THE PALAEONTOLOGY OF THE NAMURIAN ROCKS OF SLIEVE ANIERIN, CO. LEITRIM, EIRE

by the late PATRICIA J. YATES

ABSTRACT. On Slieve Anierin the Lower and Upper *Eumorphoceras* Stages of the Namurian contain an unbroken sequence of faunas; these are described in detail for the first time in Ireland. The simple geological structure enables marine bands to be collected in their undoubted order of superposition, in contrast to some equivocal sections elsewhere in Britain. Shale is the dominant rock type throughout the succession, but a thick grit, with coal seams, occurs in the lower part of E_2.

The faunas of the marine bands consist dominantly of goniatites and lamellibranchs, the most common goniatite genera being *Eumorphoceras*, *Cravenoceras*, and *Cravenoceratoides*, with *Anthracoceras* and *Dimorphoceras* abundant at certain levels. The goniatite species have relatively short time ranges and are unsurpassed for the recognition of zones and subzones. The lamellibranch species usually have longer time ranges, but are also shown to be valuable stratigraphically, supplementing the goniatites. The following new species and subspecies are described: *Eumorphoceras rostratum; E. bisulcatum erinense, ferrimontanum*, and *leitrimense; Posidonia corrugata elongata* and *gigantea; Caneyella membranacea horizontalis; Obliquipecten costatus; Posidoniella variabilis erecta;* and *Chaenocardiola bisati.*

Detailed stratigraphical correlations are made with beds of the same age in Ireland, the Pennine region in England, north-west Europe (notably Germany and Belgium), and North America. Some important revisions in correlation are suggested, and the remarkable extent of Namurian goniatite-lamellibranch faunas is demonstrated.

Editorial note. Miss Yates died on 7 August 1960 at the early age of twenty-eight, only five days before the examination of a thesis she had prepared for the Ph.D degree of the University of London. Since this work is a major contribution to Carboniferous stratigraphical palaeontology, it has been edited for publication (with the consent of her brother, Dr. E. M. Yates, Department of Geography, King's College, London) by Dr. W. H. C. Ramsbottom (Geological Survey Office, Ring Road Halton, Leeds 15) and Dr. Gwyn Thomas (Department of Geology, Imperial College, London, S.W.7). The title of the thesis has been retained for this paper, and the editors have not introduced material not known to the author or published since her death. Thanks are due to Mrs. Judith Creighton for undertaking the difficult task of sorting the author's manuscripts and cataloguing her extensive collections.

Repository. Copies of the author's thesis (containing some palaeontological descriptions not included in this paper) are in the Watts Library of Geology, and the author's collection is housed in the Murchison Museum, Department of Geology, Imperial College, London. Registration numbers without a prefix in the paper refer to specimens in this collection. Specimens in the Geological Survey Museum which are referred to in the text have the prefix GSM, and those from the British Museum (Natural History) the prefix BM.

Localities. Fossiliferous localities on Slieve Anierin, including those in P_1 and P_2, are shown on text-figs. 2, 3, and 4, and listed in the Appendix. Each Irish Ordnance Survey 6-inch sheet has been divided into sixteen quadrants; the figure in brackets following the sheet number is the number of the quadrant in which the locality referred to may be found, and is followed by the locality number, e.g. Leitrim 20(8)1, abbreviated to L20(8)1. It has been found necessary to renumber the specimens and localities mentioned in Yates (1961); a check list of the new numbers is given in the Appendix (section 2).

Abbreviations. The only departure from the normal custom of abbreviation of generic names to the initial letter is the use of *Ct.* for *Cravenoceratoides*, in order to avoid confusion with *C.* for *Cravenoceras*.

Authorship of species and subspecies. The authorship of the chief species and subspecies mentioned in this paper is as follows: *Anthracoceras glabrum* (Bisat), *A. paucilobum* (Phillips), *A. tenuispirale*

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Demanet; *Cravenoceras africanum* Delépine, *C. cowlingense* Bisat, *C. gairense* Currie, *C. holmesi* Bisat, *C. leion* Bisat, *C. malhamense* (Bisat), *C. subplicatum* Bisat; *Cravenoceratoides bisati* Hudson, *Ct. edalense* (Bisat), *Ct. lirifer* Hudson, *Ct. nitidus* (Phillips), *Ct. nititoides* (Bisat), *Ct. stellarum* (Bisat); *Dimorphoceras looneyi* (Phillips); *Eumorphoceras angustum* Moore, *E. bisulcatum* Girty, *E. bisulcatum grassingtonense* Dunham and Stubblefield, *E. bisulcatum varicata* Schmidt, *E. girtyi* Elias, *E. hudsoni* Gill, *E. medusa* Yates, *E. medusa sinuosum* Yates, *E. plummeri* Miller and Youngquist, *E. pseudobilingue* (Bisat) emend. Moore, *E. pseudobilingue A* Bisat, *E. pseudobilingue C* Bisat, *E. pseudocoronula* Bisat, *E. rota* Yates, *E. sp.* form *A* Moore, *E. stubblefieldi* Moore; *Girtyoceras limatum* (Miller and Faber), *G. meslerianum* (Girty); *Goniatites elegans* Bisat, *G. falcatus* Roemer, *G. granosus* Portlock; *Kazakhoceras scaliger* (Schmidt); *Lyrogoniatites newsomi georgiensis* Miller and Furnish; *Neodimorphoceras hawkinsi* (Moore); *Nuculoceras nuculum* Bisat; *Sudeticeras alaskae* Gordon, *S. crenistriatum* (Bisat), *S. newtonense* Moore.

Actinopteria fluctuosa (Etheridge), *A. persulcata* (M'Coy); *Caneyella membranacea* (M'Coy), *C. wapanuckensis* (Girty); *Chaenocardiola footii* (Baily), *C. haliotoidea* (Roemer); *Dunbarella elegans* (Jackson); *Euchondria levicula* Newell; *Obliquipecten laevis* Hind; *Posidonia becheri* Bronn, *P. corrugata* (Etheridge), *P. lamellosa* (de Koninck), *P. trapezoedra* Ruprecht; *Posidoniella sulcata* (Hind), *P. variabilis* Hind; *Pseudamusium praetenuis* (von Koenen).

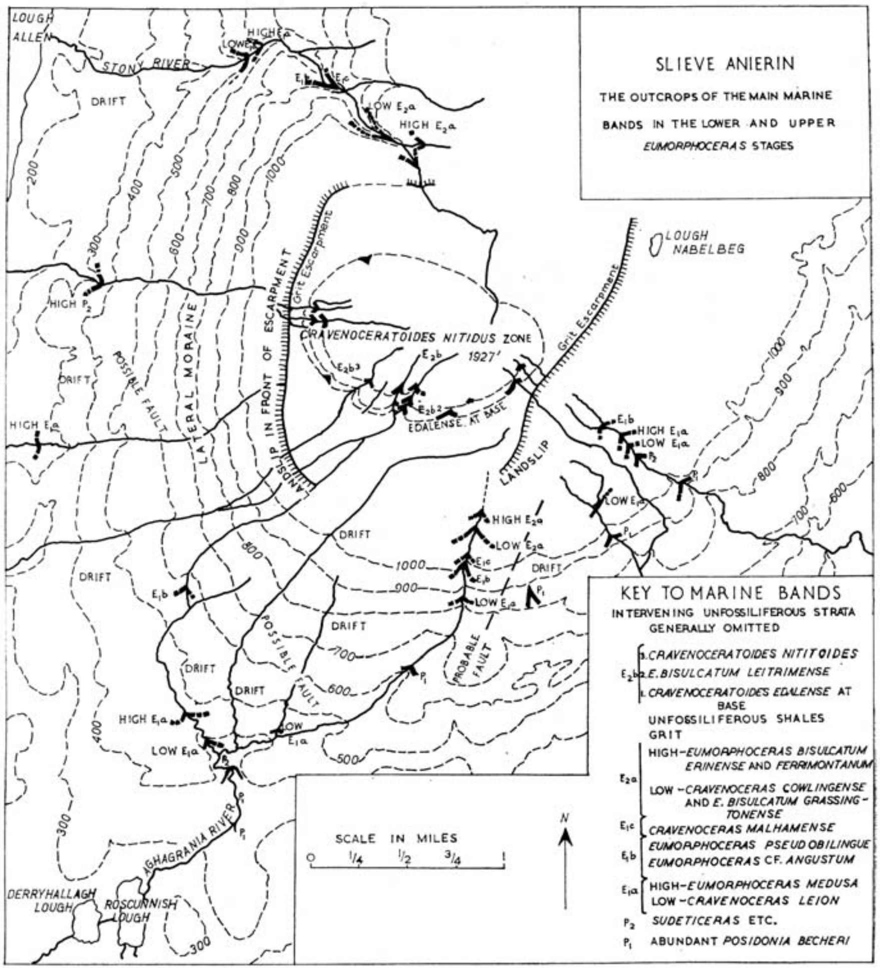
Leiorhynchus carboniferus polypleurus Girty, *Lingula parallela* Phillips, *Orbiculoidea nitida* (Phillips), *Productus hibernicus* Muir-Wood; *Thrincoceras hibernicum* (Foord), *Stroboceras subsulcatus* (Phillips), *Cycloceras purvesi* Demanet; *Mourlonia striata* (de Koninck); *Archaeocidaris urii* (Fleming); *Weberides* cf. *W. shunnerensis* (King); *Coleolus namurcensis* Demanet.

THE goniatite zones established by Bisat had not been extensively applied in Ireland until Hodson (1954*a*) made the first attempts to interpret previous records and discover new fossiliferous localities in Co. Clare; this led to a fuller understanding of Upper Carboniferous palaeontology and palaeogeography in Ireland and gave this field of study a great stimulus.

The *Eumorphoceras* Stage has not previously been the subject of detailed study in Ireland. Smyth (1950) described part of E_2 in North Co. Dublin but as this was only a portion of a larger work the description was not detailed; furthermore the complex structural pattern made the interpretation of the succession difficult. Nevill (1957) described the Summerhill Basin, Co. Meath, but again no detailed study of the faunas was possible.

At Professor Hodson's suggestion a reconnaissance was made of Benbrack Mountain, which lies south of Cuilcagh (2,188 ft.) (see Padget 1953), on the borders of Co. Fermanagh and Co. Cavan, but although *Eumorphoceras bisulcatum* Girty (GSM 95317) was collected from the summit the exposures were thought to be too poor for further work. Slieve Anierin (1,927 ft.), which lies south-west of Benbrack in Co. Leitrim, proved to be more suitable, since a virtually continuous succession from basal P_1 up to E_2b is for the most part well exposed in stream sections, the E_1 and E_2 beds being particularly fossiliferous; moreover the area is fortunately not complicated structurally (text-fig. 1).

In the north of England there are many records of exposures of beds from the E_1 and E_2 Zones but no really continuous section is available except from borehole records. Hudson and Cotton (1943, pp. 142–73) described the E_1 and E_2 succession from a borehole in Alport Dale in Derbyshire. Although a borehole section is obviously of considerable value in establishing the order of superposition of many previously isolated records, there are equally obvious advantages in being able to collect over a continuous succession of beds, concentrating on particularly fossiliferous levels and obtaining a



TEXT-FIG. 1. Map of Slieve Anierin showing the outcrops of the main marine bands in the Lower and Upper *Eumorphoceras* Stages.

far wider picture of the fauna at such levels than can possibly be obtained from one borehole core. The value of the exposed succession on Slieve Anierin thus lies in the unbroken sequence of faunas which it provides. The fauna is described and figured, and correlations made with other areas.

Slieve Anierin lies in an area of Upper Carboniferous rocks which extends from the southern tip of Lough Allen northwards for about 30 miles to the northern extremity of Lough Erne. At its greatest width this outcrop stretches for about 20 miles westwards from Swanlinbar in the east. The outcrop narrows northwards and is interrupted by a deep embayment of Carboniferous Limestone in the Belcoo area, to the north of which it widens again but rapidly narrows towards Lough Erne. Slieve Anierin lies at the southern end of this mass on the eastern side of Lough Allen.

Slieve Anierin is a flat-topped mountain with a prominent grit escarpment, which from a distance is easily mistaken for the summit of the mountain; in fact 200 feet of shales form a small residual outlier overlying the grit. The solid geology is virtually limited to stream sections by a thick obscuring mantle of peat bog and glacial drift below the grit escarpment (text-fig. 1), while high-level peat bog forms a thick mantle over most of the upland plateau above. The rocks are normally horizontal or only very gently dipping (up to about 5°), except in landslipped areas.

Previous work. Slieve Anierin was first mapped for the Geological Survey of Ireland by R. J. Cruise, and the results were published in 1876 on 1-inch Sheet 67. An explanatory memoir appeared in 1878, written by Cruise with palaeontological notes by W. H. Baily. The map shows Lower Coal Measures at the summit of the mountain overlying Millstone Grit, in which there are coal-seams; the slopes of the mountain below the Millstone Grit are mapped as Yoredale Beds (shales with ironstones).

Much of this memoir is devoted to the Arigna Mountains on the west of Lough Allen, including Kilronan to the south and Altagowlan further north, which are still being mined for coal. The coal from Kilronan was first used around 1788 to smelt the clay-ironstone bands which are very prolific in the lower shales. Despite glowing reports of the great economic possibilities of the coals on the Arigna Mountains by Griffith (1818) and by later authors, the history of the Connaught coalfield has hardly fulfilled early expectations. Du Noyer (1863) published a map of the mountains to the west of Lough Allen, gave the coal analyses earlier published by Kane (1845) and stated that the coalfield had 'little prospect of ever being properly developed'.

In the 1878 memoir it is stated that there are two coal-seams within the grit on Slieve Anierin corresponding with the lowermost (or Crow Coal) and the Middle Coal on the Arigna Mountains. Above the grit the Lower Coal Measures are said to be brown and black splintery shales attaining a considerable thickness and apparently without the top coal seam seen on Altagowlan. However, the Dail Commission of Inquiry into the Reserves and Industries of Ireland (1921, p. 132) reported that there was no information on the top coal but that it was said to exist on Altagowlan and on Slieve-an-Iarain but not on Kilronan. Altagowlan, being 300 feet higher than Kilronan, contains the upper strata including the third seam. On Slieve Anierin there is certainly no coal seam above the grit escarpment and it seems unlikely that it exists on Altagowlan either.

Boate (1652) said that 'The mountains on the east side of Lough Allen are so full of this metal, that thereof it hath got in Irish the name Slew Neren, that is, mountains of iron'. Hull (1878, p. 38) refers to Slieve-an-Ierin (or the Iron Mountain), and describes shales with rich beds of ironstone, regarded as the Yoredale Shales of the north of England, overlain by the Millstone Grit. He also refers (pp. 39, 40) to Gannister Beds or Lower Coal Measures, 600 feet in thickness, with two or three seams of coal and several beds containing marine genera such as *Phillipsia*, *Orthoceras*, *Goniatites*, *Productus*, *Pallustra*, *Orthis*, &c. These beds are said to occur on the tops of the hills bordering Lough Allen. They are now proved to be of E_2 age on Slieve Anierin.

In a later work Hull (1881, pp. 330–3) published a section, based on one given by Du Noyer (1863, p. 84, fig. 4), dealing with the area west of the Lough and showing three coal-seams on Kilronan and two on Altagowlan. Du Noyer's original section in fact carries the two seams on Altagowlan over to the other side of the Lough to Slieveanierin Mount. The recognition of this third seam on Kilronan by Du Noyer and by Hull thus appears to be at variance with the memoir, which places a third seam on Altagowlan but not on Slieve Anierin or Kilronan. The Memoir, in turn, differs from the Dail Commission which, although admitting that no information was available on this seam, placed it on Altagowlan and on Slieve Anierin.

Cole and Halissy (1924, pp. 31, 32) do not differentiate between Kilronan and Altagowlan but refer only to Arigna. They mention only a lower and upper coal, the inference being that they only believed in the existence of two coal-seams, but this is never actually stated. They suggest (p. 32) that the upper coal is in true Coal Measures 'which here remain only as a capping to the highest hills'. Later Charlesworth (1953, p. 93) referred to a Leitrim Coalfield, specified three coal-seams and reproduced Hull's figure (originally taken from Du Noyer). He also subscribed to the view that some Lower Coal Measures occurred in this area. The succession on Slieve Anierin does not get higher than the Namurian.

The geology of Cuilcagh, to the west of Swanlinbar, was described by Padget (1953, pp. 17-27) but the details of the faunas given by him are disappointing, since they might be expected to correlate with the succession on Slieve Anierin. The great grit escarpment on Slieve Anierin corresponds to that on Cuilcagh, and yet the E_2 horizons which can be demonstrated to exist below the grit on Slieve Anierin do not seem to have been found on Cuilcagh. It is possible, however, that scree in the Sruh Croppa (the stream which Padget (p. 19) refers to as yielding the most complete succession) may have obscured the horizons below the grit which are better exposed on Slieve Anierin. Cuilcagh appears to have been a much more visited mountain than Slieve Anierin; Phillips (1836, introduction, p. 15) describes a visit made to Cuilcagh from Florence Court, the home of the Earl of Enniskillen, where he was staying with Sedgwick, Murchison, Griffith, Sir Phillip Egerton, and Agassiz.

Caldwell (1959, pp. 163–89, pl. 6), in his account of the Lower Carboniferous rocks of the Carrick-on-Shannon Syncline, describes the lithology and fauna of the Roscunnish Shales in the Aghagrania River; they are of P_1 and P_2 age and immediately underlie the author's basal E_1 beds.

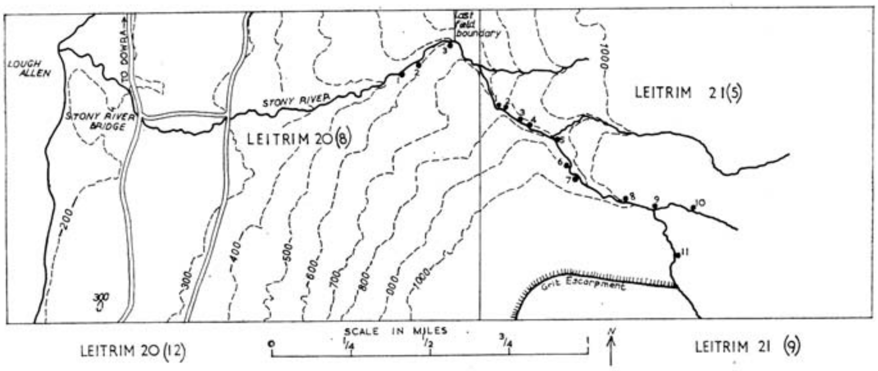
The highest faunal band on Slieve Anierin is of E_2 age and thus the summit is in Namurian deposits and not in true Lower Coal Measures. The *Gastrioceras subcrenatum* Marine Band, which is the horizon used in western Europe to define the base of the Lower Coal Measures, has been detected in the Leinster Coalfield (Nevill 1956), where true Lower Coal Measures are in fact present, but on Slieve Anierin there is no indication of it or of stages H and R.

The Millstone Grit with Coal Seams of the Memoir (1878) is clearly the grit which forms the escarpment on the mountain. Since it can now be demonstrated that *Eumorphoceras bisulcatum* occurs beneath this grit and *Cravenoceratoides edalense* almost directly above it, the grit must therefore lie within E_2. The *Ct. edalense* beds are considered to be at the level of *Ct. bisati*, which also occurs but is much less common. Hudson (1945) has placed the *Ct. bisati* subzone at the base of the *Ct. nitidus* zone. It is thus possible to assign the grit to E_2a or E_2b, but for convenience the *edalense* beds themselves are considered to be the base of E_2b and the grit assigned to E_2a. Both the grit and the beds above it are therefore placed in the Arnsbergian stage of the Namurian (Hudson and Cotton 1943, p. 152).

The two coal-seams within the grit marked on the 1-inch geological map may, with some difficulty, be traced along the grit escarpment on the western side of the mountain. On the southern flanks, however, they are completely obscured by drift deposits, but are misleadingly continued as broken lines on the map.

An attempt was made in 1957 to mine the lower coal-seam about 400 yards west of the Rocking Stone but the level was abandoned. The coal is poor in quality and the seams are probably impersistent. On the eastern side of the mountain there is another abandoned level to the west of the track on Leitrim 21(9). An old coal level is marked on the 6-inch map to the east of the track, but has not been found; it may be the one mentioned by Cruise (1878) as being above Aughacashel House and in the upper seam, which was found to be 1 foot thick. The level to the west of the track is certainly in the lower seam (about 3 ft. 6 in. thick). Coal-seams are not unknown from within the Millstone Grit series elsewhere, though they are usually poor in quality; e.g. the Bradley Coal occurs within the Skipton Moor Grit, of E_1 age, in the Bradford and Skipton area (Stephens *et al.* 1953, p. 17).

The so-called Yordale Beds extend down to the Lough edge on the west and to the top of the Carboniferous Limestone on the south and south-east. The term Yoredale is not particularly well chosen for these beds. The name was first used by Phillips (1836, pp. 36–37), with the type section in Wensleydale. Hudson (1926, pp.125–35) subsequently amplified the term and described the Yoredale Beds as essentially a shallow-water series in which a rhythmic unit passing from shale through sandstone to limestone is continually repeated; goniatites are rare in these deposits. The shales on Slieve Anierin are in no way comparable with such a succession. At the base of the succession occur



TEXT-FIG. 2. Map showing the northern area of fossiliferous localities on Slieve Anierin, including the Stony River.

limestones, calcareous mudstones, and sandstones which are known to be of P_1 and P_2 age but from the base of the Namurian upwards shales were deposited continuously until the grit horizon. The only variation within this series is a greater concentration of clay ironstone bands at certain levels. They are a notable feature on Slieve Anierin; in the Stony River in particular the large nodules which weather out of these bands are seen plentifully in the river bed. Some bands in the shales are extremely fossiliferous and goniatites are very abundant, together with lamellibranchs. The succession has more in common with that described by Parkinson (1936, pp. 318–19) for the Upper Bowland Shales of the Slaidburn district of Yorkshire, where at least 400 feet of shales with goniatites and lamellibranchs as the common fossils succeed the P_2 beds. The onset of the Pendle Top Grit, however, occurs a short distance above *C. malhamense*, i.e. at a lower horizon than the grit on Slieve Anierin.

The 1-inch geological map shows some faulting of the grit and overlying shales but no supporting field evidence has been found. Impressive landslides have occurred along the western face of the mountain and at the south-western and south-eastern corners; the faults are all thought to be due to a failure to appreciate the magnitude of the landslipping. A fault shown on the 1-inch map between Slieve Anierin and the mountain to the north is continued as a broken line across the upper reaches of the Stony River but the faunal band exposed at L21(5)11 does not appear to be displaced. Two faults have been inferred on the basis of displacement of faunal bands on the southern flanks of the mountain; it is impossible to do more than tentatively suggest the position of these faults (text-fig. 1).

Acknowledgements. It is my pleasant duty to acknowledge all the assistance I have received during the course of this work. Mr. W. S. Bisat has been a constant source of advice and encouragement on all matters relating to the goniatites; his unflagging interest has always been an invaluable stimulus. Dr. Gwyn Thomas has read and criticized this manuscript and has given much assistance over all aspects of this work. Mr. Murray Mitchell has provided easy access to material at the Geological Survey Museum, and in particular I am grateful for the ease with which I have been able to borrow specimens to photograph. Dr. W. H. C. Ramsbottom has also rendered assistance in discussion on several points. Professor Hodson must be thanked for my first introduction to the Namurian of western Ireland and for advice on photography. Thanks are also due to the Central Research Fund of the University of London for several grants towards field expenses. (The editors also wish to express their appreciation of the generous grant received from the Central Research Fund to defray the cost of the collotype plates in this paper.)

FAUNAL SUCCESSION

Throughout the succession lamellibranchs and goniatites are particularly abundant and in numbers of individuals and of species are dominant over all other groups.

The number of goniatite genera is small; *Eumorphoceras*, *Cravenoceras*, and *Cravenoceratoides* are the most important and their various species are representative of definite levels in the succession. *Anthracoceras* and *Dimorphoceras* are abundant at certain levels, but are considered to be less valuable because of the difficulties of identifying species when no sutural evidence is available; only one species of *Anthracoceras* is of real value in indicating a precise stratigraphical level.

At the horizons in which *Anthracoceras* or *Dimorphoceras* abound, other goniatite genera usually do not occur in any abundance and are sometimes absent. This probably reflects differences in the conditions under which the two groups of genera flourished, a phenomenon which has already been observed in deposits of this age. Hudson and Cotton (1943, p. 151) believed that the *Anthracoceras—Dimorphoceras* faunas could exist in sea water less saline than normal. Bisat, Duncan, and Moore (1931, p. 4), commenting on the occurrence of *Anthracoceras* in the Upper Limestone Series of Scotland and in the Coal Measures of England, believed that this genus could withstand conditions which could not be tolerated by other goniatite genera. In beds on Slieve Anierin in which *Dimorphoceras* and *Anthracoceras* abound, these goniatites are usually associated with *Posidonia* and *Posidoniella*. These two lamellibranchs also occur abundantly with the other goniatite genera but appear to be the only genera able to survive the conditions in which *Anthracoceras* and *Dimorphoceras* flourished. It seems, however, that *Anthracoceras* had greater powers of resistance to a less favourable environment than even these two lamellibranchs, since over considerable barren thicknesses of shale with only plant fragments and *Lingula*, a stray *Anthracoceras* can still occasionally be found, but no lamellibranchs.

It is a matter for conjecture why certain levels were so extremely fossiliferous and why conditions then were so suitable for goniatites and lamellibranchs. Hudson and Cotton (1943, p. 150) suggested that salinity was a controlling factor. At periods of maximum freshwater intake, and therefore low salinity, the faunas were unable to survive; at periods when the freshwater intake was low and the salinity correspondingly high normal marine populations were able to flourish. An additional factor, however, has to be considered in the Slieve Anierin area, since the unfossiliferous shales frequently contain numerous clay-ironstone bands, often separated by only a few inches of shales. At these horizons the amount of iron in solution may well have made conditions intolerable for marine organisms, even those like *Dimorphoceras*, *Anthracoceras*, or *Lingula* which could tolerate low salinity.

At most of the fossiliferous levels in the Namurian beds on Slieve Anierin the number of individuals is usually very high whereas the number of species and genera is low. Two of the richest levels in genera and species are both in E_2 deposits. The lower yields about twelve species, the assemblage consisting entirely of goniatites and lamellibranchs, apart from some crinoidal debris and a nautiloid. The highest faunal band on the mountain is undoubtedly the richest in numbers of individuals, genera, and species, and in the diversity of the groups represented; apart from the ubiquitous goniatites and lamellibranchs there are brachiopods, trilobites, gastropods, fish remains, bryozoa, echinoid spines and plates, and crinoidal debris. It is also the most narrowly concentrated band, extending through only about 10–12 inches of rock. Other faunal bands, with far fewer species and consisting entirely of goniatites and lamellibranchs, extend through 10–12 feet of strata.

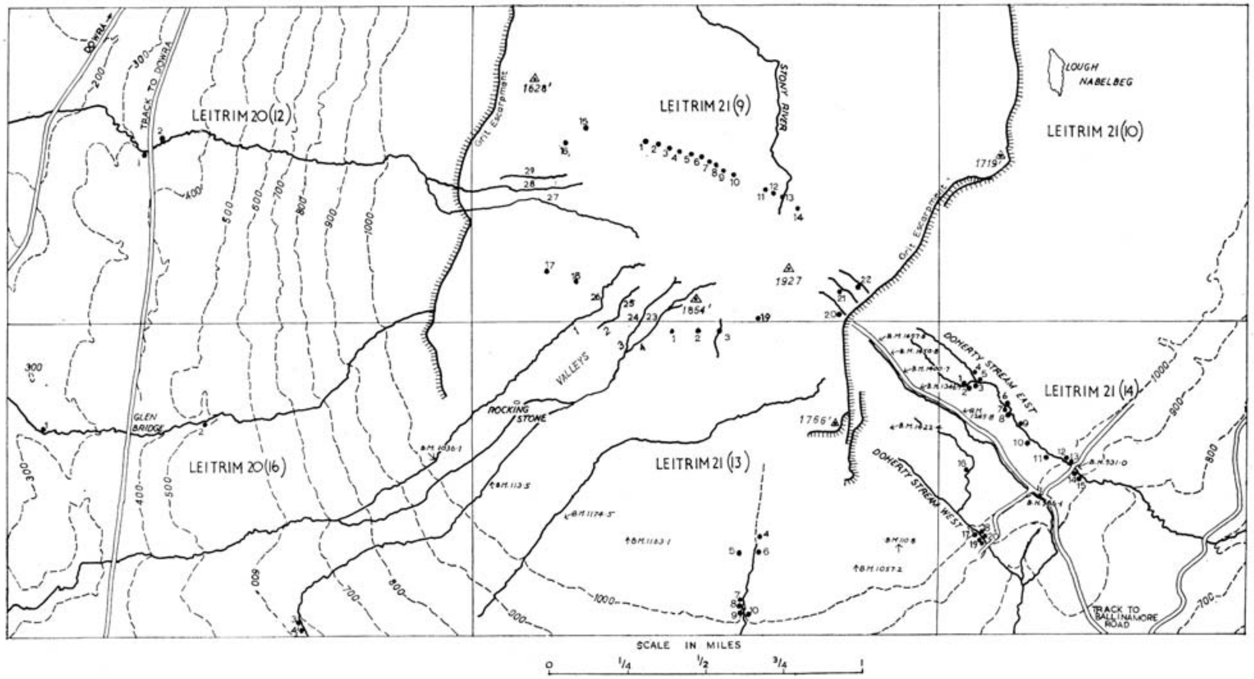
During P_2 times in the Slieve Anierin area, the deposition of argillaceous material became increasingly important and there was a diminution in the more calcareous shallower-water deposits which were laid down in P_1 and previous periods. By early Namurian times shales were the established lithological type. The shales of fossiliferous horizons are fairly solid and tough, and frequently split into large slabs, but those of the intervening unfossiliferous horizons are noticeably far more fissile and fragmentary, a slight tap with a hammer usually resulting in a cascade of small splinters of shale.

P_1–P_2 *Faunas*

The shales between the Carboniferous Limestone and the Millstone Grit were originally mapped as Yoredale Shales, but the succession in no way resembles the Yoredale succession in Yorkshire. In addition to the systematic study of the Namurian shales on Slieve Anierin, some collecting was also carried out in the Upper Viséan deposits (P_1 and P_2) which outcrop on the lower slopes of the mountain, chiefly on the southern and south-eastern sides, in order to trace the base of the Namurian (text-figs. 1, 3, 4).

