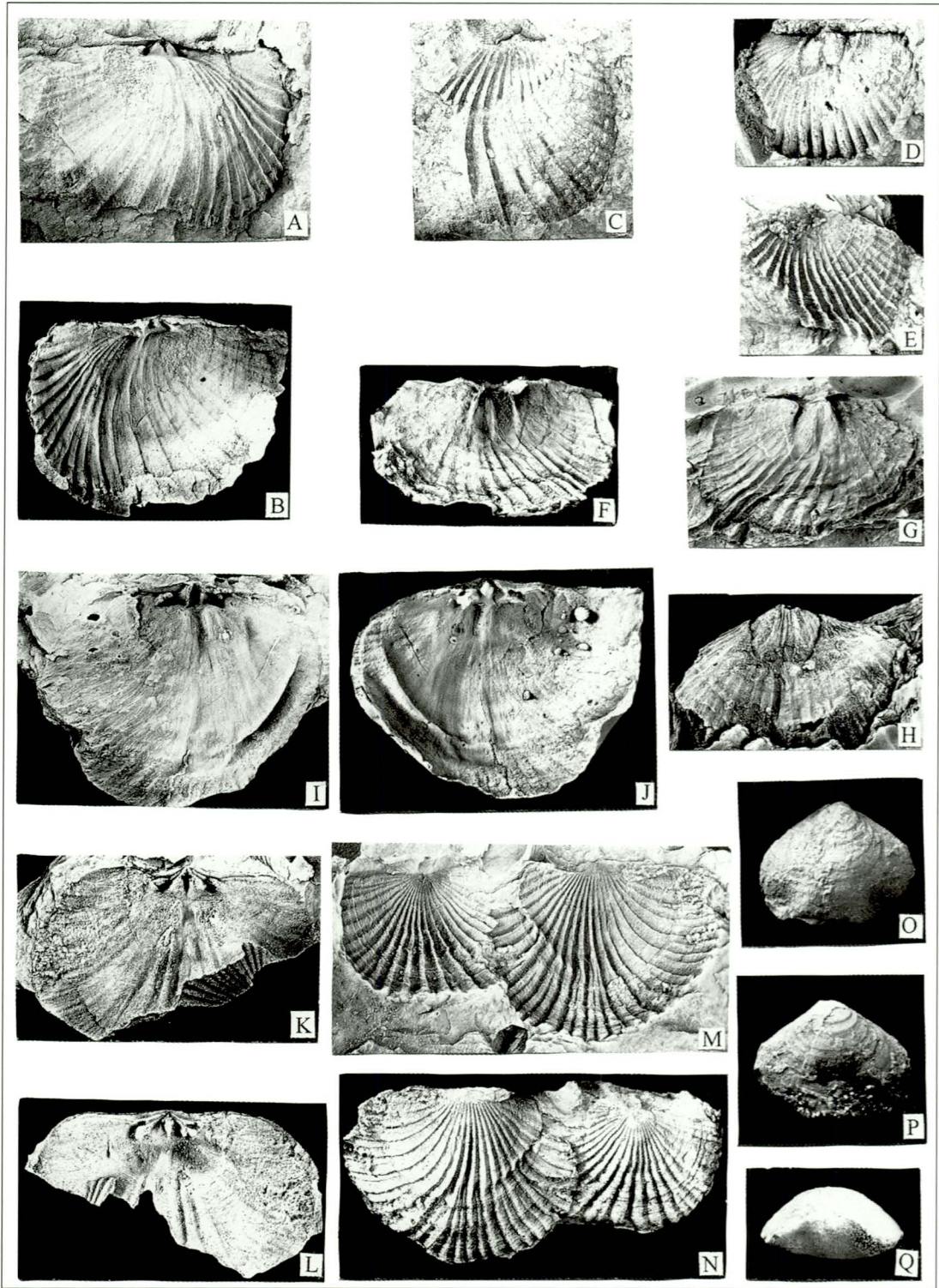
Fig. 4. Brachiopods from the Kalstad Limestone, A-N, Meldal A locality; O-Q, Bergsbakken locality, .

Plectorthis sp., all X1.5.

A-C, dorsal valve (PMO 141035), internal mold, internal cast, partial external mold.

D,   ventral valve (PMO 141042), internal mold.

E-G, ventral valve (PMO 141041), partial external mold, internal cast, internal mold.

H,   ventral valve (PMO 141040), deformed internal mold, posterior margin folded under the top of specimen seen in this view.

I-J, dorsal valve (PMO 141036), internal mold, internal cast.

K-L, dorsal valve (PMO 141037), internal mold, internal cast.

M-N, ventral valve, left (PMO 141039). dorsal valve, right (PMO 141038), external molds, external casts in reversed positions.

?Parastrophina simplex Reed.

O-Q, articulated valves (PMO 32976), Pl.22, figs 11, 11a of Reed *in* Kiær, 1932, X3, dorsal, ventral, and anterior views. V. E. Krantz photo.

dorsal valve (Figs. 4, A-B, I-J, K-L) the short, low notothyrial platform bears a stout, bulbous cardinal process that rises from a short, low shaft; the posterior face of the cardinal process is marked by a crenulated myophore that in most specimens is medially divided by a narrow groove, and by a median ridge in the largest (gerontic) specimens. The brachiophores are anteriorly divergent and coextensive with the margins of the notothyrial platform at their bases, beyond which they diverge laterally and become stout, paddle- shaped blades with blunt terminations. Small fulcral plates define the sockets of some specimens. The adductor muscle scars are variably preserved; where present they are shallow ovoid depressions that are separated by a broad, low ridge. Mantle canals are not preserved on either valve. Inside the ventral valve (Figs. 4, D, F-G) the stout teeth are supported by short, slender, receding dental plates that rise from the posterior margins of the large, cordate muscle field. The diductor scars are deeply set and longer than the narrow adductor scars between them.

Dalmanella sp. PMO 141043 - 141049, Figs. 5, A-K. These specimens have features that are characteristic of the genus, but they are not well enough preserved to permit specific identification. The suite includes a wide size range, as summarized here: length, dorsal-6.5 mm, 5 valves [>3.0, <9.0]; length, ventral-7.3 mm, 4 valves, [>3.5, <9.1]; width, dorsal-8.6 mm, 5 valves [>5.0, <10.0]; width, ventral-10.6 mm, 4 valves [>5.0, <14.0]. They are variable in outline, ranging from circular to laterally extended and suboval, with obtuse cardinal angles. In profile they are ventribiconvex with a broad, moderately deep, dorsal sulcus and a corresponding highly arched ventral fold. The external surface is densely pitted; the radial ornament, known from one small (3.0 mm long) specimen (PMO 141049; not figured), is strongly costellate, branching at about one-third and two-thirds shell length, the costellae numbering about 25 near the anterolateral margin. Inside the dorsal valve the shaft of the cardinal process extends the full length of the low, narrow notothyrial platform; bilobed myophores whose lobes are separated by very fine grooves are preserved on two specimens (PMO 141044, Figs. 5, C-D; PMO 141046, Figs. 5, G-H). The brachiophore bases are perpendicular to the hinge and parallel to each other, and linked to the posterior shell wall by fulcral plates. The distal part of the brachiophores are short and thick, and their terminations are blunt; although the brachiophores are now askew due to deformation, originally they were probably perpendicular to the shell floor. The undifferentiated adductor scars are a pair of eliptical pads of thickened shell separated by a low myophragm that occupies the posteromedial sector of the shell floor to near mid-length. The mantle canal system of neither valve is preserved. In the ventral valve the short, thick teeth are supported by receding dental plates that were probably erect originally, but are now obliquely tilted. Their bases form the sides of the relatively short trilobed muscle field in which diductor scars are more deeply set and longer than the adductors.

Sowerbyella sp. PMO 141050, Figs. 5, L-M. The best preserved of the three small specimens is the nearly complete ventral valve whose internal mold is figured here together with a cast made from it. This specimen is about 8mm long, and 11mm wide at the hinge. Its wide teeth and short dental plates are characteristic of the genus as is the pattern of pustules and the large elliptical scars of the diductor muscles. No denticulation is visible along the hinge line.

Rafinesquina sp. Figs. 5, N-V, PMO 141051 - 141056. Specimens are both fragmentary and deformed, but characters of the genus can be distinguished. The best preserved specimen (PMO 141051; Fig. 5, R-S), somewhat distorted, is a large, nearly flat dorsal valve (length-19mm, width-25mm), wider than long, and its outline was probably subquadrate. The two more complete ventral valves of comparable size indicate a moderately convex profile, but deformation obscures their outlines (PMO 141054; Figs. 5, U-V). A fragment of the exterior of a dorsal valve (PMO 141053, Fig. 5, T) preserves the impression of parvicostellae ornament, the stronger costellae alternating with four to eight weaker ones. Specimens that preserve the interiors of dorsal valves (e.g., PMO 141052, Fig. 5, Q) have a bilobed cardinal process and widely divergent socket ridges. Ventral valves have short, widely divergent dental plates. The lateral margins of the transversely elliptical muscle field are outlined by thickened shell, but musculature within it cannot be differentiated.

Trilobites, by D.L. Bruton

Annotations of the identifications of the trilobites from this locality are given below together with comparisons of congeners elsewhere in Europe that indicate the affinities of these trilobites are with species recorded from rocks of Ashgill age.

Only *Illaenus* is recorded from rocks of the 'Lower Hovin Group', which otherwise contains genera of Whiterock age that are known also from Nevada, western Newfoundland, and Spitsbergen (for summary see Neuman & Bruton 1974, 1989). *Hadromerus* and *Atractopyge* are known from Ashgill-age rocks of the Oslo Region, Norway and are widespread elsewhere in many environments of a similar age including the Boda Limestone in Dalarna, Sweden, the Kildare Limestone in Ireland, and from the Late Caradoc age Mjøsa Limestone Formation in the northern part of the Oslo Region (Owen et al. 1990).

Illaenus (?Parillaenus) sp. indet. Fig. 6, A-D, 1 cranidium (PMO 140993) and 2 pygidia (PMO 140994, 140995). The specimens of pygidia are more compressed than are those from the 'Lower Hovin Group' previously figured (Bruton *in* Neuman & Bruton 1989, fig.10 D,E,H,I. J-L), which includes both elongated (sag.) and wide (trans.) forms. Likewise, the present material has a relatively long, sloping articulating facet. Both types of pygidia can be compared with distorted material of *Illaenus* and *Stenopareia* figured by Ingham (1970) from the Ashgill of northern England. The short (sag.) specimen (Fig. 6A), resembles that of *Illaenus (Parillaenus)* cf.
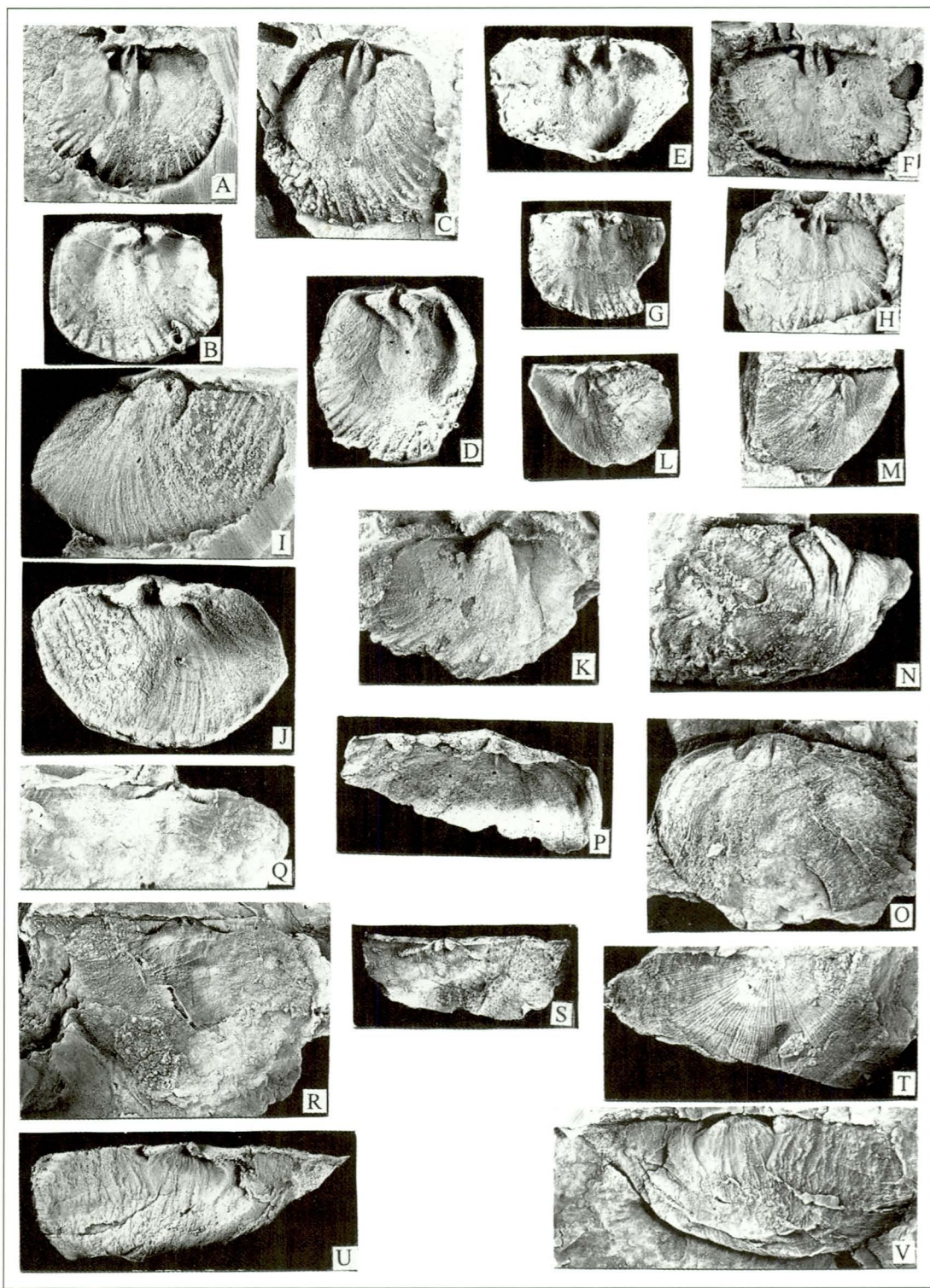
Fig. 5. Brachiopods from the Kalstad Limestone at the Meldal A locality.
Dalmanella sp., all X3.
A-B,   dorsal valve (PMO 141045), internal mold, internal cast.
C-D,   dorsal valve (PMO 141044), internal mold, internal cast, oblique
        view showing fulcral plates.
E-F,   dorsal valve (PMO 141043), internal cast, internal mold.
G-H,   dorsal valve (PMO 141046). internal cast, internal mold.
I-J,   ventral valve (PMO 141047), internal mold internal cast.
K,   ventral valve (PMO 141048), internal mold.

Sowerbyella sp., X2,
L-M,   ventral valve (PMO 141050), internal cast, internal mold.
Rafinesquina sp., all at X1.5.
O-P,   ventral valve (PMO 141055), external mold, internal mold, cast of
        posterior part of O, showing interarea with pseododeltidium.
Q,   dorsal valve (PMO 141052), internal mold.
R-S,   dorsal valve (PMO 141051), internal mold, internal cast of pos-
        tero-medial part.
T,   dorsal valve (PMO 141053), external mold.
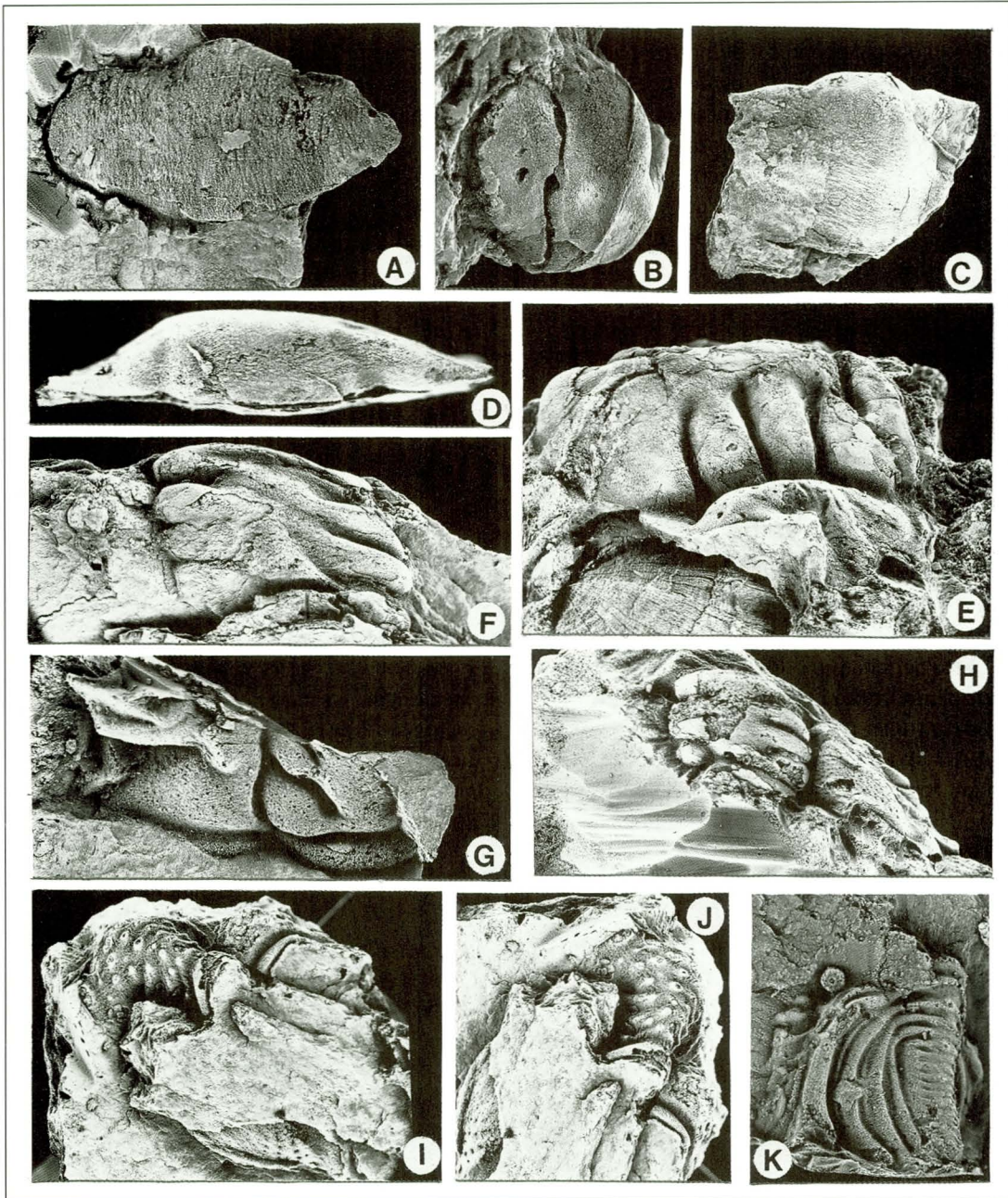U-V,   ventral valve (PMO 141054), internal cast, internal mold.

Fig. 6. Trilobites from the Kalstad Limestone at the Meldal A Locality.
Illaenus (?*Parillaenus*) sp. indet.

A,   pygidium (PMO 140994), internal mold, dorsal view, X2.

B,   pygidium (PMO 140995), internal mold, dorsal view, X2.

C-D, cranidium (PMO 140993), internal mold, anterior (X1) and dorsal (X2) views.

Hadromerus sp. indet.

E,   cranidium (PMO 140996), internal mold, left (X2) and lateral view (X2.5).

F,   cranidium (PMO 140997), internal mold, dorsal view, X3.

G,   cranidium (PMO 140998), internal mold, dorsal view, X2.5.

H,   cranidium (PMO 140999), rubber cast from external mold, dorsal view, X3.

Atractopyge sp. indet.

I-J, cranidium (PMO 141000), internal mold, oblique posterior and dorsal views X2.

K,   pygidium (PMO 141001), rubber cast from external mold, dorsal view, X4.

roemeri (see Ingham 1970, pl. 3, figs. 8, 9, 13, 14) but unfortunately does not reveal details of the doublure. However, slight compression along the left lateral margin indicates that the doublure is vertical here as it is in uncompressed material from the Ashgill of the Oslo Region figured by Bruton & Owen (1988, fig. 7d,f,g,h). The cranidium (Figs.6 C-D) is folded along the posterior margin but shows the glabella to be long (sag.) forward of the eyes, a feature shared with *I.(P.) roemeri*.

Hadromerus sp. indet. Figs. 6, E-H, 4 cranidia (PMO 140996, 140997, 140998, 140999). The laterally compressed specimen (Fig. 6E), and two frontally compressed specimens (Figs.6 F,H) can be compared with many of the British cheirurid genera discussed by Lane (1971) but they appear to be most like those assigned to *Hadromerus*, especially the Ashgill-age species *H. keisleyensis* (Dean, 1971 pl. 7, figs. 1, 4, 5; Lane 1971, pl.3, fig. 3, pl. 4, figs. 1-4) on account of the shape of the glabella furrows and form of the basal lobe (Fig. 6 G). In this respect they are unlike the cranidium of the pliomerid *Ectenonotus* (Bruton *in* Neuman & Bruton 1989, figs. 10 M-N) in which the glabellar lobes are expanded distally and the 3P is reduced to a pit. *H. keisleyensis* has been described from a number of Ashgill-age localities including the Chair of Kildare, Ireland. It is probably conspecific with *H. clasonii* (Törnquist, 1905) from the Boda Limestone, Sweden (Dean 1971), although Kielan-Jaworowska et al. (1991) suggested otherwise. *H.* aff. *keisleyensis* is also known from the Ashgill of the Oslo Region (Owen 1981, p. 40, pl. 9, figs. 15-22; pl. 10, fig. 1, and references).

Atractopyge sp. Figs. 6, I-K; one cranidium (PMO 141000) and one pygidium (PMO 141001). The cranidium (Figs. 6, I,J), is very compressed but shows clearly a less dense tuberculation on the glabella than is known from the type species, *A. verrucosa* (Dalman) (for discussion, see Dean 1971 pp. 35-40, pl. 14, 15, 16; 1974, pp. 97-98, text-fig. 4), known from the Ashgill of Wales and Eire.

The pygidium (Fig. 6, K), although incomplete posteriorly, is similar to that of *A.* cf. *verrucosa* (Dean 1971, pl. 16, figs. 5,6,8,9), from the Chair of Kildare, in the broad curvature of pleural ribs and bands of the first four complete rachial rings and at least 12 smaller rings. These features of the pygidium and tuberculation of the glabella allow comparison with *A. confusa* Owen (1981, pp. 57-59 pl.13, figs. 17-21, pl. 14, figs. 1-7,10) from the Ashgill of the Oslo Region, and material from the Caradoc, including the Mjøsa Formation, formerly assigned to *A. brevicauda* (Angelin) by Nikolaisen (1961 pl. 2, figs. 6,7). For discussion see Owen (1981).

Berg Farm locality

Coquinas of brachiopods were found in 1970 by Neuman and Bruton in two large, freshly excavated blocks of tuff in a field of the Berg farm adjacent to Highway 700 (Fig. 2; Berg Farm locality, GR 354/916). The source of these blocks was indicated as outcrops at a building site in a copse at the southern edge of the field (GR 355/918), but shell beds were

not found there. By 1980 the field had become a housing development, the outcrops had been incorporated in the landscaping behind new houses, and were thus unavailable to us.

These rocks mark the boundary between the Kalstad Limestone and the overlying Ryanda Formation of Ryan et al. (1980), and presumably belong to the base of the latter.

The fossiliferous rock is strongly cleaved, and, except for the shell beds, is an aphanitic, hard, massive, grey tuff. Indications of bedding are lacking except where expressed by the shell beds (one or more, about 5 cm thick) where cleavage is oblique (~45 degrees) to bedding.

Deformation prohibits identification of most of the specimens from this shell bed. Of the uncounted scores that were examined, nine were found whose features, taken together, suggest that, with one exception, they belong to a single indeterminate species of *Catazyga*. The exception is a fragment of the external mold of an indeterminate strophomenacean (PMO 141065, Fig.7, Q).

Catazyga sp. PMO 141057 - 141064, Figs. 7, A-P. The specimens have an external ornament of fine costellae like that of other species of the genus (PMO 141058, Figs.7, D-E). The elongated internal mold of a specimen of conjoined valves (PMO 141057, Figs.7, A-B) has a ventribiconvex profile, an outline that is narrow at the hinge, and cardinal extremities that are narrowly rounded; the sides are broadly rounded posteriorly, straightening and converging to a narrowed arc at the front (present dimensions: length-17 mm, hinge width-10 mm, maximum width-13mm, thickness-4 mm, maximum width and thickness at about midlength). These dimensions contrast strongly with those of undeformed specimens of the genus that are tumid in profile and nearly circular in outline. Only the most robust internal features are preserved, such as the narrow notothyrial cavity, the weakly impressed myophragm of the dorsal valve, and the broad delthyrial cavity of the ventral valve. The deeply impressed ventral muscle scars that are characteristic of this genus are not preserved on this specimen, but they are in several other specimens as are the stout teeth and incurved beak. These specimens resemble those identified as *Catazyga* cf. *C. anticostiensis* (Billings) from Ashgill-age rocks in Maine (Boucot et al. 1964) that are similarly preserved but somewhat less deformed.

Catazyga commonly occurs in tightly crowded monospecific accumulations such as *C. headi* in the Late Ordovician Bull Fork Formation in Kentucky (Weir et al. 1984) and the Nicolet River Formation in southern Quebec (Bretsky 1977).

Svartsætra locality

Brachiopods occur in shaly rocks and siltstone at three places west of the Svorka River near the 6992 latitudinal grid line (Fig. 1). These rocks were assigned to the 'Upper Hovin Group by Walsh (1986), having previously been classed as Lower Sandå Group by Chaloupsky (1970, 1977) and
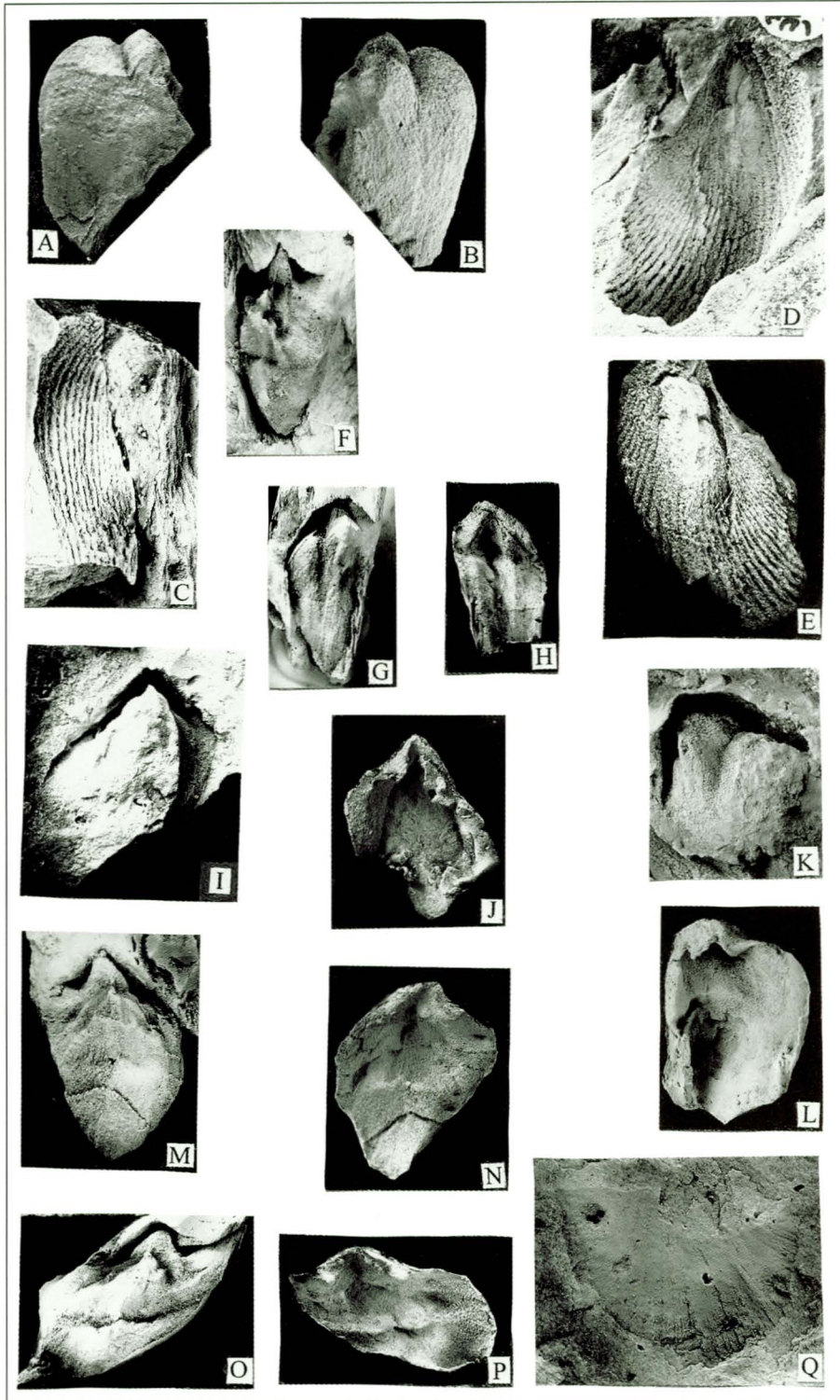
Fig. 7. Brachiopods from the former Berg Farm at Meldal.
Catazyga sp. indet., all at X2.

A-C,   articulated valves (PMO 141057), internal mold, ventral view; dorsal view; external mold, dorsal view.

D-E,   ventral valve (PMO 141058); external mold, external cast.

F,   ventral valve (PMO 141063), internal mold.

G-H. ventral valve (PMO 141061), internal mold, internal cast.

I-J,   ventral valve (PMO 141060), internal mold, internal cast.

K-L,   ventral valve (PMO 141059), internal mold, internal cast.

M-N, ventral valve (PMO 141064), internal mold, internal cast.

O-P,   ventral valve (PMO 141062), internal mold, internal cast.

Strophomenacean indet.

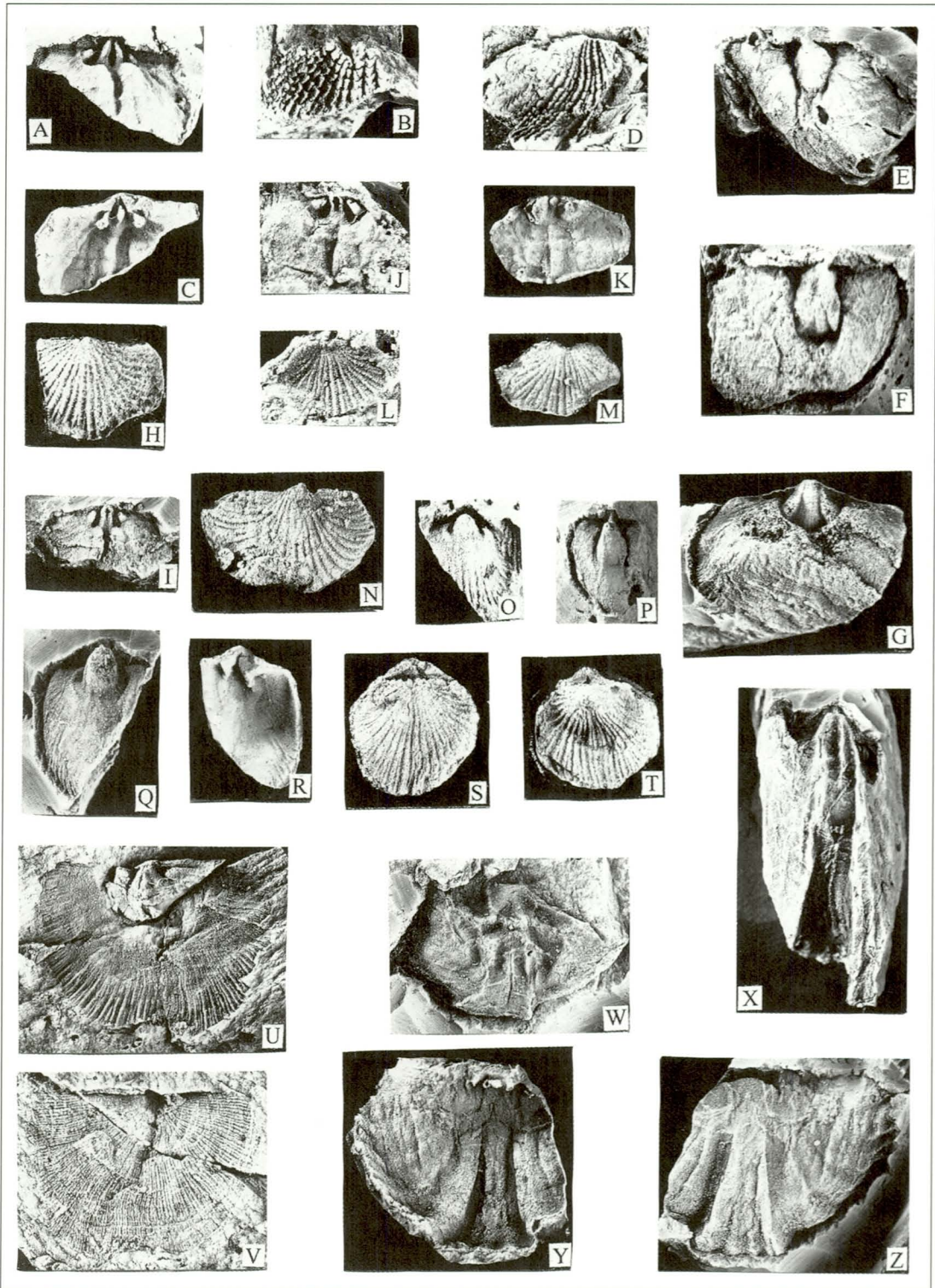Q.   dorsal valve? (PMO 141065), external mold, X1.5.