Caldwell (1959, pp. 178–80) has given some details of the P_1 and P_2 beds in the Aghagrania River, where the succession is best seen, but the beds are only broadly divisible into the subzones established elsewhere on the basis of goniatites. Hodson and Moore (1959, pp. 384–96) were able to collect beautifully preserved goniatites in P_1b on Dough Mountain, farther north in Co. Leitrim, thus accentuating the very poor and scanty material available on Slieve Anierin at least in P_1.

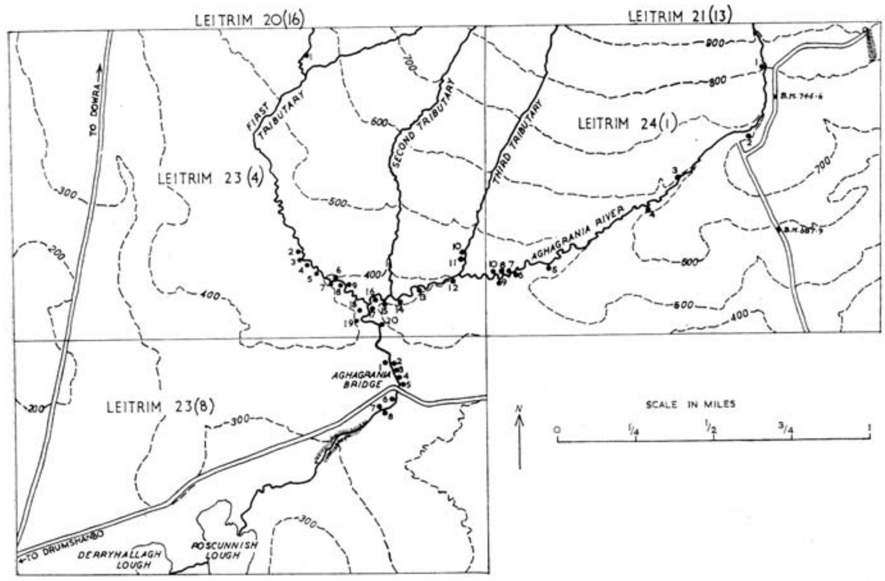
The succession in the Aghagrania River consists (see also Caldwell 1959) of alternations of shales, calcareous mudstones, mudstones, and muddy limestones. At Aghagrania Bridge a sandstone 20 feet thick is exposed. There is also an intercalation of decalcified limestone north of the bridge at L23(4)19, where the section is at least 30 feet high; there are many sandy seams, and the whole exposure has a curiously slumped appearance. *Goniatites*, broadly referred to the *striatus* group, has been collected below the



TEXT-FIG. 3. Map showing the central area of fossiliferous localities on Slieve Anierin.

sandstone south of Aghagrania Bridge, together with *Posidonia becheri*, *Thrincoceras hibernicum*, poor pleurotomariid gastropods, brachiopods, and orthoceratids. North of the bridge, above the sandstone intercalation but below the decalcified beds, *P. becheri* continues to be very abundant and occurs with rarer *Dunbarella elegans*, *Mourlonia striata*, rare spines of *Archaeocidaris urii*, and rare *Goniatites* cf. *G. falcatus*.

Above the decalcified beds there is a slight improvement in the faunas; softer mud-



TEXT-FIG. 4. Map showing the southern area of fossiliferous localities on Slieve Anierin, including the Aghagrania River.

stones are present at the base of L23(4)19 but shales become the dominant rock type at about 8 feet above the base of this section and, apart from occasional hard calcareous mudstone bands, apparently continue at least to the base of E_1. At about 3 feet above the base of L23(4)19 *Leiorhynchus carboniferus polypleurus* occurs in abundance, while in a mudstone 3 feet above this again there are abundant examples of *Goniatites granosus* associated with *Sudeticeras* cf. *S. crenistriatum*. The genus *Sudeticeras* with crenulate radials is typical of P_2 deposits while *G. granosus* is very abundant in the *G. granosus* subzone (P_2a) elsewhere. At about 20 feet above the base of this section *Sudeticeras sp.* is abundant in shales, accompanied by very rare *G. granosus*, and with the first appearance of *Caneyella membranacea* s.l., which has not been seen lower in the succession. *P. becheri* does not occur at these P_2 levels, in contrast to its extraordinary abundance lower in the succession. *P. corrugata* becomes common in P_2 at about the same time as *Caneyella*, although it may also occur lower than *Caneyella*. *Dunbarella* continues into these P_2 levels. The problematical striated tube-like structure *Coleolus namurcensis*

Demanet, which also occurs rarely in P_1 beds, is very abundant in the lower beds at L23(4)19. Another feature noted at about the level at which *Caneyella* appears in the upper part of L23(4)19 is the appearance of a thin, compressed and sharp-ventered goniatite referred to *Kazakhoceras sp.*; this species continues into E_1 and may in part be the same form as that mentioned and figured by Nevill (1957, p. 296, pl. 22, figs. 6, 7).

Two other exposures continue the succession. Locality L20(12)1 yields *C. membranacea* s.l. and *Sudeticeras* cf. *S. newtonense*. The presence of *Caneyella* indicates an horizon at least as high as the highest band at L23(4)19. *S. newtonense* is placed high in the succession of species of this genus (Moore 1950, p. 47). Locality L23(4)16 (which is close to L23(4)9, where basal E_1 beds are exposed) yields *C. membranacea* s.l. and *Lyrogoniatites newsomi georgiensis*. Bisat (1950, p. 12) refers the latter to a band at the top of the Viséan.

A clay-like band with a rich and varied fauna occurs at L23(4)17 and also high in the section at L23(4)15. At the latter locality, however, basal E_1 material occurs in the scree in front of the section and is believed to come from a horizon not far above the clay band which, although it has a rich fauna including two lamellibranch species which become very abundant in undoubted E_1 beds, does not itself include E_1 goniatites. The fauna of the clay band includes *Weberides sp.*, *Chonetes sp.*, *Lingula* cf. L. *parallela*, *P. corrugata*, *Pseudamusium* cf. *P. praetenuis* and *Obliquipecten costatus* sp. nov.

Various exposures are seen along the course of the Aghagrania River to the east of L23(4)18 and most are high in P_2 and below the basal E_1 band which is present at L23(4)9 and at high levels in L23(4)15. Farther north-east there are exposures of the decalcified beds seen just south of L23(4)19. The decalcified limestones are often extremely white and cherty, and rusty sands also occur. These beds have not been collected exhaustively but have yielded *Productus sp.* and crinoidal debris. A good exposure of these decalcified beds occurs at L24(1)1 with an excellent exposure of basal E_1 farther upstream at L24(1)1. Unfortunately the intervening exposures are inaccessible, but this is the part of the succession which is exposed, at least in part, at L23(4)19.

Farther north-east in Doherty Stream East (L21(14)14 and 15) there is a succession of alternating shales, mudstones, calcareous mudstones, and limestones similar to the succession south of Aghagrania Bridge. *P. becheri* and *Goniatites* of the *striatus* group (see Hodson and Moore 1959) occur. Beds very rich in *P. becheri* occur at L21(14)12. At L21(14)11 and in a deep gorge to the north-west, at least 40 feet of sandstone horizons and some sandy shales occur, containing only poor brachipods and *Dunbarella sp.*; these beds have been correlated with the sandstone at Aghagrania Bridge. At L21(14)10 a hard calcareous mudstone occurs at the base, overlain by about 10 feet of pale, decalcified and sandy beds reminiscent of the decalcified beds seen in the Aghagrania River at L23(8)1.

In Doherty Stream East L21(14)9 yields only *C. membranacea* s.l., and is therefore some distance up in the P_2 succession. At L21(14)8 there is a rich faunal band which is the equivalent of that seen at L24(1)1 and is undoubtedly basal E_1 in age. The section in this stream is therefore broadly comparable with the main Aghagrania River section, although the good goniatite material above the decalcified beds is not exposed in it, the only faunal evidence for P_2 being *C. membranacea*.

In Doherty Stream West, rich *P. becheri* beds occur at L21(14)17 to 20 and are probably partly equivalent to those seen at L21(14)12 in the eastern stream. The overlying

40 feet of sandstones and soft sandy shales (with some coaly layers) are at an equivalent horizon to L21(14)11 in the eastern stream. No further exposures occur in Doherty Stream West until L21(14)16, where beds with *Cravenoceras leion* indicate an E_1 horizon.

It is suggested that the sandstone horizon seen at Aghagrania Bridge thickens north-eastwards in this direction, while the underlying limestones and calcareous mudstones are more numerous at the expense of the shale and mudstone horizons. It is not possible, however, to estimate whether the whole succession is actually thicker than in the Aghagrania River, since the top of the Cavetown Limestone which lies below the P_1 beds is not exposed; the Cavetown Limestone is well exposed in the lower reaches of Doherty Stream East. The north-easterly thickening of the P_1 sandstone would not be inconsistent with the appearance of a sandstone horizon at the base of the 'Yoredale Shales' on Cuilcagh (Padget 1953; and Irish Ordnance Survey Maps 67 and 56), where the lowest collected horizon in the Yoredale Shales is P_1b.

Pendleian and Arnsbergian faunas

The appearance of *Eumorphoceras* and *Cravenoceras* at the base of the Namurian is a striking event in the sequence of goniatite faunas and the former genus is used as a name for the basal division of the Namurian; beds are said to be of Lower or Upper *Eumorphoceras* Age (E_1 or E_2 respectively). Several of the stage names originally suggested by Bisat (1928, pp. 125–30) have now been replaced by others. The most important for the present study are Pendleian, proposed by Hudson and Cotton (1943, p. 152) to replace Bisat's Grassingtonian for beds of Lower *Eumorphoceras* Age, and Arnsbergian, proposed by the same authors for beds of Upper *Eumorphoceras* Age to replace Bisat's Lower Sabdenian.

These stages are further subdivided into zones and subzones:

E_2 Zones and Subzones

Stage	*Zone*	*Subzones*
	Nuculoceras nuculum	*Nuculoceras nuculum* *Cravenoceratoides nititoides*
Arnsbergian	*Cravenoceratoides nitidus*	*Cravenoceratoides stellarum* *Cravenoceratoides nitidus* *Cravenoceratoides bisati*
	Eumorphoceras bisulcatum s.s.	(Not divided)

This table is based on a portion of one published by Hudson (1945, p. 2). The inclusion of the *Nuculoceras nuculum* zone in the Sabdenian (*Homoceras* Age) is the practice adopted in the Bradford and Skipton Memoir (Stephens *et al.* 1953, p. 95) but does not concern the present work.

The succession of zones within the Pendleian Stage adopted in the same Memoir (op. cit., p. 91) is as follows:

E_1 Zones

Cravenoceras malhamense	E_1c
Eumorphoceras pseudobilingue	E_1b
Cravenoceras leion	E_1a

The appearance of *Eumorphoceras* and *Cravenoceras* at the base of the Pendleian on Slieve Anierin is accentuated by the relative poorness of the P_2 and P_1 faunas in the area.

The genus *Girtyoceras*, from which *Eumorphoceras* probably evolved, is here absent from the P_2 and P_1 horizons, but elsewhere appears to have been fairly abundant at the end of P_2 times. Moore (1946, pp. 387–445, pl. 22–27) described several new species of *Girtyoceras* from horizons in Lancashire and Yorkshire ranging from B_2 to P_2. Bisat (1936, pp. 533–4) suggested that *Cravenoceras* was probably derived from *Beyrichoceratoides*, which is found elsewhere in the Viséan zone B, and lingers on sporadically into E_1 but after P_1a is never common. In the Slieve Anierin area there are no deposits of B age, and P_1a beds (although probably present south of Aghagrania Bridge) yield only very poor *Goniatites sp.*

(*a*) Cravenoceras leion *zone* (E_1a). Reference has already been made to the clay band with a rich fauna devoid of goniatites which is believed to be just under the base of E_1 at L23(4)15 and 17. At L24(1)1 and at L21(14)8 the faunas consist of *Eumorphoceras pseudocoronula*, *E. rota*, *C. leion*, *P. corrugata*, *Chaenocardiola bisati* sp. nov., *Pseudamusium praetenuis*, *Kazakhoceras sp.* Above this rich fauna there are beds several inches thick with only *Caneyella membranacea*. *P. praetenuis* was also a prominent member of the clay band seen elsewhere without goniatites and believed to be slightly lower than this material. *Caneyella* was frequently abundant towards the top of P_2 where it was associated with *Sudeticeras*.

At L23(4)9 and at L20(8)1 slightly later E_1 faunas occur. The most abundant goniatite is *C. leion*, mostly in the form of very small young individuals. Specimens of *Eumorphoceras* are extremely rare and are referred to *E. pseudocoronula;* at L20(8)1 a possible *E.* cf. *E. sp.* form *A* Moore also occurs. The fauna is dominated by *Obliquipecten costatus* sp. nov., which is so abundant that the beds are reminiscent of those in P_1 dominated by *P. becheri*. In the clay band just under the base of E_1 *O. costatus* sp. nov. was associated with other lamellibranchs, brachiopods, and trilobites; at this higher level in E_1 it is extremely abundant and continues through at least 2 feet of beds. *Chaenocardiola bisati* sp. nov. does not continue from the lower level at L24(1)1.

At L23(4)7 there are beds extremely rich in *E. pseudobilingue A* and *C. leion*, the latter of normal adult size; no lamellibranchs occur.

The sequence of faunas described so far is contained within about 10 feet of sediment, in contrast to some later levels where one fauna appears to continue through this thickness with little or no change. At the base of E_1 there is a rapid succession of faunas in a short vertical sequence, with scarcely any unfossiliferous sediments (see Table 1).

After *E. pseudobilingue A* the next species in ascending sequence to occur in great abundance is *Posidonia trapezoedra*, which extends through 10 feet of shales. This form is believed to be very close to *P. corrugata* seen lower in the succession but has strong radial corrugations in addition to the concentric folds, and a very characteristic outline as the name implies. In the lower part of its range it is associated with *Kazakhoceras sp.* which is believed to be the same form with a carinate venter as that seen high in P_2.

The succeeding beds consist of a narrow band with *E. medusa*, which is closely related to *E. pseudocoronula* seen very near the base of E_1. Stray specimens of *Kazakhoceras sp.* also occur at this level, with *P. trapezoedra* and *P. corrugata*, but the dominant lamellibranch is *Pseudamusium praetenuis*, which occurs sparsely with *E. pseudocoronula* near the base of E_1. Very rare specimens of *C. leion* are still present. *E. medusa sinuosum* has

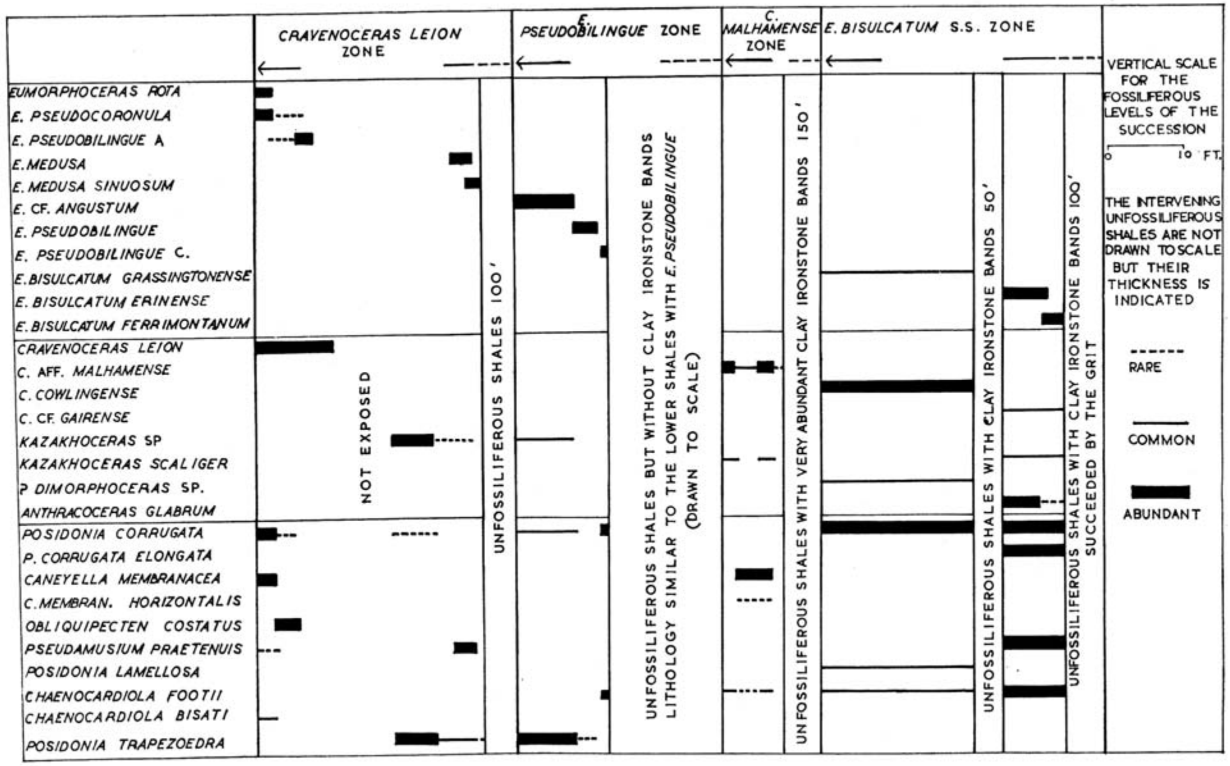


TABLE 1. Distribution of goniatites and lamellibranchs from the *Cravenoceras leion* zone to the *Eumorphoceras bisulcatum* s.s. zone on Slieve Anierin, compiled from localities below the grit.

been collected at L23(4)2 from what is believed to be a later horizon and where it is still associated with *P. trapezoedra;* a rare example has also been collected at L20(8)2 where the beds are dominated by *E. medusa*, as at L21(14)6 and 7. The highest fossiliferous level in the *C. leion* zone apparently occurs at L23(4)2.

Some of the goniatites referred to as *Kazakhoceras sp.* may correspond to those referred to by Nevill (1957, p. 296, pl. 22, figs. 6, 7); they have a notched venter, and appear in P_2 and E_1. There are also some extremely large compressed specimens, so far only seen at L24(1)1, which have a sharp venter, an ornament very like a *Dimorphoceras* with two forward bows in the striae between the umbilicus and the venter, but which possess a definite nautiloid suture.

The series of faunas so far described occur in rapid succession within about 30 feet of beds. Within this comparatively small thickness of rock the genus *Eumorphoceras* shows a rapidly evolving series of species, reflecting a period of great activity following the inception of the genus. In contrast, *Cravenoceras* appears to have been more conservative, and one species, *C. leion*, which it has not been possible to subdivide, persisted with the several species of *Eumorphoceras* throughout the succession.

There follows a considerable thickness (up to about 100 feet) of unfossiliferous sediments. Ironstone bands are a feature of these beds, though they are not so frequent as later in the succession, and stand out from the shales which form dreary and steep exposures on either side of the Stony River.

(*b*) Eumorphoceras pseudobilingue *zone* (E_1b). This portion of the succession can be seen in the Stony River to the north, and in the headwaters of the Aghagrania River to the south, and close correlation exists between these two areas (text-figs. 1–4).

The unfossiliferous shales with ironstones are followed by beds with fairly abundant *Eumorphoceras* cf. *E. angustum*, but with the conservative *Posidonia* stock persisting together with the *Kazakhoceras sp.* from E_1a. The first species to appear above the unfossiliferous horizon at L21(5)1 and 2 is *P. trapezoedra*, which was also the last to be seen in E_1a. The two goniatite species have been collected not only in the Stony River at this level but also in the Aghagrania River at L21(13)9 and 10. No new species of *Cravenoceras* occur at this level nor indeed any evidence of the genus.

E. cf. *E. angustum* probably has its maximum abundance in the upper parts of the *P. trapezoedra* beds. In Doherty Stream East, at L21(14)5, it is seen abundantly with *P. corrugata*, *P. trapezoedra*, and *Kazakhoceras sp.* above a considerable thickness of unfossiliferous shales with clay-ironstone bands which succeed the last indications of the *C. leion* zone with *E. medusa* at L21(14)6.

Succeeding the beds with *E.* cf. *E. angustum* there are beds with abundant *E. pseudobilingue* s.s. occurring in large flat slabs of dark-grey shale characteristic of this level, e.g. at L21(5)4 (*c.* 20 feet), and L23(4)1. It is associated with less abundant examples of the two species of *Posidonia* seen lower in the succession; rare specimens of *Chaenocardiola footii* also occur.

Fifteen feet of similar beds occur in the Aghagrania River at L21(13)8; at the base occurs a thin band, which is also seen at L21(5)4, above the beds with *E. pseudobilingue* s.s.; it is dominated by *P. corrugata*, most of which are very small; it also yields rare *Chaenocardiola footii* and *Cycloceras purvesi*. At this level occur a few specimens of a *Eumorphoceras* which is neither *E. angustum* of the lower horizon nor *E. pseudobilingue* s.s., which at L21(5)4 is collected directly below it. It is referred to as *E. pseudobilingue C*. The nature of the ribbing in these specimens is very like that of *E. pseudobilingue* s.s. but the decided groove at the shoulder is unlike the latter. The sparse collecting contrasts with the abundance of *E.* cf. *E. angustum* and *E. pseudobilingue* s.s. below. Between L21(13)9 and 10, and 8, there is an overgrown waterfall where collecting is difficult, and this is the level at which *E. pseudobilingue* s.s. occurs at L21(5)4.

Above the harder *pseudobilingue* material is a barren succession 8–10 feet thick, also seen at L21(14)1 and 4 in Doherty Stream East, with many horizons of very thinly leaved shales which still weather out into particularly large rectangular slabs. No clay-ironstone bands occur. They are overlain by the calcareous horizon with *C. malhamense* (E_1c).

(*c*) Cravenoceras malhamense *zone* (E_1c). Within 40 feet or less of beds it is possible to distinguish a lower group of goniatites which culminates in *E. pseudobilingue* s.s. followed closely by *E. pseudobilingue C* and an upper group in which there are no specimens of *Eumorphoceras* but in which the most common goniatite is *C. malhamense*, with far less common *Kazakhoceras scaliger*. As yet no undoubted specimens of *E. bisulcatum* have been seen and the beds are still regarded as Pendleian. Elsewhere in E_1, e.g. in the borehole section from Alport Dale in Derbyshire (see Hudson and Cotton 1943, pp. 167–8), the *C. leion* zone is succeeded by the *E. pseudobilingue* s.s. zone and then the *C. malhamense* zone (E_1c). This division is also applicable on Slieve Anierin, where the last two zones are concentrated into a relatively thin sequence, though in the absence of faunal evidence it is impossible to determine the exact position of the unfossiliferous beds below *Eumorphoceras* cf. *E. angustum* within E_1a or E_1b. It is noticeable that on Slieve Anierin the beds with *Eumorphoceras* in E_1b do not contain any species of *Cravenoceras* and the reverse is true in the higher beds with *C. malhamense*. However, this was not so at the E_1a levels where the two genera occur in apparently equal abundance.

At the base of L21(5)5 a hard calcareous mudstone, 1 foot thick, yields *C. malhamense* and is overlain by fairly solid shales which fracture irregularly. At about 1 foot above the hard mudstone the shales become thinly leaved and contain abundant *Caneyella membranacea* through a thickness of about 3 feet of beds; *C. malhamense* is more sparse than in the lower calcareous horizon, and *Kazakhoceras scaliger* also occurs. The doubts over the true affinities of the latter are mentioned on p. 393 but as the ornament seems unmistakable and as it is clearly indicative of certain levels, Schmidt's specific name has been retained here. This is the lowest horizon at which this species has been collected during the present work. At L21(13)7 in the Aghagrania River it occurs with *C. malhamense* above *E. pseudobilingue C;* specimens of *Actinopteria persulcata* also occur, but this species has not been collected elsewhere on Slieve Anierin at this level.

The fossiliferous beds are succeeded by an unfossiliferous sequence 150 feet thick similar to the lower one separating the E_1a and E_1b fossiliferous levels, except that here the clay-ironstone bands are far more numerous and are often separated by only a few inches of unfossiliferous strata. Upstream from L21(5)5 the sections in the Stony River take on the dreary character (already seen below the *E. angustum* beds) of high exposures of very friable shales with frequent ironstone bands which diminish in frequency upwards, particularly through the upper 50 feet or so of beds.

(*d*) Cravenoceras cowlingense *fauna* (*Low E_2a*). The next fossiliferous level is exposed in the Stony River, and can be traced along the sides of the valley high above the unfossiliferous sediments until at L21(5)9 it occurs at stream level and forms a prominent waterfall. Collecting from this horizon is easiest at L21(5)9, but it is also accessible at L21(5)8 some distance above the river bed. The same horizon is exposed in the Aghagrania River at L21(13)5 and 6; the former locality occurs high on the valley side and the total thickness is not exposed; at the latter the entire horizon is present, overlain by unfossiliferous beds.

The beds at these levels are more arenaceous than those lower in the succession but never show the large rectangular slabs which are characteristic of the *E. pseudobilingue* beds. The sequence is about 20 feet thick and the fauna, which is poor in species and also in individuals compared with lower and higher levels, remains the same throughout. It is dominated by *Cravenoceras*, and the specimens are all believed to belong to *C. cowlingense* Bisat. One rare specimen displays a suture-line and it is very like the suture figured for this species by Hudson (1941, p. 281) from material collected by him in Mirkfell. A few rare specimens of *E. bisulcatum* s.l. were collected, and therefore this faunal band is the first in E_2. The specimens are figured and described, and are compared with *E. bisulcatum grassingtonense* Dunham and Stubblefield (1944, pp. 258–60, pl. 11, figs. 4*a*–*c*). The only other goniatites at this level are poor specimens of Dimorphoceratids which, in the absence of sutural evidence, are of little value.

A rare specimen of *Stroboceras subsulcatus* (Phillips) was also collected; this form was also noted at lower levels in E_1. *Chaenocardiola footii* and the ubiquitous *P. corrugata* continue from lower levels, but *P. trapezoedra*, which occurs in great abundance lower down, has not been found at this level. *P. lamellosa* occurs but is never abundant, and might at first sight be easily mistaken for *P. becheri* from P_1 beds, though there are significant differences.

These beds are succeeded by 40–50 feet of very friable unfossiliferous shales, again with frequent clay-ironstone bands which are particularly abundant in the middle 20 feet of the sequence.

(*e*) Eumorphoceras bisulcatum *fauna* (*High E_2a*). The fauna of the next fossiliferous horizon is still dominantly a cephalopod-lamellibranch fauna, though a great deal of crinoidal debris occurs, for the first time above the more calcareous horizons of the Viséan. Sedimentation was slower at this time than in the earlier period when the beds with *C. cowlingense* were being deposited.

The horizon, which is estimated to be only 6–8 feet thick, is rich both in numbers of species and individuals when compared with the lower fauna with *C. cowlingense* as the dominant goniatite seen at L21(5)8 and 9, and at L21(13)5 and 6. The band is seen at three localities. At L21(5)10 the lower part of the band, of which about 4 ft. 6 in. are exposed, is seen at the top of the section overlying unfossiliferous friable shales. At the other two localities the base of the band is not exposed but the upper part and the overlying unfossiliferous sediments are seen; at L21(5)11 about 4 feet of the band occurs at stream level; at L21(13)4, where some excavation is necessary, about 2 feet are exposed in the valley side with unfossiliferous shales above.

There are slight faunal differences between the basal beds at L21(5)10 and the upper beds at the other two localities. Most of the fauna is common to all three localities; the most abundant constituent is *E. bisulcatum; E. bisulcatum erinense* subsp. nov. is only seen in the lower beds associated with rare specimens of *E. bisulcatum ferrimontanum* subsp. nov., which succeeds it and which is dominant in the higher parts of the sequence at L21(13)4 and at L21(5)11, where the lower subspecies no longer occurs. Both subspecies are in many respects close to *E. bisulcatum* s.s. but significant differences exist; they appear to be closer to *E. bisulcatum* s.s. than to other subspecies, namely *E. bisulcatum grassingtonense* Dunham and Stubblefield, *E. bisulcatum varicata* Schmidt, and *E. bisulcatum* mut. *B* Schmidt.

The subspecies of *Eumorphoceras* are accompanied at this level by *Cravenoceras* cf. *C. gairense*, specimens of which are easily distinguished by means of three raised spiral lines around the umbilicus (a diagnostic feature, which is not seen in any other species of this genus). It has been collected at all three localities but is never as abundant as either subspecies of *Eumorphoceras*. *Kazakhoceras scaliger*, which occurs in E_1 with *C. malhamense* and *Caneyella membranacea*, also occurs at the three localities. Its two associates do not survive E_1 times but *K. scaliger* apparently has a wider range. However, these are the only two levels at which this problematical species has been seen.

Anthracoceras glabrum occurs at the three localities but is decidedly more abundant in the lower levels at L21(5)10. Very rare specimens of the conservative *Stroboceras subsulcatus* also occur, contrasting with the more rapidly evolving goniatites.

Neither *C. membranacea* s.s. nor *C. membranacea horizontalis* subsp. nov. persist beyond E_1 beds, but at this level in E_2 an elongate subspecies of *P. corrugata* occurs, which it is thought may have been misidentified as *C. membranacea* by other authors; it is described as *P. corrugata elongata* subsp. nov. It is always associated with the ubiquitous *P. corrugata*, the most abundant species in the entire succession, and abundant specimens of the persistent *Chaenocardiola footii*, which occurs at several levels in E_1 and in E_2. The latter was not present in the faunas of the *C. leion* zone at the base of E_1, but *Chaenocardiola bisati* sp. nov. occurs at this level. *Chaenocardiola* never occurs in such swarms as some of the species of *Posidonia*, but it reaches its acme at this horizon.

Dunbarella aff. *D. elegans* is present, although this record does not conform with the horizon given by Jackson for the species; it is thought that the forms at this level are identical with those in P_1 and P_2. The species was not collected at any level in E_1 but is present again at this horizon in E_2.