Fig. 8. Brachiopods from the Svartsaetra locality, a.
Glyptorthis sp., X2 except A-C at X3.

A-C,   dorsal valve (PMO 141066), internal mold, external mold, internal cast.
D-E,   ventral valve (PMO 141067), partial external mold, internal mold.
F,   ventral valve (PMO 141069), internal mold.
G,   ventral valve (PMO 141068), internal mold.
H,   ventral valve (PMO 141070), external mold.

Paucicrura sp, X3.
I,   dorsal valve (PMO 141073), internal mold.
J-M,   dorsal valve (PMO 141072), internal mold, internal cast, external mold, external cast.
N,   ventral valve (PMO 141074), external mold.
O,   ventral valve (PMO 141078), internal mold.
P,   ventral valve (PMO 141079), internal mold.
Q-R,   ventral valve (PMO 141077), internal mold, internal cast.

Nyplassen Formation by Ryan et al. (1980). The brachiopods were widely scattered through the upper 200 m (GR 485/918-486-919) of a vertical, south-facing sequence of gray and black silty shale that crops out in low cuts along the north side of a narrow lane that leads to the old house named Svartsætra (Fig. 3; Bruton & Bockelie, 1982). Beneath the shale are beds of limestone and tuff, the former having yielded the conodonts described by Bergström (1997); they also contain gastropods and rugose corals that have not been studied.

Most specimens are deformed and fractured. Nevertheless, eight brachiopod genera were identified in collections from this locality as follows:

Glyptorthis sp., 22 specimens, Figs. 8, A-H;
Skenidioides sp., 4 specimens, Figs. 9, C-F;
Paucicrura sp., 28 specimens, Figs. 8, I-T;
Triplesia sp., 1 specimen, Fig. 8, W;
Oxoplecia sp., 3 specimens, Figs. 8, X-Z;
Sowerbyella sp., 7 specimens, none figured
Leptaena sp., 23 specimens, Figs. 9, I-T;
Rafinesquina? sp., 3 specimens, Figs. 9, A-H.

Brachiopods were also collected at two places west of Svartsætra. Large numbers of relatively undeformed brachiopods occur on bedding sufaces of thin-bedded siltstone about 1.5km. SW of Svartsætra (Chaloupsky 1970). These rocks crop out in a low, moss-covered ledge at the edge of a bog that surrounds a small circular pond (GR 479/916). The brachiopods were identified as Sowerbyella (Sowerbyella) Jones, 1928 by Havlíček (in Chaloupsky 1970); figure 13 of that paper shows latex casts of three of these specimens. No other brachiopods were seen in our large sample from this locality, but it did contain one specimen of a bellerophontid gastropod.

About 2.35 km to the southwest, on the west side of a small creek at GR 457/909 (about 400 m southeast of Rikstadstra), highly cleaved dark-gray siltstone contains small zoaria of hemispherical bryozoans and nearly obliterated unidentifiable brachiopods.

Notes on the generically identifiable brachiopods at the Svartsætra locality are given below.

Glyptorthis sp. Figs. 8, A-H, 22 specimens, five figured (PMO 141066 - 141070). The specimens are elliptical to subquadrate in outline, wider than long (the three largest and best preserved average 13 mm long, 15 mm wide), ventribiconvex, with a short (0.5 mm) orthocline dorsal interarea and a slightly concave, apsacline ventral interarea three times longer. The lateral profile of the posterior third of the dorsal valve is marked by a shallow sulcus that disappears at midlength; the ventral valve is broadly rounded, somewhat deeper than the dorsal valve, and the anterior commissure is rectimarginate. The radial ornament consists of strong, rounded, anteriorly expanding costellae, a few of which branch at two zones, one about one-third shell length, the other at two-thirds shell length, numbering 35 to 40 around the perimeter of the larger shells. Prominent growth lamellae characteristic of the genus are spaced at about 0.5 mm intervals. The cardinalia in the dorsal valve, visible on only one fragmentary specimen (PMO 141066, Fig. 8, A-C), consist of an elevated notothyrial platform whose full length is occupied by the base of a high, bladelike cardinal process; the brachiophores were probably perpendicular to the shell floor prior to deformation but are now oblique to it and parallel to each other; they are long, thin, and have sharply rounded terminations. The sockets are defined by thickened shell at the junction of the posterolateral faces of the brachiophore bases on the posterior shell wall. Deformation has obliterated some internal features of ventral valves, and distorted others. The teeth and dental plates are not preserved in any of them. Although the thickened margin of the muscle field is preserved, details have been obscured and distorted so that its shape and length/width proportions are significantly different in the two best preserved specimens, one having the more robust adductor track that is longitudinally striated, wider than the diductors, and stands slightly above them (PMO 141068, Fig.8, G; PMO 141069; Fig. 8, F). Mantle canals are not preserved in any of them.

Skenidioides sp. Figs. 9, C-F, four specimens, one (PMO 141071) figured. This genus is represented by two small dorsal valves that are reasonably well preserved, and two ventral valves, both caught in tight folds. The dorsal valve illustrated is triangular in outline (length - 3.5 mm, hinge-width - 10 mm), deeply sulcate in transverse profile, and ornamented by about 32 angular costellae. Its elevated cardinalia are supported by a median septum; the notothyrial platform bears a bladelike cardinal process that is contiguous with the septum. The brachiophore bases are short and rodlike. A pair of elliptical depressions on the posteromedial part of the shell floor mark the undifferentiated adductor muscle scars. In both specimens of the ventral valve a short median septum supports the spondylium.

Paucicrura sp. Figs. 8, I - T, 28 specimens, eight figured (PMO 141072 - 141079. Identification of these dalmanellid
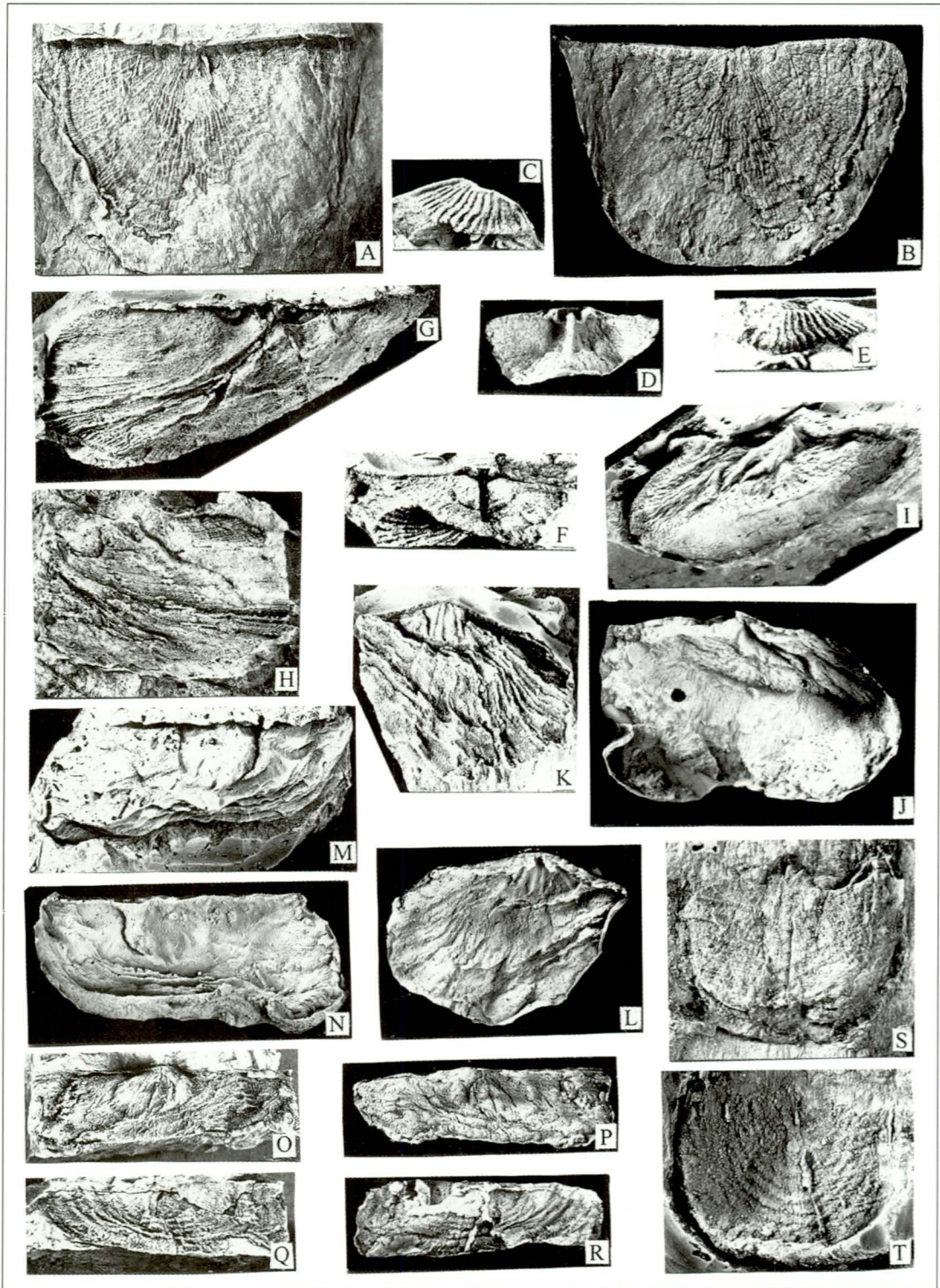

Fig. 9. Brachiopods from the Svartsætra locality, b.

Rafinesquina? sp.

A-B,   dorsal valve (PMO 141090) X1, external mold, external cast.

G-H,   dorsal valve (PMO 141091) X1.5, internal mold of obliquely defor-
        med specimen, partial external mold corresponding with left-
        hand part of internal mold.

Skenidioides sp.

C-F,   dorsal valve (PMO 141071) X3, external cast, internal cast, exter-
        nal mold, internal mold.

Leptaena sp., X1.5,

I-J,   ventral valve (PMO 141086), internal mold of obliquely deformed
        specimen sharply folded away from the viewer, internal cast.

K-L,   ventral valve (PMO 141088), internal mold of laterally deformed
        specimen, internal cast.

M-N,   ventral valve (PMO 141087), internal mold of longitudinally com-
        pressed specimen, internal cast.

O-R,   ventral valve (PMO 141085), laterally compressed specimen, in-
        ternal mold, internal cast, external mold, external cast.

S-T,   Dorsal valve (PMO 141089), incomplete specimen lacking poste-
        rior parts, internal mold, external mold.

specimens as *Paucicrura* sp. is based on internal features of dorsal valves, particularly the configuration of the cardinal process, and the absence of fulcral plates. These are small shells (average dimensions of the three whose outlines are best preserved: length - 6 mm, width - 8 mm) that are subcircular to transversely subelliptical in outline. Ventral valves have a high beak that extends beyond the hinge and are broadly arched in lateral profile; dorsal valves have a shallow sulcus. The coarsely costellate radial ornament consists of two to three costellae per millimeter near the front of larger valves; branching is largely limited to the front third of the shell surface. Punctae are relatively coarse, closely spaced, and cover the entire shell surface. Inside the dorsal valve the notothyrial platform is low and narrow, and its sides are nearly parallel between the stout brachiophore bases; sockets have floors of thickened shell withouut indications of fulcral plates. The cardinal process shaft is a low, narrow ridge through the anterior half of the notothyrial platform, rising and thickening posteriorly to the myophore whose lateral lobes are separated by a median crest (PMO 141073, Fig. 8, I). Where well impressed the quadripartite adductor scars occupy the posterior half of the shell floor, medially divided by a myophragm, the posterior pair slightly smaller than the anterior pair. Inside the ventral valve the strong hinge teeth are supported by short dental plates that are narrowly divergent at their bases forming the lateral margins of the muscle field. The muscle scars are weakly differentiated; the adductor track occupies about two-thirds of the width of the field and extends slightly beyond the diductors to define its broadly curved anterior margin. A pedicle callist is present on some specimens.

Triplesia sp. Fig. 8, W; one specimen, PMO 141080. An internal mold of a dorsal valve is large (length-15 mm, width-22 mm at midlength) and moderately convex (thickness-4 mm at midlength), bears the imprint of a sharply defined, flat-crested fold. Neither fold nor flanks are marked by indications of costation. Cardinalia are not preserved, but the posterior and anterior adductor muscle scars and the thin septum that separates the latter, features that are characteristic of the genus, are well impressed on the specimen.

Oxoplecia sp. Figs. 8, X-Z, three specimens, PMO 141081 - 141083. This genus is represented by two sulcate ventral valves and one plicate dorsal valve, all deformed. One longitudinally compressed dorsal valve (PMO 141081, Fig. 8, Y-Z) is 15 mm long, about 24 mm wide, and 3 mm thick; one ventral valve (PMO 141082, Fig. 8, X) that is strongly compressed laterally is 21 mm long, 10 mm wide, and 10 mm thick, and one moderately compressed ventral valve (PMO 141083, not illustrated) is 24 mm long, 22 mm wide, and 8 mm thick. Despite deformation the original shape of these specimens can be inferred; the outline was suboval, cardinal extremities were rounded, and the hinge-width was about two-thirds maximum width at about midlength. The narrow dorsal fold and ventral sulcus are bordered by pairs of strong costae and extend the full length of the shell. The ornament of angular

costae is best preserved on the external mold of the moderately deformed ventral valve; five costae are included between the stronger costae at the sides of the sulcus, and about six on the flanks of the shell; growth lines are strong, especially near the anterolateral margins where they are extended into short growth lamellae. The exterior of the dorsal valve is not preserved, but the steep-sided fold and the strong costae at its sides are reflected in the internal mold. The preserved parts of the cardinalia that arise from an elevated plate include the short notothyrial platform, the base of the cardinal process at its center, and the bases of the brachiophores at its sides, beyond which is a pair of short supports that link the plate to the shell floor. A pair of lobate, weakly impressed scars in front of these supports probably mark the adductor muscles. Mantle canals are not preserved. Internal molds of ventral valves preserve evidence of the large apical foramen, and stout teeth supported by short, erect dental plates. A short ridge at the apex of the delthyrial cavity (emphasized in the laterally compressed specimen) indicates the adductor muscle scars, but diductor scars are not evident, nor are mantle canals.

Sowerbyella sp. No specimen of *Sowerbyella* from this locality is well enough preserved to warrant illustration here. They are presumed to be congeneric with the well preserved specimens illustrated by Chaloupsky (1970) from the exposure of thin-bedded siltstone 1.25 km to the SW, mentioned above, where they are abundant on bedding surfaces.

Leptaena sp. Figs. 9, I-T, 23 specimens, five figured, PMO 141085 - 141089. These specimens have the rugose ornament and thin-bodied, concavo-convex geniculate profile that is characteristic of the genus. Their size is normal for the genus, as is their subquadrate shape; one minimally distorted specimen (PMO 141.084, not figured) selected as average for the suite at hand has a disc-width of 21 mm and a disc-length of 22 mm, both dimensions extended by a trail that is 5 mm long at the sides and 4 mm long at the front. Deformation has altered the shapes of most specimens, extending the width of some to nearly twice their length. The shell surfaces are ornamented by fine, nearly uniform costellae, about 4 per millimeter, that continue from disc to trail and by concentric rugae at about 1 mm intervals on the disc. The trail is sharply deflected dorsally; the boundary between them is marked by a sharp crease parallel to the rugae on the dorsal valve and a somewhat less conspicuous concentric ridge on the ventral valve. The interarea of neither valve is preserved, nor is there a specimen of a dorsal valve that permits observation of internal structures. In specimens of deformed ventral valves the muscle field is large and was probably nearly circular in shape before deformation; its lateral and anterior margins are raised above the shell floor, and are slightly undercut at the sides. The adductor scars are probably the small pads at the front of the field adjacent to a short median groove, and the diductor scars are to the sides and behind them (PMO 141086, Figs. 9, I, J). Of special interest are three closely adjacent articulated specimens that lie at

angles to each other on a small block (PMO 141084), all having the same dorsal-ventral positions, and all having quartz-pyrite intergrowths in their inner surfaces that suggest post-burial mineralization in shells that had not been filled with sediment.

Rafinesquina? sp. Figs. 8, U-V, 9, A-H, three specimens (PMO141090-141092). The shield-shaped outline of an external mold (Figs. 9, A-B) is nearly complete, 30 mm long, 50 mm wide at the hinge; its profile is little deformed although perhaps somewhat flattened. In outline its cardinal extremities are slightly extended, with long, nearly straight sides that extend to about two-thirds shell length where it merges with the broadly rounded front. Its profile, beyond a small postero-medial area of low convexity, is slightly concave. The parvicostellate ornament, preserved on a small part of the shell surface, consists of about 2 costae per millimeter, with two to five finer costellae lying between somewhat coarser ones. The internal mold of a tightly folded and sheared dorsal valve (Figs. 9, G-H) preserves impressions of the thick cardinal process lobes bordered on one side by a laterally directed socket plate behind which the elevated distal edge of thickened shell of the socket floor resembles a fulcral plate. Parvicostellate ornament is well preserved on the nearly flat external mold of a somewhat smaller ventral valve (Figs.8, U-V) that is 16 mm long and 22 mm wide. Fractures obscure most features of the internal mold, but the posterior part of the muscle field is preserved; its lateral margins are defined by the advancing bases of the widely divergent dental plates. The anterior margin of the muscle field does not extend beyond the fracture that cuts the specimen near its midlength.

Espehaug boulder and Brannsås locality

The source of the first fossils reported from the Hovin area (Brøgger 1875, 1878) was a large boulder of volcanogenic quartzitic sandstone of the Hovin Sandstone near the farm Espehaug (GR 568/973). The brachiopods were more fully described and illustrated by Reed (*in* Kiær 1932) as were the gastropods and a pelecypod by Strand (*in* Kiær, 1932). In 1980 we discovered an exposure with fossils 2.5 km S30W of Espehaug, about 300 m northwest of Brannsås farm (GR 553/953). The rock of this outcrop is identical to the fossiliferous rock of the Espehaug boulder, and several brachiopod genera occur in both. The local derivation of the Espehaug boulder is thus assured. Fossils are not abundant in the outcrop, and presumably they were similarly sparse in the Espehaug boulder, the latter having yielded about 30 brachiopod specimens, while only 13 specimens were obtained from the Brannsås outcrop; both yielded smaller numbers of gastropods and pelecypods.

Poor preservation (due to cleavage) and their small numbers render uncertain the generic identification of many of these specimens. Reed's list of 17 brachiopod taxa (*in* Kiær 1932) takes cognizance of these limitations with expressions of varying degrees of confidence in the names as-

| | | Number of specimens in collections | |
This paper	Identifications Reed (*in* Kiær, 1932)	Espehaug	Brannsås
Nicolella? sp.	1	1	—
Sulevorthis? sp.	2	1	—
Hesperorthis?	3	2	—
Schizophorella sp.	4	4	1
Hirnantia? sp.	5	1	2
Onniella? sp.	6	1	—
Kjaerina? sp.	7	1	—

Names used by Reed (*in* Kiær, 1932):

1 - *Orthis (Plectorthis) plicatella* Sowerby

2 - *Orthis (Austinella)* cf. *whitfieldi* Winchell

3 - *Orthis* cf. *tricenaria* Conrad and *Orthis (Plectorthis?) hovinensis* Reed

4 - *Orthis (Schizophorella) fallax* (McCoy) and *Plectatrypa* var. *marginalis* (Dalman) var.

5 - *Catazyga* cf. *anticostiensis* (Billings)

6 - *Orthis (Pionodema)* aff. *subaequata* Conrad

7 - *Strophomena* cf. *planodorsata* Winchell and Schuchert

Table 2. Comparison of names of brachiopod taxa from the Espehaug boulder in this paper with those of Reed (*in* Kiær, 1932).

signed to specimens, both by the use of question marks and by qualifying remarks in his descriptive text. Restudy of this collection included decalcification of some specimens to determine their internal features. Additional specimens were sought in excess rock that surrounded some of Reed's specimens, and this process yielded some gastropods and pelecypods, a solitary rugose coral, but only two additional brachiopods. As a result of this work, the brachiopods listed in Table 2 can be seen to have distinguishing characteristics that are sufficiently well preserved to permit their generic identification with a high degree of confidence. Explanations and caveats concerning these determinations and those of the less well preserved specimens are given in the following descriptive notes *Schizophorella* sp.= *Orthis (Schizophorella) fallax* (McCoy) of Reed (*in* Kiær 1932, p. 118-119, pl. 18, figs. 3-5); ventral valves from Espehaug, PMO 32833,32835, 32842; Fig. 12, P-T of this paper; ventral valve from Brannsås, PMO 141008, Fig. 10, A-B; dorsal valve, ex. *Plectatrypa marginalis* (Dalman) var. of Reed (*in* Kiær 1932, p.124-125, pl. 19, figs. 8,9, PMO 32822; Fig. 12, L-O of this paper). Although the generic identity of these specimens is confirmed with confidence, their preservation precludes determination of the species characteristics noted by Wright (1964) in his discussion of *Schizophorella fallax silicis*. The outline of each specimen is an ellipse that is deformed to varying degrees; all are widest at about midlength, most are wider than long, but one is longer than wide. In none of them is the interarea well exposed, but it is inferred to be apsacline, relatively long, and its width is equal to, or less than,
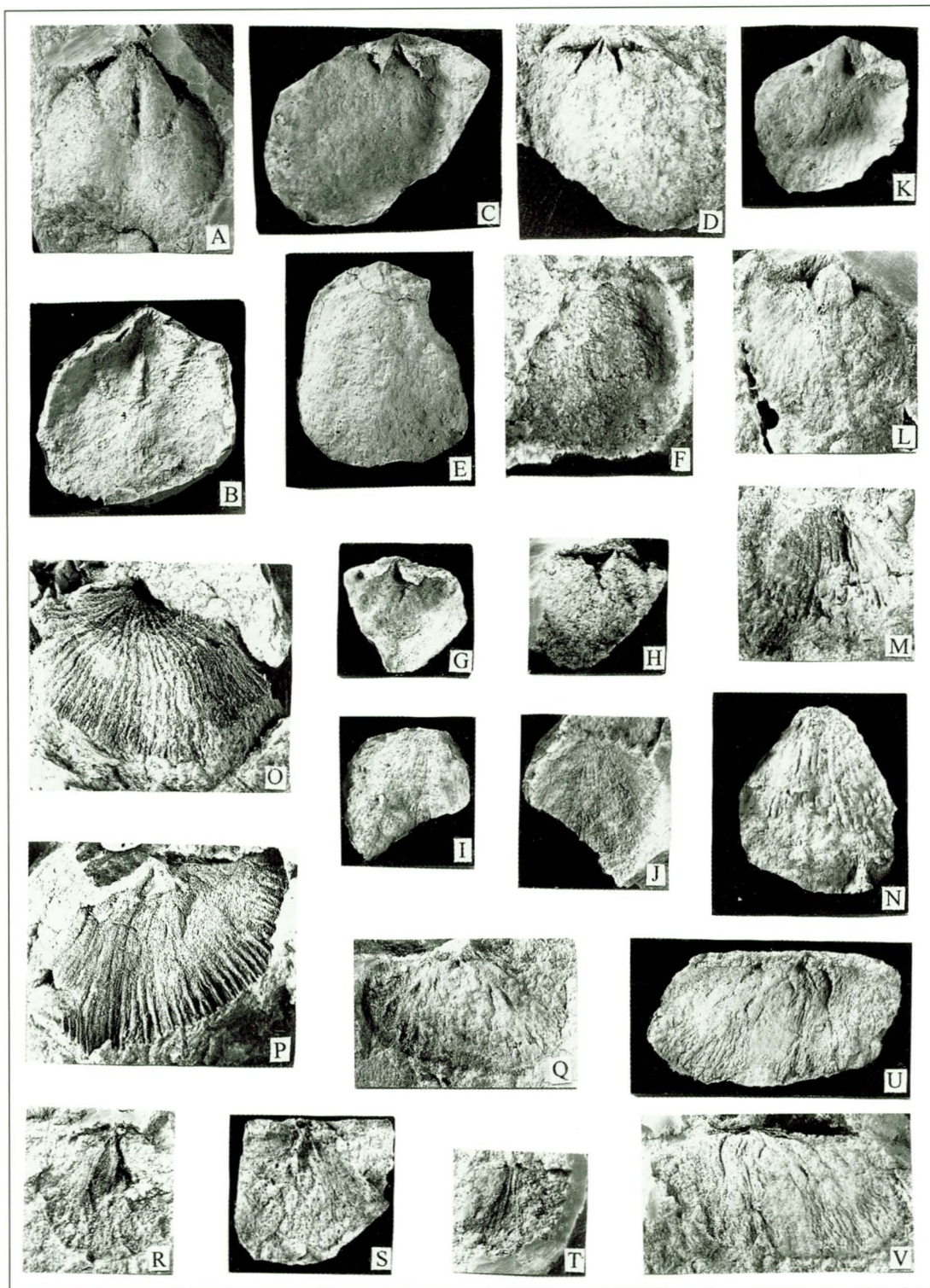
Fig. 10. Brachiopods from the Brannsås locality.
Schizophorella sp., X1.5.
A-B, ventral valve (PMO 141008), internal mold, internal cast.
Hirnantia? sp., X2.
C-F, dorsal valve (PMO 141009), internal cast, internal mold, external cast, external mold.
G-J, ventral valve (PMO 141014), internal mold, internal cast, external mold, external cast.
Orthid, genus and species indet. a, X2.
K-N, ventral valve, (PMO 141011), internal cast, internal mold, external

mold, external cast.
Plaesiomys? sp.
O-P, Incomplete ventral valve (PMO 141010), X 1.5, external mold, internal mold.
Sowerbyella sp., X 1.5.
Q, ventral valve (PMO 141007), internal mold.
R-S, dorsal valve (PMO 141004), internal mold, cast.
T, dorsal valve (PMO 141005), internal mold.
U-V, ventral valve (PMO 141006), cast, internal mold.

the maximum width of the shell; cardinal angles are thus right-angles or obtuse. All specimens are convex but flattened to varying degrees; maximum thickness is at about one-third shell length, beyond which a shallow sulcus appears, widening to about one-third shell width at the valve front. Ornament of fine costellae numbering 13 to 15 per 5 mm in a small, relatively well preserved part of a ventral external mold (PMO 32835, pl. 18 fig. 5 of Reed *in* Kiær, 1932; Figs. 12, S-T of this paper). The apparent median costa of this specimen is a post-mortem crack that cuts costellae at a low angle. Internal features of these ventral valves are those characteristic of the genus; hinge teeth are not well preserved; dental plates are stout, widely divergent, and form the posterolateral margins of the muscle area. The muscle area is large, cordate in outline, and occupies one-third to one-half the postero-medial part of the shell floor. The diductor scars have sharply rounded anterior margins and are deeper and longer than the narrow adductor track that divides them. No remnants of the mantle canal system are preserved.

A dorsal valve (PMO 32822, 32823) originally identified as *Plectatrypa marginalis* (Dalman) var. by Reed (*in* Kiær, 1932, p. 124-125, pl. 19, figs. 8,9; Figs. 12, L-O of this paper) is incomplete and laterally compressed. It bears a narrow, steep-sided fold; the posteromost edge of the specimen is a fracture surface along which its interarea, notothyrial platform, brachiophores, and related features were cut off. The subtriangular shape of the specimen, its convergent sides, and sharply rounded anterior margin are due to compression, as are the oversteepened and faulted margins of the flanks of its fold; thus it was probably originally slightly wider than its present dimensions (length-18 mm, width at midlength-19 mm). Deformation obscures details of its ornament, but its costae and interspaces appear to be rounded and to expand anteriorly with little increase in number beyond the beak; there are about 14 costae on each flank and 4 on the fold. Concentric ornament, if any, is not preserved. Visible internal features include quadripartite adductor muscle scars; the posterior pair are transversly oval depressions medially divided by a broad myophragm at the edge of the specimen; the low, short, widely divergent ridges at the posterior edge of the specimen probably projected from the brachiophore bases. The anterior pair of adductor scars are slightly thickened oval callosities medially divided by a short, thin, septum-like myophragm. Comparison of this specimen with dorsal valves of *Schizophorella* illustrated by Wright (1964, pl. 5, fig. 17) and by Harper (1984, pl. 10, figs. 1,2) supports this determination.

Sowerbyella sp.= *Sowerbyella (Eochonetes)* cf. *advena* (Reed) *in* Kiær (1932, p. 124; pl. 18, figs. 17, 18, PMO 32795-6, Figs. 13, G-J of this paper; pl. 19, fig. 12, PMO 32804, Figs. 13, K-L of this paper). Four specimens from the Brannsås locality: two dorsal valves (PMO 141004; Figs. 10, R-S of this paper; PMO 141005, Fig. 10, T of this paper); two ventral valves (PMO 141006, Figs. 10, U-V of this paper; PMO 141007, Fig. 10, Q of this paper). In the absence of «...traces of 2-3 small oblique

tubules on each side of the beak...» (Reed, *idem*.) on one specimen (PMO 32795) and on any of the three other ventral valves of this kind that are now available for study, all of these specimens are considered to belong to *Sowerbyella* s. s. rather than *Eochonetes*, a name originally introduced (Reed, 1917) as a subgenus of *Sowerbyella*. The three ventral valves are large, moderately convex in profile, transversely elliptical in outline, and their cardinal extremites are right-angles or slightly obtuse. The average dimensions of the three specimens whose outlines are best preserved are: length - 15mm, hinge-width - 22mm, maximum width at about midlength - 24mm. Parvicostellate ornament of costae separated by several finer costellae is poorly preserved in a small part of the external mold of one specimen (PMO 32795, Fig. 13, I). A convex, apparently imperforate pseudodeltidium is preserved on the specimen whose interarea is best preserved (PMO 32804, Fig.13, L). Hinge teeth are poorly preserved in internal molds; remnants of dental plates where best preserved are widely divergent (105°) and form the postero-lateral margins of the muscle field. Diductor scars widen anteriorly to their sharply curved terminations near midlength of the shell floor; the adductor track is a short median ridge between the posterior ends of the diductors. The anterolateral half of shell floor is coarsely pustulose and is marked by poorly defined grooves that are probably remnants of the vascular system.

The dorsal valve is represented by two specimens of concave shells from the Brannsås locality (PMO 141004, 141005, Fig. 10, R-S, T). Both are distorted and incomplete in outline and in most internal and external details. The cardinalia are not preserved in either, but both bear a pair of narrowly divergent slender septa that extend to midlength on the shell floor from the presumed site of the notothyrial platform; they are more conspicuous in one specimen than the other, apparently the result of their different response to deformation.