(*f*) *The arenaceous interlude*. The very fossiliferous beds at L21(13)4, L21(5)11, and L21(5)10 are followed by about 100 feet of shales with clay-ironstone bands increasing in abundance upwards, overlain by a massive quartzitic grit, about 200 feet thick, which forms the prominent escarpment on the western and eastern sides of Slieve Anierin. Two thin coal-seams of poor quality occur within the grit; the lower is the most easily traced, and varies in thickness up to about 3 feet; the upper seam is only up to 1 foot in thickness, and is separated from the lower by about 50 feet of flagstones and sandy shales with plant remains. The lower part of the grit consists of the more massive beds but is usually the most obscured by the vast landslides which have occurred in front of the escarpment. About 75 feet of massive grits with some flagstones probably occur beneath the lower seam, while 25 feet of rusty arenaceous shales with ironstone nodules, followed by 50 feet of massive grit, overlie the upper seam.

It is clear that a great influx of fairly coarse arenaceous material entered the Namurian seas in the area at this time, associated with advancing delta fronts which periodically allowed a coal swamp vegetation to flourish.

(*g*) Cravenoceratoides edalense *and* Ct. bisati *fauna* (E_2b1). The first fossiliferous horizon above the grit is exposed at L21(9)20, which is the nearest exposure to the top of the grit escarpment on the south-eastern side of Slieve Anierin; the intervening beds, about 40 feet thick, are obscured. At L21(13)3, on the south of the mountain where the grit is obscured by drift, the fossiliferous beds occur above 20 feet of unfossiliferous shales, the remainder being concealed.

The horizon is about 8 feet thick and consists of dark-grey to black shales which split into large regular slabs. The number of species is low but individuals are abundant. The commonest species is *Ct. edalense*. This is the first appearance of *Cravenoceratoides*, which is closely related to *Cravenoceras*, a frequent member of the faunas at lower horizons and which still continues to flourish at this level. Associated with *Ct. edalense*, but much more rare, is *Ct. bisati;* it shows an irregular and repeated bifurcation of the lirae instead of the single division seen in *Ct. edalense* s.s. No specimens of *Eumorphoceras* were seen at this level. The only other members of the fauna are *P. corrugata* and *P. corrugata elongata* subsp. nov.; the latter was also common in the high E_2a faunal band beneath the grit.

This horizon is believed to be in the *Ct. bisati* subzone (the lowest subzone of the *Ct. nitidus* zone) although it is here dominated by *Ct. edalense*, and *Ct. bisati* itself is only a rare member of the fauna. In the absence of evidence for precise dating, the shales above L21(13)4 and L21(5)11, the grit formation and the 40 feet of beds between the grit and the *Ct. edalense* band, can only be loosely assigned to either the top of the *E. bisulcatum* s.s. zone or the *Ct. bisati* subzone.

(*h*) Cravenoceras subplicatum *fauna* (E_2b1). The succession from the level of *Ct. edalense* to the summit of Slieve Anierin is exposed in its entirety in Valley 4 (L21(9)23). However, better collections can be made in Valley 3 (L21(9)24), despite the fact that the succession is slightly less complete, beginning higher at the level of *E. bisulcatum leitrimense* subsp. nov. The succession from *Ct. edalense* to *E. bisulcatum leitrimense* will therefore be described from Valley 4, and the rest of the succession from Valley 3 (see Table 2).

The *Ct. edalense* beds are succeeded by 8 feet of shales in which specimens are so abundant at certain levels that individual outlines become obscured. At other levels sediment is more abundant and the details of the fauna are consequently less obscure. Some of the best examples of *P. corrugata* s.s. have been collected at these levels, associated with *Posidoniella variabilis* and *P. variabilis erecta* subsp. nov. This is the first appearance of *Posidoniella* in the area.

The goniatites at this level belong to the genus *Cravenoceras*. At first the writer was inclined to assign these specimens, which are by no means good, to the *cowlingense* group, but many of the better ones are now compared with *C. subplicatum*.

The fauna undergoes a change in the succeeding 2 feet of beds. It is still a goniatite-lamellibranch fauna but now *Dimorphoceras* is the only goniatite. The difficulty of identifying the species of this genus without sutural evidence has already been mentioned, and the specimens at this level are therefore only tenatively attributed to *Dimorphoceras* cf. *D. looneyi*. This form dominates the fauna, and the only other fossils are

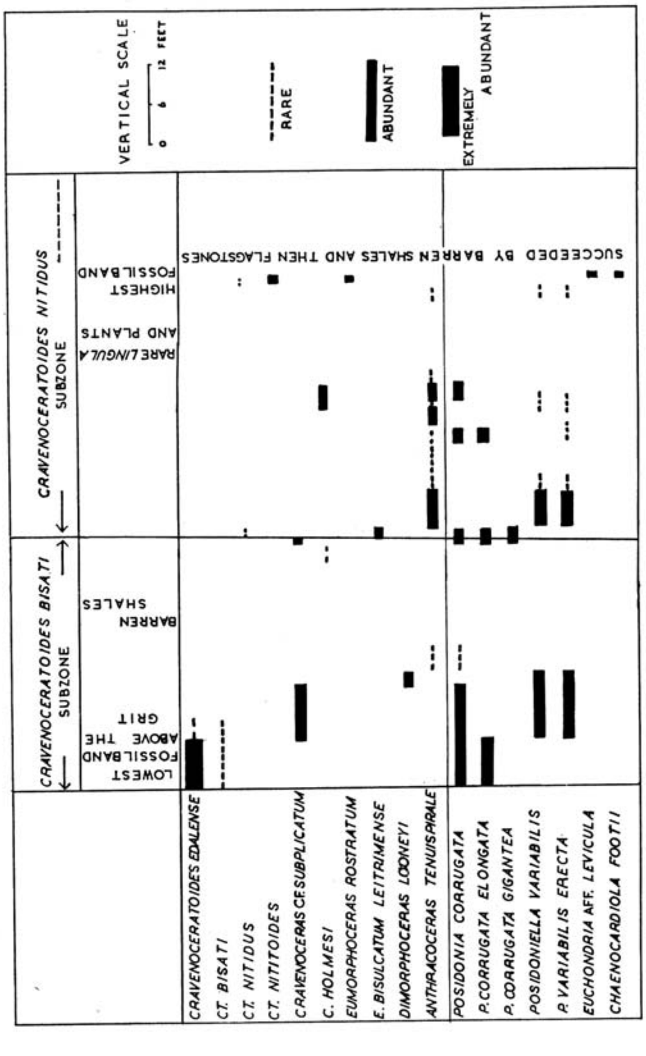


TABLE 2. Distribution of goniatites and lamellibranchs in the subzones of *Cravenoceratoides bisati* and *Cravenoceratoides nitidus* on Slieve Anierin, compiled from Valleys 3 and 4, L21(9)24 and 23.

Posidoniella variabilis and *P. variabilis erecta* subsp. nov., both of which were present at the lower level but subordinate to *Posidonia.*

Above this band there are about 4 feet of shales which are virtually barren except for very infrequent narrow seams of *P. corrugata* indistinguishable from those at lower levels, and occasional specimens of *A. tenuispirale*. The succeeding 12–15 feet of shales are completely barren, but they are overlain by a very fossiliferous band about 9 inches thick, crowded with fossils which frequently obscure each other. *P. corrugata* and *P. corrugata gigantea* subsp. nov. abound, but *P. corrugata elongata* subsp. nov. is slightly less common. Poorly preserved goniatites are present, and as in the case of the lower forms they are assigned to *C. subplicatum*.

In summary, the succession up to this point consists of about 16 feet of shales during the deposition of which a population rich in individuals but poor in species flourished. In the succeeding 2 feet *Dimorphoceras*, believed to be indicative of more brackish conditions, is the only goniatite. Thereafter, through about 16 feet of beds, conditions were unsuitable for goniatites, except for stray specimens of *Anthracoceras* and a few lamellibranch seams at the base. Overlying this portion of the succession is another fossiliferous horizon.

(*i*) Eumorphoceras bisulcatum leitrimense *fauna* (E_2b2). The description of the succession from this horizon to the top of Slieve Anierin is continued from Valley 3 (L21(9)24). *E. bisulcatum leitrimense* subsp. nov. extends through about 18 inches of sediment, and is associated with abundant specimens of *P. corrugata* s.s., its two subspecies *elongata* and *gigantea*, and less common examples of *Posidoniella variabilis*. The specimens of *Eumorphoceras* are mostly rather small and are not usually so well preserved as the forms occurring below the grit, and also at higher levels than *leitrimense*. This band is a very useful marker horizon and collections have been made from it at several other localities; it is thought that it may in fact represent the base of the *Ct. nitidus* subzone. At L21(9)19 *E. bisulcatum leitrimense* has been collected with very scanty pieces of *Cravenoceratoides* ornament, but the lirae on these fragments, although showing the bifurcations seen in the lower *Ct. edalense* s.s. material, are asymmetrical as in the two species *Ct. nitidus* and *Ct. nititoides*.

(*j*) Anthracoceras tenuispirale *fauna* (E_2b2). The *E. bisulcatum leitrimense* horizon is followed by 19 feet of shales, the only goniatite being *Anthracoceras tenuispirale*. This species has not hitherto been recorded in the British area but it occurs in abundance on Slieve Anierin. I am also informed by Dr. J. S. Jackson (*in litt.*) that the same species occurs in the Kingscourt inlier, Co. Meath. The possibility that specimens of *A. tenuispirale* from other areas have been wrongly identified as *Cravenoceras* cf. *C. holmesi* is discussed on p. 395.

On Slieve Anierin *A. tenuispirale* is usually associated with *Posidoniella variabilis* and *P. variabilis erecta* subsp. nov. It may also have been the species present with *E. bisulcatum leitrimense* but the material at this level is not sufficiently clear. Throughout the lower 5 feet of this 19-foot thickness of shales the proportion of fossils to sediment is about the same as in the lower *leitrimense* band so that individual specimens do not obscure each other; the lithology varies from pale brown decalcified siltstone to an intensely black siltstone.

In the next 7 feet of shales within the 19-foot sequence, fossils are very rare except for a few specimens of *A. tenuispirale* and *Lingula sp.* Bisat (1933, pp. 412–14) believes *Anthracoceras* to be a semi-estuarine genus, and its scanty occurrence with *Lingula* here supports this contention. In the lower part of this 7-foot section *P. variabilis* is also present with *A. tenuispirale*, and seems to have been capable of withstanding a lower salinity than *Posidonia*.

After this barren interlude there is a thickness of about 2 ft. 6 in. in which *P. corrugata* and *P. corrugata elongata* are dominant, and *A. tenuispirale* and *Posidoniella variabilis* both rare. There follow two white sandstone bands, each about 4 inches thick and separated by about 8 inches of sandy unfossiliferous shales. This brief arenaceous interlude is succeeded by about 2 ft. 9 in. of beds in which *A. tenuispirale* is the only fossil present apart from internal moulds of minute mollusca and impressions of conodonts. In the upper 9 inches *Posidoniella variabilis* and *P. variabilis erecta* appear again. Conditions during the deposition of these 19 feet of shales therefore obviously fluctuated from semi-estuarine to littoral. At no point in the succession were clay-ironstone bands observed.

(*k*) Cravenoceras holmesi *fauna* (E_2b2). Succeeding these 19 feet of shales is a 15-inch band dominated by *C. holmesi*. At L21(9)13 a few internal moulds of this form were collected just below the *E. bisulcatum leitrimense* material but at L21(9)24 it appears for the first time as a very abundant component of the fauna about 20 feet above *leitrimense*. Associated with this species are very rare specimens of *A. tenuispirale* and a few rare *P. variabilis erecta*.

C. holmesi persists through the overlying 2 ft. 6 in. of shales and at certain levels is very abundant, but at other levels *A. tenuispirale* is dominant. At those levels at which *Cravenoceras* abounds specimens of *P. corrugata* and *P. corrugata elongata* are also common. *A. tenuispirale* occurs mostly in isolation, although sometimes in association with conodont impressions.

The next 3 feet of sediments are barren apart from rare *A. tenuispirale* and *Lingula sp.*; the upper 6 inches of this section has yielded no fossils at all. A narrow sandstone band then occurs, followed by 9 feet of beds containing *Lingula sp.*, a narrow sandstone band and then 2 feet of shales with obscure ?*Anthracoceras* and *Posidoniella* and plant fragments only.

(*l*) Cravenoceratoides nititoides *fauna* (E_2b3). These less interesting deposits are terminated by a 6-inch band of decalcified mudstone in which fossils, though exceedingly abundant, are poorly preserved. This band, however, is the prelude to more rewarding material since it immediately underlies the richest faunal horizon on Slieve Anierin. The latter is only about 9 inches to 1 foot in thickness but the individuals are more abundant and there is less sediment than in the *leitrimense* band. The band is tough, pale brown in colour, completely decalcified, and loose slabs are frequently found in the streams winding through the peat on the upland area above the grit in front of the four main valleys on the south-western face of the mountain (text-figs. 1, 3).

The fauna consists of *Eumorphoceras rostratum* sp. nov., *Ct. nititoides*, rare *Ct. nitidus*, *Euchondria* aff. *E. levicula*, *Chaenocardiola footii*, *C.* cf. *C. haliotoidea*, *Dunbarella* aff. *D. elegans*, *Posidoniella* cf. *P. vetusta* (Sowerby), *Weberides* cf. *W. shunnerensis*, *Productus hibernicus*, *Orbiculoidea nitida*, *Mourlonia striata*, *Archaeocidaris urii*, crinoidal debris, *Stroboceras subsulcatus*, *Fenestella sp.*, *Edestodus sp.*

This is the richest and most diverse band in the succession in terms of species present. Trilobites, brachiopods, gastropods, and echinoid plates and spines only occur elsewhere in the sequence in P_2 or very low E_1 levels. This is the only level at which any bryozoa have been seen.

After the accumulation of the thick grit formation the succession on Slieve Anierin up to the band just described has oscillated from decidedly marine horizons (e.g. those with *Ct. edalense*, *C. subplicatum*, and *C. holmesi*) to beds deposited under far more brackish-water conditions with *Dimorphoceras* or *Anthracoceras* alone at certain levels or associated with *Posidoniella variabilis*. Between the grit and the *Ct. nititoides* band clay-ironstones have not been observed but there are several thin sandstone horizons with *A. tenuispirale*, particularly in the brackish sequences.

Overlying the *Ct. nititoides* band there are 40 feet of barren sandy shales with clay-ironstone bands becoming more numerous towards the top. This is virtually a return to the lithology typically seen separating the various fossiliferous beds below the grit. The clay-ironstone horizons both below the grit and above the *Ct. nititoides* band occur as thin continuous beds as well as bands of nodules. The last solid beds seen under the peat deposits which cover the top of Slieve Anierin consist of about 12 feet of white or pale-buff flagstones with plant fragments.

SYSTEMATIC DESCRIPTIONS

Order AMMONOIDEA Zittel 1884
Suborder GONIATITINA Hyatt 1884
Superfamily GONIATITACEA de Haan 1825
Family GONIATITIDAE de Haan
Subfamily GIRTYOCERATINAE Wedekind
Genus EUMORPHOCERAS Girty 1909

Genotype: Eumorphoceras bisulcatum Girty 1909.

In his diagnosis of this genus Moore (1946, pp. 417–18) includes the following features: pronounced ribs as early as the second whorl and continuing into the late youthful stage; a ventro-lateral groove; a generally rounded venter; and a ventro-lateral salient and ventral sinus. In his original description Girty (1909, pp. 67–68) defined *Eumorphoceras* as lacking constrictions; however, species and subspecies have subsequently been described which show constrictions. Moore (1946, p. 393) has commented on this and added this feature to his diagnosis of the genus (p. 418), which now therefore includes some taxa with constrictions.

Eumorphoceras pseudocoronula Bisat

Plate 51, fig. 1

Eumorphoceras pseudocoronula Bisat 1950, p. 19, pl. 2, fig. 4.

Description. The umbilicus is widely open. There are prominent constrictions which after a short radial passage from the umbilicus soon curve smoothly forward to pass obliquely into the ventro-lateral groove. The edges of the constrictions are sharp and raised into ribs. Between each pair of constrictions there appear to be two or three ribs which are strongly seen in the umbilical edge and close to it, but which fade some distance before the groove. The umbilical edge is beaded. The groove on the ventro-lateral area is divided into two by a strongly rounded ridge. The test ornament of delicate striae is seen in some specimens, and their course follows that of the constrictions as far as the groove. At the groove these striae have a prominent lingua, from which they curve backwards to a sinus on the venter. There are spiral striae in the ventro-lateral region.

Localities. This species is a very common member of a rich fauna at L24(1)1 and at L21(14)8.

Horizon. It is associated with *Cravenoceras leion* and *Eumorphoceras rota* (Yates 1961, pp. 57–58, pl. 6, figs. 6, 7). The stratigraphical level is E_1a.

Discussion. Although this form has already been described by Bisat, a description of the forms collected on Slieve Anierin is given here to facilitate comparison with the later closely related form of *E. medusa* (Yates 1961, pp. 54–56, pl. 6, figs. 1, 2). Specimen 7213 has been figured (op. cit., pl. 6, fig. 3).

Eumorphoceras pseudobilingue A Bisat

Plate 51, fig. 2; Plate 53, fig. 6

Eumorphoceras pseudobilingue A Bisat 1928, pl. 6 (facing p. 130).

Description. This form is sharply ribbed with a wide umbilicus and in this material no evidence of constrictions has been seen. The ribs are numerous and sharp; they are sickle-shaped and separated by wide interspaces; close to the shoulder ridge they have a well-marked and smoothly-curved forward swing and pass into the ventro-lateral furrow. The umbilicus has a raised and beaded edge. The ventro-lateral furrow is divided into two by a well-marked ridge. Both the two resulting furrows are well defined. The specimens with shell preserved show fine striae which follow the rib direction; spiral striae are strongly developed in the region of the ventro-lateral ridge.

Dimensions. 7016 (pl. 1, fig. 2): diameter 22 mm.; umbilical diameter 7 mm. 7017 (pl. 3, fig. 6): diameter *c.* 35 mm.; the ribbing is still strong on this large specimen though it is becoming more indistinct on the last visible piece of whorl.

Locality and horizon. The best examples on Slieve Anierin occur at L23(4)7. *E. pseudobilingue A* is associated with equally abundant examples of *C. leion* and is therefore an E_1a species.

Discussion. Moore (1946, p. 426) points out that although Bisat (1928) has divided *E. pseudobilingue* into three forms, *A*, *B*, and *C*, he has given no statement as to their differences, but apparently groups form *A* with *C. leion*. Moore also describes a form which seems to agree with one seen in younger beds on Slieve Anierin and it is therefore

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EXPLANATION OF PLATE 51

All specimens are from Slieve Anierin, Co. Leitrim, Eire.

Fig. 1. *Eumorphoceras pseudocoronula* Bisat. 7015*c*. External mould; also showing two internal moulds of *E. rota* Yates (7015*a*, *b*), ×3·5.

Fig. 2. *Eumorphoceras pseudobilingue A* Bisat. 7016, external mould showing spiral ornament on the ventro-lateral ridge, ×4.

Figs. 3–5. *Eumorphoceras pseudobilingue* (Bisat) emend. Moore. 3, 7039, showing wavy nature of narrow ribs, ×3·6. 4, 7037, ×3·6. 5, 7040, showing angular beaded venter of large specimen, ×2.

useful and appropriate to describe the earlier form which agrees well with those figured by Nevill (1957, pl. 22, figs. 1–3) from the Summerhill Basin.

Eumorphoceras pseudobilingue (Bisat) emend. Moore 1946

Plate 51, figs. 3–5

Glyphioceras pseudobilingue Bisat 1922, *The Naturalist*, pp. 225–6.
Eumorphoceras pseudobilingue (Bisat) *partim*. Bisat 1924, pp. 99–100, pl. 10, figs. 1, 2.
Eumorphoceras pseudobilingue (Bisat); Schmidt 1934, p. 446, fig. 1. (non) *Eumorphoceras pseudobilingue* (Bisat); Demanet 1941, pp. 135–6, pl. 5, figs. 11–14.
Eumorphoceras pseudobilingue (Bisat) emend. Moore 1946, pp. 426–9, pl. 23, fig. 2; pl. 25, fig. 3; text-fig. 27.

Description. The very early whorls have not been seen. At 12 mm. diameter the ribbing is strong and there are about 13/half whorl. The following description is based on many specimens of which 7037 (Pl. 51, fig. 4) is a typical example. At *c*. 20 mm. there is a ventro-lateral ridge and a wide umbilicus. The venter is broad but the mid-venter becomes raised and angular. It is not certainly known at what diameter this angularity of the mid-venter appears, but it is a well marked character by *c*. 25 mm. Large fragments show a distinct notching of the mid-ventral ridge (Pl. 51, fig. 5). The ribs in this species have a typically wavy character. In the adult whorl they are thin and sharp, separated by wide interspaces. In the earliest part of the whorl they are sharp on the umbilical edge and continue over the greater part of the flank. Near the ventro-lateral ridge they curve forward and terminate at the ridge. At this stage there is one quite noticeable bend in the course of the ribs close to the umbilical edge. As the whorl advances the ribs fade over most of the flank and are sharp only in the immediate neighbourhood of the umbilicus. They swing strongly forward just after leaving the umbilical edge but then disappear. At very advanced diameters there are still indications of the ribs at the extreme umbilical edge, and they persist when the ventro-lateral ridge has all but disappeared.

Dimensions. 7037: diameter *c*. 20 mm. (Pl. 51, fig. 4). 7038: diameter *c*. 25 mm. Most of the specimens approximate to these dimensions but crushing has obscured many, making their exact measurement impossible.

Localities. L23(4)1 and L21(5)4.

Horizon. L23(4)1 is isolated but is probably in low E_1b. At L21(5)4, which is also in low E_1b, the fauna occurs a little distance above beds with *Eumorphoceras* cf. *E. angustum*, *Posidonia corrugata*, and *P. trapezoedra*; the latter horizon is separated by a considerable thickness of unfossiliferous rusty shales from the highest faunal band in the *C. leion* zone (E_1a).

Discussion. The Slieve Anierin examples are considered to conform to the lectotype (GSM 72972) from Little Mearley Clough described by Moore (1946), and other specimens deposited by Moore at the Geological Survey Museum from Cow Close Syke, Malham. Moore gives no stratigraphical placing beyond assigning an E_1 age. A few feet above this form on Slieve Anierin occur forms referred to *Cravenoceras* aff. *C. malhamense*, *Kazakhoceras scaliger*, and *Caneyella membranacea*. The figure given by Schmidt (1934, p. 446, fig. 1) shows a similarity in the wavering nature of the ribbing and the ridge which develops in the mid-venter. Demanet (1941, pp. 135-6, pl. 5, figs. 11–14) has forms which do not resemble either the Irish specimens or Moore's material. They apparently have a far smaller umbilicus, the ribbing disappears at far smaller diameters and there is apparently a strong shoulder groove. These specimens do not resemble *Eumorphoceras pseudobilingue A*.

Eumorphoceras pseudobilingue C Bisat

Plate 52, figs. 1, 2

Eumorphoceras pseudobilingue C Bisat 1928, pl. 6.

Description. There is a marked groove on the ventro-lateral area which persists to advanced diameters. At 10 mm. diameter (umbilical diameter 3 mm.) there are ribs which are strongly defined at the umbilical edge but which lose their strength over the flanks. In their thinness and wide interspacing they resemble those of *E. pseudobilingue* s.s., but lack the typical wavering character of the ribs in that species although they still show a kink near the umbilical edge. At this stage there are slight constrictions. By 15 mm. diameter the ribs are seen only at the extreme umbilical edge and no constrictions are seen. The ventro-lateral groove is still strong.

Dimensions. 7041: diameter 15 mm. (Pl. 52, fig. 1). 7042: diameter 10 mm. (Pl. 52, fig. 2). 7043: diameter *c*. 8 mm. 7044: diameter *c*. 10 mm.

Localities. L21(5)4, low E_1b; L21(13)8, high E_1b.

Horizon and associated fauna. These forms have all been collected from a very thin band immediately above beds with *E. pseudobilingue* s.s., which are in turn above beds containing *Eumorphoceras* cf. *E. angustum*. They are associated with rare specimens of *Chaenocardiola footii* and gregarious small individuals of *Posidonia corrugata*.

Discussion. This species has points of similarity with *E. angustum* Moore (1946, pp. 424–6, pl. 24, figs. 1–7; text-fig. 26), namely the early fading of the ribs and the comparatively small umbilicus; however the ribs, although fading early, are still quite strong at diameters at which in *E. angustum* they are little more than plications. In *E. pseudobilingue C* there is an undoubted groove in the ventro-lateral area which contrasts strongly with the poorly developed ridge seen in this area in *E. angustum*. A large distorted specimen at about 22 mm. diameter still shows the ventro-lateral groove. A comparison has also been made with *E. hudsoni* Gill, originally described by Moore (1946, pp. 419–20, pl. 24, figs. 2, 2*a*) as *Eumorphoceras sp.* form *B* aff. *Sagittoceras costatum* Ruprecht. Moore states that in this species the groove in the ventro-lateral

EXPLANATION OF PLATE 52

All specimens are from Slieve Anierin, Co. Leitrim, Eire.

Figs. 1, 2. *Eumorphoceras pseudobilingue C* Bisat. 1, 7041, showing early loss of ribs and strong ventro-lateral groove, ×5·5. 2, 7042, ×6.

Figs. 3, 4. *Eumorphoceras bisulcatum grassingtonense* Dunham and Stubblefield. 3, 7047, the inner whorls show rib bifurcation and a relatively early reduction in their strength; the outer whorl is preserved as an internal mould showing a strong groove only, ×5·3. 4, 7046, fragment showing two constrictions, ×7.

Fig. 5. *Eumorphoceras bisulcatum ferrimontanum* subsp. nov. 7055, paratype, showing ribs only at the umbilical edge, merging into finer striae over the flanks, ×4.

Fig. 6. *Cravenoceratoides nitidus* (Phillips). 7094, external mould showing relatively large umbilicus and asymmetrical lirae, ×4.

area continues up to about 20 mm. On the holotype (GSM 72650) at 11 mm. diameter there appears to be very little sign of a groove, but only a slight ridge. This ventro-lateral groove does not appear as a very strong feature on GSM 72649, 72651–5, all collected from Carla Beck, near Skipton. *E. pseudobilingue C* has a strong groove, and a smaller umbilicus than *E. hudsoni*.

The Slieve Anierin specimens are, however, similar to *E. pseudobilingue* s.s. The thin ribs with wide interspaces are common to both but in *E. pseudobilingue C* the ribs fade earlier and do not show the wavy character seen in the ribs of *E. pseudobilingue* s.s. The ribs (see 7041, Pl. 52, fig. 1), before fading on the flanks, show the same kink after leaving the umbilicus as is seen in *E. pseudobilingue* s.s. In the latter, however, there is a definite ridge in the ventro-lateral area. Bisat has mentioned but never described or figured *E. pseudobilingue C* (1928, pl. 6). Slieve Anierin forms have so far been referred to *E. pseudobilingue A* and to *E. pseudobilingue* s.s. At the Geological Survey Museum GSM Z1 5777, collected in Little Mearley Clough, has been labelled *E. pseudobilingue C*, but the specimens are very poor though they appear to possess a groove on the ventro-lateral area. There are also slabs collected by Parkinson from Studforth Gill, Tosside, 5 miles south-west of Settle, Yorkshire, which are said to be high *E. pseudobilingue C*. On these slabs only one specimen, GSM Z1 5775, resembles the Slieve Anierin examples; although poor it has a groove on the shoulder. On the other slabs the examples appear to be closer to *E. pseudobilingue* s.s. It has been decided (with Bisat's approval, *in litt.*) to refer these examples from Slieve Anierin below *Cravenoceras malhamense* to *E. pseudobilingue C*.

Eumorphoceras bisulcatum grassingtonense Dunham and Stubblefield

Plate 52, figs. 3, 4

Eumorphoceras bisulcatum Girty mut. *grassintonensis* Dunham and Stubblefield 1944, pp. 258–60, pl. 11, figs. 4*a–c*.

Description. At a diameter of about 10 mm. the umbilical diameter is about 3·5 mm.; in 7045 at this diameter there are about fourteen strong ribs in slightly under half a whorl; these ribs are strong and slightly swollen at the umbilical edge, where they seem to project over the edge; there are two clear constrictions in this specimen. At a diameter of about 7 mm. 7046 shows one clear constriction and a rib forking very close to the umbilical edge just before the constriction. In 7047 at 12 mm. diameter the ribs show raised, swollen tips at the umbilical edge but they are very muted across the rest of the flank; at 19 mm. diameter over the flank (which is all this specimen shows at this diameter) only growth lines are seen. At this, the largest diameter seen, the shoulder groove is still strong. From above these constrictions are not very strong; they are most easily seen at their break into the shoulder groove. This is also true in the type specimen GSM KD423. This feature is also commented on by Currie (1954, p. 582) in describing *E. bisulcatum* aff. *grassingtonense* Dunham and Stubblefield.

Dimensions. 7047: greatest diameter 19 mm., diameter of inner ribbed part 12 mm. (Pl. 52, fig. 3). 7046: diameter 7 mm. (Pl. 52, fig. 4). 7045: diameter 10 mm.

Localities. L21(13)6 and L21(5)8.

Horizon. Low E_2a. This is the earliest record on Slieve Anierin of *E. bisulcatum*. It occurs very scantily indeed, the dominant goniatite at this level being *Cravenoceras cowlingense*. *Dimorphoceras sp.* is also present. Lamellibranchs are not common and include *Chaenocardiola footii*, *Posidonia lamellosa* and *P. corrugata*.

Discussion. The material at this level is very scanty and *Cravenoceras* individuals far exceed *Eumorphoceras* in abundance, but as this is the lowest horizon at which *E. bisulcatum* occurs they are particularly important specimens. At 10·5 mm. diameter *grassingtonense*, described by Dunham and Stubblefield (1944, pp. 258–60), has an umbilicus of 4·0 mm. and about sixteen ribs in half a whorl. Specimen 7048 corresponds approximately to these figures; only two constrictions have been seen in this specimen but others may be concealed between these two. 7046 shows a bifurcation of the ribs at a point immediately before the single clear constriction. Rib bifurcation is a feature of *grassingtonense*, in which at 10·5 mm. diameter there are about five constrictions with five ribs between them, but the number is not constant. The ribs of *grassingtonense* are said to 'take origin at the margin in a raised tubercle', and this feature is seen in the Slieve Anierin material. In the original description of this mutation it is stated that the diameter at which the ribbing becomes reduced is not known. In 7047, at about 12 mm. diameter, the ribs are still strong at the edge of the umbilicus but less apparent on the flank. At this diameter also bifurcations in the ribs appear to be slightly commoner and to take place further over the flank.