Catazyga sp. = *Catazyga* cf. *anticostiensis* (Billings) of Reed *in* Kiær (1932, p. 125); four illustrated specimens as follows: ventral valve, internal and external molds (PMO 32850-32851), pl. 18, figs. 6,9 of Reed (*in* Kiær, 1932), Figs. 13, Q-S of this paper; ventral valve, internal and external molds (PMO 32848 and 32849) pl. 18, figs. 7,8 of Reed (*in* Kiær, 1932), Figs. 13, M-P of this paper; internal mold of a dorsal valve (PMO 32832), pl. 18, fig. 11 of Reed (*in* Kiær, 1932), Figs. 13, T-U of this paper; an internal mold of a deformed ventral valve (PMO 32825), pl. 18, figs. 12, 12a of Reed (*in* Kiær, 1932), is not refigured in this paper. The specimen (PMO 32826; Pl. 18 fig. 10 of Reed (*in* Kiær, 1932), which was questionably assigned to this genus, is not a *Catazyga* but an indeterminate drabo-viid (Figs. 13, A-B). Visualized from these disarticulated specimens, this species is ventribiconvex in profile and elliptical in outline, slightly longer than wide, and bears a faint dorsal sulcus and a similarly faint ventral fold. The shell surface is ornamented by fine, rounded costellae that are uniformly spaced at 15-20 per cm through the anterior half of the
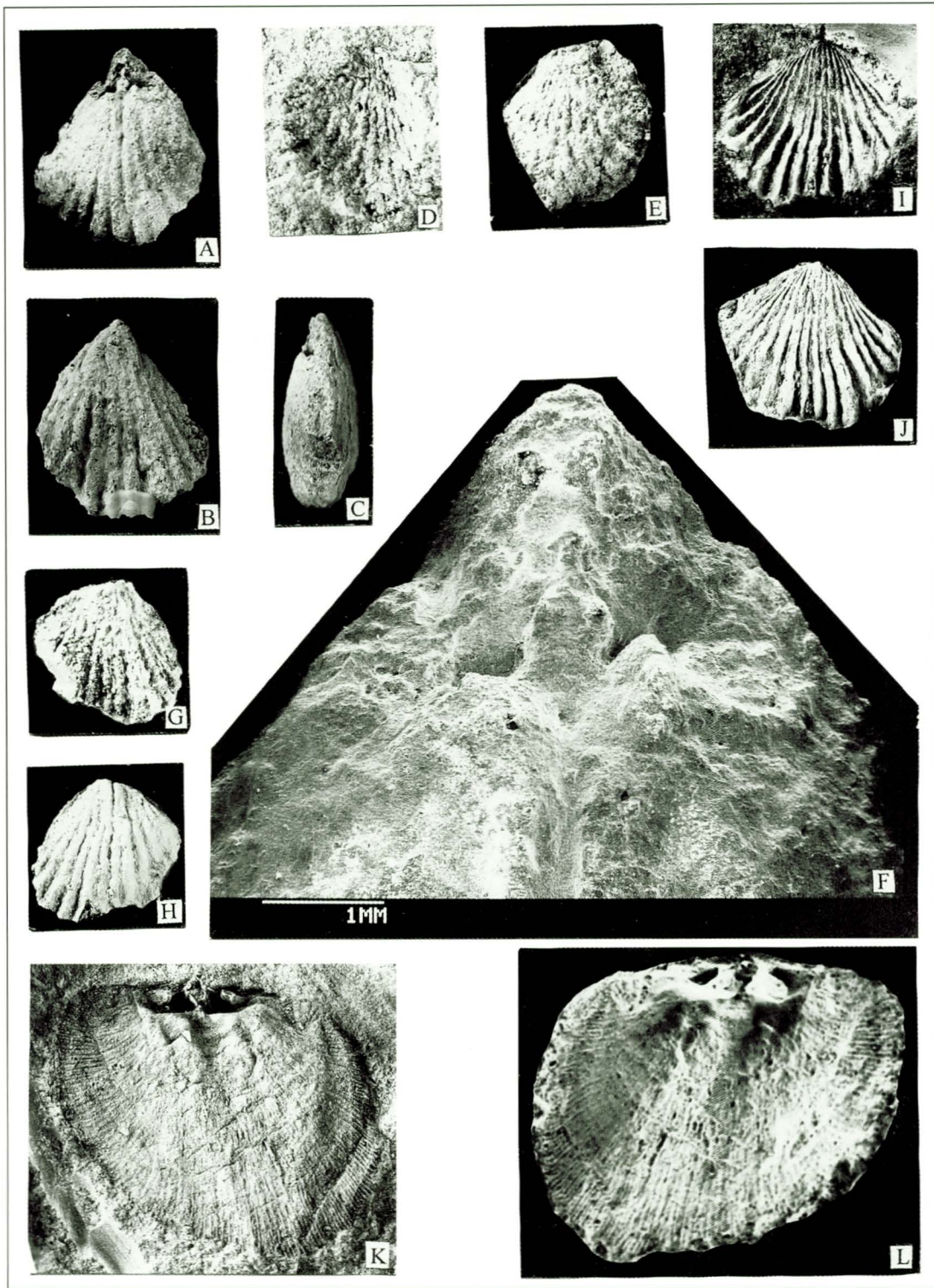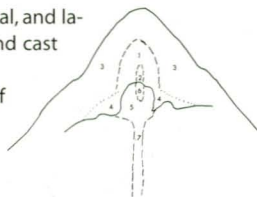
Fig. 11. Brachiopods from the Espehaug boulder and Brannsås locality, a. *Rhynchotrema?* sp. indet.

A-E, articulated valves (PMO 141012), X3, dorsal, and lateral views of steinkern, external mold and cast of dorsal valve; Brannsås locality.

F, same specimen, X20, posterior part of steinkern, dorsal view showing features indicated in sketch (SEM by W. R. Brown, Smithsonian Institution)

G-H, articulated valves (PMO 141013). X2, ventral and dorsal views of steinkern; Brannsås locality.

I-J, ventral valve, PMO 32841, (*Orthis (Playstrophia)* cf. *elegantula* McEwan, var. *triplicata* of Reed *in* Kiær 1932, p. 122, pl. 18, fig. 15), X2, external mold, external cast; Espehaug boulder.

Onniella? sp. (*Orthis (Pionodema)* aff. *subaequata* Conrad of Reed (*in* Kiær 1932, p. 120-121, pl. 19, fig.1).

K-L, dorsal valve (PMO 32840), X2, internal mold, internal cast; Espehaug boulder.

Significant features:

Ventral valve

1-Inner surface of deltidial plates
2-Gap between deltidial plates
3-Inner surface of incurved beak

Dorsal valve

4-Hinge plates with hidden crural bases
5-Floor of notothyrial platform
6-Cardinal process
7-Median septum

specimens, apparently increasing in number with shell growth, but poor preservation obscures details of the pattern of increase.

Dimensions of the more complete specimens are tabulated below.

Width				
Dorsal valve	Length	Maximum	Hinge	Thickness
PMO32832	18	14	10	2
Ventral valves				
PMO32848	18	14	8	5
PMO32851	16	12	8	3

The linking of the dorsal valve with ventral valves is based on their inferred common fine costellate ornament, the similarity of size and pre-deformation outline of Reed's specimens of ventral valves, and their internal features that are appropriate for ventral valves of this genus. The dorsal valve is less convex than dorsal valves of known species of the genus (Copper 1977), and it does not have a median septum as is common but variably developed in other species. Internal features include a pair of hinge plates divided by a narrow, steep-sided notothyrial cavity that lacks a cardinal process; crural bases are stout, and sockets are excavated at their postero-lateral sides. Thickening of the shell floor beneath the crural bases narrows to a broad, short myophragm between the shallow impressions of the elliptical adductor scars.

The ventral valves show that the delthyrial cavity is deep and partially filled with shell material at its apex; the teeth are strong and lack supporting plates but rise from the sides of the cavity and are curved dorsally. The muscle field is underlain by a shelf of thickened shell that ends at an abrupt step at about one-third shell length, accentuated and preserved as a transverse ridge in the compressed specimen. The adductor track is relatively narrow and divided by a small median ridge; diductor scars are shallow, oval depressions. Mantle canals are not preserved. Thus, although these ventral valves are like those of Catazyga, the low convexity of the dorsal valve and its lack of a median septum exclude them from C. anticositiensis but they cannot be assigned to a known species.

Below are my low-confidence identifications and comments on the remainder of the specimens identified by Reed from the Espehaug boulder.

Nicolella? sp. = Orthis (Plectorthis) plicata Sowerby of Reed (in Kiær 1932, p. 119, pl. 18, fig. 16; PMO 32805; Figs 14, M-N of this paper). One specimen, an internal mold of a ventral valve, is 19 mm long, 21 mm wide at the hinge. Its outline, formerly obscured by matrix that has been removed for this study, is subtriangular. The imprint of radial ornament around the anterolateral margin indicates the presence of about 20 strong costae including a median interspace. The muscle field is not as well preserved as shown in Reed's figu-

re, but enough of it remains to see that the adductor scars are longer than the poorly defined diductor track, and its anterior terminations are sharply rounded. The pair of shallow grooves («vascular sinuses» of Reed) extend midway into the shell floor from the anterior termination of the diductor track. Neither the Espehaug nor Brannsås collection contained a specimen of a dorsal valve whose morphology is appropriate for this genus.

Hesperorthis? sp. = Orthis cf. tricenaria Conrad of Reed (in Kiær 1930, PMO 32831, p. 121, pl. 18, fig. 14; Figs. 14, Q-R of this paper), an internal mold of a ventral valve, and Orthis (Plectorthis?) hovinensis Reed (in Kiær 1932), Reed's specimen PMO 32845, p. 119, pl. 19, fig. 10; Figs. 12, H-I of this paper), a dorsal valve. The semi-elliptical shape and subpyramidal profile of the ventral valve permit its identification as Hesperorthis? sp., as does the internal impression of its costate ornament. Internal features that might confirm this identification have been largely obliterated, the only preserved remnant being the trace of dental plates seen as a pair of very fine dorsally divergent lines beneath the beak on the posterior wall of the shell. Decalcification of the dorsal valve shows that its cardinalia are flattened and its brachiophores are fused with the palintrope; the front of the notothyrial platform is elevated above the shell floor except in front of the cardinal process (preserved as a low ridge) that merges with a broad median ridge that extends to midlength of the shell floor; adductor muscle scars can not be seen. The impression of about thirty coastae around the anterolateral margin of the specimen indicate the strongly costate radial ornament characteristic of Hesperorthis.

Plaesiomys? sp.; one specimen from the Brannsås locality (PMO 141010), Figs. 10, O-P. This ventral valve is large (length - 18 mm, hingewidth - 16 mm, restored from 12 mm, maximum width - 21 mm), incompletely preserved, resupinate, costellate. It probably had rectangular cardinal extremities and a semicircular anterolateral outline. The interarea is not preserved. The shell profile is moderately convex from beak to about one-fourth shell length, moderately concave at midlength, flattening near the front. Costae are spaced at about 12 per mm on the better preserved parts of the external mold and the anterolateral margin of the internal mold (Fig. 10, O). The internal mold (Fig. 11, P) preserves a remnant of the angular anterior margin of one adductor muscle scar.

Kjaerina? sp.= Strophomena cf. planodorsata Winchell and Schuchert of Reed in Kiær 1932. (PMO 32839; Reed in Kiær 1932, p. 123, Pl. 19, fig. 11; Figs. 13, E-F of this paper). After decalcification, this specimen proves to be a strophomenid ventral valve in which the muscle field is marked only by low subparallel ridges at its sides. Its present asymmetical outline suggests that it was originally subquadrate in outline, about one-fifth longer than wide, and its cardinal angles were about 90°. Its shallow profile is probably little different from the original, having low convexity in its postero-medial part and a shallow sulcus from midlength to anterior margin. Strain is indicated by deformation of details, such as the

elongation of the palintrope and its appression onto the shell floor, and the asymmetry of the ridges on the shell floor; the one on the left of the internal mold (Fig.14, E) is now thickened and inclined leftward, nearly parallel to the remnant of the one on the right, suggesting that originally they were erect. Individual muscle scars are not preserved.

Sulevorthis? sp., ex *Orthis (Austinella)* cf. *whitfieldi* Winchell of Reed (*in* Kiær 1932, p. 120; pl. 22, fig. 15; PMO 32820; Figs.12, J-K of this paper). Decalcification of this one of the two specimens identified as *O. (A.) whitfieldi* by Reed revealed a tripartite muscle field that is incompatible with that identification. Despite its incompleteness, it can be seen that the shell was moderately convex and its outline is wider than long (hinge width preserved-8 mm, restored-14 mm; maximum width near midlength-15 mm; length-12 mm). Its radial ornament, indicated by internal impressions, consists of about 6 costae per 5 mm near the front of the shell. The muscle field is a subtriangular pad of thickened shell; adductor scars are slightly thicker, longer, and wider than diductors.

Onniella? sp. = *Orthis (Pionodema)* aff. *subaequata* Conrad of Reed (*in* Kiær, 1932, p. 120-121, pl. 19, fig. 1; PMO 32840; Figs. 11 K-L of this paper). Decalcification of this large specimen shows that it is a gerontic dorsal valve whose thickened cardinalia render its generic identification uncertain. Its presumed original dalmanelloid transversely elliptical shape and low convexity was distorted by left-lateral shearing so that the angle betweeen the hinge-line and midline (in the trough of the shallow sulcus) is 70°; the profile has also been altered, deepening the right side (internal mold), and steepening its right lateral margin. Impressions of the finely costellate ornamentation on the shell floor reflect deformation, because the spacing of costellae ranges from about 12 per 5 mm on the left of the center line to as many as 16 per 5 mm on the right side. The notothyrial platform is filled by the cardinal process that is mound-shaped and bears a small medially cleft myophore on its posterior face. The widely divergent brachiophores are long, thick, and club-like, with blunt terminations; sockets have floors of thickened shell, one of the pair resembling a fulcral plate in having a distinct rim that meets the posterior shell wall. The posterior third of the shell floor bears a myophragm between the opposite halves of the well-marked quadripartite adductor muscle scars.

Dalmanellid, genus and species indet.= *Zygospira* cf. *recurvirostris* (Billings) of Reed (*in* Kiær 1932, pl. 19, fig. 3; PMO 32846, Figs. 13, C-D of this paper. Examination after decalcification of this one of the two specimens that Reed assigned to *Zygospira* indicates that it is probably the ventral valve of a generically indeterminate dalmanellid. It is small, moderately convex, transversely elliptical, 6 mm long, 8 mm maximum width at mid-length, about one-fourth greater than its 6 mm hinge width. It has short dental plates that border the muscle field for one-fourth its length. The muscle field is well impressed, tripartite; about half its width is occupied by the

adductor track which is raised slightly above the diductors; the spacing of impressions of fine costella on the antero-lateral margins of the shell floor are appropriate for a dalmanellid brachiopod. Evidence of punctation, if originally present, is not preserved.

Hirnantia? sp. Two specimens of dorsal valves from the Brannsås locality (PMO 141009, Figs. 10, C-F; PMO 141014; Figs. 10, G-J) and one specimen of a ventral valve from the Espehaug boulder (PMO 32826, = *Catazyga* cf. *anticostiensis* (Billings)? of Reed *in* Kiær 1932, pl. 18, fig. 10; Fig. 13, A-B of this paper). The best preserved specimen (PMO 141009, Figs. 10, C-F) is moderately convex and elongate and its cardialia are preserved in its internal mold; its counterpart external mold is less well preserved and little of it retains indications of its ornament. The outline of the shell is elliptical, 15 mm long, 9 mm wide at the hinge, maximum width of 12 mm at midlengh where it is about 3 mm thick. A narrow, shallow sulcus extends from near the beak to its anterior margin. An ornament of very fine costellae is suggested by a few very faint lines near the middle of the external mold. The flat, anacline interarea is about 1 mm long. Internal features seen on the internal mold are the cardinal process with its long ridgelike shaft and small knoblike myophore, and the bases of the brachiophore supports that diverge at 45° and extend beyond the cardinal process shaft. In the latex cast the brachiophore support plates are vertical at the sides of the notothyrial platform, rising to join the brachiophore bases that are triangular blades perpendicular to the support plates and linked to the inner face of the notothyrium by small fulcral plates.

The other dorsal valve from the Brannsås locality (PMO 141014; Figs. 10, G-J) is tentatively identified as congeneric in the absence of a more compelling alternative. Its incompletely preserved outline is estimated to have been semielliptical, about 9 mm long, about the same as maximum width at the hinge; cardinal extremities are rectangular, sides convergent, front narrowly rounded; profile is moderately convex and it bears a shallow sulcus through the posterior third but not beyond. The radial ornament of fine ribs (~12 per 5 mm at the front) is poorly preserved on the external mold, and its branching pattern cannot be determined. The notothyrial platform of slightly thickened shell is relatively large and wide; its posterolateral sides are defined by the widely divergent, short brachiophore bases; its front is marked by a transverse step to the shell floor. The small, knoblike cardinal process is confined to the apex of the platform, without indications of a shaft. The adductor scars are not preserved.

Decalcification of the specimen from the Espehaug boulder shows that it is a ventral valve more like *Hirnantia* than *Catazyga*. It is transversely elipical in outline, with obtuse, rounded cardinal extremities. It is 14 mm long, 16 mm in maximum width, and 3 mm thick near midlength. Its interarea is flattened and incompletely preserved. The remains of its interarea, presumably originally apsacline, is now orthocline in the commissural plane. The profile is highly arched
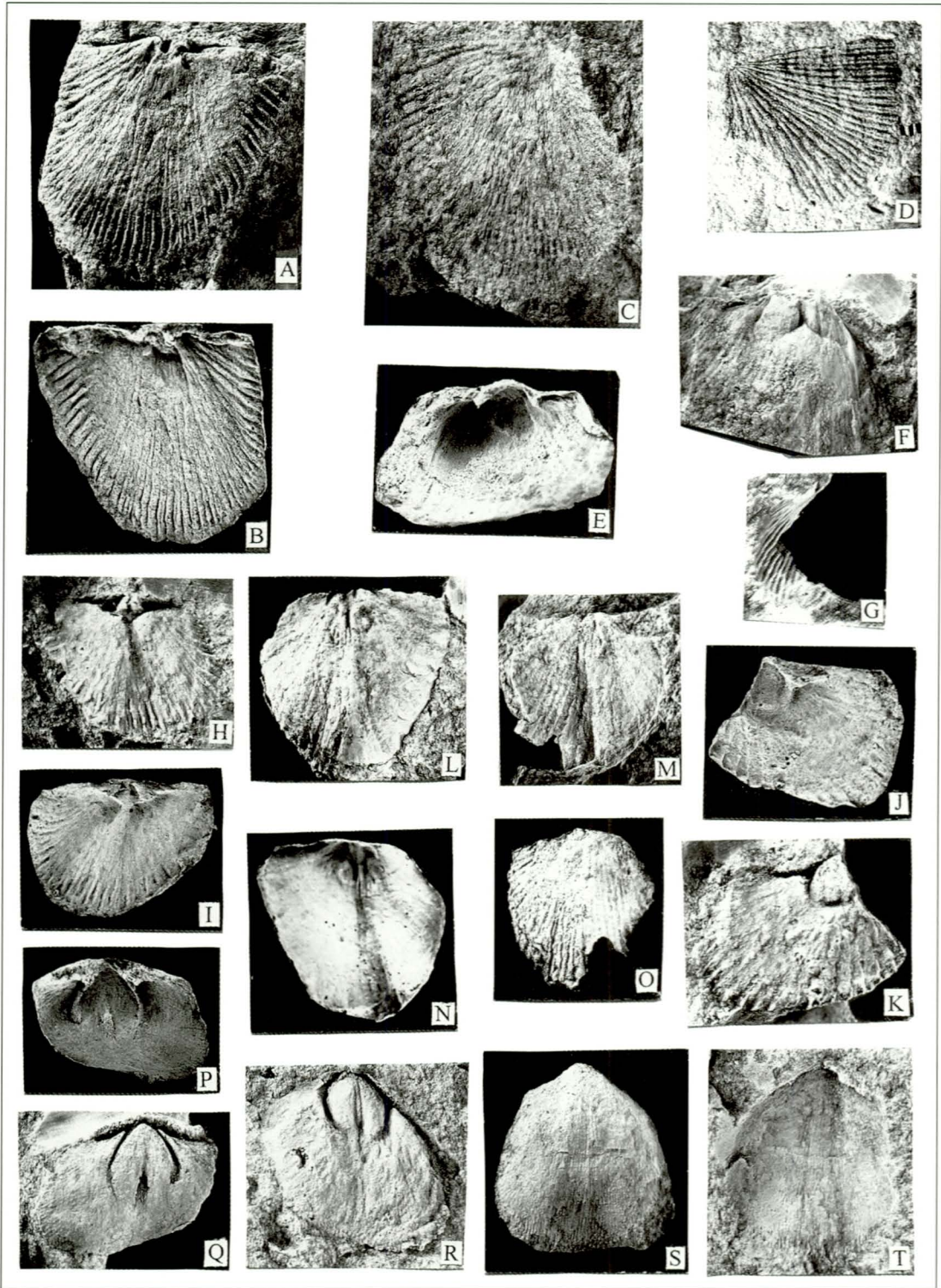
Fig. 12. Brachiopods from the Espehaug boulder, a.
Orthid, genus and species indeterminate b.