Eumorphoceras bisulcatum erinense subsp. nov.

Plate 53, figs. 1, 2; Plate 54, fig. 7

Description. The ribs are strong and numerous. They continue across the flanks almost to the shoulder groove; very close to the latter they bend forward rather sharply. After a short oblique passage forward they end at the groove. The ribs are still apparent at a diameter of 14 mm. in 7049 and the umbilical diameter is about a third of the total diameter. In some specimens the ribs are still strong at 18 mm. over most of the flank (see 7050) and the shoulder groove is also still strongly defined.

Holotype. 7049*c* (counterpart 7274): the large specimen, diameter 14 mm. (Pl. 53, fig. 1). *Paratypes*. 7049*a*, *b*: two small specimens on the same slab, diameter 8 mm. and 9 mm. (Pl. 53, fig. 2). 7050: diameter 17–18 mm. (Pl. 54, fig. 7). 7052: diameter 12 mm.

Type locality and horizon. This subspecies has so far only been collected from one locality, L21(5)10, which is thought to be very close to L21(13)4 and L21(5)11 in stratigraphical level, which is high E_2a. The associated fauna at the three localities is the same, and *E. bisulcatum ferrimontanum* subsp. nov. occurs at L21(5)10 with *erinense*, but less abundantly. At the other localities mentioned only *ferrimontanum* is present.

EXPLANATION OF PLATE 53

Except for fig. 3, all specimens are from Slieve Anierin, Co. Leitrim, Eire.

Figs. 1, 2. *Eumorphoceras bisulcatum erinense* subsp. nov. 1, 7049*c*, holotype, showing geniculate aspect of ribs, ×4·3. 2, 7049*a*, *b*, paratypes, external moulds, ×4.

Fig. 3. *Eumorphoceras* cf. *E. bisulcatum ferrimontanum* subsp. nov. Edge Marine Band, Cononley Beck, 200 yds. S. 47° W. of Cononley Church, Yorks. GSM GM3675, ×4·25.

Figs. 4, 5. *Eumorphoceras bisulcatum leitrimense* subsp. nov. 4, 7060, holotype, showing constrictions with 2–3 short intervening ribs, ×5·3. 5, 7063, paratype, ×9·4.

Fig. 6. *Eumorphoceras pseudobilingue A* Bisat. 7017, external mould, ×3.

Discussion. This subspecies resembles *E. bisulcatum ferrimontanum* subsp. nov. in some respects. Both forms have abundant and strong ribs, but in *erinense* they persist to much larger diameters. The groove is strong to large diameters in both subspecies. Apart from the greater persistence of the ribs in *erinense* there is also a difference in their appearance when compared with those of *ferrimontanum*. In *erinense* they pass almost to the groove before bending forward rather sharply to pass obliquely into the groove. The result is a geniculate appearance and a larger radial portion to the rib. In these specimens of *erinense* although the ribs persist to about 18 mm. diameter they merge distally into the finer striations on 7049*c* where the geniculation begins at about 14 mm. diameter. In 7050 they are strong over about three-quarters of the flank and then degenerate. At a diameter of at least 25 mm. 7053 has a marked ridge at the shoulder with a slight furrow on its lateral and ventral side. As with *ferrimontanum* there are differences when compared with *E. bisulcatum* Girty s.s. The geniculate aspect of the ribs in *erinense* is closer to Girty's figures than the ribs in *ferrimontanum*. Occasional indications of rib bifurcation are seen in *erinense* but these do not seem to follow any definite pattern. They are not mentioned in Girty's description (1909, pp. 68–70) nor by Miller and Youngquist (1948, pp. 662–4). The umbilicus of the type specimen of *E. bisulcatum* s.s. is smaller than that seen in *erinense*.

Eumorphoceras bisulcatum ferrimontanum subsp. nov.

Plate 52, fig. 5; Plate 53, fig. 3; Plate 54, figs. 1–4

Description. Most of the specimens are rather small. The ribs are strong from the earliest whorls. By the time a diameter of 12 mm. has been reached the ribs are sharp on the immediate umbilical edge only. At smaller diameters the ribs pass over the flanks with a slightly forward trend towards the shoulder groove. They have a slight twist at the umbilical edge. Close to the groove they curve forward and are much less distinct, merging into finer growth striae. They pass forwards to form a lingua in the ventro-lateral region. The rounded termination of the lingua is situated on the ventral side of the shoulder groove. There are indications also of spiral ornament in this region. The shoulder groove is seen to advanced diameters (see 7054 and 7055). The groove is strong, with the inner and the ventral wall showing about equal angles of slope. At a radius of 15 mm. 7056 shows a ridge at the shoulder with a strong furrow still on its lateral side and a far fainter furrow on the ventral side. So far no undoubted constrictions have been seen in these specimens. The umbilical diameter is about a third of the total diameter at 14 mm. diameter. The ribs in 7057 number about 17/half whorl. There is evidence of at least nine ribs in the small fragment of the umbilicus seen in 7055.

Holotype. 7054 (counterpart 7048): diameter 18 mm. (Pl. 54, fig. 1). *Paratypes.* 7058: incomplete, ?27 mm. (Pl. 54, fig. 2). 7059: diameter 11 mm. (Pl. 54, fig. 3). 7055 (Pl. 52, fig. 5). 7057: diameter 14 mm. (Pl. 54, fig. 4).

Type locality and horizon. This form is abundantly represented on Slieve Anierin at L21(13)4, the type locality, and at L21(5)11. The horizon is high E_2a. The rich associated fauna includes *Cravenoceras* cf. *C. gairense*, *Kazakhoceras scaliger*, *Chaenocardiola footii*, *Dunbarella elegans*, and several varieties of *Posidonia corrugata*.

Discussion. In this form the ribs apparently fade away relatively early. 7058 is almost smooth apart from the growth-lines and the faint indication of ribs at the umbilical edge. The lingua is relatively deep (see 7055 and 7054). The rib counts are fairly large. These examples are obviously broadly referable to *E. bisulcatum* Girty. Unfortunately Girty's description (1909, pp. 68–70, p. 11, figs. 15–19*c*) is based on specimens of about 10 mm. diameter and the later stages well seen on the Slieve Anierin specimens have not been discussed in detail beyond the statement that the ventro-lateral groove persists for longer than the ribs. From Girty's plates it seems that his specimens apparently have rather more geniculate ribs than are seen in the author's material. Moore (1946, pp. 430–3) describes a form which he refers to *E. bisulcatum* Girty s.l. but it does not agree with the present subspecies. The latter is probably close to the form *E. bisulcatum* as described by Girty, but differs in the less geniculate nature of the ribs. Most of the Irish specimens have an umbilical diameter of about a third of the total diameter. The type specimen of *E. bisulcatum* (refigured by Moore 1946, pl. 25, figs. 5*a-d*) has an umbilical diameter of about 25 per cent of the whole. The inability to compare very closely the specimens at slightly more advanced stages is also a difficulty. However, since this form occupies a definite level and appears to be distinct in at least one feature it is proposed to name it *E. bisulcatum ferrimontanum*.

Subspecies of E. bisulcatum. The three subspecies of *E. bisulcatum* which have been described may look very similar superficially but a study of many specimens collected from beds whose order of superposition is known with certainty is valuable and shows that three subspecies of this species do exist. Two of these occur on approximately the same level and are stratigraphically higher than the third. For the sake of clarity the salient features of these three subspecies and their order of appearance are summarized.

(*a*) Specimens collected at L21(13)6 and L21(5)8 from a low E_2a horizon show:

1. About sixteen ribs in half a whorl.
2. Constriction (at least at small diameters).
3. Rib-bifurcation (more frequent at advanced diameters and taking place farther from the umbilical edge).
4. Ribs which are somewhat swollen at the umbilical edge and project over it.
5. Ribs fading over the flanks at 12 mm. diameter.
6. An umbilical diameter which is about 35 per cent of the whole.
7. The groove still strong at the largest diameter seen.

These are identified as *E. bisulcatum grassingtonense*.

(*b*) The high E_2a band at L21(5)10 yields specimens attributable to a subspecies showing:

1. Geniculate ribs.
2. Ribs still apparent at 17–18 mm.

EXPLANATION OF PLATE 54

All specimens are from Slieve Anierin, Co. Leitrim, Eire.

Figs. 1–4. *Eumorphoceras bisulcatum ferrimontanum* subsp. nov. 1, 7054, holotype, external mould showing early failure of ribs, and spiral ornament on the ventro-lateral area, ×3·75. 2, 7058, paratype, external mould, with the ventro-lateral groove still seen over most of the specimen although the ribbing has been lost, ×3·3. 3, 7059, paratype, external mould, ×5. 4, 7057, paratype, external mould, ×4·75.

Figs. 5–6. *Eumorphoceras bisulcatum leitrimense* subsp. nov. 5, 7065, showing constrictions persisting over the venter, ×8. 6, 7064, paratype, ×4·75.

Fig. 7. *Eumorphoceras bisulcatum erinense* subsp. nov. 7050, paratype, showing geniculate ribs to relatively large diameter, ×3·75.

3. An umbilical diameter about 33 per cent of the whole.
4. Constrictions not apparent.
5. Occasional indications of rib bifurcation.
6. Groove persistent to advanced diameters. At very large diameters a ridge appears with a shallow groove laterally and ventrally.

These are identified as *E. bisulcatum erinense* subsp. nov. Rare examples of the following subspecies are also present.

(*c*) Specimens collected from the high E_2a band at L21(5)11 and L21(13)4 show:

1. No bifurcations or constrictions.
2. An umbilical diameter which is about 33 per cent of the whole.
3. Ribs fading on the flanks at about 12 mm.
4. The groove persisting to advanced diameters; at very advanced diameters there is a ridge at the shoulder with a strong groove laterally.
5. About seventeen ribs in half a whorl.

These are identified as *E. bisulcatum ferrimontanum* subsp. nov.

All these early examples of *E. bisulcatum* show features of resemblance to *E. bisulcatum* s.s. A close relationship exists between the three subspecies despite the several distinguishing features which each has developed. The earliest subspecies, *grassingtonense*, resembles the much later *ferrimontanum* in the early fading of the ribs on the flanks, but no rib bifurcations and constrictions have been seen in the latter and the umbilical diameter may be slightly smaller in *ferrimontanum* at comparable diameters. *Erinense* and *ferrimontanum* are alike in umbilical diameter but the ribs persist to greater diameters in *erinense* and are rather geniculate in aspect. The latter shows an occasional rib bifurcation, a link with *grassingtonense*. All three subspecies in common have a strong shoulder groove persisting to the large diameters but at very large diameters in *erinense* and *ferrimontanum* a ridge appears on the shoulder. A strong furrow is present laterally of this ridge in *ferrimontanum* but there appears to be a less strong furrow each side of the ridge in *erinense*. Comparably large diameters of the lower form *grassingtonense* are not available for comparison. There is still a groove at *c*. 20 mm. in this subspecies. The distinguishing features are the relative persistence of the ribs, their aspect, and whether or not they show bifurcations. Constrictions have so far only been seen clearly in *grassingtonense*, the earliest form.

Eumorphoceras bisulcatum leitrimense subsp. nov.

Plate 53, figs. 4, 5; Plate 54, figs. 5, 6; Plate 55, fig. 5

Description. These specimens are all rather small. Constrictions are clearly seen. 7060 is the best specimen and shows in the earlier part of the last whorl three short ribs between the constrictions. Later there appear to be only two ribs between the constrictions. The intermediate ribs are short and do not extend to the ventro-lateral groove. This groove is strong to advanced diameters. Fragments of shell devoid of all indications of ribs or constrictions are not uncommon and represent an extremely gerontic stage of this subspecies. The umbilicus is not large; at small diameters it is about 29 per cent of the total diameter. A few short ribs persist at the umbilical edge after the last constrictions, and are rather fat and stubby. At least in the early stages the constrictions are strong over the venter; unfortunately the venter at later stages has not been seen.

Holotype. 7060: diameter 10 mm.; umbilical diameter 2·5–3 mm. (Pl. 53, fig. 4). *Paratypes.* 7061: diameter 16 mm. (Pl. 55, fig. 5). 7062: diameter 10 mm. 7063: diameter 5 mm. (Pl. 53, fig. 5). 7064: diameter 7–8 mm.; umbilical diameter 1·5–2 mm. (Pl. 54, fig. 6).

Type locality and horizon. Basal beds at L21(9)27, western exposure. It also occurs in basal beds at L21(9)28 and in Valley 3 (L21(9)24) and Valley 4 (L21(9)23). The E_2b2 horizon on which this form occurs is above beds rich in *Ct. edalense* and well below the top faunal band. Associated with this form are several variants of *Posidonia corrugata*, and *Anthracoceras* cf. *A. paucilobum*.

Discussion. From a consideration of specimens 7060 and 7064 it appears that in the last constrictions seen, there are only two intervening short ribs, of which either one or both coincide with the actual edge of the constriction, which is raised and rib-like close to the umbilicus. In the earlier part of the last whorl, which shows these intermediate short ribs, one of these, the first to develop, coincides with the edge of the constriction. The constrictions show a strong forward curve in all cases.

Not many subspecies of *E. bisulcatum* with constrictions have been described. H. Schmidt (1934, p. 455) defines *E. bisulcatum varicata;* this form, at a diameter of 12 mm., has seven ribs reducing to four between the constrictions. The constrictions are shown on his figure (op. cit., p. 449, fig. 29) to continue strongly over the venter and the umbilicus looks quite large compared with the Slieve Anierin material. The short intermediate ribs are the same in both cases but in the German specimens there are greater numbers of intermediate riblets between the constrictions.

E. bisulcatum grassingtonense Dunham and Stubblefield (1944, pp. 258–60) has constrictions which number about five/whorl and usually have about five ribs between them. However these intermediate ribs are not short but geniculate, and reach to the ventro-lateral groove. Also there is occasionally the appearance of a bifurcation. The type specimen of this form does not show any constrictions over the venter and the form is obviously distinct from the Slieve Anierin material. The constrictions are less obvious in *grassingtonense*. The only form so far described which bears any resemblance to the author's specimens is *E. bisulcatum varicata*, but the former can be distinguished by means of the very low number of intermediate riblets between the constrictions.

The varieties of *E. bisulcatum* from the Scottish limestones (see Currie 1954, pp. 581–4, pl. 4, figs. 5–7) do not seem to resemble this subspecies. GSM Da 1593, 1594, and 1599, collected from a section in the left bank of the stream, 150 yards south-east of Low Stubbing and 820 yards N. 10° W. of Holy Trinity Church, Cowling, are thought to be the same as the Slieve Anierin form.

EXPLANATION OF PLATE 55

All specimens are from Slieve Anierin, Co. Leitrim, Eire.

Figs. 1–4. *Eumorphoceras rostratum* sp. nov. 1, 7066, paratype, showing one rib bifurcation and the shallow groove between the curve of the flank and the ridged edge of the venter, ×3·8. 2, 7067*a*, holotype, external mould, ×3·5. 3, 7067*b*, paratype, ×6. 4, 7068, paratype, ×3.

Fig. 5. *Eumorphoceras bisulcatum leitrimense* subsp. nov. 7061, paratype, external mould showing persistent ventro-lateral groove but early loss of ribs and constrictions, ×4·6.

Fig. 6. *Cravenoceras leion* Bisat. 7076, fragment of internal mould showing two constrictions and the acute edged umbilicus, ×4.

Eumorphoceras rostratum sp. nov.

Plate 55, figs. 1–4

Description. These specimens are very strongly ribbed from the smallest diameters seen. The largest complete specimen at 27 mm. diameter still shows very strongly developed ribs. At 10 mm. diameter there are about eleven ribs in half a whorl. Occasionally a rib forks (e.g. in specimen 7066). At 18 mm. diameter there are about fourteen ribs in half a whorl. The ribs pass strongly and radially (with a forward trend) over the flank for about half to two-thirds of the distance between the umbilical edge and the shoulder groove. They then begin to curve forwards, and thereafter lose their strength and merge into growth lines which pass forwards into an extremely deep lingua over the strong ridge at the shoulder. There is a shallow concavity between the curve of the flank and the strong ridge which marks the junction of the curved flank and the venter (the venter is usually embedded but the ridge at the edge of the flank apparently passes straight down into, and is the edge of, the flattened venter).

Holotype. 7067*a* (counterpart 7211): diameter 27 mm. (Pl. 55, fig. 2). *Paratypes.* 7067*b* (counterpart 7212): small specimen on this slab, diameter 10 mm. (Pl. 55, fig. 3). 7066: diameter 20 mm. (Pl. 55, fig. 1). 7068: diameter 20 mm. (Pl. 55, fig. 4). 7069: diameter 20 mm.

Type locality and horizon. Valley 4, L21(9)23; also Valley 2, L21(9)25. All the specimens were collected from a very prominent fossiliferous horizon which is the highest on Slieve Anierin, E_2b3. They are members of a very abundant fauna which includes *Ct. nititoides*, *Chaenocardiola footii*, *Weberides* cf. *W. shunnerensis*, &c., and which occurs about 40 feet above *E. bisulcatum leitrimense* subsp. nov.

Discussion. The distinguishing features of these specimens are the very pronounced lingua in the growth-lines; the early merging of strong ribs into fine growth-lines which often takes place about half-way across the flank; the strong ridge at the junction of venter and flank; and the very shallow depression between this ridge and the gently curved flank. The ribs are still strong at large diameters. No constrictions have been seen. Moore (1946) has described specimens of *E. bisulcatum* s.l. from Samlesbury Bottoms, River Darwen, Lancs., where they are associated with *Nuculoceras nuculum*. They therefore occur at a higher horizon than the Slieve Anierin specimens. A study of Moore's specimens in the Geological Survey Museum results in the conclusion that the forms are not the same. In GSM 72603 (Moore 1946, pl. 22, fig. 3) there is a definite groove at the shoulder and the ribs persist across the flanks to this groove. 7067*b* from Slieve Anierin is approximately the same size for comparison and is distinctly different. The strong ribs have merged into growth-lines and start their forward swing to the lingua about half-way across the flank; also, there is no prominent shoulder groove but only a slight dip on the flank side of the sharp edge which lies between flank and venter. The test is seen in the specimens described by Moore and shows spiral lirae (GSM 72602, pl. 27, fig. 2). These have not been seen in the Slieve Anierin material, but the vagaries of preservation may well be responsible for this absence. A point of similarity is that the ridge (at the margin of the flank) which slopes down to the venter is also present in Moore's material, but in the latter is flanked by a decided groove which is already present by 3 mm. diameter.

Miller and Youngquist (1948, pp. 665–7, pl. 100, figs. 1–4, 20, 21) have defined the species *E. plummeri*, which they believe closely resembles the form described by Moore.

From their plate and descriptions the same distinctions from the Slieve Anierin specimens as those for Moore's material are valid.

Subfamily HOMOCERATINAE Spath
Genus CRAVENOCERAS Bisat 1928

Genotype: Cravenoceras malhamense (Bisat 1924). Bisat originally defined this genus in 1928 but subsequently described it far more fully (1932, pp. 27–36, pl. 1, 2). Within the genus he separated two groups, one around forms like *C. leion* Bisat and *C. malhamense* (Bisat) with delicate non-dichotomizing striae, and another group with stronger dichotomizing ornament and including such forms as *C. edalense* Bisat and *C. nitidum* (Phillips). Hudson (1941, p. 282, footnote) later separated off the latter group as a new genus, *Cravenoceratoides*, but left the other group as *Cravenoceras*.

Cravenoceras cf. *C. gairense* Currie

Plate 56, figs. 1, 2

Cravenoceras gairense Currie 1954, pp. 577–9, figs. 8–10; text-figs. 6*b*, *c*.

Description. This form is interpreted as moderately globose. The umbilicus is not large and probably occupies about a quarter or less of the diameter. The ornament consists of fine non-bifurcating striae, having a distribution of three or four per 1 mm. at about 6 mm. from the umbilical edge. The striae are radial with a very slight forward trend from the umbilicus. There are three raised spiral ridges around the umbilicus; in the impressions they are seen in reverse as impressed furrows separated by low curved ridges. The spiral ridges are raised above the general curvature of the flanks to form a rim around the umbilicus.

Dimensions. The specimens are generally too fragmentary for accurate measurement; the following are relatively complete, although squashed, specimens. 7082 (counterpart 7256): diameter *c*. 8 mm.; umbilicus 2 mm. 7083 (counterpart 7257): diameter *c*. 8 mm.; umbilicus 2 mm. (Pl. 56, fig. 1).

Localities and horizon. The specimens were all collected at localities L21(13)4, L21(5)11, and L21(5)10, which are all thought to be at approximately the same stratigraphical level and represent a high E_2a horizon.

Discussion. This distinctive species has been described by Currie from the Gair Limestone of Lanarkshire, and other specimens from the Calmy Limestone of Lanarkshire are also mentioned. Currie (1954, p. 532) has given a table showing the possible stratigraphical relationships of the Scottish deposits, from which it appears that the Calmy Limestone and the Gair Limestone are both higher in E_2 than the beds on Slieve Anierin

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EXPLANATION OF PLATE 56

All specimens are from Slieve Anierin, Co. Leitrim, Eire.

Figs. 1, 2. *Cravenoceras* cf. *C. gairense* Currie. 1, 7083, ×5·25. 2, 7084, fragmentary external mould showing spiral ornament around the umbilicus, ×5.

Figs. 3, 4, 6. *Cravenoceratoides* cf. *Ct. bisati* Hudson. 3, 7103, showing irregular bifurcating lirae, ×4·5. 4, 7104, external mould showing repeated bifurcation of lirae, ×3·5. 6, 7105, external mould showing irregular bifurcation of lirae, ×4.

Fig. 5. *Cravenoceratoides edalense* (Bisat). 7101, part of internal mould with a constriction, and an external mould showing the symmetrical lirae with one bifurcation, ×5·3.

Fig. 7. *Chaenocardiola footii* (Baily). 7174, external mould, ×6·5.

are believed to be. The fauna associated with *C. gairense* in the Scottish limestones is rather similar to that which occurs at a higher level on Slieve Anierin within the *Ct. nitidus* zone E_2b. Currie (*in litt.*, 1959) admits the great similarity of the Irish material to her specimens but is unwilling to go any further with shale impressions only. The specimens are therefore probably best identified as *Cravenoceras* cf. *C. gairense*. Currie mentions a specimen in the Geological Survey Museum (GSM RM77) which resembles her species but apparently lacks the middle spiral line. In addition GSM JS1479 and JS1492 from Crickton, Glam., appear to be very close to *C. gairense*. GSM JS1121 from near Ilston, Glam., is also close.

Cravenoceras subplicatum Bisat

Plate 57, fig. 1

Cravenoceras subplicatum Bisat 1932, pp. 30–31, pl. 1, fig. 5.

Description. The shape of these specimens is not easy to interpret but is apparently a slightly flattened cadicone. The ornament consists of very fine non-bifurcating striae, which are radial with no backward deflection near the umbilical edge. The umbilicus is about a quarter or slightly more of the total diameter. There are two noticeable features in these specimens. The first is seen on 7085, which shows the impressions of rather widely spaced striae over the venter and more sharply incised impressions of some of the striae at the umbilical edge. The other feature is seen on the internal mould 7086, which shows a tendency to form undulations of the surface which fan outwards from the umbilicus and fade away over the flanks and venter. Each of these undulations bears on its surface several striae, one of which usually appears somewhat more prominently than those on either side of it.

Dimensions. All the specimens are small and imperfectly preserved, and it is difficult to give accurate dimensions; the diameters are considered to be from 10–14 mm.

Localities and horizon. Most of the specimens have been collected from Valley 4, L21(9)23, from an E_2b1 level between the *Ct. edalense* beds and beds with *E. bisulcatum leitrimense* subsp. nov. They are particularly common in a band just beneath that containing the latter. They are associated with *Posidonia corrugata* and its subspecies. Less perfect examples have been collected from just above the *Ct. edalense* beds. Good specimens have been collected at localities L21(9)1–14.

Discussion. These specimens are very abundant and in view of their stratigraphical position it is important to decide on their affinities. They contrast with *C. cowlingense* Bisat (1932, pp. 29–30, pl. 1, figs. 1–3) in the absence of any backward deflexion in the ornament; also the ornament is rather finer (at any rate at these diameters though possibly larger specimens would show a coarser ornament). They differ from *C. holmesi* Bisat (1932, p. 31, pl. 1, fig. 6) in the absence of a rim around the edge of the umbilicus. Two features of the Slieve Anierin material have been particularly noted and despite the differences in preservation both features are revealed in an examination of the type material of *C. subplicatum*. The holotype, GSM 49963 (from Birstwith Beck, near Hampsthwaite, Yorks.), of about 11 mm. diameter, shows very fine striations with periodically sharper plications at the umbilical edge. These become less obvious away from the umbilicus but there is still a tendency for periodic striae on the flanks and venter to be stronger than their adjacent ones, which are frequently so faint as to be barely perceptible. As a result of this the stronger striae stand out and give the impression of a very widely spaced ornament (seen in 7085). The other feature, already described in 7086, may possibly be associated with slightly larger size. GSM Z1 5806, a topotype of *C. subplicatum*, with a diameter of about 13 mm., shows the plications at the umbilical edge, but in this case there is apparently a raising up of several striae, and this bundle fans outwards away from the umbilicus and fades over the flanks and venter back into the normal convexity.

Genus CRAVENOCERATOIDES Hudson 1941

Genotype: Cravenoceratoides nitidus (Phillips).

Cravenoceratoides nitidus (Phillips)

Plate 52, fig. 6

Goniatites nitidus Phillips 1836, pp. 235–6, pl. 20, figs. 10–12.
Homoceras nitidum (Phillips); Bisat 1924, p. 106.
Cravenoceras nitidum (Phillips); Bisat 1932, pp. 34–35, pl. 2, fig. 3.
Cravenoceratoides nitidus (Phillips); Hudson 1946, pp. 376, 383, pl. 21, fig. 11; pl. 21*a*, figs. 1*a-c*.

Description. The shape is apparently cadicone. The umbilicus is rather wide, and about a third of the diameter. The ornament consists of radial bifurcating lirae. In the external impressions these can be seen to be asymmetrical (canted). The bifurcation in the lirae at a diameter of 14 mm. is about 1 mm. from the edge of the umbilicus; at the same diameter the lirae are about two per mm. on the venter. There is no forward arching in the lirae even in the largest specimens. The tendency in this species is for the bifurcation to stay uniformly close to the umbilical edge, with little or no tendency to migrate over the flank as growth advances.

Dimensions. 7094: diameter 14 mm., umbilicus 4·5 mm. (Pl. 52, fig. 6). 7095: diameter 28–30 mm., umbilicus *c.* 9 mm. 7096: diameter *c.* 22 mm., umbilicus 7·5–8 mm.

Locality and horizon. All the specimens so far collected come from the highest faunal band, E_2b3, in Valley 3, L21(9)24. The fauna at this level is very rich in *Ct. nititoides*, *E. rostratum* sp. nov., *Euchondria* aff. *E. levicula*, *Chaenocardiola footii*, *Weberides* cf. *W. shunnerensis*, &c. The specimens of *Ct. nititoides* are more abundant than *Ct. nitidus*.

Discussion. This species is distinguished from *Ct. nititoides* by the larger umbilicus and the lack of the forward curve in the lirae, which in *Ct. nitidus* are radial. In all the examples of *Ct. nititoides* examined there is a tendency for the bifurcation of the lirae to

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EXPLANATION OF PLATE 57

All specimens are from Slieve Anierin, Co. Leitrim, Eire.

Fig. 1. *Cravenoceras subplicatum* Bisat. 7087, external mould showing in the later whorls striae which are more widely spaced and stronger at the umbilical edge, ×4·25.

Fig. 2. *Cravenoceratoides edalense* (Bisat). 7102, external mould showing singly bifurcating symmetrical lirae, ×5.

Fig. 3. *Anthracoceras tenuispirale* Demanet. 7129, crushed specimen showing spiral ornament, ×16.

Figs. 4, 5. *Cravenoceratoides nititoides* (Bisat). 4, 7099, external mould showing bifurcating asymmetrical lirae tending to curve forward over flanks, and the small umbilicus, ×3·3. 5, 7097, ×5.

move over the flank during ontogeny. This is hardly seen at all in *Ct. nitidus* where the position of the bifurcation stays close to the umbilical edge. In both species the lirae are asymmetrical (canted), in contrast to the symmetrical lirae (tented) of *Ct. edalense* and *Ct. bisati* (Hudson, 1946). Schmidt (1934, p. 449, fig. 42) figures *Cravenoceras* cf. *C. nitidum* (Phillips) from Germany, and his figure shows an umbilical diameter of about a third of the total diameter, but the bifurcations are not very clear on the drawing, which cannot be compared with the present specimens. The latter are closely comparable, however, with the lectotype of *Ct. nitidus*, BM C279*a*, which has been figured by Hudson (1946, pl. 21*a*, figs. 1*a-c*).

Cravenoceratoides nititoides (Bisat)

Plate 57, figs. 4, 5

Cravenoceras nititoides Bisat 1932, p. 35, pl. 2, fig. 2.
Cravenoceras nititoides Bisat; Schmidt 1934, p. 450, fig. 47.
Cravenoceras nititoides Bisat; Demanet 1941, pp. 143–4, pl. 6, figs. 6–8.
Cravenoceratoides nititoides (Bisat); Hudson 1941, p. 282.
Cravenoceratoides nititoides (Bisat); Hudson 1946, pp. 375, 376, 383, pl. 21, fig. 8.

Description. This species occurs crushed, but if undeformed it would probably be a slightly flattened cadicone. The plications bifurcate once, the bifurcation occurring a short distance over the flanks away from the edge of the umbilicus. The plications have a very slight forward swing over the flanks and are asymmetrical (canted). The umbilicus is small.

Dimensions. 7097: diameter 11 mm. (Pl. 57, fig. 5). 7098*a*: large specimen, diameter 18 mm., umbilical diameter 3 mm. 7098*b*: one small specimen, diameter 11 mm., umbilical diameter 2 mm. 7099 (counterpart 7261): very squashed, umbilicus 3·5 mm. (Pl. 57, fig. 4). 7100: diameter 24 mm., umbilicus 4 mm.

Locality. All the specimens were collected from the highest faunal band on Slieve Anierin, and mainly from Valley 3, L21(9)24. The band, which is about 9 inches thick, is exposed at stream level almost at the upper end of this valley. Above the band there are about 40 feet of unfossiliferous rusty shales which are followed by about 12 feet of white, flaggy sandstones with plants.