A-B,   dorsal valve (PMO 32815), X 2 *(Orthis (Dinorthis)?* sp. of Reed *in*
        Kiær 1932, pl. 19, fig. 4), internal mold, internal cast.
C,   external mold (PMO 32813), X 2, same specimen as above (pl. 19,
        fig. 5 of Reed *in* Kiær 1932),
D,   dorsal valve? (PMO 32809), X 1.5 *(Orthis (Dinorthis?)* sp. of Reed *in*
        Kiær 1932, pl. 19, fig. 6), external mold.

E-G,   ventral valve, partial specimen (PMO 141002), X2, internal cast, in-
        ternal mold, fragment of external mold.
Hesperorthis?,
H-I,   dorsal valve (PMO 32845), X 2 *(Orthis (Plectorthis?) hovinensis* of
        Reed *in* Kiær 1932, pl. 19, fig. 10), internal cast, internal mold.
Sulevorthis? sp.,
J-K,   ventral valve (PMO 32820, X2 *(Orthis (Austinella) cf. whitfieldi*
        (Winchell) of Reed *in* Kiær 1932, pl. 22, fig. 15), internal cast, inter-

and a low fold is developed through the front third to the anterior margin. Reed's drawing of the partly exfoliated surface of this specimen prior to decalcification portrays a nearly smooth surface to about midlength that grades into pronounced ribbing, and around the anterolateral margin some ribs are branched. Rib spacing, greater than that of associated specimens of *Catazyga*, averages about 1 per mm, with a maximum of 12 per 17 mm in the medial sector of the shell. The ribbing pattern is faintly impressed on the decalcified internal mold. The short, stout teeth are supported by receding dental plates which at their bases diverge at ~50° defining the sides of the delthyrial cavity. A pedicle calyst is visible at its apex. The muscle field of somewhat thickened shell consists of narrow diductor scars and an adductor track whose arcuate termination extends slightly beyond them. The posterior part of the muscle field is deeply set, but individual muscle scars are not preserved. Radial ornament is impressed on the floor of the specimen beyond midlength, spaced at about 10 costae per 5 mm at its anteromedial margin near midwidth.

Orthid, genus and species indet. a (PMO 141011, Figs.10, K-N) from the Brannsås locality. An internal and external mold of this costate, moderately convex, semielliptical ventral valve is 13 mm long and 12 mm wide at the rounded cardinal extremities. Its interarea is flat, short (~1 mm), and has a low apsacline slope, approaching orthocline. Its profile from beak to about midlength is highly arched, possibly a low fold that is marked by three costae, but the imprint of the median sector of the external mold beyond midlength is obliterated. Five costae are visible on the best preserved lateral slope. The internal mold preserves stout teeth supported by short, receding, nearly vertical dental plates that define the posterolateral margins of the triangular muscle field. The relatively narrow diductor scars are more deeply set and slightly longer than the adductor scars. The orthid affinities of this specimen are indicated by its reasonably well preserved musculature, but poor preservation of other features prohibits a more precise identification.

Orthid, gen. and species indet. b = *Orthis (Dinorthis)?* sp. of Reed (*in* Kiær 1932, p. 121); three specimens from the Espehaug boulder (PMO 32813, 32815; pl. 19, figs. 4, 5, Figs. 12, A-C of this paper; PMO 32809, pl. 19, fig. 6, Figs.12, D of this paper); one specimen (PMO 141002; Figs. 12, E-G) not known to Reed, from rock trimmed from another specimen from the Espehaug boulder. The identification of none of these specimens can be confirmed. One (PMO 32813) is an

internal mold of a large, nearly planar fine-ribbed dorsal valve and its counterpart external mold; it is shield-shaped in outline, widest at the hinge; cardinal extremities are rectangular, sides are subparallel to about midlength, merging with broadly rounded anterior margin. Its dimensions are: 18 mm long, 18mm wide at the hinge, 16mm at midwidth, ~3 mm maximum thickness at ~3mm shell-length, becoming nearly flat toward the front. The multicostellate radial ornament is poorly preserved on the external mold, but well impressed around the periphery of the internal mold, where there are about 8 costae per 10 mm at the front, some apparently branched. The cardinalia are obscured by a small fracture. Details of the ornament are not preserved in the external mold.

The third specimen (PMO 32809; pl. 19, fig. 6 of Reed (*in* Kiær 1932); Fig. 12, D of this paper) is the external mold of a fragment of a nearly planar multicostellate shell.

A ventral valve from the Brannsås locality (PMO 141002; Figs. 13, E-G) not known to Reed, may be conspecific with the dorsal valve noted above. It is incomplete, moderately convex, and has dinorthid muscle scars. Preserved width (15 mm) is about one-third greater than its length; it is about 4 mm thick at about midlength. A fragment of its external mold preserves deeply set impressions of narrow, costellae spaced at about 10 per 5 mm. The bilobed muscle field has large dinorthid diductor scars that border but do not enclose the short, elevated adductor track.

Orthid, genus and species indet. c = *Orthis (Austinella)* cf. *whitfieldi* Winchell of Reed (in Kiær 1932, p. 120, pl. 22, figs. 14, 15; PMO 32819, Fig. 14, S of this paper). One of the two specimens assigned to this taxon by Reed is a fragment of a coarsely ribbed, nondescript external mold. No other specimen in these collections is similar to it.

Orthid, genus and species indet. d. = *Catazyga* cf. *anticostiensis* Billings of Reed (*in* Kiær 1932, pl. 18, fig. 19, one specimen (PMO 32828), Fig. 14, O of this paper). The identification of this specimen, an internal mold of a ventral valve, is uncertain because much of its posterior part is missing. The specimen is an internal mold of a ventral valve of a fine-ribbed shell that is elongate-oval in outline (15 mm long, 12 mm wide at about two-thirds shell length); convexity is low, greatest (~1.5 mm thick) near one-third shell length; lateral and anterior slopes are nearly uniform; front is rectimarginate. Nearly uniform radial ornament is impressed through the entire shell floor; impressions of costae number 13 per 5 mm at midwidth at the front. Interarea is incomplete, the long
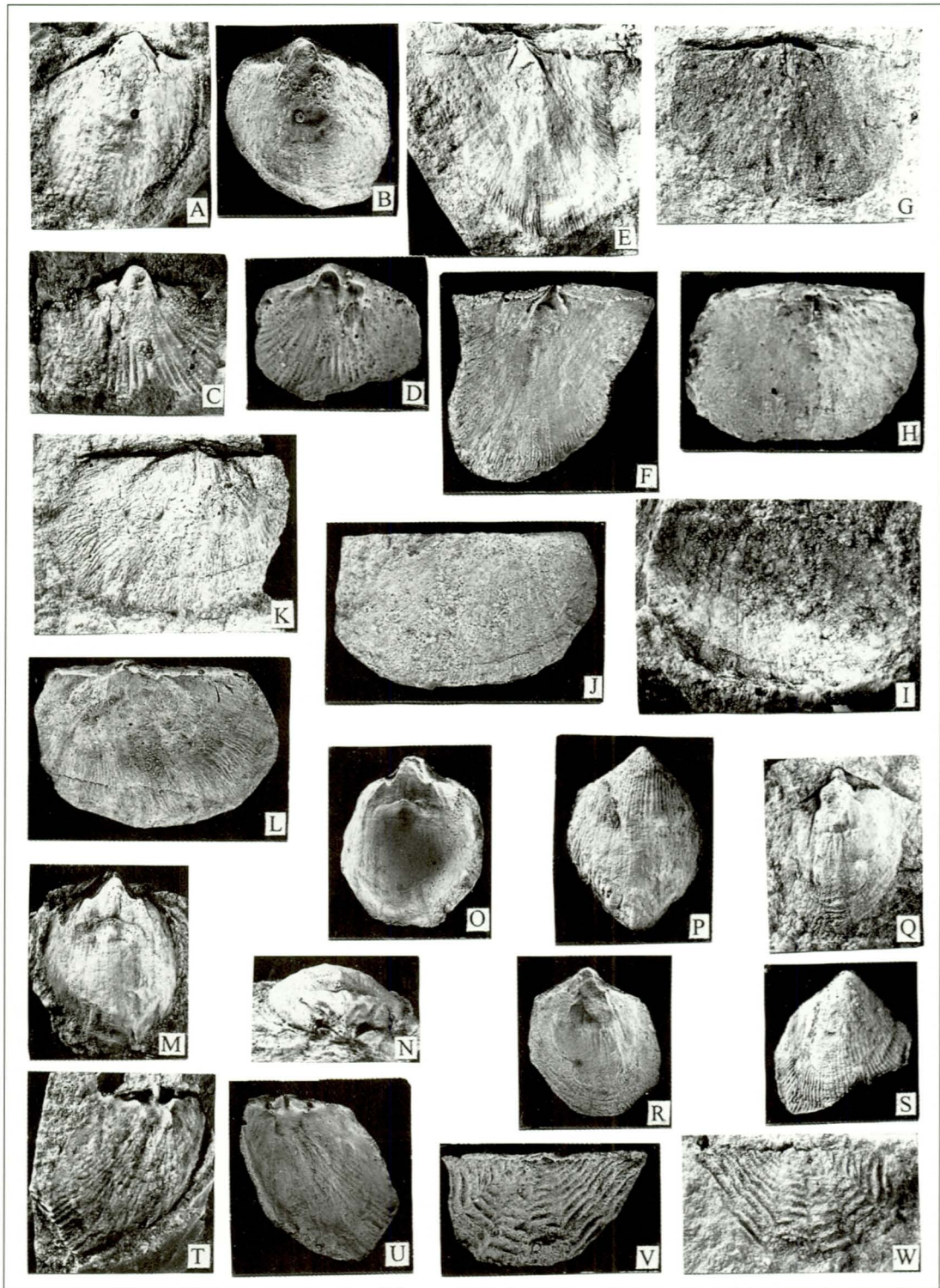
Fig. 13. Brachiopods from the Espehaug boulder, b.

Hirnantia? sp.

A-B,   ventral valve (PMO 32826) X2 (*Catazyga cf. anticostiensis* (Billings)? of Reed *in* Kiær, 1932, pl. 18, fig. 10), internal cast, internal mold.

Dalmanellid, genus and species undetermined

C-D,   ventral valve (PMO 32846), X3 (*Zygospira cf. recurvirostris* (Billings) of Reed in Kiær 1932, pl.19, fig.3), internal cast, internal mold.

Kjaerina? sp.,

E-F,   ventral valve (PMO 32839), X1.5 (*Strophomena cf. planodorsata* Winchell and Schuchert? of Reed *in* Kiær 1932, pl. 19, fig. 11), internal mold, cast.

Sowerbyella sp.

G-J,   ventral valve (PMO 32795-6), X2 (*Sowerbyella (Eochonetes) cf. advena* Reed of Reed *in* Kiær 1932, pl. 18, figs 17-18), internal mold, internal cast, external mold, external cast.

(~3 mm) remnant part is orthocline. The delthyrium is open; teeth are not preserved; the remaining (left) dental plate is thick, erect, and diverges from the centerline of the shell at ~50°. The delthyrial cavity is poorly defined in the absence of the second dental plate; impressions of muscle scars are not preserved.

Zygospira cf. *recurvirostris* of Reed (*in* Kiær 1932, p. 125, pl. 19, fig. 2; PMO 32843; Fig. 14 P of this paper) is a shell fragment that remains unidentified. It has four costae preserved in a shallow depression that may be a sulcus like that of *Zygospira*, but features that distinguish it from several other distantly related brachiopods are not preserved. The actual outline of the fragment does not allow the reconstructed outline shown on Reed's illustration.

Ptychoglyptus? pauciradiatus Reed (*in* Kiær 1932, pl. 18, figs. 1, 2; PMO 32799, 32803; Figs. 13, V-W of this paper). Decalcification of one of the two specimens assigned to this species illustrated by Reed (PMO 32803) showed that it is a ventral valve in which internal features like those of *Ptychoglyptus* are preserved; it is here designated the holotype of the species. The other specimen adds no useful information and is not reillustrated here. Reed (*in* Kiær 1932) recorded the presence of several imperfect specimens, but these have not been located. Thus, although the species name may be valid, its generic assignment remains uncertain in the absence of a dorsal valve.

Rafinesquina cf. *alternata* (Emmons) of Reed (*in* Kiær 1932, p. 123, not figured) = *Strophomena euglyfa* Sowerby of Brøgger 1877, pl. 2, fig. 33. Because this specimen has not been located no comments concerning it are offered.

Rhychotrema? sp. indet. Four specimens discussed below are assigned to this category; two from the Brannsås locality are better preserved than the two from the Espehaug boulder that were known to Reed. These specimens confirm the presence of one or more genera of rhynchonellid brachiopods in the Espehaug and Brannsås assemblages, but their generic identity remains uncertain because poor preservation prohibits observation of features by means of which genera of Ordovician brachiopods of this kind are discriminated (Cooper, 1956; Howe, 1965; Amsden, 1974).

The specimens from the Brannsås locality are internal molds of articulated shells (steinkerns). The longer of the two (PMO 141012; Fig. 11, A-F) is tear-shaped in outline; the ventral valve is posteriorly elongated by a beak that extends beyond the hinge by about 10 percent the length of the dorsal valve. It is 11 mm long, and 8 mm wide at midlength where

its divergent, nearly straight sides merge with its broadly rounded anterior margin. The lateral profile of both specimens is dorsibiconvex, reflecting the presence of a pronounced fold on the dorsal valve and a corresponding sulcus on the ventral valve; the fold bears four costae, two on each side of a median interspace, coincident with the three costae of the sulcus. An SEM photograph of the posterior part of this specimen (Fig. 11, F) shows that the dorsal part of the beak portion of this specimen has a small concave surface that is smooth except for a thin median ridge; this surface is interpreted to indicate the presence of deltidial plates medially separated by a suture or narrow gap. The delthyrial cavity is short and shallow; teeth are not distinguishable; dental plates are not present. Visible features of the dorsal valve include posterior-facing undercuts that mark the positions of the divided hinge plates; the small notothyrial cavity and its blade-like cardinal process are clearly impressed, as is the short median septum whose anterior termination corresponds with the internal impression of the median interspace. The three costae of the fold and four or five of the flanks are poorly preserved on the external mold of the ventral valve of this specimen. The other internal mold (PMO 141013, Fig. 11, G-H) is shorter (11 mm long, 12 mm wide) because its ventral beak is missing. The partial external mold of the dorsal valve of this specimen preserves the angular shape of its costae and interspaces, but the only internal feature of this specimen is the short median septum of the dorsal valve. A larger specimen of a dorsal valve of a similar rhynchonellid from the Sjursmoen locality is discussed below.

The two specimens from the Espehaug boulder that were placed in different genera by Reed are here assigned to this broad category, as follows.

Rhynchotrema cf. *capax* (Conrad)? of Reed (*in* Kiær 1932, p. 126; Pl. 18, fig. 13), PMO 32829, Fig. 14, E-F of this paper. After decalcification, this specimen appears to be the posteromedial part of a deformed fragment of a dorsal valve that might equally well be that of an unidentifiable orthid.

Orthis (Platystrophia) cf. *elegantula* McEwan var. *triplicata* McEwan of Reed (*in* Kiær 1932), p. 122, pl. 18, fig. 15) PMO 32841; Fig. 11, I, J. of this paper. An incomplete external mold of a strongly ribbed, moderately convex, sulcate, subpentagonal ventral valve, 12 mm long and 13 mm wide at midlength; its sulcus is about 5 mm wide at the front, and is occupied by three costae; there are six costae on each flank, those nearest the sides being considerably finer than the others. Although the costae are variably deformed and ob-
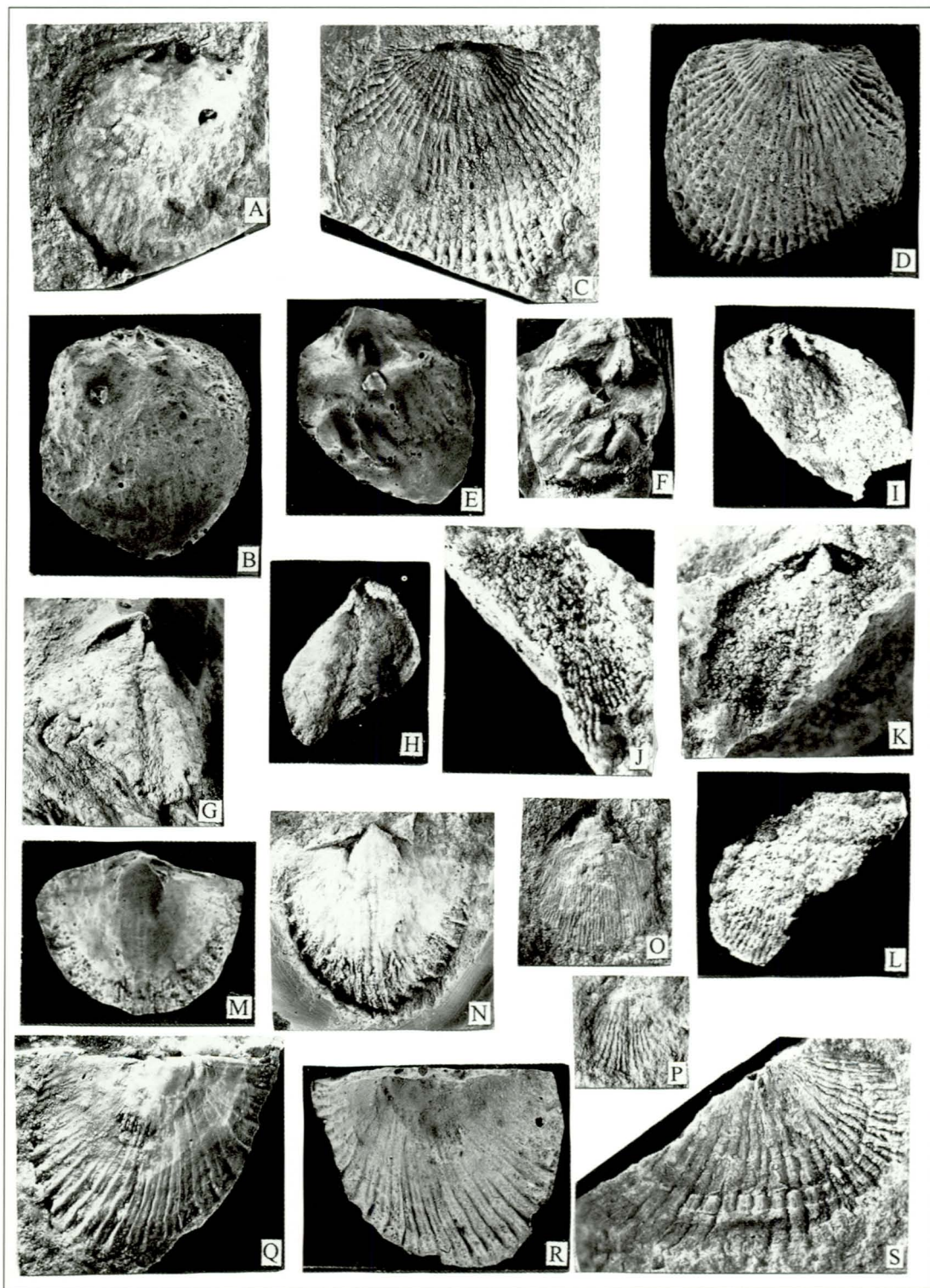
Fig. 14. Brachiopods from the Espehaug boulder and Brannsås locality, b.

Aff. *Protatrypa* sp. indet.

A-D,   dorsal valve (PMO 141003), X3, internal mold, internal cast, external mold, external cast; Brannsås locality.

Rhynchonellid genus and species indet.

E-F,   dorsal valve (PMO 32829), X2 (*Rhynchotrema* cf. *capax* (Conrad)? of Reed *in* Kiær, 1932, pl. 18, fig. 13), internal mold, internal cast; Espehaug boulder.

Camerella sp. indet.

G-H,   ventral valve (PMO 141015), X3, internal mold, internal cast; Brannsås locality.

aff. zygospirinid, genus and species undetermined.

I-L,   dorsal valve (PMO 141034), X3, internal cast, external mold, internal mold, external cast; Brannsås locality.

Nicolella? sp.

M-N,   ventral valve (PMO 32805), X1.5 (*Orthis* (*Plectorthis*) cf. *plicatella*

scured by mineral overgrowth, their original shape and surface texture is indicated by those that have angular crests and interspaces, and that have surfaces that are crossed by closely spaced growth lines. The internal mold is not preserved, and the outline of the external mold is incomplete, but the fineness of the outermost costae indicates its rhynchonellid affinities like those of two specimens from the Brannsås locality.

Camerella? sp. (PMO 141015; Fig. 14. G-H). A deformed but nearly complete internal mold of a convex ventral valve from the Brannsås locality is subtriangular in outline, slightly longer than wide (9 mm long, 8 mm wide), and has an apical angle of about 90°; the sides are nearly straight and extend to greatest width at about two-thirds shell length; the incompletely preserved front was presumably broadly rounded, and somewhat extended as a tongue at the floor of the sulcus. Its lateral profile is moderately convex; maximum thickness is about 1.5 mm at midlength. The sulcus extends the full length of the shell, with the impressions of a pair of costae and a median interspace appearing at about midlength. Impressions of costae on the flanks are weak, and suggest the presence of about three costae near the front of each flank. At the apex of the specimen is a narrow, steep-sided spondyllium, about 1 mm wide, 2 mm long, that is coextensive with a low median septum; hinge teeth are not preserved. The triangular outline of this specimen suggests that its generic affinities are more with *Camerella* than *Parastrophina*, but a dorsal valve is required to distinguish these two genera.

Aff. *Protatrypa* sp. (PMO 141003; Fig. 14, A-D), from rock that had been cut away from one of Reed's specimens from the Espehaug boulder. One dorsal valve has the shape, ornament, and cardinalia that suggest that it belongs to an unnamed genus related to *Protatrypa*. The outline of the specimen is nearly circular, its width and length both about 13 mm; its hinge-width is about two-thirds maximum width; the cardinal extremities are rounded. Its lateral profile of nearly uniform low convexity is highest at mid-valve, about 1.5 mm above the commissural plane. A shallow sulcus is confined to the posterior third of the shell, beyond which the shell is broadly arched. Its ornament has been somewhat obscured by deformation, the radial component being better preserved than the concentric component; the former consists of anteriorly expanding costae, a few of which branch at midlength, numbering about 12 per 10 mm in the medial sector of the anterior margin. The concentric ornament of growth lamellae probably covered the entire shell surface

but is now incompletely preserved, perhaps because the the individual lamellae were very thin. Where best preserved, near the front of the shell and on one side, impressions of the lamellae are spaced at about half millimeter intervals; their presence elsewhere on the shell surface is suggested by small-scale undulations of the costae. Internal features are poorly preserved; the shallow notothyrial cavity lacks indications of a cardinal process; it is bordered by short, narrow hinge plates that enclose shallow sockets. Poorly defined shallow depressions on opposite sides of a broad low median ridge (myophragm) probably mark the adductor scars.

No ventral valve that could be considered conspecific with this specimen is known.

Aff. zygospirinid, genus and species undetermined (PMO 141034; Figs. 14, I-L); one small fragmentary specimen of a dorsal valve from the Brannsås locality. Restoration suggests that this specimen was originally subpentagonal in outline, 10 mm in both length and width at midlength. It is variably biconvex in profile, maximum convexity at about one-fourth shell length, flattening at midlength, followed by an anteromedial shallow sulcus that includes a median costa. A small remnant of the anterolateral external surface preserves deeply impressed costellae spaced at about 8 per 5mm. The interarea is short, steeply apsacline, and medially divided by an unmodified delthyrium. The floor of the deep notothyrial cavity lacks any indication of a cardinal process. The widely flared crural bases are stout, and enclose shallow crural fossettes. No ventral valve in the collection is a likely counterpart of this specimen.

Pelecypod molluscs, by John Pojeta, Jr.

The pelecypod faunule consists of five specimens from the Brannsås locality and two from the boulder at Espehaug that were described by Strand (*in* Kiær 1932). The Brannsås specimens are placed in four genera and five species, an impressive diversity, all readily compared to Middle and Late Ordovician taxa from cratonic eastern North America.

Of the two Espehaug specimens, one is an internal mold classified as *Ctenodonta?* sp.; the other is an unnamed external mold (Strand *in* Kiær 1932, figs. 19a, 19b). On the basis of dentition, shape, and ornament, both specimens are paleotaxodonts, but in my opinion neither can be placed in a genus with confidence.

Strand (op. cit., p. 162, pl. 27, fig. 13) also described a pelecypod from gray nodular limestone at Vestre Katuglås, rocks

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Sowerby of Reed *in* Kiær 1932, pl. 18, fig. 16), internal cast, internal mold.

Orthid, genus and species indet., d.

O,   ventral valve (PMO 32828), X1.5 (*Catazyga* cf. *anticostiensis* (Billings)? of Reed *in* Kiær 1932, pl. 18, fig. 19), internal mold; Espehaug boulder.

P,   dorsal valve? (PMO 32843), X3 (*Zygospira* cf. *recurvirostris* (Billings) of Reed *in* Kiær 1932, pl.fig. 2), partial internal mold; Espehaug

boulder.

Hesperorthis? sp.

Q-R,   ventral valve (PMO 32831), X3 (*Orthis* cf. *tricenaria* Conrad of Reed *in* Kiær 1932, pl. 18, fig. 14), internal cast, internal mold; Espehaug boulder.

Orthid, genus and species indet. c.

S,   dorsal valve (PMO 32819), X2 (*Orthis* (*Austinella*) cf. *whitfieldi* Winchell of Reed *in* Kiær, pl.22, fig. 14), external mold; Espehaug boulder.
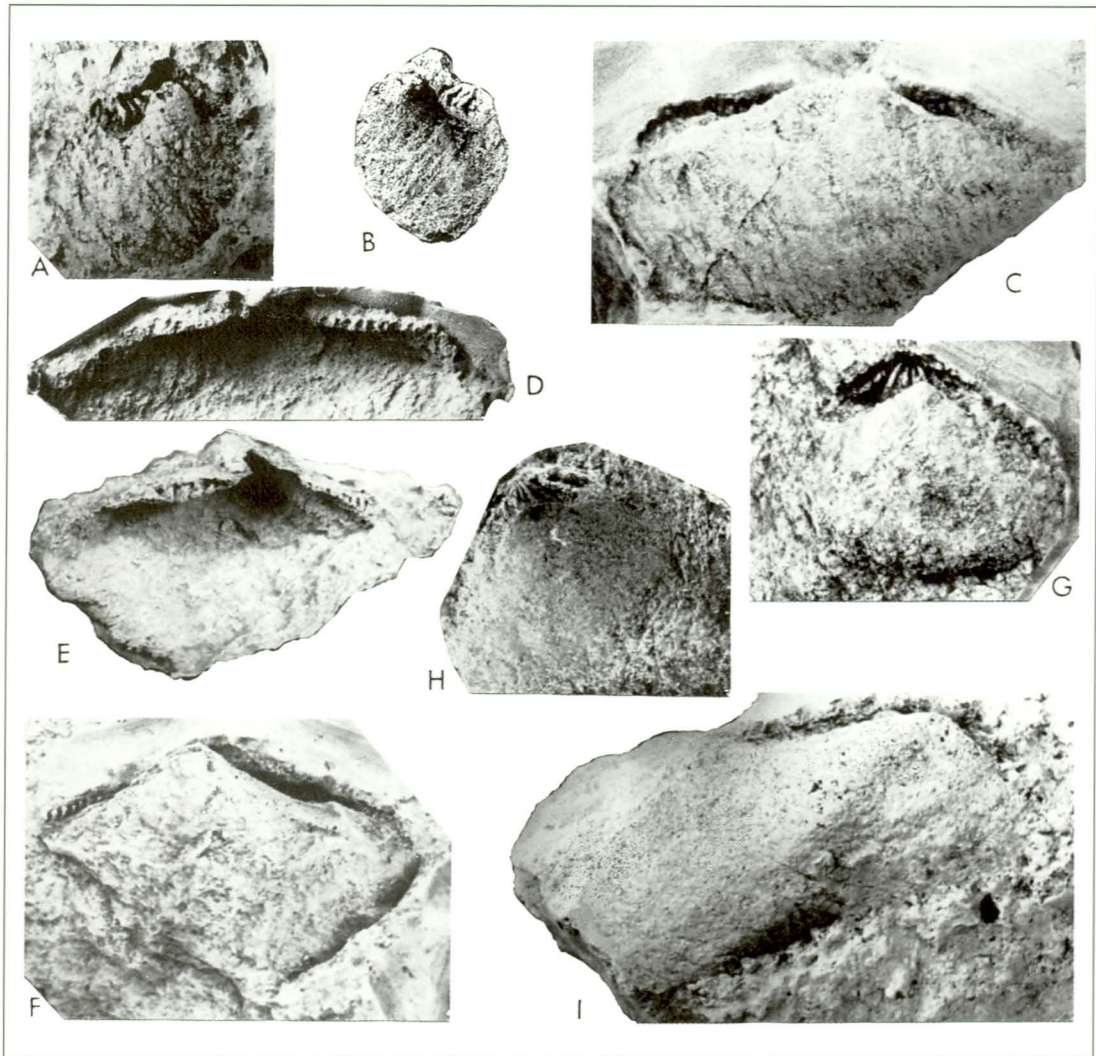
Fig. 15.Pelecypod molluscs from the Brannsås locality.

A-B,   Deceptrix sp., left valve (PMO 141097), X3, internal mold and latex cast; shape probably distorted and posterior tooth row nearly obliterated.

C-D,   Ctenodonta cf. C. nasuta (Hall), left valve (PMO 141096), X4, internal mold and latex cast of dorsal margin showing taxodont dentition.

E-F,   Ctenodonta cf. C. logani Salter, left valve (PMO 141095), X2, latex cast showing taxodont dentition, and internal mold.

G-H,   Lyrodesmatid, right valve (PMO 141099), X4, internal mold and latex replica showing dentition.

I,   Colpomyid?, right valve (PMO 141098), X2, internal mold showing shape.

now considered to belong to the 'Lower Hovin Group of early Middle Ordovician (Whiterockian) age (Neuman & Bruton, 1989). He identified this specimen as Modiolopsis? sp.; on the basis of this figure, in my opinion, it is not clear that it is a modiomorphid, and this specimen cannot be classified to genus.

The following notes pertain to the specimens from the Brannsås locality.

Ctenodonta cf. nasuta (Hall), 1847; PMO 141096; Fig. 15, C). For a full description and discussion of the present use of the genus Ctenodonta, see Pojeta, 1988. The known stratigraphic range of the genus is Ibexian-Richmondian (Lower-Upper Ordovician). Ctenodonta is widely distributed geographically, occurring in North America from Alaska to New

York, and in Malaysia, continental Australia, Tasmania, and Argentina. Prior to this study, Ctenodonta as redefined was not known from Europe.

Both the anterior and posterior taxodont tooth rows of C. nasuta are subparallel to the dorsal margin and form an angle close to 180 degrees. The shell is expanded anteriorly, and the beaks are anterior to the shell midlength. The specimen illustrated here is an incomplete internal mold of a left valve. It has the subparallel taxodont tooth rows typical of C. nasuta, but it is incomplete posteriorly, and neither ligament supports nor other internal features are preserved.

The known stratigraphic range of Ctenodonta nasuta is Blackriveran-Edenian (middle Middle to lower Upper Ordovician). The species is widespread in eastern North

America, having been reported from Quebec, Ontario, Minnesota, Wisconsin, New York, probably New Jersey, Indiana, Missouri, Kentucky, and Tennessee.