Horizon. This band, which is of E_2b3 age, is rich in fossils; *Ct. nititoides* is very common and occurs with *E. rostratum* sp. nov., *Chaenocardiola footii*, *Euchondria* aff. *E. levicula*, *Weberides* cf. *W. shunnerensis*, *Productus hibernicus*, plates and spines of *Archaeocidaris urii*, *Stroboceras subsulcatus*, *Fenestella sp.*, &c.

Discussion. In his original description Bisat distinguishes this form from *Ct. nitidus* by the fact that 'the plications are somewhat forwardly arched on the conch in adolescence, becoming radial in the adult'. Also the umbilicus is smaller in *nititoides* than in *nitidus*. The canted (asymmetrical) nature of the plications in these two species distinguishes them from sharply symmetrical (tented), plicated forms such as *Ct. edalense* or *Ct. bisati*. *Ct. stellarum* also has typically tented plications. The holotype of *Ct. nititoides* from Pace Gate Beck, near Bolton Abbey, is remarkably like the forms from Slieve Anierin. Tonks (1925, pp. 251–2) originally described the Pace Gate Beck section and the fauna, as on Slieve Anierin at this level, includes *E. bisulcatum*, trilobites, and a *Productus*. Unfortunately there are no exposures at this locality now and very little of the original material is available apart from the holotype of *nititoides*.

Cravenoceratoides edalense (Bisat)

Plate 56, fig. 5; Plate 57, fig. 2

Cravenoceras edalense Bisat 1928, p. 132, pl. 6, 6*a*, figs. 4, 4*a*.
Cravenoceratoides lirifer Hudson 1946, pp. 380–5, pl. 21, figs. 1–3, 5–7.

Description. This form shows a planulate stage in the very early whorls, but with advancing development an increasingly globose shape is assumed. In most examples a wide and deep umbilicus reveals the early planulate whorls. The degree of involution is not very great even at the very advanced stages. There is a strong and bifurcating ornament; the lirae are sharply defined and symmetrical. Hudson (1946, p. 383) uses the expression 'tented' for such lirae. The early planulate whorls show much finer and closer ornamentation. The venter is broad with little or no indication of a ventral sinus in the lirae. In these specimens it is rather difficult to determine the exact position of the bifurcation of the lirae; in many the single bifurcation appears very close to the umbilical edge, but in others it appears to be nearer the edge of the broad venter.

Dimensions. The rather imperfect preservation of these globose forms results in distortion of their original dimensions and accurate measurements are difficult to make. The diameters of the shells have not been measured, except in the less deformed planulate stages, which are up to 5–6 mm. approximately.

Localities and horizon. All the specimens have been collected from the shales in the lower part of Valley 4, L21(9)23, and from localities L21(13)2, L21(13)3, and L21(9)20. They occur in the first fossiliferous horizon above the thick grit, E_2b1. They are associated with subspecies of *Posidonia corrugata*.

Discussion. Bisat (1928) originally figured *Cravenoceras edalense*, and subsequently refigured it (1932, p. 33, pl. 1, figs. 4*a*, *b*). The specimens refigured in 1932 were later placed by Hudson (1946) in a new species, *Cravenoceratoides bisati*. Hudson also erected the new species *Cravenoceratoides lirifer* (1946, pp. 380–5, pl. 21, figs. 1–3, 5–7). The specimens separated by Hudson from *Ct. edalense* s.s. as *Ct. bisati* are distinguished by an irregular and repeated bifurcation of the lirae. This character is seen also in the figures given by H. Schmidt (1934, p. 448, figs. 23, 24) of *Cravenoceras edalense*. These forms appear to be specifically distinct from *Ct. edalense* s.s., in which there is only one bifurcation, but the writer has been unable to recognize any way of separating *Ct. edalense* s.s. from *Ct. lirifer*, and since the species predated *Ct. lirifer* the name of *Ct. edalense* seems more applicable to the abundant examples which occur on Slieve Anierin.

Cravenoceratoides cf. *Ct. bisati* Hudson

Plate 56, figs. 3, 4, 6

Cravenoceratoides bisati Hudson 1945, pp. 376–80, pl. 21, figs. 4, 10; text-fig. 1*a*.

Description. These specimens are similar in general shape to *Ct. edalense* but are distinguished by an irregular bifurcating ornament. In addition to the tendency for repeated bifurcation there is a tendency for the neighbouring branchlets from two bifurcating lirae to run together and continue as one lira, which may subsequently be seen to bifurcate. This is best seen in specimens 7103 (Pl. 56, fig. 3) and 7105 (Pl. 56, fig. 6).

Localities and horizon. These specimens occur at the same localities as *Ct. edalense* s.s. and on the same horizon, E_2b1, but they are not so abundant.

Superfamily DIMORPHOCERATACEAE Hyatt 1884
Family DIMORPHOCERATIDAE Hyatt 1884
Genus KAZAKHOCERAS Ruzhencev 1947

Kazakhoceras scaliger (Schmidt)

Plate 59, fig. 4

Dimorphoceras? scaliger Schmidt 1934, p. 458, fig. 2.

Description. Compressed and involute forms with a sharp venter and minute umbilicus. The most obvious feature is the lattice or reticulate pattern which covers the surface and which is unmistakable even in very small fragments of the shell. This lattice pattern bears no relationship to the growth-lines, which can frequently be seen with it. The growth-lines are suggestive of a member of the Dimorphoceratidae; the strong umbilical bow is well seen in 7108 with lattice ornament also.

Dimensions. 7109 (counterpart 7249): diameter 21 mm. 7112: radius 11 mm. (Pl. 59, fig. 4). 7110: diameter 14 mm. 7111 (counterpart 7246): radius 30 mm.

Localities and horizons. These specimens have been collected from two levels on Slieve Anierin. At the lower level seen at L21(13)7, and at L21(5)4 and 5, they are associated with *Cravenoceras* aff. *C. malhamense*, *Caneyella membranacea*, and *Chaenocardiola footii* in E_1c. At the higher level seen at L21(5)11 and at L21(13)4 the fauna is a larger one and includes *Cravenoceras* cf. *C. gairense*, *E. bisulcatum erinense* subsp. nov., *E. bisulcatum ferrimontanum* subsp. nov., *Posidonia corrugata* and subspecies, *Chaenocardiola footii*, and *Dunbarella elegans*. The species is more abundant at this higher level, which is considered to be in high E_2a.

Discussion. In his original description of this form H. Schmidt (1934, p. 458) doubts whether the lattice pattern is true ornament, and expresses the belief that it may be the wrinkled layer. I believe the lattice pattern is ornament, but it is impossible to be definite on this issue without studying solid specimens capable of dissection. The species is found on Slieve Anierin only at the two levels indicated above, with its greatest abundance undoubtedly in the E_2a horizon. Schmidt's original examples were apparently from E_1 beds, as are those from the lower level on Slieve Anierin. Ruzhencev (1947) erected *Kazakhoceras* to include forms like *Neodimorphoceras* but with differences in the suture and with a sharply keeled venter. The Slieve Anierin specimens with the lattice pattern are tentatively placed here. Many specimens with this lattice ornament in the Geological Survey Museum collection have been identified as *Neodimorphoceras hawkinsi* (Moore). In particular the material from Holbeck (Stephens *et al.* 1953, p. 28) has been referred to this species, but on examination these specimens appear to be the same as those which I have referred to *K. scaliger*. Schmidt (1934, pp. 458; 446, fig. 2) does not comment on the suture of his species. Neither does Moore (1958, pp. 225–6) make any comment on the ornament of *K. hawkinsi*, nor does he include *K. scaliger* in the synonymy of his species. In the absence of any definite sutural proof that these two forms are conspecific, I prefer to retain the specific name *scaliger* for specimens showing the lattice pattern. This practice has some stratigraphical value since the specimens only occur on two horizons. Moore (1958, p. 225) records *K. hawkinsi* from P_2 and E_2 horizons and says that it is impossible to distinguish between the specimens from two such widely different levels. *Neodimorphoceras* cf. *N. scaliger* is recorded by Hudson and Cotton (1943, p. 163) at the base of E_2 and in the *C. malhamense* E_1c zone (op. cit.,

p. 167), and these are the same two levels at which the species has been found on Slieve Anierin.

Genus ANTHRACOCERAS Frech 1899

Anthracoceras tenuispirale Demanet

Plate 57, fig. 3; Plate 58, fig. 4; Plate 59, fig. 1

Anthracoceras tenuispirale Demanet 1941, pp. 148–9, pl. 6, fig. 18; pl. 7, figs. 1, 2.

Description. A very involute species with a small umbilicus. The shell is ornamented with delicate radiating lirae, which when first seen are evenly curved over the flanks but progressively develop a lingua on the ventro-lateral area. With high magnification it is possible to distinguish a spiral ornament on the very early part of the shell which fades as the radial ornament becomes important. The spiral ornament is seen to be dominant on specimens up to 6 mm. diameter, at which stage the radial ornament is appearing. Thereafter the radial ornament becomes increasingly important, with a high and moderately deep lingua forming by 9 mm. diameter (7127). Indications of constrictions are present in the spirally striated specimens; 7128 shows at least three such constrictions.

Dimensions. 7126: diameter 6 mm. (radials more or less smoothly curved and just appearing). 7128 (counterpart 7357): diameter 6 mm. (radials more or less smoothly curved and just appearing) (Pl. 58, fig. 4). 7129: diameter 5 mm. (spirals only) (Pl. 57, fig. 3). 7130: diameter 3·5 mm. (spirals only). 7131: diameter 8 mm. (radials beginning to show the lingua). 7132: diameter 10 mm. (radials beginning to show the lingua). 7127: diameter 9 mm. (radials showing definite lingua) (Pl. 59, fig. 1).

Localities and horizon. Most of the specimens were collected in Valley 3, L21(9)24. The species occurs in abundance in E_2b2 between the band with *E. bisulcatum leitrimense* subsp. nov. and the top faunal band with *E. rostratum* sp. nov. and *Ct. nititoides*. It is associated with *C. holmesi*, *P. corrugata*, *Posidoniella variabilis*, and *P. variabilis erecta* subsp. nov.

Discussion. These specimens undoubtedly show the characteristics of Demanet's species, which has so far only been described from Belgium. Demanet apparently believes that the spirals are a feature of the inside of the test and the radials the outside. He comments that in some specimens the two forms of ornament may be seen superimposed. The author's specimens, though numerous, are inconclusive on this point. If the spirals are internal ornament then the outside of the shell would seem to have been without ornament until about 5–6 mm., when the first radials appear in the author's material. Currie, with experience of better material of *Anthracoceras*, states (*in litt.*) that the spiral ornamentation she has seen in other species has been a feature of both the inside and the outside of the test.

EXPLANATION OF PLATE 58

All specimens are from Slieve Anierin, Co. Leitrim, Eire.

Figs. 1, 2. *Euchondria* aff. *E. levicula* Newell. 1, 7165, external mould of right valve with no radial ornament, ×7·25. 2, 7158, internal mould of left valve with external ornament impressed upon it, ×6.

Fig. 3. *Actinopteria persulcata* (M'Coy). 7223, external mould of left valve, ×4.

Fig. 4. *Anthracoceras tenuispirale* Demanet. 7128, showing spiral striae with indications adorally of the radial ornament, ×20.

Fig. 5. *Posidonia corrugata* (Etheridge). 7144*a*, left valve, ×6·5.

In view of the great abundance of *A. tenuispirale* on Slieve Anierin at E_2b levels it seems remarkable that it has not been described from beds of the same age elsewhere. The very high magnification that is needed to see these early spirals makes it very likely that such specimens have been assigned to *A. paucilobum* (Phillips) or *A. glabrum* Bisat, which it closely resembles in other respects.

GSM CS891 from the Colsterdale Marine Band (E_2b) in a stream section 300 yards west of Ivin Waite, west of Pateley Bridge, Yorks., although labelled as *Cravenoceras* cf. *holmesi* is seen to be *A. tenuispirale* when suitably magnified. Bisat has seen a photograph and agrees with me (*in litt.*, 1960) that this is the case. He also comments that this raises the question of whether some other records of *C. holmesi* in the literature may not in fact also be *A. tenuispirale*. This occurrence is interesting in that it is thought to occur at a similar level to that on which the species is so abundant on Slieve Anierin.

Class LAMELLIBRANCHIATA Blainville 1816
Family PTERINOPECTINIDAE Newell 1937
Genus POSIDONIA Bronn 1828

Posidonia corrugata (R. Etheridge jun.)

Plate 58, fig. 5; Plate 60, fig. 4

Posidonomya corrugata Etheridge 1873, pp. 103–4.
Posidonomya corrugata Etheridge; Etheridge 1874, pp. 304–5, pl. 13, figs. 4, 5 (*non* fig. 6).
Posidonomya corrugata Etheridge; Hind 1901, pp. 30–31, pl. 6, figs. 1, 2, 5.
Posidonomya corrugata Etheridge; Weigelt 1922, pp. 93–95, fig. 17.
Posidonomya corrugata Etheridge; Schmidt 1934, p. 446, fig. 8; p. 451, fig. 52.
Posidonia corrugata (Etheridge); Ramsbottom 1959, p. 406.

Description. The hinge-line is short. The height and greatest antero-posterior measurement are approximately the same. The umbo is prominent and nearer the anterior end of the hinge from which it is separated by a narrow anterior wing, which in some specimens is slightly concave but in most is flattened. The anterior margin descends from the hinge-line at first vertically but soon swings forward obliquely to this short vertical piece; farther downwards the direction of the anterior margin changes from this forward swing to a steeper one and it then curves round smoothly into the ventral margin.

The posterior margin is oblique, and both it and the ventral margin show a considerable degree of backward extension. The surface of the valve bears strong concentric corrugations as well as less prominent growth lines.

Dimensions. 7144*a* (counterpart 7277): left valve, height 9 mm., greatest antero-posterior measurement 10 mm. (Pl. 58, fig. 5). 7144*b*, *c* (counterpart 7277): two left valves, height 8 mm., greatest anterio-posterior measurement 7 mm. 7145 (counterpart 7278): two left valves, height *c*. 9 mm., greatest anterio-posterior measurement 13 mm. (Pl. 60, fig. 4). 7146: right valve, height 7–8 mm., greatest antero-posterior measurement 7–8 mm. 7147 (counterpart 7282): left valve (also deformed right valve), incomplete greatest antero-posterior measurement 8 mm.

Localities and horizons. This species has been collected abundantly at numerous horizons ranging from P_2 to E_2. The localities on Slieve Anierin are too numerous to list separately. Specimens are particularly abundant in the shales above the grit in E_2, and they are frequently the only forms present. The abundance is often such that good individual specimens are very difficult to obtain. Some of the best examples were collected in E_2b1 shales almost immediately above the *Ct. edalense* beds in Valley 4, L21(9)23. Locality L23(4)5 lies in the *C. leion* zone but the specimens are in every way like the ones from E_2.

Discussion. R. Etheridge jun. (1873, pp. 103–4) described this species as being very variable. In his view nearly all the adult specimens have radial ribs in addition to the concentric corrugations. The most common form of *P. corrugata* in Ireland is dominated by concentric corrugations. Specimens do exist with radial corrugations but these are not the most common and have been given specific rank as *Posidonomya trapezoedra* by Ruprecht (1937, pp. 30–31). Subspecies of this typical *P. corrugata* occur at certain horizons and are described below. They are always associated with *P. corrugata* as interpreted above.

Posidonia corrugata elongata subsp. nov.

Plate 60, fig. 1

Description. The specimens ascribed to this subspecies resemble *P. corrugata* in the possession of a narrow anterior wing and a short hinge-line. The more dorsal part of the anterior margin also resembles *P. corrugata* in that it descends vertically for a short distance and then swings forward. Thereafter, however, the anterior margin differs in following a backward course in its passage into the ventral margin and in being approximately parallel to the oblique posterior margin. The corrugations of the valves are in every way similar to those in *P. corrugata.*

Holotype. 7148*a* (counterpart 7216*a*): probably incomplete, height 10 mm., antero-posterior measurement 6 mm. (Pl. 60, fig. 1). *Paratype.* 7220: height *c.* 12 mm., antero-posterior dimension *c.* 8 mm.

Type locality and horizon. This subspecies is most common in E_2 but similar forms have been observed in lower beds. Some of the best examples were collected from the high E_2a horizon exposed at L21(13)4, the type locality, and at L21(5)11, and also from the E_2b2 beds with *E. bisulcatum leitrimense* subsp. nov. in Valley 4, L21(9)23.

Discussion. Specimens of this subspecies differ from the typical *P. corrugata* in being longer and narrower in shape. This difference in aspect is produced by the more backward passage of the ventral portion of the anterior margin, and also the steeper posterior margin. In some respects this subspecies might be confused with the more oblique specimens of *Caneyella membranacea* but in the latter the umbo is not so close to the anterior margin as in *elongata*, where the anterior ear is extremely narrow as also in the typical *P. corrugata.* Radial ribbing is usual in *C. membranacea* whereas it has not been clearly observed in *elongata;* if present in the latter it is faintly seen only on the more ventral part of the shell. The anterior margin in *C. membranacea* descends more or less vertically for some distance before curving round into the posteriorly inclined part of the margin,

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EXPLANATION OF PLATE 59

All specimens are from Slieve Anierin, Co. Leitrim, Eire.

Fig. 1. *Anthracoceras tenuispirale* Demanet. 7127, showing spiral ornament in the early whorls, and radial ornament in the adult whorl, ×20.

Figs. 2, 3. *Obliquipecten costatus* sp. nov. 2, 7217, paratype, left valve, showing radial ornament, ×5·3. 3, 7219, holotype, right valve, ×2.

Fig. 4. *Kazakhoceras scaliger* (Schmidt). 7112, showing brickwork-like pattern, ×7.

while in *elongata* it descends in an anterior direction obliquely to the hinge-line before curving back.

Posidonia corrugata gigantea subsp. nov.

Plate 60, fig. 2

Description. This subspecies is larger and more coarsely and irregularly corrugated than *P. corrugata* or *P. corrugata elongata.* Like the latter the more ventral portion of the anterior margin descends obliquely backwards but in this subspecies it is less oblique. There is considerable backward extension of the posterior and ventral margin. The posterior margin is less steep than in *elongata.* The height and antero-posterior measurement in this subspecies are approximately the same as in *P. corrugata.* The concentric corrugations are somewhat coarser and more irregular than in the other forms.

Holotype. 7149: height 22 mm., antero-posterior measurement *c.* 20 mm. (Pl. 60, fig. 2). *Paratype.* 7150 (counterpart 7353): height 20 mm., antero-posterior measurement *c.* 16 mm.

Type locality and horizon. The best specimens have been collected in Valley 4, L21(9)23, the type locality, and Valley 3, L21(9)24. This form has so far only been seen in E_2 beds. It appears to be most common in the E_2b2 beds containing *E. bisulcatum leitrimense* subsp. nov. or just below these in E_2b1. It is also present in the slightly lower *Ct. edalense* beds, E_2b1.

Discussion. Apart from the large size and the coarse ornament this subspecies appears to combine some of the features of the normal *P. corrugata* and of *P. corrugata elongata.* In the posterior margin, which is less steeply inclined than in *elongata*, it resembles *P. corrugata.* The anterior margin resembles that of *elongata* though it is less oblique and steeper, and only slightly backwardly inclined. As a result of its large size this subspecies is particularly vulnerable to fracture and complete specimens are rare.

Genus CANEYELLA Girty 1909

Caneyella membranacea (M'Coy)

Plate 60, fig. 3

Posidonomya membranacea M'Coy 1844, p. 78, pl. 13, fig. 14.
Posidonomya membranacea M'Coy; Hind 1901, pp. 33–34, pl. 5, figs. 18–23.
Posidonomya membranacea M'Coy; Schmidt 1934, p. 446, fig. 10; (*non*) p. 448, fig. 28.
Posidonomya (*Posidonia*) *membranacea* M'Coy; Demanet 1941, pp. 80–81.
Posidonia membranacea (M'Coy); Smyth 1950, p. 317, pl. 17, fig. 6.
Caneyella membranacea (M'Coy); Ramsbottom 1959, p. 406, pl. 71, fig. 14.

Description. The hinge-line is of moderate length, with the umbo about midway along or slightly anterior. The posterior margin is very oblique to the hinge-line and passes ventrally and backwards in an almost straight line. The anterior margin at first descends approximately vertically and then curves round to pass obliquely backwards in a path approximately parallel with the posterior margin. The surface of the valve is ornamented with concentric folds and with finer growth-lines. There is also a radial ornament of obscure radial folds, of varying strength, which pass from the umbo across the valve and terminate on the ventral margin; they are most obvious over the central area of the valve.

Dimensions	*Length—greatest distance measured parallel with the hinge-line*	*Greatest distance from the umbo to a point opposite on the ventral margin (measured parallel with the posterior margin).*
7154 (counterpart 7247)	*c.* 17 mm.	*c.* 31 mm.
7051 (counterpart 7266) (Pl. 60, fig. 3)	*c.* 22 mm.	*c.* 38 mm.

Localities and horizons. These are given in the description of *C. membranacea horizontalis* subsp. nov. below, and the two forms are considered together in the discussion of that subspecies.

Caneyella membranacea horizontalis subsp. nov.

Plate 61, fig. 5

Description. In this subspecies the posterior margin is not so obviously oblique to the hinge-line, instead the two lie in practically a straight line. The growth lines, however, terminate on the anterior part of this long straight apparently dorsal margin, and the actual length of hinge-line is about the same as in *C. membranacea*. After the initial vertical descent the anterior margin curves round to describe a course approximately parallel with the straight dorsal edge. The ornament in this subspecies is the same as in *C. membranacea* except that the radial folds tend to be stronger.

Dimensions	*Length—greatest distance measured parallel with the hinge-line*	*Greatest measurement from the umbo to a point opposite on the ventral margin (measured parallel with the posterior margin)*
7157, holotype, (Pl. 61, fig. 5)	25 mm.	22 mm.
7156	36 mm.	32 mm.

Type locality and horizons. L21(14)9, the type locality, and L23(4)19 are both considered to be high P_2; at the latter, 20 feet above the base of the section, *C. membranacea* and *C. membranacea horizontalis* are associated with *Goniatites granosus*, *Dunbarella elegans*, and *Sudeticeras crenistriatum*.

Some of the best examples on Slieve Anierin have been collected from localities L21(5)5 and L21(13)7, which are believed to be at about the same horizon, i.e. E_1c; at both these localities *C. membranacea* and *C. membranacea horizontalis* have been collected with *Cravenoceras* aff. *C. malhamense*, *Kazakhoceras scaliger*, and, about 20 feet above, *E. pseudobilingue* s.s.

Discussion. C. membranacea is a very variable species, but it is possible to separate two extreme forms according to the angle made by the posterior margin with the hinge-line. The forms figured by Hind and the original type from the Skerries, Co. Dublin

EXPLANATION OF PLATE 60

All specimens are from Slieve Anierin, Co. Leitrim, Eire.

Fig. 1. *Posidonia corrugata elongata* subsp. nov. 7148*a*, holotype, right valve showing dorso-ventrally elongated form, ×7.

Fig. 2. *Posidonia corrugata gigantea* subsp. nov. 7149, holotype, left valve, ×2·8.

Fig. 3. *Caneyella membranacea* (M'Coy). 7155, showing posterior margin oblique to hinge-line, ×3.

Fig. 4. *Posidonia corrugata* (Etheridge). 7145, two left valves, ×4.

Fig. 5. *Posidoniella variabilis* Hind. 7173*a*, *b*, *c*, internal moulds, ×4.

(refigured by Hind 1901, pl. 5, fig. 18), are of the more oblique form considered as *membranacea* s.s. The specimens illustrated by Demanet (1938, pl. 10, figs. 5, 10, 11) are nearer to *horizontalis;* so also is the specimen figured by Ramsbottom (1959, pl. 71, fig. 14). On Slieve Anierin the two forms usually occur together and so far have not been found in E_2. All Demanet's records are from E_1 (1941, p. 81). Schmidt (1934, p. 448, fig. 28) figures the species in beds with *Ct. edalense;* the very narrow anterior wing suggests that this may be *Posidonia corrugata elongata* or *P. corrugata gigantea*, both of which occur near this level on Slieve Anierin. Smyth (1950, p. 317) reports the species in E_2, but here again I believe the specimen may be more correctly regarded as a subspecies of *P. corrugata*. Ramsbottom (1959, p. 406) placed the species in the genus *Caneyella*, which he defined as including costate and non-costate species with a relatively long hinge-line, with the umbo usually towards the anterior end. It is believed that *horizontalis* is rather more abundant in the P_2 horizon than in the E_1c band, where *membranacea* s.s. is dominant.

Family EUCHONDRIIDAE Newell 1937
Genus EUCHONDRIA Meek 1874

Euchondria aff. *E. levicula* Newell

Plate 58, figs. 1, 2

Euchondria levicula Newell 1937, p. 107, pl. 1, figs. 6, 7; pl. 19, figs. 5, 10, 11, 18.

Description. Left valve. The hinge length is about half or slightly less than half of the greatest antero-posterior measurement. The umbo is slightly anterior of the mid point of the hinge-line. The shell has a postero-ventral extension. The anterior wing is small and defined from the body of the valve by a strong downfold which passes from the umbo to the anterior margin. The posterior wing is larger than the anterior but has no distinct fold marking it off externally. The anterior margin of the anterior wing is very gently curved, the posterior margin has a deep embayment below the hinge-line which swings outwards in to the postero-ventral extension. The surface of the valve is ornamented with radiating costae. These are regularly spaced at about 4–5/ mm. They are crossed by concentric fila in which the spacing is a little more variable, from 5–7/ mm. The intersection of the two results in a cross-hatched pattern of ornamentation on the left valve. The fila continue on to the ears and there are also three to four costae on the anterior ear. The posterior ear has about five costae. It is not always easy to determine these numbers with absolute certainty as the costae do not appear to be as strong on the ears as on the body of the valve but they are definitely present in small numbers. Along the hinge margin specimen 7158 (Pl. 58, fig. 2) shows a line of denticles, which may represent the position of a row of ligamental pits.

Right valve. This valve lacks the postero-ventral extension. There is less discrepancy between the greatest antero-posterior measurement and the hinge length; with increase in size the discrepancy increases slightly. The anterior wing is defined by a deep furrow from the umbo to the anterior margin. This wing, although small, is very convex. The posterior wing is not defined by a furrow but is clearly distinguished by the sharp descent in the umbonal region from the convexity of the valve to the flat wing. There are no radiating costae on this valve. The fila are very clearly seen in external impressions, the spacing being about 8/mm. Although costae are absent from the valve they are present on the ears. The anterior ear has three or four costae and the posterior four to five costae.

Dimensions	*Dorso-ventrally*	*Antero-posteriorly*
7160, left valve	10 mm.	*c.* 12–13 mm.
7161*a*, large left valve	*c.* 13 mm.	*c.* 15 mm.
b, small left valve	*c.* 10 mm.	*c.* 12 mm.
c. broken right valve	10 mm.	
7162, incomplete left valve	*c.* 14 mm.	
7163*a*, right valve	15 mm.	15 mm.
b, left valve	5 mm.	5 mm.
c, on lower side, right valve	9 mm.	9 mm.
7164, incomplete right valve	10 mm.	
7165, right valve (Pl. 58, fig. 1)	8·5 mm.	9 mm.
7158, left valve (Pl. 58, fig. 2)	13 mm.	15 mm.
7159*a*, left valve	16 mm.	18 mm.

Localities and horizon. This species has only been found in the topmost faunal band on Slieve Anierin, E_2b3, associated with *Ct. nititoides* and *E. rostratum* sp. nov. Numerous specimens were collected in Valley 3, L21(9)24.

Discussion. The genus *Euchondria* (Meek 1874, pp. 488–9), as understood by Newell (1937, pp. 102–5), is typified externally by the costae and fila on the left valve, which by their intersection produce a distinctive cross-hatched ornament, and the absence of costae in the right valve, which is smooth, possessing only obscure concentric fila. The ligament area has a series of ligamental pits both before and behind the median resilifer. These two features, namely discrepant ornament on the two valves and the multiple resilifers, are taken to be the chief characters of the genus.

Newell (1937, p. 102) has erected a family for these forms, in which he also places *Crenipecten*. He describes several species of *Euchondria*, of which *E. levicula* Newell (1937, p. 107, pl. 19, figs. 5, 10, 11, 18) looks very like the specimens from Slieve Anierin. The latter seem slightly different in the distinctness of the fila in the right valve and the very deep anterior auricular sulcus in this valve, but the left valve seems indistinguishable from *E. levicula*. Newell (*in litt.*) agrees with the differences just mentioned but believes that the Irish specimens should be regarded as very closely related to *E. levicula*. They are therefore identified as *Euchondria* aff. *E. levicula*. There appear to be no previous records of this genus in the Carboniferous rocks of either England or Ireland. The holotype and topoparatypes come from the Hushpuckney black and grey shales, Swope formation (Missouri subseries), at Devil's Backbone, near Winterset, Iowa. Apart from the fact that this is the first record of this species outside America it is interesting also

EXPLANATION OF PLATE 61

All specimens are from Slieve Anierin, Co. Leitrim, Eire.

Figs. 1, 2. *Chaenocardiola bisati* sp. nov. 1, 7184, holotype, external mould showing low number of relatively sharp ribs separated by wide flat interspaces, ×4·5. 2, 7185, paratype, internal mould, ×5.

Fig. 3. *Chaenocardiola* cf. *C. haliotoidea* (Roemer). 7183*a*, *b*, two internal moulds, ×3·5.

Fig. 4. *Posidoniella variabilis erecta* subsp. nov. 7129*b*, holotype; 7129*c*, *d*, paratypes, an internal mould and two external moulds respectively, showing the near vertical anterior margin, ×6.

Fig. 5. *Caneyella membranacea horizontalis* subsp. nov. 7157, holotype, external mould of right valve showing hinge-line and posterior margin in more or less continuous line, ×5.

that it occurs in a rather different lithology from the American specimens. These (Newell, *in litt.*) are almost invariably found in dark to black shales, associated with pyrite, and he believes they were adapted to a low pH and strongly reducing conditions. The Slieve Anierin specimens occur in a decalcified calcareous shale with a fauna including other lamellibranchs, goniatites, a productid, crinoidal debris, trilobite remains, and occasional echinoid spines and plates. The genus does not occur beneath this band in shales of lithology similar to Newell's description.

Newell states (*in litt.*) that the denticles along the hinge margin in the Slieve Anierin forms (see particularly the left valve 7158 (Pl. 58, fig. 2) and less obviously the right valve 7163*c*) tend to confirm an idea that he has had for several years that these are not ligament grooves but rather hinge denticles which are found in the juvenile stages of many modern scallops.

External impressions of this species provide the clearest details of the external ornament but inevitably show nothing of the ligamental area. Natural moulds of the interior, with details of the external ornament impressed upon them, have frequently been preserved and these are less sharp in the details of the ornament. In 7158, a left valve, an internal mould of the ligamental area is seen along the dorsal margin of an internal mould with external ornament impressed upon it; this opinion is confirmed also by Newell. Specimen 7165 (Pl. 58, fig. 1) is the impression of a right valve in which there seems to have been breakage of the valve during the life of the shell and a subsequent repair of the damage after which the growth-lines return to the normal pattern. Specimen 7166 shows the moulds of a right and a left valve closely associated, and once more internal moulds have the external ornament impressed upon them.

Family AVICULOPECTINIDAE Etheridge jun., emend. Newell 1937

Genus OBLIQUIPECTEN Hind 1903

Obliquipecten costatus sp. nov.

Plate 59, figs. 2, 3; Plate 62, fig. 5

Description. Right valve. The hinge-line is short. The posterior margin makes an obtuse angle with the hinge-line and is gently curved and smoothly continuous with the ventral margin. The anterior margin is concave below the anterior ear but soon becomes very convex forwards. The anterior ear is very distinct in this valve and is extended above the hinge-line (this feature is well seen in 7167). There are apparently two broad undulations of the surface of the ear. The posterior ear is very small indeed. The extension forward of the valve becomes more apparent with the increase in size of the specimen; it is very marked in the holotype but less apparent in some of the smaller paratypes. Growth-lines are seen on all the specimens and are particularly sharp on the ears. There is also a distinct radial ribbing of the surface. On some of the larger right valves (notably the holotype) the ribbing is stronger on the anterior part of the shell and rather muted over the rest of the surface. In the more dorsal part of the shell the convexity of the valve decreases very sharply posteriorly but ventrally there is a much more gradual change.

Left valve. In this valve the anterior ear is defined by the broad umbonal fold. The anterior margin of the ear is apparently smoothly continuous with the anterior margin of the valve. The posterior wing is again very small. The growth-lines and radial ribbing are as in the right valve, except that in the largest specimens of the left valve seen the ribs are still apparently strong all over the surface with no particular attenuation in the anterior region.

Holotype. 7219 (counterpart 7265): right valve, dorso-ventrally 40 mm. (incomplete), antero-posteriorly 45 mm. (Pl. 59, fig. 3). *Paratypes*. 7169: right and left valve, dorso-ventrally 21–22 mm., antero-posteriorly 18 mm. (Pl. 62, fig. 5). 7217: left valve, dorso-ventrally 14 mm., antero-posteriorly 12 mm. (Pl. 59, fig. 2). 7167 (counterpart 7168*a*): right valve, incomplete. 7168*b*: left valve, other side of slab bearing counterpart of 7167, dorso-ventrally 30 mm., antero-posteriorly 28 mm.

Type locality and horizon. L20(8)1; also L23(4)8. *O. costatus* appears to be particularly abundant in E_1a, where it has been found with *Cravenoceras leion* and *Eumorphoceras* cf. *E. sp.* form *A* Moore; the latter occurs at the type locality L20(8)1. The species occurs, however, at other horizons in E beds but never so abundantly.

Discussion. *Obliquipecten* is characterized, in Newell's opinion (1937), by 'the remarkable extent to which the opisthocline obliquity has been carried and the nearly complete loss of the posterior auricle'. There can be no doubt that the Slieve Anierin specimens are members of this genus but they are specifically distinct from the only described species *O. laevis* Hind, which is described by that author (1903) as being smooth apart from the growth-lines. Newell describes the species as 'nearly smooth save for a few fine radiating costae on the anterior part of each valve and a few coarse fila on the anterior auricle of the right valve'. The Slieve Anierin specimens are considered to be specifically distinct by reason of their ribbed character. Demanet (1941, pp. 84–86) identified specimens in the E_1 deposits of Belgium as *Obliquipecten* aff. *O. laevis* Hind but described these forms as smooth apart from concentric growth-lines.

Family MYALINIDAE Frech
Genus POSIDONIELLA de Koninck 1885

Posidoniella variabilis Hind

Plate 60, fig. 5

Posidoniella variabilis (Brown MS.) Hind 1897, pp. 100–1, pl. 7, figs. 7–9.
Posidoniella variabilis Hind; Ramsbottom 1959, p. 405, pl. 71, fig. 10.

Description. Convex forms in which the umbo is pointed and terminal. The usual aspect is rather mytiloid. Internal moulds are frequent and are either smooth or bear somewhat irregular concentric corrugations, which appear to be more frequent nearer the ventral edge of the valves and absent or poorly seen in the more dorsal part of the valve under the umbo. The hinge-line is short and the anterior margin descends obliquely backwards making an acute angle with the hinge-line. The posterior margin is approximately parallel with the anterior, but rather more curved than the anterior. External impressions of the shell show fine concentric growth-lines and a few obscure corrugations.

Dimensions. 7172: dorso-ventrally 9·5 mm., antero-posteriorly 6 mm. 7173*a*, *b*, *c*: largest specimen, dorso-ventrally 8 mm., antero-posteriorly 6·5 mm. (Pl. 60, fig. 5).

Localities and horizon. Specimens have been collected abundantly on Slieve Anierin at many levels in E_2 shales above the grit from the level of the *Cravenoceras subplicatum* fauna, E_2b1, upwards.

Discussion. The author's specimens agree closely with the species *P. variabilis*. Ramsbottom (1959, p. 405) has selected a lectotype from Hind's original specimens and figured it (op. cit., pl. 71, fig. 10). He believes that of the several Millstone Grit species referred to Posidoniella, only *P. variabilis* rightly belongs to that genus. However, although many of my forms agree closely with *P. variabilis* there are others in which the mytiloid aspect is not present and a squarer form has been assumed. This change in shape is reflected in the nearly vertical downward descent of the anterior margin, in contrast to the oblique backward passage of the margin in undoubted *P. variabilis*. The Slieve Anierin form resembles *P. laevis* (Brown) (Hind 1897, pl. 6, figs. 12–14, 24), but in Ramsbottom's opinion (*in litt.*) Brown's original specimen had an anterior wing and therefore cannot belong to *Posidoniella*. However, in E_2 shales on Slieve Anierin forms with a vertical anterior margin undoubtedly exist. From a study of many specimens it seems likely that in fact *P. variabilis* and the squarer form represent two extremes of variation, since many specimens are difficult to assign to either end of the series. It seems desirable to name this squarer form, since the two end-forms of the series are so distinct, and this can most appropriately be done by designating it as a subspecies of *P. variabilis*. The name *P. variabilis erecta* subsp. nov. (Pl. 61, fig. 4) is proposed for those forms in which the anterior margin descends vertically; holotype, 7129*b*, paratypes, 7129*c*, *d*.

Demanet (1941, pp. 76–77, pl. 2, fig. 3) records *P. variabilis* within the *Dimorphoceras* cf. *D. looneyi* horizon, which corresponds with one of the periods of dominance of *P. variabilis* on Slieve Anierin. However, Demanet considers that the oblique anterior margin is a constant feature. H. Schmidt (1934, p. 44, fig. 45) also records this species in beds with *D. looneyi*.

Family PTERIIDAE Meek 1864
Genus ACTINOPTERIA Hall 1884

Actinopteria persulcata (M'Coy)

Plate 58, fig. 3

Pteronites persulcatus M'Coy 1851, p. 170.
Actinopteria persulcata (M'Coy); Hind 1901, pp. 23–25, pl. 4, fig. 14.

Description. The umbo is swollen but not quite terminal on the hinge-line, there being a narrow expansion anterior to it. The anterior margin runs obliquely backwards to the curved ventral margin. The posterior margin is smoothly continuous with the ventral margin but is ultimately concave beneath the hinge-line. The posterior wing is a long isosceles triangle in shape (with its apex at the umbo and its base the concave portion of the posterior margin). It is flattened compared with the convexity of the rest of the valve. The surface of the valve and the wing show concentric lines of growth which are quite widely spaced and reflect clearly the concavity of the posterior margin ventral to the hinge-line. There are also radial corrugations of the surface of the valve which seem to be absent on the wing in all the specimens seen. They are strongest on the middle of the valve and show a slight offset of their courses at the growth-lines. There is a long posterior extension of the hinge-line area, that of each valve being concave towards its fellow of the opposite valve. They are all unfortunately broken in this material and it is therefore impossible to tell how far this extension reached beyond the body of the valve.

Externally this extension first appears faintly as a convex ridge just below the dorsal edge of the valve at about 5 mm. behind the umbo, but is a distinctly rounded ridge just below the dorsal margin at 7 mm. from the umbo. It then continues to the posterior margin and beyond.

Dimensions. 7223 (counterpart 7250): dorso-ventrally 10 mm., antero-posteriorly 12 mm. (Pl. 58, fig. 3).

Locality and horizon. L21(13)7, about six specimens. The horizon is E_1c. The specimens are associated with *Caneyella membranacea*, *Kazakhoceras scaliger*, *Chaenocardiola footii*, and *Cravenoceras* aff. *C. malhamense*.

Discussion. This is not a common species on Slieve Anierin. I compared the form initially with *Actinopteria fluctuosa* (Etheridge) (Hind 1901, pp. 25–26, pl. 5, figs. 8–12). However, R. B. Wilson, who has been working on these species, informs me (*in litt.*) that he considers that *A. fluctuosa* should now be included in *A. persulcata*, and this practice is followed here. In Scotland the species is particularly abundant at the P_1–P_2 boundary, although starting in Zone D. It therefore has a long range, since in Ireland it occurs on a high E_1 horizon.

?Family CONOCARDIIDAE Neumayr

Genus CHAENOCARDIOLA Holzapfel 1889, emend. Beushausen 1895

Chaenocardiola Holzapfel 1889, pp. 61–62.
Chaenocardiola Holzapfel; Beushausen 1895, pp. 364–5.
Chaenocardiola Holzapfel emend. Beushausen 1895; Hind 1900, pp. 474–6, pl. 52, figs. 5–7.
Chaenocardiola Holzapfel emend. Beushausen 1895; Demanet 1941, pp. 67–69, pl. 1, figs. 5–7.

Little appears to be known about the internal structure or the true affinities of this very distinctive genus. Hind mentions a certain resemblance to *Conocardium*. Demanet refers it to the family Conocardiidae Neumayr. Hind further states that he believes the genus is more nearly related to the Cardiidae. It is impossible to make any comment on the affinities of the Carboniferous specimens to be described.

The most obvious generic features are the very strong forward curvature of the umbones and the slightly concave area just beneath the umbo on each valve. The ribbing is strong and continues from the umbo to the ventral margin and the valves are ribbed on the inside of the shell, though this usually fades before the umbo and is strongest on the ventral margin. Hind (1900, p. 476) mentioned fine striations parallel to the upper edge and interpreted them as the site of the ligament. These fine striations parallel to the upper edge have also been seen on internal moulds in many of the Slieve Anierin specimens.

Chaenocardiola footii (Baily)

Plate 62, fig. 3

Lunulacardium footii Baily 1860, pp. 18–19, fig. 9.
Conocardium footii (Baily); Etheridge 1888, p. 281.
Chaenocardiola footii (Baily); Hind 1900, pp. 475–6, pl. 52, figs. 5–7.
Chaenocardiola haliotoidea Roemer; Schmidt 1934, p. 446, fig. 7.
Chaenocardiola footii (Baily); Demanet 1941, pp. 67–68, fig. 5, ?fig. 6.

Description. The shape is approximately semicircular. The dorsal margin is gently convex but rather more sharply so at the anterior end where it descends to the umbo.

At the posterior end the dorsal margin is truncated sharply by the posterior margin, which curves quickly round into the ventral margin. At the anterior end of the shell there is a slight concavity of the surface immediately beneath the umbones. The original form does not appear to have been very convex. The umbo appears to be incurved. Strong ribs radiate from the umbo across the body of the valve and are crossed by fine concentric lines of growth. The ribs are about twenty-five in number on most specimens but may vary up to thirty.

Dimensions. 7174: largest on slab, height 6 mm., length 9·5 mm. (Pl. 62, fig. 3). 7175*a*: height 13 mm., length 16 mm. 7175*b*: height 13 mm., length 17 mm. 7176: height 3·5 mm., length 5 mm. 7177*a-d*: *a*, height 5 mm., length 11 mm.; *b*, height 5 mm., length 9 mm.; *c*, height 4 mm., length 9 mm.; *d*, height 10 mm., length 15 mm. 7148*b*: height 8 mm., length 12 mm. 7178: height 11 mm., length 15 mm. 7179: height 10 mm., length 16 mm. 7180: height 20 mm., length 24 mm.

Localities and horizons. This species has been collected from E_1 and E_2 beds. It has its maximum abundance in E_2. The high E_2a beds at L21(13)4, L21(5)11, and at L21(5)10 are rich in examples associated with the subspecies of *E. bisulcatum*, and *Cravenoceras* cf. *C. gairense*, &c. It occurs in abundance in the highest faunal band on Slieve Anierin, which is considered to be in the *Ct. nitidus* zone, E_2b3, and here the species is associated with *E. rostratum* sp. nov., *Ct. nititoides*, and *Ct.* cf. *Ct. nitidus*.

The species has been collected in E_1 beds from all the prominent faunal bands above the *C. leion* zone (at this lower level it has not been collected, but *Chaenocardiola bisati* sp. nov. occurs).

Discussion. It is apparent from a study of many specimens of this form that the shape is rather variable, ranging from young individuals in which the height of the valve is about half the length to larger specimens in which height and length are approximately equal. (Slab 7177 has young and adult specimens.) The dimensions originally given by Baily (1860, p. 19), when converted into millimetres give a height of about 20 mm. and a length of about 28 mm. This would be considered large for most of the Slieve Anierin specimens, but 7180 approximates to these measurements, while a few rare incomplete individuals (which if complete would be larger still) have been found. The area beneath the umbo often appears to be broken and since it carries about five ribs results in deficient rib counts. Although Baily's original figure for the ribs is twenty-five, they vary up to about thirty, but twenty-five appears to be the average. The internal moulds show a distinct ribbing around the ventral margin, becoming less strong towards the umbo. Plasticine impressions of these internal moulds show that the ribs on the inside of the shell were very broad and flat-topped at the extreme ventral edge, becoming narrower as they fade towards the umbo. At the extreme ventral edge very short furrows can sometimes be seen on the flattened summits of these internal ribs. On the original specimens these short furrows appear as short intercalated ribs between the larger ribs. In internal ribbing, at least, they resemble members of the Cardiidae, for example *Prosodacna sp.* (Morley Davies 1935, p. 153, fig. 201), which is a member of the Adacnidae, an aberrant Miocene offshoot of the Cardiidae. The resemblance between the superficial morphology of this form and the Carboniferous *Chaenocardiola* is close. More detailed knowledge of the hinge and ligament area in *Chaenocardiola*, however, is needed before its true affinities can be determined.

This species is mentioned in several faunal lists from beds of E_1 and E_2 age from the north of England and most of these are included by Demanet in the synonymy of the species (1941, p. 67). Stephens *et al.* (1942, p. 348; also 1953, p. 94) state that *E. bisulcatum* and *Chaenocardiola footii* are the two most abundant forms in the Edge

Marine Band in the Rombalds Moor area in Yorkshire. This band may be on the same horizon as that seen at L21(5)11 and at L21(13)4. Hudson and Cotton (1943, p. 167) record the species at two levels within E_1 which can also be broadly correlated with the Slieve Anierin horizons containing the species. In Ireland the form has been recorded in North Co. Dublin by Smyth (1950, p. 320) in E_2 beds. Moseley (1954) records it in the Lancaster Fells in the Tarnbrook Wyre Marine Beds of E_2a age. The species is widespread at this low E_2 level, although it occurs both lower and higher in the succession. The first E_1 fauna to be described in Ireland (Nevill 1957, pp. 297–8) does not include this species nor is it mentioned in E_2 (pp. 298–300). Baily's original specimens were from Rosscliff, Co. Clare, and he mentions material from Westown, Co. Dublin; from near Drogheda, Co. Meath; and from Cahernanalt, Kendue, Co. Roscommon.

Chaenocardiola cf. *C. haliotoidea* (Roemer)

Plate 61, fig. 3

Cardita? *haliotoidea* Roemer 1850, p. 49, pl. 8, fig. 5.
Chaenocardiola haliotoidea (Roemer); Holzapfel 1889, pp. 62–63, pl. 7, figs. 5, 6.
Chaenocardiola haliotoidea (Roemer); Demanet 1941, pp. 68–69, pl. 1, fig. 7; *non* fig. 6.

Description. The shape is long and low and not very convex. The ribs are very narrow and number about forty.

Dimensions. 7183*a*, *b*: two specimens, one complete, length 10 mm., height 4 mm. (Pl. 61, fig. 3).

Locality and horizon. Valleys 4 and 2, L21(9)23 and 25 respectively; *Ct. nititoides* band, E_2b3.

Discussion. In his description Roemer mentions forty to forty-five ribs, but there are less than this in his figure, which has a count nearer *C. footii*. Demanet describes this form as differing from *C. footii* in its smallness and its large number of ribs. Of his two figures I would refer pl. 1, fig. 6 to *C. footii*, but fig. 7 appears to be specifically distinct and to resemble 7183*a* and *b*. On Slieve Anierin this form has only been found in the *Ct. nitidus* zone. Demanet reports it also from E_1 horizons. Specimens referred to this species by H. Schmidt (1934, p. 446, fig. 7) show only twenty-one ribs and may possibly be incomplete examples of *C. footii;* they occur in E_1 beds. *Chaenocardiola sp.* is referred to but not figured in the *nitidus* zone.

Hudson and Cotton (1943, p. 167) record *C. footii* (Baily) (or *C. haliotoidea* (Roemer)) in E_1d and E_1c. The writer is uncertain exactly what is meant by this form of identification unless they intend to suggest that the two species are probably the same. The original plate given by Roemer certainly closely resembles *C. footii* but the definition of forty to fifty ribs is precise in the text. The highest band on Slieve Anierin contains a few rare specimens which accord with this definition and Roemer's specific name has therefore been retained for them.

Chaenocardiola bisati sp. nov.

Plate 61, fig. 2

Description. The general outline of this species is as already described for *Chaenocardiola footii*. All the Slieve Anierin specimens discovered so far are small, but not smaller than he smallest individuals of *C. footii*. The valves are more convex than *C. footii* in the younger stages and bear a smaller number of strong ribs, which are separated by wide flat-bottomed furrows in which, at larger dimensions, intermediate finer ribs are present. There are about fifteen to seventeen ribs. There is a small distinctly concave area beneath the umbo.

Holotype. 7184: external mould, length 8 mm., height 5 mm. (Pl. 61, fig. 1). *Paratype*. 7185 (counterpart 7237): internal mould, length 7 mm., height 4 mm. (Pl. 61, fig. 2).

Type locality and horizon. L24(1)1. This form is very rare and occurs in the lowest *Cravenoceras leion* band, E_1a, associated with *C. leion*. Specimens have also been collected at L23(4)19 in P_2 beds, associated with *Goniatites granosus;* they are compared with this species although they are not so well preserved as the E_1 examples.

Discussion. Specimens of *Chaenocardiola footii* have their normal rib quotient at sizes comparable to those so far seen in this species (cf. 7167, which is a very small *C. footii*), and *C. bisati* is therefore to be distinguished by the smaller number of ribs (*c*. 17) separated by wide interspaces. In the Geological Survey Museum, two slabs (GSM Ca 1938 and 1939) collected from Holden Clough, Holden, Yorks., show incomplete large specimens of this species, and are associated with *Goniatites elegans* Bisat and are therefore of P_1c age. They show low numbers of sharp ribs (about seven but very incomplete) separated by wide interspaces. It is considered that these specimens are more adult individuals of the *C. bisati* described from Slieve Anierin. The dimensions of the two valves on Ca 1939 are: height *c*. 16 mm., length *c*. 23 mm. There are indications at these dimensions that in flat-bottomed grooves seen at smaller sizes there are three finer intermediary ribs, which are persistent from the umbo to the margins of the valve. The species is named in honour of Mr. W. S. Bisat.

Order PTYCHOPARIIDA Swinnerton 1915
Suborder ILLAENINA Jaanusson 1959
Superfamily PROETACEA Salter 1864
Family PHILLIPSIIDAE Oehlert 1886
Genus WEBERIDES Reed 1942

Weberides cf. *W. shunnerensis* (King)

Plate 62, figs. 1, 2

Griffithides shunnerensis King 1914, pp. 392–4, pl. 32, figs. 1–7.

Description. *Headshield*. The glabella is inflated anteriorly and pear-shaped. The occipital ring is distinctly separated from the rest of the glabella, and bears a central tubercle, with indications of others on each side of it. A pair of glabellar furrows slope back to meet the occipital furrow and define a pair of triangular-shaped basal lobes of the glabella. No other indications of glabellar furrows have been seen in front of this pair. The fixed cheeks are narrow with a well-defined palpebral lobe. The eyes are situated very close to the sides of the glabella and are distinctly reniform. In 7190 the eye is about 2·5 mm. long and is therefore about a third of the total length of the head shield. In relation to the convexity of the glabella the free cheeks are only very slightly raised. There are well-defined genal spines. In 7190 one of the spines is about 4 mm. long but without a complete specimen it is impossible to say where this spine would end in relation to the thoracic segments. Surrounding the free cheeks there is a border which is about 1 mm. wide. In 7190, an impression, this border appears as a furrow in which there are about five striations which run parallel to the outer margin. Up to eight of these striations have been seen on several free cheeks. In the original trilobite the border must have been a convex band with a variable number of fine striations running parallel to the outer margin, There is a slight band between the anterior end of the glabella and the edge of the head shield; the border is very reduced in this region, its area having been invaded by the glabella. A constantly recurring feature on the glabella in the Slieve Anierin specimens is the presence of a pair of pits in front of the eye lobes and situated in the depression which surrounds and outlines the glabella. These pores are commented on by King (1914, p. 394). Each pore is situated about a quarter of the distance between the eye lobe and the front margin of the cranidium.

Thorax. Unfortunately, since there are no complete specimens in the collection, the original number and form of the thoracic segments is not known. Specimen 7191 shows some fragmentary thoracic segments. The axis in these segments appears to be about 2 mm. in width and more convex than the flanking pleurae. The pleurae are not visible. On the very small and distorted specimen 7067*c* the thoracic pleurae appear to have straight terminations with no indications of the development of pleural spines.

Pygidium. There are several good specimens of pygidia. The length varies from about 8–10 mm. The axis of the pygidium is strongly arched above the flanking pleurae, which are only moderately convex. The pygidium is surrounded by a wide border. There are about sixteen segments in the axis and about ten in the pleural region. Each axial segment has a single row of granules just in front of the posterior border. A single row of granules also occurs in a similar position on each of the pleurae. Some moulds of the pygidium show a concave area surrounding the pleurae (and not the convex border seen in other moulds) and are interpreted as moulds of the ventral surface of the pygidium showing the doublure, which has striations parallel to the margin.

Dimensions. 7190: the only complete headshield, width between the two genal angles 11 mm., length 7·5 mm. (Pl. 62, fig. 2). 7192 (counterpart 7283): pygidium, *c.* 6 mm. long (Pl. 62, fig. 1). 7193: cranidium, 6·5 mm. long; length of pygidium *c.* 7 mm., maximum width 10 mm.

Localities and horizon. Fragments of trilobites occur abundantly in the highest faunal band, E_2b3, on Slieve Anierin. The most extensive collecting from this band was carried out in Valley 3, L21(9)24. The trilobite specimens are associated with *Ct. nititoides*, *E. rostratum* sp. nov., *Chaenocardiola footii*, *Euchondria* aff. *E. levicula*, &c.

Discussion. These specimens compare very closely, allowing for differences in preservation, with *Griffithides shunnerensis*, described by King (1914), now known as *Weberides shunnerensis* (see Reed 1942, p. 653). The type specimens were collected from the Shun-

EXPLANATION OF PLATE 62

All specimens are from Slieve Anierin, Co. Leitrim, Eire.

Figs. 1, 2. *Weberides* cf. *W. shunnerensis* (King). 1, 7192, pygidium, ×7. 2, 7190, cranidium, ×6.

Fig. 3. *Chaenocardiola footii* (Baily). 7174, external mould, ×6·5.

Fig. 4. *Edestus* (*Edestodus*) *sp.* GSM 86950, external mould, ×4.

Fig. 5. *Obliquipecten costatus* sp. nov. 7169, paratype, external mould of right valve partly obscuring a right valve, probably an internal mould with external ornament partially impressed upon it, ×3·3.

ner Fell Limestone, Great Shunner Fell, Wensleydale, north Yorkshire, a highly fossiliferous rock which yields an E_2 fauna. The Yorkshire specimens are therefore of the same general age as those from Slieve Anierin. Slight differences may exist in the number of axial segments in the pygidium, but most of the Slieve Anierin specimens are broken at the anterior end of the pygidium and the number of segments may well be more than the figures given.

There are several records of trilobites at this level in England and Ireland, but a generic name is not usually given. Scanlon (1953), Smyth (1950), and Nevill (1957) all record trilobite remains in E_2 beds in Ireland. Hudson and Cotton (1943) record a trilobite in the Alport Dale boring, Derbyshire, associated with a fauna very similar to that on Slieve Anierin. Tonks (1925) lists a trilobite in the fauna from Pace Gate Beck, Yorkshire, in beds which also yielded the type of *Ct. nititoides*. Demanet (1941, p. 154, pl. 7, figs. 4, 6) describes and figures a trilobite from E_2 near Bioul in Belgium, but it is not the same species and appears to be rather larger.

Superclass PISCES
Class CHONDRICHTHYES
Subclass ELASMOBRANCHII
Order SELACHII
Suborder HYBODONTOIDEA
Family EDESTIDAE
Genus EDESTUS Leidy 1856

Edestus (*Edestodus*) *sp.*

Plate 62, fig. 4

Description. The crown of this tooth is triangular, laterally compressed and symmetrical. Small subsidiary cusps occur at the base both anteriorly and posteriorly. The anterior and posterior edges of the tooth are serrated. There are eleven to twelve of these small denticulations along each margin but some may have been rubbed away near the apex. Each denticulation appears to be undivided. At the base of the tooth there are several raised ridges (seen as furrows in this impression).

Dimensions. Height 16 mm., width at base 18·5 mm. (Pl. 62, fig. 4).

Locality and horizon. A single specimen only has been collected (GSM 86950) from the horizon of *Ct. nititoides*, E_2b3, in Valley 3, L21(9)24.

Discussion. Specimens of *Edestus* are extremely rare in English deposits and this is believed to be the first record from Ireland. The writer is indebted to Dr. Ramsbottom of the Geological Survey for identifying this specimen, indicating its rare nature, and also pointing out to me the paper in Russian by Obruchev (1953) on this family. The relevant generic definitions in this work (pp. 59–60) were translated with the assistance of Dr. Skiba of the Department of Geology, Imperial College. The Slieve Anierin specimen accords most nearly with the subgenus *Edestodus* Obruchev (type species *Edestodus minor* (Newberry)) in the sharply triangular outline and the small angle at the apex of the tooth which in *Edestodus* is 25–35°, and which in this specimen is approximately 29°. In the presence of the subsidiary cusps each side at the base the specimen shows some resemblance to *Edestus heinrichsii* Newberry and Worthen (1870, pp. 350–3, pl. 1, figs. 1*a*, *b*), which is now assigned by Obruchev to the subgenus *Protopirata* Trautschold (in which the apical angle varies from 70–90°). In this species the denticles are few in number and the basal ones at the anterior and posterior margins are enlarged almost to form subsidiary cusps. The type species of the subgenus *Lestrodus* Obruchev is *L. newtoni* (Woodward) and in the original description by Woodward (1916, pp. 1–6, pl. 1) was described as possessing vertical plications or flutings at the base of the crown. These are also seen on the Slieve Anierin specimen but are more regular and more marked than in the specimens of *L. newtoni;* in this genus the apical angle varies from 40–45°.

CORRELATIONS WITH OTHER AREAS

P_1–P_2 Beds

The fossils preserved in beds of P_1–P_2 age are too poorly preserved to allow close correlation with beds of the same age elsewhere. Hudson and Cotton (1945 *a*, pp. 273–8), working on the Alport borehole, established a correlation with Germany. The sequence of faunas within P_1 was correlated with that from Edertal on the eastern side of the Rhenish Schiefergebirges (Pickel 1937) and the P_2 succession was compared with that in the northern Sauerland (Ruprecht 1937). There is less similarity between the P_2 faunas than those of P_1 but this, in the opinion of Hudson and Cotton (op. cit., p. 275), is mostly due to the poor definition of the diagnostic features of the species and the resulting difficulty in identification. The material of this age from Slieve Anierin adds nothing to the detailed subzoning and correlation established by Hudson and Cotton.

Basal E_1 to Middle E_2

1. *Ireland*

North Co. Dublin. Smyth (1950, pp. 297–304) showed that Pendleian deposits are absent in North Co. Dublin and that Arnsbergian beds succeed beds of P_2 age and overlap onto the Lower Palaeozoic. This absence of E_1 and overlap of E_2 is due to the Sudetian orogeny. As a result of faulting the succession is not so simply interpreted as the Slieve Anierin succession, nor do the described faunas appear to be so abundant.

A fauna is described (op. cit., p. 298) which is in part reminiscent of the highest *Ct. nititoides* fauna on Slieve Anierin, a notable similarity being the occurrence in both of *Productus hibernicus* and a Phillipsiid trilobite (*Weberides* cf. *W. shunnerensis* on Slieve Anierin). Unfortunately this band was not found in direct relationship to any of the other described sections; Smyth (p. 302) believes that the Rowans Brook and Walshestown sections cover the *E. bisulcatum* s.s. and *Ct. nitidus* zones, and that the *P. hibernicus* fauna is higher than any part of these two sections. On Slieve Anierin the fauna with *P. hibernicus* is included in the *Ct. nitidus* subzone. In the Rowans Brook section, which is the most complete, there are about 400 feet of beds, predominantly shale, of which about 60 feet at the base are in the Balrickard Sandstone; at other localities it is estimated that this sandstone must be considerably over 100 feet in thickness. North Co. Dublin and Slieve Anierin are alike, therefore, in the presence of a considerable thickness of arenaceous rocks within the lower part of E_2. The first *E. bisulcatum* to be found above this grit has not been figured but has been described by Stubblefield (*in* Smyth 1950, pp. 318–19) as intermediate between *E. bisulcatum grassingtonense* and examples of *E. bisulcatum* from the Edge Marine Band at Cononley Beck, Yorkshire. It is probable that these forms represent a higher horizon than those on Slieve Anierin since within 20 feet they are succeeded by *Ct.* cf. *Ct. stellarum*, a species which has not been found on Slieve Anierin. No account is given of any faunas between the grit and this band with *E. bisulcatum*.