Ctenodonta cf. *C. logani* Salter, 1859 (PMO 141095; Fig. 15, E,F). *Ctenodonta logani* differs from *C. nasuta* in having the anterior taxodont tooth row at a slight angle to the posterior tooth row, and in being anteroventrally elongated. The specimen compared to *C. logani* is an internal and external mold of a left valve; the external mold is too poorly preserved to illustrate. The internal mold has the gross features of *C. logani* and preserves the posterior adductor muscle scar; the anterior part of the specimen is missing, and the ligament support structures are not known.

Deceptrix sp. (PMO 141097; Fig. 15, A, B). One internal mold of a small, distorted left valve whose posterior tooth row has been nearly obliterated.

Colpomyid? (PMO 141098; Fig. 15, I). One poorly preserved external mold of the righ valve of an isofilibranch has a slight median sulcus, a feature most prominent in Ordovician colpomyid pelecypods (Pojeta & Gilbert-Tomlinson 1977; Pojeta 1978). Colpomyids range from the early Middle to middle Late Ordovician (late Arenig-Maysvillian).

Lyrodesmatid (PMO 141099; Fig. 16, G, H). One internal mold of a right valve has cardinal teeth with denticles radiating from below the beak. This feature is characteristic of lyrodesmatid pelecypods. The family is geographically widespread and stratigraphically long-ranging, from the Middle Ordovician to Middle Devonian (upper Arenigian-Givetian) (Pojeta & Zhang 1986).

Sjursmoen

A few brachiopod specimens were obtained from dark-gray, thick-bedded siltstone that is interbedded with polymict conglomerate at the southwestern end of the roadside exposure about 2 km west of Hovin, 400m east of the farm Sjursmoen (GR 606 986; field trip stop 8-6 of Oftedahl and Wolff *in* Wolff et al. 1980; stop 5:8 of Bruton & Bockelie *in* Bruton & Williams 1982). A few brachiopod specimens are visible in the exposure, but a sample of about 15kg yielded about thirty specimens whose generic or family identities are determinable as shown in Table 1 and anotated in the paragraphs that follow.

Plectorthis? sp. Three external molds of articulated valves (two casts illustrated: PMO 141016, Figs. 16, B-C; PMO 141017, Fig. 16,A), and one incomplete dorsal valve (Figs. 16, D-G, PMO 141018). The smallest of these (PMO 141016), 7 mm long, 8 mm wide, is about half the size of the others which average 15 mm in length and 20 mm in width. The more complete specimens are ventribicovex in profile, transversely suboval in outline, with width about one-third greater than length; cardinal angles are obtuse, sides and front are broadly rounded. Interareas, preserved only on the small specimen, are of greatly different lengths, that of the ventral valve is apsacline and about 3 mm long, whereas that of the dorsal valve is orthocline and about 0.75 mm long. The ventral valve has a high beak; its lateral profile is more highly arched than that of the dorsal valve; the greatest thickness of articulated valves is at about one-third shell length. Large dorsal valves have a shallow sulcus that begins near midlength and is increasingly well defined anteriorly.

The radial ornament consists of about thirty anteriorly expanding, flat-crested, subangular costae and complementary interspaces that extend from beak to anterior margin with little or no increase in number on most specimens. On the largest specimen, not figured, the number of costae appears to increase near the front of both valves, by insertion on the ventral valve, and by branching on the dorsal valve. The concentric ornament of closely spaced growth lines is preserved on the sides and troughs of interspaces, but not on the crests of costae.

The one disarticulated specimen that provides information on the interior of this taxon is an incomplete and poorly preserved dorsal valve (PMO 141018; Figs. 16, D-G). Its notothyrial platform is of thickened shell whose anterior margin is a poorly defined transition with the shell floor; the base of the cardinal process extends across its full length. The cardinal process is a stout, equilateral triangular plate, now bent aside by deformation. The one brachiophore base that is preserved is stout and pyramidal that, prior to deformation, may have risen nearly vertically to its sharply pointed top. If a fulcral plate was present it is obscured by deformation.

Platystrophia sp. One poorly preserved sulcate, costate ventral valve (PMO 141020; Figs. 16, H-I) is subcircular in outline (17 mm long, 17 mm wide). The anterior third of the sulcus contains three strong, angular costae; six weaker costae can be seen on its best preserved flank. The shell surface bears strong, closely spaced growth lines and is marked in several places by closely spaced fine pustules as is characteristic of many species of *Platystrophia*. All but the posteromedial internal structures have been obliterated, preserving only the impressions of the posterior parts of the dental plates and the delthyrial cavity between them that is marked by narrow, deep diductor scars that are separated by a wide, elevated adductor track.

Dalmanellids, genera and species indeterminate. Athough dalmanellids are the most abundant brachiopods from this locality (>17 specimens), poor preservation prohibits their generic and specific identification. Differences in their size, shape, ornament pattern and internal features as shown by the seven illustrated specimens (PMO 141021-141028; Figs. 16, J-T) suggest the possibility that the suite includes more than one genus. The number of articulated valves (8 of 17) is notable, as is the 8:1 ratio of ventral valves over dorsal valves among the disarticulated shells. The punctate shell structure is indicated by closely spaced, very fine pustules on parts of a few internal molds.

All specimens are considerably distorted, but their original outlines seem to have been normal for dalmanellids, i. e., suboval, maximum width at about midlength, about 15 per cent greater than width. Cardinal angles are rounded and
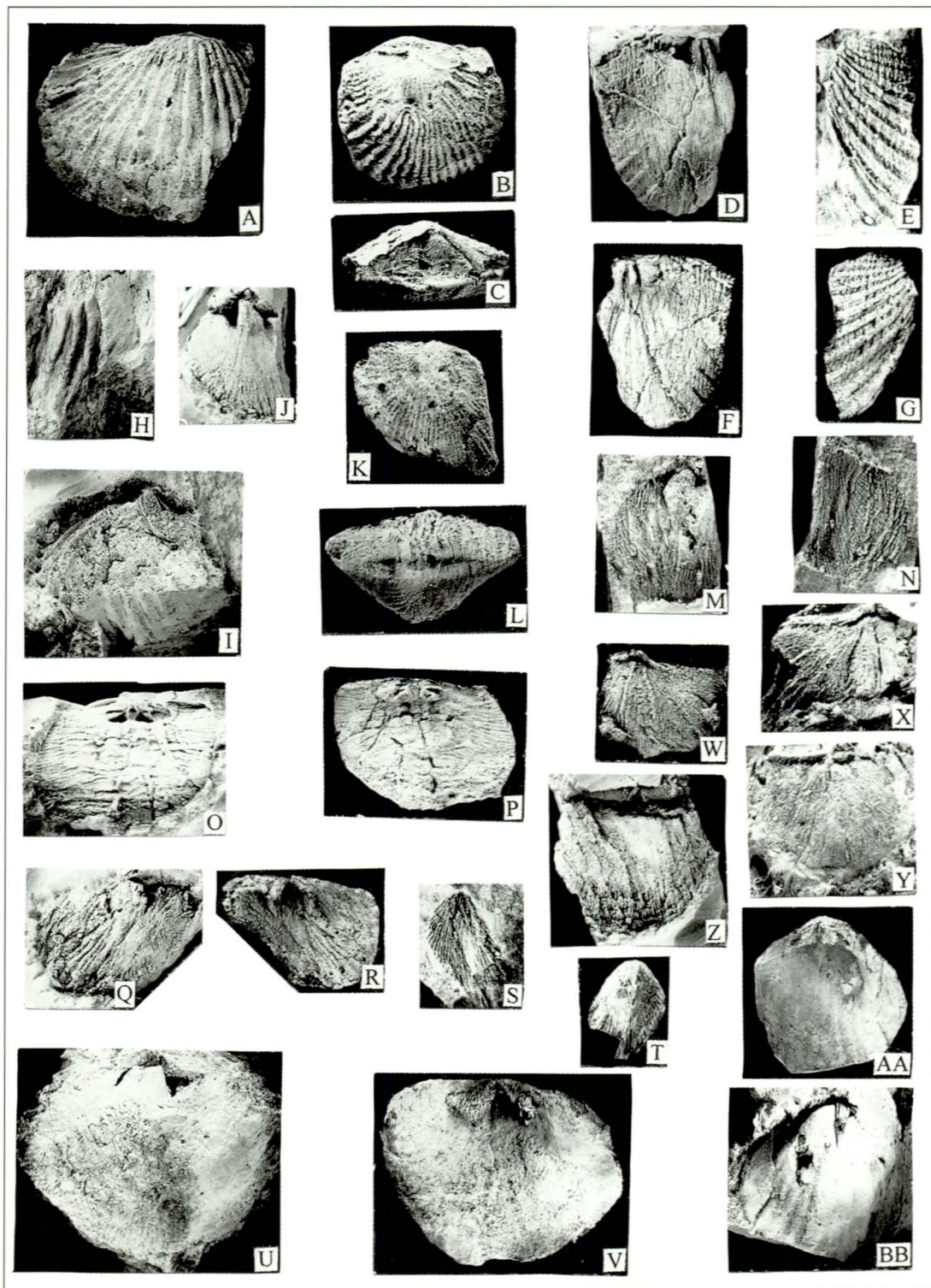
Fig. 16. Brachiopods from the Sjursmoen locality.

Plectorthis? sp.

A,   articulated valves (PMO 141017), X2, external cast, ventral view.

B-C, articulated valves (PMO 141016), X3, external cast, ventral view, posterior view showing ventral palintrope.

D-G, dorsal valve (PMO 141018), X2, internal mold, internal cast, incomplete external mold, external cast.

Platystrophia sp.

H-I, ventral valve (PMO 141020), X1.5, external mold that preserves part of sulcus, poorly preserved internal mold of the same specimen.

Dalmanellid, genus and species indet.

J,   ventral valve (PMO 141024), X3, internal mold.

K,   articulated valves (PMO 141022), X3, external cast, dorsal view.

obtuse; sides and front are broadly rounded. Visible ventral interareas are short and slightly concave; the delthyrium appears to be open. No dorsal interarea is well enough preserved to determine its inclination. Shell profiles are ventribiconvex; maximum thicknesses are at about one-third shell length.

The shallow sulcus of the dorsal valve is variably preserved; it is poorly defined on the best preserved but tectonically shortened internal mold (PMO 141023; Fig. 16, O-P). The radial ornament is of fine, branching costellae whose spacing and branching pattern are largely obscured by deformation. The cardinalia are preserved in this specimen: the knoblike cardinal process, like that of *Paucicrura* (Cooper, 1956) rises directly from the posterior edge of the notothyrial platform, with no indication of a shaft. Its posterior face fully occupies the notothyrium, and its myophore bears a narrow median ridge between its lateral lobes. The brachiophores are thick, wedge-shaped, and have blunt terminations; the outer sides of their bases is linked to the posterior shell wall by fulcral plates. The adductor muscle field is quadripartite, medially divided by a broad, low myophragm; the posterior pair are smaller than the anterior pair marked by margins of slightly thickened shell. The anterolateral margins of the shell bear impressions of the radial ornament; its floor is marked by lateral crenulations of tectonic origin. Mantle canals are not preserved.

The four specimens of ventral valves preserve remnants of interiors that are difficult to identify because they are incomplete and tectonically deformed. Differences between them suggest that they might belong to as many as three genera, but it is more likely that they all belong to one genus. They are transversely elliptical in outline, and moderately convex in profile. The dimensions of the best preserved specimens of ventral valves are tabulated below:

PMO no.	Figure	Length	Width	Thickness
141024	16, K	7	9	2.0
141025	16, Q-T	10.0	12.0	2.0
141027	—	13.0	9	1.5
141028	16, Y-Z	14.0	19.0	3.0

Two specimens (PMO 141024, Fig. 16, K; PMO 141027, not figured) have long, narrow, cordate muscle scars on the floors of deep delthyrial cavities; their pyramidal teeth are supported by short, thick, receding dental plates. Another specimen (PMO 141025; Figs. 16, Q-T) is wider than these and obliquely deformed, the bases of its dental plates extend along the sides of its proportionally wider muscle field whose adductor track is longer than its diductor scars. In this specimen a broad, low, median ridge extends from the front of the muscle scar to near the anterior margin of the shell. The better preserved of the teeth of the largest and most convex ventral valve (PMO 141028; Figs. 16, Y-Z) is a three-sided, bluntly terminated, anteriorly directed pyramid whose fluted inner face partly overhangs the delthyrial cavity. Faint ridges on the floor of the delthyrial cavity suggest a tripartite muscle field whose adductor track is about equal in width to its diductor scars, but the their anterior margins are not preserved. Faint impressions of closely spaced lines around the anterolateral margins of this specimen indicate that its radial ornament was finely costellate.

Sowerbyella sp. Eight specimens, five articulated, are assigned to this genus. None is well preserved. A transversely elliptical outline is inferred from incomplete specimens, but the specimen whose outline is most nearly complete, an internal mold of a disarticulated ventral valve (PMO 141029; Fig. 16, Y), is laterally compressed and lacks its posterolateral extremities. The external mold of an articulated specimen (PMO 141031; Fig. 15, Z) preserves its conjoined interareas; that of the ventral valve is about 1 mm long, short, planar, apsacline, about twice as long as its apsacline dorsal counterpart; this specimen also displays the pseudodeltidium and chilidial plates. Radial ornament characteristic of *Sowerbyella* is preserved on parts of a few specimens; principal costae that arise near the beak, diverge at low angles and are spaced at about 1 mm intervals at the front of specimens about 6 mm long where they enclose 8 to 10 fine costellae. Neither concentric ornament nor posterolateral rugae are preserved.

Dorsal interiors are known from two specimens (PMO 141030; Figs. 16, W-X; PMO 141032, not illustrated). Submedian, narrowly divergent septa are displayed on both; the illustrated specimen preserves the distinctive sowerbyellid hoodlike structure that combines the cardinal process, chilidial plates, and socket ridges, but the short median septum is preserved only on the specimen that is not illustrated.

The ventral interior, seen only on one specimen (PMO 141029; Fig. 16, Y) has a muscle field of thickened shell that extends from the bases of the short dental plates to about one-fourth shell length; the splayed diductor scars are medially divided by a prominent myophragm. Impression of large, closely spaced pustules are preserved on the anteromedial

L,　articulated valves (PMO 141021). X3, external cast, posterior view.
M-N,　ventral valve (PMO 141026), X2, internal mold, external mold.
O-P,　dorsal valve (PMO 141023), X2, internal mold, internal cast.
Q-T,　ventral valve (PMO 141025), X2, internal mold, internal cast, partial external replica, partial external mold.
U-V,　ventral valve (PMO 141028), X2, internal mold, internal cast.

Sowerbyella sp.
W-X,　dorsal valve (PMO 141030), X3, internal cast, internal mold.
Y,　ventral valve (PMO 141029) X2, internal mold.
Z,　articulated valves (PMO 141031), X2, external mold of dorsal valve and ventral palintrope.
Rhynchotrema sp.,
AA-BB,　dorsal valve (PMO 141033), X2, internal cast, internal mold.

part of the shell floor.

Rhynchotrema sp. This genus is represented by one specimen, an internal mold of a dorsal valve (PMO 141033; Figs. 16, AA-BB). It is subcircular in outline and thick bodied in profile (11 mm long, 10 mm wide near midlength, 3 mm thick), and has a weakly differentiated fold. The internal expression of costation indicates the presence of three strong costae on the fold and eight weaker ones on the flanks. The septalium is supported by a thick median septum and bears a thin, bladelike cardinal process. The crural bases are wide, but their distal extremities are indistinctly preserved. Hinge plates are short and moderately concave; sockets are shallow, elliptical, and widely divergent. The median septum thins rapidly beyond the termination of the septalium, and extends as a low, narrow ridge on the shell floor to about one fourth shell length.

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Addendum, by Robert B. Neuman, 28 July, 1997.

All of the specimens identified as *Rafinesquina* sp. from the Meldal A locality and one of the two specimens from the Svartsætra locality are here reidentified as *Mjoesina* sp., based on their external and internal features. Despite deformation, ventral vales can be seen to be of low convexity, and one specimen (PMO 141054, Fig. 5, U, V) preserves the dorsad geniculation of the anterolateral margin that is characteristic of the genus; the ventral interior has short, widely divergent dental plates and a relatively small flabellate muscle scar. Dorsal valves are nearly flat, and have strophomenoid rather than rafinesquinoid cardinalia; the socket plates are widely divergent and their posterior faces are crenulated (PMO 141052, Fig. 5, Q). The large dorsal valve from the Svartsætra locality (PMO 141090, Fig. 9, A,B) is retained in *Rafinesquina*? sp.

Mjoesina was erected (Spjeldnæs 1957) to include *M.*

mjoesensis (Holtedahl), the type species from the upper part of the Mjøsa Limestone, and *M. gregaria* from the 'Coelospharidium zone [in the] Toten district.' Additional species of the genus have since been described from late Caradoc and Ashgill age rocks of the Girvan District, Scotland (Williams 1962) and middle Ashgill (Cautleyan) rocks of Pomeroy, northern Ireland (Mitchell 1977).

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