E_2 deposits from near Garristown were described by Scanlon (1953, pp. 145–57). The faunas are too poor for close comparison and there is no record of *E. bisulcatum* itself but of *Ct. stellarum* and *Cravenoceras sp.*

Co. Meath. Nevill (1957, pp. 297–300) recorded both Pendleian and Arnsbergian stages in the Summerhill Basin, but lack of detailed information on the faunas and incomplete exposure of parts of the succession precludes any close correlation. The combined E_1–E_2 stages are about 2,000 feet thick and the precise position of the boundary between the two stages has not been established. A basal E_1 goniatite fauna which has much in common with the fauna at L23(4)7 on Slieve Anierin is described, but the rest of the Pendleian is not exposed and the lowest exposed E_2 horizon is of E_2b age, consisting of beds with *Ct. edalense*. Two hundred feet of the succession are not exposed, and this would account for the absence of all the horizons which are present above *Ct. edalense* on Slieve Anierin. *Ct. stellarum* was collected about 300 feet above *Ct. edalense*.

In two isolated exposures in the Summerhill Basin which have not been related to the main succession (described from a drainage dyke at Mullagh) *E. bisulcatum* is associated with a *Cravenoceras*, an *Anthracoceras*, and a rich brachiopod fauna including *P. hibernicus*, a trilobite, *Dunbarella sp.*, *Posidoniella sp.*, *P. sulcata* (Hind), a coiled nautiloid and crinoid ossicles. Nevill believes that these beds are closely followed by Sabdenian strata and therefore higher than the succession described from the Mullagh dyke. On Slieve Anierin *P. hibernicus* is associated with *E. rostratum* sp. nov., *Ct. nititoides*, and *Weberides* cf. *W. shunnerensis* and is at a lower horizon than *Ct. stellarum*, which does not occur on Slieve Anierin. If Smyth and Nevill are correct in attributing their isolated faunas to high E_2 then a somewhat similar band must also occur at the lower level within the *Ct. nitidus* subzone. Neither author has described or figured the *E. bisulcatum* which occurs at this level but both refer to *Cravenoceras sp.* On Slieve Anierin the associated goniatite is undoubtedly *Cravenoceratoides*. The Slieve Anierin fauna includes several other forms which one would have expected to see in the faunal lists of these authors if they were describing the same horizon, e.g. *Chaenocardiola* and *Euchondria*, both abundant in the *Ct. nititoides* band.

Nevill (1957, p. 296) also mentions the abundance in P_2 and low E_1 horizons of a large compressed goniatite referred to as *Anthracoceras*? (pl. 22, figs. 6, 7). Similar forms have been collected on Slieve Anierin at these levels and identified as *Kazakhoceras sp.*

Both Smyth and Nevill therefore provide information on what is probably the highest subzone of the *Ct. nitidus* zone (i.e. the *Ct. stellarum* subzone), but do not shed any light on the lower parts of E_2 or E_1, except for the basal beds of the latter in the Summerhill Basin. A considerable sandstone episode within E_2 also occurs in North Co. Dublin, as in Leitrim. The greywacke facies described by Nevill at the base of E_1 has not been observed in Leitrim.

Cuilcagh, borders of Co. Cavan and Co. Fermanagh. Padget (1953, pp. 17–26) described the geology of Cuilcagh (2,188 feet), which is only 10 miles from Slieve Anierin and is included in the same area of Upper Carboniferous rocks. He recorded only E_1 fossils (apart from the P_2 and P_1 forms) and found no evidence of E_2. The fauna from a low E_1 horizon included *E. stubblefieldi* and *C. leion;* no higher goniatite-bearing beds were found *in situ*, but *C.* cf. *C. malhamense* was collected from some loose blocks.

Padget makes no suggestion as to the age of the succeeding shales or the grit which forms the escarpment. The latter is identical with that on Slieve Anierin, which has been proved to lie within E_2. On Benbrack (1,648 feet), to the south of Cuilcagh, the writer has collected *Eumorphoceras* cf. *E. bisulcatum grassingtonense* (GSM 95317) and believes it occurs at the same level as at localities L21(5)8 and 9, and at L21(13)5 and 6. It is therefore probable that the same faunas exist on Cuilcagh, though possibly not so well exposed as on Slieve Anierin.

Palaeogeography. Hodson (1959, pp. 134–50) has discussed the palaeogeography of western Europe in *Homoceras* times and has shown (pl. 1) an embayment of the sea into the North Atlantic Continent in the north-western area of Ireland, which includes Slieve Anierin, where the Namurian beds succeed the Viséan conformably. The position of the southern margin of this embayment is based on evidence provided by the (unpublished) work of Hodson and Kelk, and there is apparently overlap to the south-west so that E_2 shales lie on Carboniferous Limestone in the south-western part of the Slieve Carna outlier north of Balla in Co. Mayo.

South of the North Atlantic Continent lay a Central Trough of sedimentation. Hodson (1954*a*) demonstrated the effects of the Sudetian earth-movements in north-west Co. Clare by the discovery there of *Homoceras* beds succeeding the Carboniferous Limestone; all the beds exposed on Slieve Anierin together with the *N. nuculum* beds (not present on the mountain) are absent and there is therefore a large non-sequence. The effects of the orogeny become less evident southwards across this trough and Hodson (1959, p. 140) describes a thick E_1 succession overlying the Carboniferous Limestone on the north bank of the River Shannon. Still further south the Lower Namurian beds are again overstepped, and the southern edge of the trough (against the westerly continuation of St. George's Land) is apparently near Ballagh, west of Newcastle West, Co. Limerick, where, as in Co. Clare, *Homoceras* is found resting on Carboniferous Limestone.

The Sudetian earth-movements have also been detected by Smyth (1950, pp. 295–326) in North Co. Dublin, where the whole of the Pendleian is absent. Farther south, in the Summerhill Basin, Co. Meath, Nevill (1957) found E_1 and E_2 beds succeeding P_2, and in this area some of the higher beds of H and R_1 are also preserved. The Summerhill Basin is farther away from the shoreline of the Central Trough than North Co. Dublin and the Arnsbergian deposits are correspondingly thicker. The relationship of the Summerhill succession to the North Co. Dublin succession is very like that of the Slieve Anierin succession to that south of the embayment at Slieve Carna. On Slieve Anierin the higher zones which are preserved in the Summerhill Basin have presumably been removed by erosion leaving only the beds of *Eumorphoceras* age.

Hodson (1959, p. 139) postulated a marine connexion between the Central Trough and the north-western Ireland embayment on the basis of the faunal and lithological similarity of the two areas. The close correlation which it is possible to establish between the Slieve Anierin succession and those of areas in the Central Trough in E_1 and E_2 times amply testify the accuracy of this statement.

2. *Southern and Mid-Pennines, England*

The only complete record of the Arnsbergian succession is that given by Hudson and Cotton (1943, pp. 160–72) from the Alport Dale borehole in Derbyshire. A large number of the other known occurrences of certain faunas do not allow an accurate determination of their order of superposition. The Pendleian succession is also included in the Alport borehole. Three zones were defined within the Pendleian by Hudson and Mitchell (1936, p. 26) in the Skipton Anticline in Yorkshire:

E_1c	Subzone of *Cravenoceras malhamense*
E_1b	,, ,, *Eumorphoceras pseudobilingue* s.s. and *Cravenoceras sp.*
E_1a	,, ,, *Cravenoceras leion* and *Eumorphoceras pseudobilingue* (early form)

Hudson and Cotton recognized these subzones in the Alport borehole section, but treated them as zones, and added E_1d, the *Eumorphoceras* aff. *E. pseudobilingue* zone. In the Slaidburn district of Yorkshire Parkinson (1936, pp. 318–20, pl. 24) recognized:

Upper E_1	*Cravenoceras malhamense*	*Chaenocardiola footii*
Lower E_1	*Eumorphoceras pseudobilingue C*	
	,, ,, *B*	
	,, ,, *A*	
	Cravenoceras leion	

In this area the *C. malhamense* beds are succeeded by the Pendle Top Grit. There is obviously a close correlation between the Slieve Anierin and Pennine successions, though the grit which succeeds the *C. malhamense* beds in the Slaidburn area is not present until later in the succession in Co. Leitrim.

(*a*) Cravenoceras leion *zone*. Apart from the plates in Nevill (1957, pl. 22, figs. 1–3) and Bisat (1950, pl. 1, figs. 1, 2) *E. pseudobilingue A* has never been described by Bisat although he contrasted it with *E. pseudocoronula* (1950, p. 19). The former is placed by Bisat (p. 24) somewhat above the base of the *C. leion* zone with *E. pseudocoronula*, *C. leion*, *E. stubblefieldi*, &c. On Slieve Anierin the maximum abundance of this species occurs with *C. leion* slightly above beds in which *E. pseudocoronula* is more abundant and it is associated with *E. rota*.

On specimen GSM 84690 from Little Mearley Clough, *E. pseudocoronula* is associated with a fragment identified as *E. rota*. At the top of the zone or nearly so on Slieve Anierin *E. medusa* occurs, and slightly higher *E. medusa sinuosum*. Both these forms are believed to be related to the stratigraphically lower *E. pseudocoronula*. Specimen GSM Ca4782, previously identified as *Eumorphoceras* aff. *E. hudsoni* Gill, is thought to belong to *E. medusa*; it was collected about 40 feet above the lowest *C. leion* beds in Bateson Wood, 550 yards north-east of Crag House, Yorkshire. Bisat, who originally identified this specimen, noting that it might be undescribed, agrees (*in litt.*, 1960) with this identification.

E. hudsoni has not been collected in this zone nor in the succeeding one; Bisat (1950,

p. 24) includes it within E_1a, although Gill (1947, p. 64) is uncertain whether the band is in E_1a or E_1b. *E. stubblefieldi* has not been seen either, although included by Bisat at the level of *E. pseudocoronula* and *E. pseudobilingue A*.

The lamellibranchs at this level seem to have been neglected. Hudson and Cotton (1943, p. 169) record *Pseudamusium* in the Alport borehole, and also *Posidonia membranacea* (now *Caneyella membranacea*) and *Posidonia* cf. *P. corrugata. Obliquipecten* is not included though it is an abundant element in very low E_1 beds in Leitrim, associated with *C. leion*, whereas *Pseudamusium* is more abundant at the top of the zone with *E. medusa*.

Several specimens from the Alport borehole material are referred to in Book 30 at the Geological Survey Museum as *Posidonia sp*. These have been examined and found to be the same as Slieve Anierin forms referred to *P. trapezoedra*, which is extremely abundant towards the upper part of the zone. GSM Zh2000 is a slab showing *Dimorphoceras sp.* and *P. trapezoedra*, and was collected from a depth of 1065–6 feet (GSM, Book 30, p. 281). This is valuable confirmatory evidence of the burst in development of this species at about this level. From a depth of 1060–1 feet, which is 6 feet below the top of the zone, GSM Zh1973 has been identified as *Girtyoceras sp.* but may be compared with *E. medusa sinuosum* which occurs at the top of the zone in Leitrim.

Bisat (1950, p. 14) refers to the occurrence of *Eumorphoceras* aff. *E. hudsoni* at 1064 feet in the Alport material. GSM Zh1993 collected at this depth, and similarly identified, is very like the Bateson Wood specimen GSM Ca4782 and is now believed to be *E. medusa*. At lower depths in the borehole (1072–3 feet) GSM Zh2026, *E. pseudobilingue A*, is very close to the specimens collected from locality L23(4)7 where this species and *C. leion* are about equally abundant.

Hudson and Cotton refer to a *Dimorphoceras* phase in E_1a and these specimens have been examined and compared with Slieve Anierin specimens referred to *Kazakhoceras sp.*, which are abundant at about the level at which *P. trapezoedra* first becomes so noticeable. The Alport specimens are all poor and apart from the fact that like the Slieve Anierin examples they are all very narrow compressed forms, little more can be established.

In the lower part of the succession in the Alport borehole *Eumorphoceras sp.* form *A* Moore is apparently more common than *E. pseudocoronula*. The former has only been imperfectly seen on Slieve Anierin at a level at which *C. leion* is dominant, with *Obliquipecten costatus*; either this horizon or the level of *E. pseudocoronula* and *E. rota* could be the one with the oldest E_1a fauna, though the writer believes that the latter band is lower. There is, however, close correspondence between the successions at Alport Dale and Slieve Anierin in the larger part of the zone and the lack of precise correspondence in the lower part is partly due to the poorness of the Alport borehole material.

(*b*) Eumorphoceras pseudobilingue *zone*. Hudson and Cotton (1943, p. 168) state that *Cravenoceras* is not common in this zone in the Alport borehole, and on Slieve Anierin it has not been collected from beds assigned to this zone. *P. trapezoedra* continues from the *C. leion* zone and in the Alport material poor specimens referred to as *Posidonia* cf. *P. costata* are believed to be the same as such specimens as GSM Zh2000 (*P. trapezoedra*) from the lower zone, so that the species apparently continues in both areas.

Eumorphoceras cf. *E. angustum* is a very abundant species at this level on Slieve

Anierin. Though it had not been defined at the time of identification of the Alport material, it nevertheless does not seem to be present. Moore (1946, p. 439) places the species in the *E. pseudobilingue* zone and states (p. 440) that the two species are not necessarily on the same horizon. On Slieve Anierin this species directly underlies *E. pseudobilingue* s.s. and is associated with *P. trapezoedra* and *Kazakhoceras sp.* showing a strongly beaded, sharp venter. The presence of notching on the sharp mid-venter is also believed to be present in the later stages of *E. pseudobilingue* s.s. which succeeds *E.* cf. *E. angustum*. Stephens *et al.* (1953, p. 92) further confirm the presence of *P. trapezoedra* in the *E. pseudobilingue* zone.

In the same memoir (loc. cit.) a goniatite referred to as *Eumorphoceras* aff. *E. pseudobilingue* is described from Ramshaw Beck in older beds than *E. pseudobilingue* s.s.; it has poorly developed ribs, a more prominent sulcus, faint spiral ornament, and a beaded keel in old age. No species which exactly fits this description has been found on Slieve Anierin. The venter has not been seen to be beaded at the diameter usually found in *Eumorphoceras* cf. *E. angustum* and the shoulder ridge is a very faintly developed feature, although in some of the specimens the faint plications of the surface which replace the earlier strong ribs ridge the surface of the faint shoulder ridge where they cross it and make the latter slightly more obvious. The beaded venter has been most obviously seen in the large compressed *Kazakhoceras sp.*

The succeeding specimens of *E. pseudobilingue* s.s. accord very well with GSM 72927 from Little Mearley Clough, near Clitheroe, and is presumably the form intended by Bisat (1928, pl. 6) as *E. pseudobilingue B*. On Slieve Anierin a few forms succeed *E. pseudobilingue B;* they have been figured and described as *E. pseudobilingue C*. Although they have some resemblance to *E. pseudobilingue* s.s. they show an earlier fading of the ribs, which are less wavy than the ribs in *E. pseudobilingue* s.s. and with a prominent groove in the shoulder region.

Parkinson (1936, pl. 24) referred to *E. pseudobilingue C* occurring below *Cravenoceras malhamense*. Bisat (*in litt*., 1960) agrees that a shoulder groove is a marked feature of this form. Specimens collected by Parkinson from Studforth Gill have been presented by Bisat to the Geological Survey Museum (GSM Zl 5773–6) and have been examined, but only one specimen resembles the Slieve Anierin examples. It seems likely therefore that those specimens occurring below *C. malhamense* should be referred to this form, but as Bisat has never defined or figured it, there is no holotype for comparison; however, Bisat (*in litt*., 1960) has agreed with the identification.

The species *E. pseudobilingue* s.l., as seen on Slieve Anierin, shows a reduction in the number of ribs; in *E. pseudobilingue* s.s. they are fewer and with wider interspaces than in *E. pseudobilingue A;* in *E. pseudobilingue C* the ribs fade earlier and are narrow and sharp as in the lower *E. pseudobilingue* s.s., but less tenuous in their passage across the flank than in that species. The shoulder ridge is lost and a groove more reminiscent of the later *E. bisulcatum* appears.

On Slieve Anierin at this level *Chaenocardiola footii* occurs. It is noted by Parkinson (1936, pl. 24) as appearing at the level of *C. malhamense* but on Slieve Anierin is definitely associated with *E. pseudobilingue C*, together with small *P. corrugata* but not *P. trapezoedra*.

(*c*) Cravenoceras malhamense *zone*. Hudson and Cotton (1953, p. 167) list *C. mal-*

hamense, *Neodimorphoceras scaliger* (Schmidt) and *Chaenocardiola footii* as the characteristic fossils of the *C. malhamense* zone in the Alport borehole, providing a striking correlation with the beds of the same age seen at localities L21(13)7 and L21(5)5 on Slieve Anierin. *Caneyella membranacea* is also abundant on Slieve Anierin, and is included in Hudson and Cotton's faunal list. On Slieve Anierin this is the highest level at which *C. membranacea* has been collected, and at this level most of the forms are referred to *C. membranacea* s.s., its subspecies *horizontalis* being less abundant.

No specimens of *Eumorphoceras* are known from Derbyshire or Slieve Anierin at this level, so that there is close correlation between the two areas on this point. In the Bradford and Skipton Memoir (Stephens *et al.* 1953, p. 92) *Cravenoceras* aff. *C. malhamense* is reported from Howgill Beck, associated with *C. membranacea* and *E. pseudobilingue;* this association contrasts with their separation in Leitrim and in Alport Dale.

(*d*) *E_1d zone or E_2a faunas*. The next fossiliferous level on Slieve Anierin is thought to correspond to the E_1d zone of Hudson and Cotton (1953, pp. 166–7). The most abundant species at this level is *C. cowlingense*. A comparison of these specimens with those collected from the Mirk Fell Beds of Tan Hill in Yorkshire by Hudson (1941, pp. 279–83) leads to the conclusion that they belong to the same species. The Mirk Fell beds are referred to E_2 by Hudson, and *Anthracoceras* aff. *A. paucilobum* occurs with *C. cowlingense*. Stubblefield (Hudson and Stubblefield 1945, p. 136) also believes that the horizon of *C. cowlingense* is low E_2 not E_1d.

On Slieve Anierin *C. cowlingense* is associated with a rather poor fauna, but including a few specimens of *E. bisulcatum grassingtonense*, *P. corrugata*, *P. lamellosa*, and *Chaenocardiola footii*. The Tan Hill fauna is rather different from the goniatite-lamellibranch fauna on Slieve Anierin since it includes nuculids and small gastropods but no examples of *Posidonia* or *Posidoniella;* there is also an apparent absence of fossil wood debris, which is quite common at the level of *C. cowlingense* on Slieve Anierin.

The lucky preservation of a suture in one of the Slieve Anierin specimens of *C. cowlingense* confirms the accuracy of the identification. Hudson (1941, p. 281) has figured the suture-line of GSM 62813 from Mirk Fell Beck and of GSM 62824, a metatype of the species from an erratic in Keighley Churchyard, and a comparison of these with the Slieve Anierin specimen leaves no doubt of their being the same form. A comparison of specimens GSM CS571–4, 582, and 584 collected from the Cockhill Marine Band in Gillfields Adit, also established this identification; a very large specimen, GSM Zh2908, is from the same horizon at the Cockhill Adit.

These examples of *C. cowlingense* are particularly interesting since the Cockhill Limestone is the horizon from which Dunham and Stubblefield (1944, pp. 237–9) described *E. bisulcatum grassingtonense* and which they place in E_2. *Cravenoceras* is dominant in the Cockhill Limestone and since there is only one specimen of *grassingtonense* at the Geological Survey Museum it would appear that specimens of *Eumorphoceras* are as rare as they are at this level on Slieve Anierin. Dunham and Stubblefield suggest a correlation of this level with the Edge Marine Band, described by Stephens *et al.* (1942, p. 348) but in a footnote (p. 238) they also consider that it may be slightly later than this band.

The Slieve Anierin succession shows two decided levels within beds referred to E_2a, the lower dominated by *C. cowlingense* and with rare examples of rather variable

Eumorphoceras, some of which are definitely *E. bisulcatum*, and which have been compared with *grassingtonense;* and the upper level with *E. bisulcatum erinense* subsp. nov. and *E. bisulcatum ferrimontanum* subsp. nov. dominant, with *Chaenocardiola footii* the most abundant lamellibranch, and with no *C. cowlingense*. The upper level is believed to be that of the Edge Marine Band.

The E_1d fauna described by Hudson and Cotton in the Alport borehole is correlated with the lower E_2a faunal band on Slieve Anierin. The *Eumorphoceras* specimens from

Slieve Anierin (*this paper*)	*Greenhow Mining Area* (*Dunham and Stubblefield* 1944)	*Bradford and Skipton Area* (*Stephens* et al. 1953)	*Lancaster Fells* (*Moseley* 1954)	*Alport Dale* (*Hudson and Cotton* 1943)
Grit	Red Scar Grit	Marchup Grit	Roeburndale Grit Group	
Barren shales	Shales and Sandstone Bands	Shales and Sandstones, &c.	Brennand Grits	
High E_2a *E. bisulcatum ferrimontanum* *Chaenocardiola footii*	not known in	Edge Marine Band		E_2a
E. bisulcatum erinense *Chaenocardiola footii*	the area	Weston Marine Band	Brennand Band	399–408 ft.
Barren shales	Shales and Sandstone Bands	Skipton Moor Grits; Weston Grit		
Lowest E_2a Dominant *C. cowlingense* and rare *E. bisulcatum grassingtonense*	Cockhill Limestone		Tarnbrook Valley Band	E_1d 453–63 ft.

TABLE 3. Suggested correlations between the fossiliferous bands in E_2a on Slieve Anierin and some bands of similar age in northern England.

this level in the borehole section are poor and have been variously referred to as *Eumorphoceras* cf. *E. pseudobilingue* and *E.* aff. *E. pseudobilingue*, but Hudson and Cotton (1943, p. 167) state that many of the latter are indistinguishable from *E. bisulcatum*. The writer compares GSM Zh1164 with forms collected from the lowest E_2a faunal band on Slieve Anierin. The evidence suggests that the forms of *Eumorphoceras* at this level are rather variable, and Hudson and Cotton's view that the fauna has more in common with the Pendleian than the Arnsbergian may be justifiable in some respects, but the writer prefers to assign these beds to E_2 because of the presence of *E. bisulcatum*.

In the Lancaster Fells, Moseley (1954, pp. 428–30) suggests that beds with *C. cowlingense* and *E. bisulcatum* should be correlated with the Edge Marine Band and included in the Arnsbergian, and not the Pendleian as in Hudson (1945, p. 3) and Hudson and Cotton (1943, p. 166). It is now suggested that the band with *C. cowlingense* and *E. bisulcatum grassingtonense* should be correlated with the Cockhill Limestone and Hudson's E_1d level at Alport Dale. The writer correlates the Edge Marine Band of

Rombalds Moor with the higher band in E_2a on Slieve Anierin in which *E. bisulcatum* is the most abundant form; the whole fauna is a richer one than at the lower level in E_2a.

Moseley (1954, pp. 429–30) states that the Tarnbrook Wyre Marine Beds (E_2a) are made up of two horizons, but as they are exposed in different localities he is uncertain of their relative positions; he believes that the Brennand outcrops in which *E. bisulcatum* is the dominant form is the lower band. The other fauna in the upper Tarnbrook Valley contains an association of *C. cowlingense* and *E. bisulcatum*. The Slieve Anierin succession shows that the Tarnbrook Valley material is lower and the Brennand outcrops probably equivalent to the second E_2a level on Slieve Anierin. Specimens of *E. bisulcatum* from some Brennand material kindly provided by Bisat appear to be close to those from the second faunal band in E_2a which are referred to as *E. bisulcatum erinense* subsp. nov.

Stephens *et al.* (1942, p. 348) describe the Edge Marine Band, and state that *E. bisulcatum* and *Chaenocardiola footii* are the most abundant forms. This is reminiscent of the second faunal band in E_2a on Slieve Anierin and contrasts strongly with the fauna of the lower E_2a band. The specimens of *E. bisulcatum* at this level on Slieve Anierin are believed to be very close indeed to *E. bisulcatum* s.s. but there are two subspecies present within this band, the lower being *erinense* and the higher *ferrimontanum*. Good specimens from the Edge Marine Band appear to be very rare and Bisat (*in litt.*, 1960) does not recall seeing any good specimens. The material mentioned in the Bradford and Skipton memoir (Stephens *et al.* 1953, p. 25) has been examined, but is extremely poor and inconclusive. Dunham and Stubblefield (1944, p. 260) refer to specimen GSM GM3675 (see pl. 3, fig. 3) and suggest a resemblance to *grassingtonense*. The writer suggests rather a resemblance to *E. bisulcatum ferrimontanum* subsp. nov. from localities L21(5)11 and L21(13)4. GSM GM3675 was collected from Cononley Beck and is about the best specimen in the material mentioned by Stephens *et al.* (1953, p. 25). There is an additional line of evidence by means of which the second faunal band in E_2a on Slieve Anierin can be correlated with beds elsewhere, since in Ireland two very easily determined goniatites, viz. *Kazakhoceras scaliger* and *Cravenoceras* cf. *C. gairense*, are associated rather less abundantly with *E. bisulcatum*. *K. scaliger* is an abundant member of the fauna attributed by Hudson and Cotton (1943, pp. 162–3) to E_2a. The fauna from 399–408 feet in the Alport borehole has been examined and although the specimens of *E. bisulcatum* are not easily compared, since many of them seem to be gerontic individuals, the examples of *K. scaliger* are easily determined even from very small fragments. Crinoid ossicles also appear to be common at this level, as on Slieve Anierin in the second E_2a faunal band. It is therefore suggested that the second faunal band on Slieve Anierin should be correlated with this level in Alport Dale.

A fauna is described in the Bradford and Skipton memoir (Stephens *et al.* 1953, p. 28) from the left bank of Holbeck, near Otley, Yorks. It is stated to be difficult to place in the succession on account of drift obscured country and faulting. The writer suggests that it should be correlated with the second E_2a faunal band in Leitrim and not with the Marchup Marine Beds as suggested in the memoir. Hudson (1944, p. 234) correlates this fauna with the E_2a horizon in Alport Dale. There is an abundance of *K. scaliger* as in Hudson's E_2a horizon at Alport, also *Pseudamusium* and crinoidal debris. Most of the specimens of *Cravenoceras* are too fragmentary to be of value and those of *E. bisulcatum* from this locality are not good. The specimens identified as *Posidonia* cf. *P. membranacea* are the forms now referred to as *P. corrugata elongata* subsp. nov., which is abundant on Slieve Anierin in the second E_2a band. *Chaenocardiola footii* is also present in both places.

A similar fauna is described in the Bradford and Skipton memoir (Stephens *et al.* 1953, p. 29) from the Washburn Valley near Leathley, Yorks., and is also correlated with the Marchup Marine Beds, but the writer would correlate it with the second faunal band in E_2a in Leitrim.

A large slab from 280 yards W. 8° S. of St. Oswald's Church, Leathley, Yorks., shows *K. scaliger* which is indistinguishable from specimens in the second faunal band in E_2a on Slieve Anierin and Hudson and Cotton's E_2a horizon at Alport. Hudson (1944, p. 234) correlates this fauna with E_2a in Alport Dale, and Stubblefield (*in* Stephens *et al.* 1953, p. 94) agrees that it may be lower than the Marchup Marine Beds. A discussion between Hudson and Stubblefield (1945, pp. 135–7) over the possible correlation of the Cockhill Limestone with the Weston Marine Beds in the Washburn Valley can be considered at this point in the light of the Slieve Anierin succession. *E. bisulcatum* from the Weston Marine Band at Leathley (GSM WE947) is compared with *E. bisulcatum erinense* from the second faunal band in E_2a on Slieve Anierin, and the *E. bisulcatum* from the Cononley Beck Edge Marine Band with *E. bisulcatum ferrimontanum* from the same band on Slieve Anierin. Both subspecies occur within one continuous fossiliferous band and it is therefore suggested that this second faunal band in E_2a should be correlated with the Weston and the Edge Marine Bands.

The Warley Wise marine band material has not been seen, but the lamellibranch fauna listed by Bray (1927, p. 53) appears to be similar to that found in the second band in E_2a. Hudson believes, on faunal and stratigraphical evidence, that this band is below the Weston Marine Band. It may be that the two subspecies of *E. bisulcatum* which occur within the one band on Slieve Anierin have elsewhere led to the conclusion that two very different levels were being seen.

The writer would suggest that the Warley Wise, the Edge and the Weston Marine Bands should all be correlated with the second faunal band in E_2a on Slieve Anierin and that the lower faunal band corresponds with the Cockhill Limestone. This would support Stubblefield's suggestion that the Weston Grit is earlier than the Marchup Grit and that the Grassington Grit is earlier than either.

Although the second faunal band in E_2a on Slieve Anierin does not yield as abundant examples of *Cravenoceras* as the lower band, it does yield a few which are referred to *Cravenoceras* cf. *C. gairense*. In the material at the Geological Survey Museum from Cononley Beck listed by Stephens *et al.* (1953, p. 25) is a *Cravenoceras* with an acute-edged open umbilicus; however, most of the specimens have been rejected and thrown away and the few fragments now left do not show the umbilicus but only simple *Cravenoceras* ornament. Since *C.* cf. *C. gairense* is typical of the second faunal band on Slieve Anierin it would be a valuable additional line of evidence if it could be found in some of the marine bands in the Pennines which it is suggested should be correlated with this level. Some specimens have been found at the Geological Survey Museum which had been identified as *Cravenoceras* cf. *C. holmesi*, presumably because the umbilical edge appears to be raised; however, in *C. gairense* there are three spiral ridges around the umbilicus which make it unmistakable. The specimens now assigned to the latter species, e.g. GSM JS1479, 1491, and 1492, were collected from a road-cutting on the east side of the road 520 yards west-north-west of Crickton, Llanrhidian, Glam.

(Survey Book 29, p. 267). Specimens GSM JS1121 and 1117 were collected from a stream in Moorlakes Wood, 250 yards north-east of Courthouse Farm, Ilston, Glam., and are also the same species. A further link with the Slieve Anierin horizon exists in the presence of *Dunbarella sp.* (GSM JS1113) in the Glamorgan fauna; it is believed to be the same species as that on Slieve Anierin and shows a large number of ribs and no definition of the anterior ear by a furrow.

(*e*) Cravenoceratoides bisati *and* Ct. edalense *fauna, lowest E_2b.* The lowest E_2b subzone, that of *Ct. bisati*, contains dominant *Ct. edalense* and less common *Ct. bisati*. The most

Slieve Anierin (*this paper*)	*Greenhow Mining Area* (*Dunham and Stubblefield* 1944)	*Simonseat Anticline near Skipton* (*Hudson* 1939)	*Lancaster Fells* (*Moseley* 1954)	*Alport Dale* (*Hudson and Cotton* 1943)
			? *Ct. stellarum*	
Ct. nititoides *E. rostratum* *Productus hibernicus* *Weberides* cf. *W. shunnerensis*		Pace Gate Beck (Tonks 1925) *Ct. nititoides* *Productus sp.*		*E. rostratum* at 300–6 ft. (referred to as the *Ct. nitidus* level by authors)
C. holmesi			*C. holmesi*	
A. tenuispirale	*A. tenuispirale*		*Anthracoceras* beds	
Dominant *E. bisulcatum leitrimense*; rare *Ct. nitidus*	Colsterdale Limestone	Birk Gill Limestone	*nitidus* Limestone	few horizons with faunas worth recording
C. subplicatum	no record of any of these species	*A.* aff. *A. discoides* *C.* cf. *C. holmesi*	*Cravenoceras* of *cowlingense* group, *Ct. lirifer* and rare *Ct. bisati*	
Dominant *Ct. edalense*, rare *Ct. bisati*		*C.* aff. *C. holmesi* *C.* cf. *C. subplicatum*		354–60 ft. *Ct. edalense*
Grit	Red Scar Grit	Red Scar Grit	Roeburndale Grit	

TABLE 4. Suggested correlations between the fauna above the grit on Slieve Anierin and ones of similar age in northern England.

common lamellibranch is *Posidonia corrugata elongata*. The succeeding beds contain very abundant but poor forms attributed to *Cravenoceras subplicatum*.

Hudson (1945, pp. 2, 4) states that there are two horizons within the *Ct. bisati* subzone, a lower faunal band with *C. subplicatum* and an upper with *Ct. bisati*. The various sections described by Hudson (1944, pp. 233–41) all appear to lead to this conclusion. On Slieve Anierin the maximum abundance of *Ct. edalense* is definitely beneath *C. subplicatum* and only unfossiliferous horizons occur beneath the former. The Marchup Marine Beds are described in the Bradford and Skipton memoir (Stephens *et al.* 1953, pp. 26–29) as characterized by *Ct. bisati*, and presumably in part at least they belong to the *Ct. bisati* subzone and can therefore be correlated with the beds immediately above the grit on Slieve Anierin. It is to this level that the beds from Holbeck and the Washburn River, which have already been discussed, have been ascribed in the memoir. Hudson and Cotton (1945*b*, pp. 9, 10), in describing the *Ct. bisati* subzone in the Edale Valley in Derbyshire, have not been able to determine the relative positions of the two faunal bands of the subzone.

In the Lancaster Fells, Moseley (1954, pp. 432–3) has not included *C. subplicatum* in his faunal list but includes *C.* cf. *C. cowlingense* group and *Ct. lirifer;* these two forms are associated together in four bands within the subzone with no distinction into lower and upper. There can be no doubt of the order of succession in these beds on Slieve Anierin.

(*f*) Cravenoceratoides nitidus *subzone*. The base of this subzone is characterized by a small *E. bisulcatum* which has constrictions and is described as *E. bisulcatum leitrimense* subsp. nov. It does not conform with *E. bisulcatum varicata* Schmidt (1934, p. 449, fig. 29 and p. 445). At this level only fragments of *Cravenoceratoides* ornament have been found, which show clearly the forking and the asymmetrical nature of the lirae, suggesting that they represent either *Ct. nitidus* or *Ct. nititoides*. It seems probable that they are fragments of the former, but for some reason the species does not appear to have been as common in this area as elsewhere, whereas the *Eumorphoceras* is relatively abundant in the shales at this level. A few rare specimens of *C. holmesi* have been found slightly lower than *E. bisulcatum leitrimense*, but are more abundant above this level.

In Alport Dale, Derbyshire, Hudson and Cotton (1943, p. 162) record a *Ct. nitidus* band from a depth of 300–6 feet and a *Ct. edalense* horizon at 354–60 feet. Between these two depths there were few horizons with faunas worth reporting, and there is no record of anything comparable with *E. bisulcatum leitrimense*. The material collected by the same authors (1945*b*, pp. 9, 10) in Edale has also been examined at the Geological Survey Museum but is extremely poor and there is no indication of this horizon.

At the Geological Survey Museum there are a few imperfect specimens which are believed to be the same subspecies; GSM Da1593, 1594, and 1599 were collected in a section on the left bank of the stream, 150 yards to the south-east of Low Stubbing and 820 yards N. 11° W. of Holy Trinity Church, Cowling, Yorks. Stubblefield has commented in Geological Survey Book 28, p. 20, that Da 1599 shows constrictions with two to three ribs between them and that the ribs resemble short stubby plications as are seen in some of the Scottish examples of *E. bisulcatum*.

Dunham and Stubblefield (1944, pp. 239–41) describe the Colsterdale Limestone as abounding in *Ct. nitidus* at the level of the Colsterdale Marine Beds in the Greenhow mining area, and with *E. bisulcatum* rare in the shales at this level. The latter is described as the variety with short stout ribs which elsewhere characterizes this horizon. GSM CS853 and CS859 (Survey Book 35, p. 51) from locality 25 of Dunham and Stubblefield have been examined, but are too poor and fragmentary to compare satisfactorily with *E. bisulcatum leitrimense*.

However, one very interesting connexion that can be established is that GSM CS891, identified as *Cravenoceras* cf. *C. holmesi*, from the Colsterdale Marine Band in a stream section 300 yards west of Ivin Waite, west of Pateley Bridge, Yorks., is now attributed to *Anthracoceras tenuispirale*, and this species first appears on Slieve Anierin at the level of *E. bisulcatum leitrimense* and soon becomes the dominant species. It is suggested therefore that the Colsterdale Limestone corresponds to the *E. bisulcatum leitrimense* level on Slieve Anierin.

In the Pateley Bridge area *Ct. nitidus* is only abundant in the limestone whereas *Eumorphoceras* occurs in the shales; it is therefore possible that the lack of suitable limestone-forming environments in the Slieve Anierin area at this time may be connected with the scarcity of *Ct. nitidus*. Dunham and Stubblefield (1944, p. 241) correlate the Colsterdale Marine Beds in general terms with the Marchup Marine Beds of the Bradford and Skipton area. There is, however, no record in the Greenhow area of beds with *Ct. bisati;* the Colsterdale Marine Beds succeed the Red Scar Grit and their fauna of *Ct. nitidus* has already been discussed. The limits of the Marchup Marine Beds do not appear to be exactly defined, but the Slieve Anierin succession suggests that the level of the Colsterdale Marine Beds is above the *Ct. bisati* subzone and at the lower level within the *Ct. nitidus* subzone. The *Ct. nitidus* fauna seen in the Greenhow area has not been seen in the Bradford and Skipton country.

(*g*) Anthracoceras tenuispirale *fauna*. *A. tenuispirale*, which was first described from the *Ct. nitidus* subzone in the Namurian of Belgium by Demanet (1941, pp. 148–9, pl. 6, fig. 18; pl. 7, figs. 1, 2), is abundant on Slieve Anierin and can now be demonstrated in beds of this age in the Pennine area. The high magnification needed to detect the spiral ornament suggests the possibility that this species may well have been overlooked in the past and may have been identified as either *A. paucilobum* or *A. glabrum*, or, like the Colsterdale specimen, as *C. holmesi*.

Moseley (1954, pp. 433–4) records *Anthracoceras* of the *paucilobum* group in the *Anthracoceras* beds above the *Ct. nitidus* limestone in the Lancaster Fells, but unfortunately, no illustrations of the fossils are given and the material does not appear to be available; it can only be suggested, therefore, that as this is the same level as that with abundant material on Slieve Anierin, Moseley's *Anthracoceras* specimens may be *A. tenuispirale*.

(*h*) Cravenoceras holmesi *fauna*. At this level *C. holmesi* has only been seen as external impressions in which the ridge around the umbilical edge in the adult is seen as an impressed groove. The species occurs rarely lower in the succession just below the *E. bisulcatum leitrimense* horizon and a few internal moulds have been found at this lower level showing the rim around the umbilicus and fragmentary sutures. The crushed impressions which are so common above the *A. tenuispirale* horizon are inferior and mostly not very large specimens. In this species the ridge is not a decided feature until the adult stage. A larger specimen, in which the ridge must have been a very marked feature, is seen as an impression in GSM Zg1349, collected from Meerbrook, Staffs.

The position of *C. holmesi* in the succession has been the subject of some discussion. Hudson (1945, p. 4) placed the *C. holmesi* fauna beneath the *Ct. nitidus* horizon on evidence from Greenholes Beck in the Lancaster Fells. Moseley (1954, pp. 432–3) disagreed with this and believed that Hudson (1944, p. 238) did not record the fauna of the *nitidus* limestone in the Greenholes Beck succession and was led astray by the rare occurrence of *Ct. nitidus* above the level with *C. holmesi*. On Slieve Anierin it appears that if the level of *E. bisulcatum leitrimense* is correctly correlated with the *Ct. nitidus* horizon elsewhere (and the evidence is distinctly in favour of this contention) then the maximum abundance of *C. holmesi* is definitely above the horizon of *Ct. nitidus*. However, it must be pointed out that the species is already scantily present slightly lower than *E. bisulcatum leitrimense* although its period of dominance is higher in the succession.

Moseley (1954, pp. 432–5) erected the subzone of *C. holmesi* above the *Ct. nitidus* subzone and below a subzone of ?*Ct. stellarum*. The evidence for the latter does not seem to be strong, since Moseley states that badly preserved specimens of ?*Cravenoceratoides* (possibly *Ct. stellarum*) were obtained from a thick calcareous band. He also states that Hudson may have had better material and that the horizon is tentatively regarded as the base of the *Ct. stellarum* subzone.

Hudson (1945, p. 4) mentions another section in the River Noe Valley in Edale, Derbyshire, where it is possible to determine the relative positions of *Ct. nitidus* and *C. holmesi*. This section was described by Jackson (1927*a*) and subsequently by Hudson and Cotton (1945*b*, pp. 9, 10); the latter describe a higher fauna including *Ct. nitidus*, *C.* cf. *C. holmesi*, and *E. bisulcatum* var. above shales with *C. holmesi* and *C. cowlingense*. The material available at the Geological Survey Museum, however, is all so poor and fragmentary that it was found impossible to compare it with any of the goniatites from Slieve Anierin. Specimens GSM Zi968 and 969 are, however, believed to be *Productus hibernicus*, which occurs in a rich faunal band above the *C. holmesi* beds on Slieve Anierin. GSM Zi1487 also shows a *Productus* and a trilobite pygidium. Hudson and Cotton (1945*b*, p. 9, footnote) state that Bisat (*in litt.*, 1945) considered that *Ct. nititoides* was an important member of this fauna, which they refer to the *Ct. nitidus* subzone.

(*i*) Cravenoceratoides nititoides *fauna*. Above the beds with *Ct. holmesi* on Slieve Anierin occurs the most prolific fossil band in the succession, rich in goniatites and lamellibranchs but also containing the brachiopods *P. hibernicus* and rare *Orbiculoidea nitida*, and the trilobite *Weberides* cf. *W. shunnerensis*. Specimens of *Ct. nititoides* are extremely abundant and it is virtually impossible to distinguish between them and the holotype (GSM 49964) collected from Pace Gate Beck, near Blubberhouses, Yorkshire (see Bisat 1932, pl. 2, fig. 2).

Tonks (1925, pp. 251–2) originally collected from this locality and includes trilobite remains in his faunal list. *E. bisulcatum* is recorded as rare. Unfortunately it is now impossible to collect from this locality and there is little material in the Geological Survey Museum collections apart from the holotype of *Ct. nititoides* and the paratypes GSM Zl5779–86. On the evidence of *Ct. nititoides* and the trilobite remains it is suggested that this band should be correlated with the Pace Gate Beck exposure. Hudson (1945, footnote, p. 5) states that the shale exposure in Pace Gate Beck is an isolated one, that it occurs towards the top of the Birk Gill Shales, and that it is not possible at this locality to locate its position in relation to other Arnsbergian faunas. The fauna given by Hudson (1939, p. 329) for the Birk Gill Limestone appears to be nearer to that of the Colsterdale Limestone, with common *Ct. nitidus*, whereas the Pace Gate Beck fauna is obviously distinct and the inference from Hudson's remarks (1945, footnote, p. 5) is that it is higher in the Birk Gill Shales than any of the faunas described by him from these beds. It is unfortunate that these exposures are so incomplete but the succession on Slieve Anierin establishes the position of this band dominated by *Ct. nititoides* about 40 feet above the horizon with *E. bisulcatum leitrimense* and very rare *Ct. nitidus*, and below the first appearance of *N. nuculum*.

In Alport Dale Hudson and Cotton (1943, p. 162) record a fauna at a depth of 300–6 feet; this fauna has been examined and specimen GSM Zh955 is considered to belong to *E. rostratum* sp. nov., which occurs at the *Ct. nititoides* level on Slieve Anierin. It shows the same merging of the ribs into fine striae at about half-way across the flanks and the same extremely prominent lingua in the striae. At this level *Ct. nititoides* is present as well as *Ct. nitidus*, trilobite remains and *Productus sp.;* all the evidence favours the correlation of this level in the borehole with the *Ct. nititoides* band on Slieve Anierin.

An interesting occurrence at the *Ct. nititoides* level on Slieve Anierin is the presence of *Euchondria* aff. *E. levicula* Newell (1937, p. 107), previously only identified in American deposits. Newell (*in litt.*, 1960) agrees that the Slieve Anierin specimens are extremely close to the American material. The species is a very abundant member of the lamellibranch fauna at this level. No information is available as to its stratigraphical level in the American succession in terms of the British goniatite succession, but it is an Upper Carboniferous (Pennsylvanian) species.

It is considered significant that Tonks (1925, p. 252) included *Aviculopecten* aff. *A. dissimilis* Fleming in the Pace Gate Beck faunal list. This species has a left valve with radial ornament and a right valve with concentric ornament only, suggesting that his specimens were the same as the lamellibranchs associated with *Ct. nititoides* on Slieve Anierin. The *Euchondria levicula* specimens from Slieve Anierin are better preserved, and show the nature of the ligamental area as well as the discrepant ornament of the two valves. This is further evidence of the postulated correlation of the two horizons.

3. *Germany*

Arnsberg, Westphalia. The Namurian succession of the Arnsberg area in Westphalia, Germany, has been described by Schmidt (1934, pp. 440–61), and there is close correspondence with the sequence of faunas on Slieve Anierin. The *E. pseudobilingue* beds are not subdivided (op. cit., pp. 445–6) and Schmidt states that the forms of this species are extremely variable and not always easy to separate from *E. bisulcatum*. The example of the former species which has been figured, however (op. cit., p. 446, fig. 1), resembles *E. pseudobilingue* s.s. with rather wavy ribs as seen at localities L21(5)4 and L23(4)1 on Slieve Anierin.

Dimorphoceras scaliger Schmidt (op. cit., p. 446, fig. 2), now *Kazakhoceras scaliger*, is found at this level in Ireland also, where it is associated with *Cravenoceras* aff. *C. malhamense* and first appears a little above *E. pseudobilingue* s.s.

The drawing of *Chaenocardiola haliotoides* (Roemer) (op cit., p. 446, fig. 7) shows only twenty-one ribs whereas this species is supposed to have rather large rib counts. It looks very much like an immature specimen of *Chaenocardiola footii*, which on Slieve Anierin first appears at about the level of *E. pseudobilingue* s.s. Schmidt does not believe that the German forms are the same as the British species, but his drawing does not seem to support his argument.

Patteisky (1929, p. 20, pl. 17, fig. 13) figured *Chaenocardiola haliotoidea* and the large number of ribs appears to conform with the original description of the species. It is associated, however, with *Sagittoceras discus* (Roemer), now *Girtyoceras discus* (Roemer), which in England is described from high B_2 (Moore 1946, pp. 397–8). On Slieve Anierin the only specimens which have been referred to this species have been collected from the *Ct. nititoides* level in E_2.

The figures given for *Cravenoceras* cf. *C. leion* (Schmidt 1934, p. 446, fig. 3) and for *C.* cf. *C. malhamense* are too poor for comparison and according to Schmidt the genus is rarely found. He mentions fish remains about 10 mm. below the described fauna and which were attributed by Aldinger (1931, pp. 190–3) to *Coelacanthus stensioi* Aldinger (now *Rhabdoderma stensioi* (Aldinger) (Demanet 1941, pp. 166–8)) and *Coelacanthus sp*. Similar remains have been found at L20(16)2 on Slieve Anierin, where they are known to be in E_1, and occur above L20(16)1, where a high *C. leion* zone fauna is exposed, including *E. medusa*.

The beds of E_2 age at Arnsberg allow a more detailed subdivision, and the fauna (op. cit., pp. 446–8) can broadly be correlated with the E_2a beds on Slieve Anierin. It is difficult to suggest any closer comparisons within E_2a as some of Schmidt's figures suggest features that are rather generalized. The figure of *E. bisulcatum* (op. cit., p. 447, fig. 12) shows several bifurcating ribs like *E. bisulcatum grassingtonense;* but the ribs appear to be rather geniculate and in fact like those of *E. bisulcatum erinense* subsp. nov. from the second faunal band in E_2a on Slieve Anierin. It would be unwise to do more than point out that the figure certainly resembles *E. bisulcatum* s.l., which occurs below the grit on Slieve Anierin.

The next horizon at Arnsberg with *C. edalense* (op. cit., p. 448) obviously represents the beds seen immediately above the grit on Slieve Anierin. The specimen illustrated in fig. 23, p. 448 would now be assigned to *Ct. bisati*, since there is repeated bifurcation of the lirae. On Slieve Anierin this form is considerably less common than *Ct. edalense*. Forms like *Cravenoceras sp.* (fig. 26, p. 448) and *C.* cf. *C. leion* (fig. 25, p. 448) are said to occur beneath the beds with *Ct. bisati*, but Schmidt's figures are small and poor, and it has not been found possible to compare them with forms from Slieve Anierin.

Schmidt (1934) refers fig. 28, p. 448 to *Posidoniella membranacea* (now *Caneyella membranacea*) but it is now thought to be *Posidonia corrugata elongata* subsp. nov., which is an abundant associate of *Ct. edalense* on Slieve Anierin, whereas *C. membranacea* does not extend beyond E_1.

The next horizon contains *Anthracoceras paucilobum* and *Cravenoceras nitidum* (now *Ct. nitidus*), and probably corresponds with the horizon of *E. bisulcatum leitrimense* on Slieve Anierin. The *Eumorphoceras* at this level is *E. bisulcatum varicata* Schmidt, which has similarities with *leitrimense*, but the latter has fewer ribs between the constrictions. *A. paucilobum* has not been seen with absolute certainty from this horizon on Slieve Anierin, but *A. tenuispirale* appears with *leitrimense* and soon becomes the dominant member of the fauna.

The occurrence of *Posidoniella laevis* Brown at this level in Germany corresponds with a similar appearance at a comparable level on Slieve Anierin. Such forms are now referred to *P. variabilis erecta* subsp. nov. *Ct. nitidus* is rare at this level on Slieve Anierin but the horizon of *leitrimense* is believed to be the same as that at which *Ct. nitidus* is common in other localities, e.g. the level of the Colsterdale Limestone in the Greenhow area, near Grassington in Yorkshire (Dunham and Stubblefield 1944, pp. 239–41).

The succeeding beds at Arnsberg, containing *Cravenoceras holmesi* and *C. cowlingense* are believed to be the equivalent of the *C. holmesi* beds on Slieve Anierin, where *C. holmesi* is abundant just above the *A. tenuispirale* beds and beneath a band dominated by *Ct. nititoides*. Fig. 40, p. 449 (Schmidt 1934) is very like the evolute examples of *C. holmesi* on Slieve Anierin, where, however, it has not been found associated with any undoubted examples of *C. cowlingense*. *Posidoniella variabilis* also occurs at this level on Slieve Anierin.

There is no record at this point in Schmidt's succession of any band comparable with the *nititoides* horizon on Slieve Anierin. The next level described by him consists of shales with *C. stellarum* (now *Ct. stellarum*) and *C. nititoides* (now *Ct. nititoides*). He describes spiral sculpture on some of these forms, which he otherwise ascribes, on umbilical diameter, to the two species just mentioned, assigning specimens in which the umbilicus is completely closed to *Nuculoceras nuculum*, and within which zone these forms are considered to be the lowest fauna.

Spiral sculpture has not been seen in any of the Slieve Anierin specimens of *Ct. nititoides* and no specimens of *N. nuculum* or of *Ct. stellarum* have been collected. On Slieve Anierin there is therefore definite evidence for a *Ct. nititoides* band below the *N. nuculum* zone which is considered by Hudson (1945, p. 2) as the top of the E_2 stage, but is placed by Bisat (1928) and also by Stephens *et al.* (1953, p. 95) as the lowest division of H. On the whole, excluding small differences in identification partly due to poor material, there appears to be a close resemblance between the sequences in the geographically widely separated areas of Westphalia and Leitrim.

Edelburg. Bisat (1950, p. 14) has compared the basal E_1 succession from Edelburg, near Menden, Germany, described by Ruprecht (1937), with the succession near Wiswell, Lancashire; Carla Beck, near Skipton, Yorkshire; the Whinney Gill Reservoir, near Skipton; and the Alport Dale boring, Derbyshire. The form referred to by Ruprecht as *E. pseudobilingue* (1937, p. 272, pl. 10, fig. 7) is now assigned to *E. pseudocoronula* and does not differ from specimens in the *C. leion* zone on Slieve Anierin. *Posidonia trapezoedra* (op. cit., pp. 272–3, pl. 10, figs. 9, 10) is very abundant near the top of E_1 on Slieve Anierin but was first described by Ruprecht from lower P_2 beds with *Goniatites granosus*. *E. tornquisti* (Wolterstorff), which Bisat (1950, p. 20) considers may be the same as *Eumorphoceras sp.* form *A* Moore, and which was originally described from Magdeburg (Wolterstorff 1899, pp. 34–36, pl. 2, figs. 12–14), is a very rare form on Slieve Anierin. Here again there appears to be close similarity between the Irish and German faunas.

4. *Poland and Czechoslovakia*

Schwarzbach (1936, pp. 442–3) described several species and varieties of *Phillipsia* from Silesia. Most of the specimens came from Horizons I*a-d*, II, and III at the top of the Ostrauer Schichten. Patteisky (1936, p. 4) has tabulated the main marine bands in these beds and described some of the goniatites. He correlates (op. cit., pp. 24–26) these younger bands with the *Ct. nitidus* beds in England. He figures *Cravenoceras* (cf.?) *C. nititoides* Bisat (op. cit., pl. 1, figs. 7*a*, *b*) but the plates are too poor to allow comparison with specimens of *Ct. nititoides* from Slieve Anierin. Even Patteisky describes this form as *Cravenoceras sp.* (p. 14) and the identification would thus appear to be far from certain. His specimen, however, is from Horizon IV*b* and most of Schwarzbach's trilobite records are from the younger marine horizons. It seems probable that these discrepancies are due to rather varying interpretations by different authors of some of the English species, and also to the poor material available.

Susta (1928, p. 421) records *Phillipsia mucronata* M'Coy, *P. eichwaldi* Fischer, *P.*

mladeki Smetana, and *Griffithides acuminatus* Roemer from the Gaebler Horizon, the youngest band in the Ostrauer Schichten. He also records *Eumorphoceras sp.* at this level but does not figure the species. On Slieve Anierin *Weberides* cf. *W. shunnerensis* is associated with *Ct. nititoides*, which occurs about 40 feet above the level of *E. bisulcatum leitrimense;* the latter is believed to represent the level of *Ct. nitidus* elsewhere and is taken as the base of the *Ct. nitidus* subzone. It therefore appears that the Silesian trilobites occur at closely similar horizons to the Slieve Anierin specimens. Schwarzbach (1936, p. 427) also records trilobites from Horizon X in the Ostrauer Schichten, which is placed by Patteisky (1936, pp. 21–23) in IV/1S. He records *Sudeticeras ostraviensis* from this horizon. Moore (1950, p. 33) has commented that so little appears to be known about this species that comparison with others is valueless. No suture is known and Patteisky admits that it can be confused with *A. paucilobum*. The other goniatites recorded at this level are *Cravenoceras sp.*, *C.* (*?Sudeticeras*) *latecostatum* Patteisky (op. cit., p. 13, pl. 1, fig. 11), *Dimorphoceras sp.*, and *?A. paucilobum*. It is difficult to place this fauna in terms of the Slieve Anierin succession, but it must lie near the P_2/E_1 boundary. It is interesting that the only other trilobites found on Slieve Anierin occur at this level, which is devoid of goniatites, but must lie either just below or just above the base of E_1. Patteisky (1933, p. 44, pl. 2, fig. 30) also describes *Phillipsia acuminatus* Roemer from this level in the Sudetenland. Trilobites thus appear to have been widespread elements in the faunas at certain levels in the lower Namurian.

5. *Belgium*

Basal Namurian faunas from the area around Namur are described by Demanet (1941; map, p. 53). The *E. pseudobilingue* beds are divided into a lower and an upper division, the former about 10 metres thick and fossiliferous, the latter about 125 metres thick and practically without fossils.

The fauna of the lower division given by Demanet (1941, p. 22) is a rich one, but rather surprisingly includes only three goniatite species. Only one form of *E. pseudobilingue* is described and figured (op. cit., pp. 135-6, pl. 5, figs. 11–14) and it does not resemble any of the forms of that species collected on Slieve Anierin, but has features much more reminiscent of the specimens of *E. bisulcatum* which occur below the grit. *C. leion* (op. cit., pp. 140–1, pl. 5, figs. 21–23) is stated to be associated with *E. pseudobilingue;* the third goniatite is *Anthracoceras sp.* There is in addition a large nautiloid and lamellibranch fauna, together with a few brachiopods, conodonts, and fish remains.

Apart from *C. leion* there are no records of any of the abundant goniatites of E_1a found on Slieve Anierin. Crushed specimens of *Cravenoceras* are notoriously difficult to deal with and, judging from the photographs, it would be difficult to be certain of the specific determination of these specimens. An illustration of the suture-line, which is only described by Demanet (op. cit., p. 141), would be desirable for comparison with that figured by Bisat (1930, p. 29). The sharply acute edge to the umbilicus, which can usually be seen on the specimens of *C. leion* from Slieve Anierin, does not appear to be a feature of the Belgian material. The photographs of *Eumorphoceras* appear to be far more conclusive and do not resemble any of the E_1 species on Slieve Anierin.

Demanet includes *Posidonomya* (*Posidonia*) *membranacea*, now *Caneyella membranacea*, in his faunal list, and on Slieve Anierin this form does not extend beyond E_1 deposits. Unfortunately the material is not figured, but Demanet has figured the species in a previous publication (1938, pl. 10, figs. 5–11) from P_2 deposits and his conception of the species obviously concurs with that of the writer. He remarks (1941, p. 80), however, on the variation in obliquity of the species within E_1. This is interesting since the writer believes that there is a more oblique form of the species than that which Demanet figured from P_2 levels, and it occurs particularly abundantly on Slieve Anierin at the level of *Cravenoceras* aff. *C. malhamense*. However, in E_2 beds there is an elongated variety of *Posidonia corrugata* which appears often to have been mistaken in faunal lists for *C. membranacea*. Without figures it is impossible to tell to which of these two forms Demanet's material should be assigned. I believe the lower form to be *C. membranacea* and since it is associated with *C.* aff. *C. malhamense* it is an E_1 form. I refer the higher forms to *P. corrugata elongata* subsp. nov. and this is most abundant in E_2a deposits and in E_2b, but I have not seen undoubted examples at lower levels. The evidence for the E_1 age of these beds does not therefore appear to be conclusive, and indeed Demanet's illustrations of *Eumorphoceras* suggest otherwise.

Demanet apparently believed that the *E. bisulcatum* which he found with *Ct. edalense* in the lower Nmlb beds was *E. bisulcatum* s.s., and he does not distinguish beds in which *E. bisulcatum* is the dominant goniatite beneath the *Ct. edalense* beds. All the available evidence from successions described elsewhere, notably Arnsberg (Schmidt 1934, pp. 446–7), Alport Dale (Hudson and Cotton 1943, pp. 162–3), and the Edale Anticline, Derbyshire (Hudson and Cotton 1945, p. 10), indicate that this zone of *E. bisulcatum* s.s. exists below the zone of *Ct. nitidus* (the basal subzone of the latter is correlated with Demanet's *Ct. edalense* beds).

Demanet does not suggest that his succession is possibly incomplete. This apparent gap in the Belgian succession appears to the writer to support the view that the beds assigned to E_1, certainly from the level at which the figured specimens of *E. pseudobilingue* were collected, are probably more correctly assigned to E_2.

Dorlodot and Delépine (1930, p. 58, pl. 8, fig. 4) described and figured *E. pseudobilingue* from Bioul in Belgium. They apparently only had one specimen, which was extremely crushed and distorted. It appears from the figure to be too poor and inconclusive to be compared with the Slieve Anierin material.

The *E. pseudobilingue* beds (Zone de Bioul, Nmla) of Belgium are succeeded by the Zone de Malonne, Nmlb, which is divided into lower, middle, and upper. The lower division (Nmlb inférieur) is characterized by *C. edalense* and is apparently present at all the Nmlb localities tabulated by Demanet (1941, p. 56). The description of this species given by Demanet (op. cit., pp. 141–2) mentions only one bifurcation of the lirae at the umbilical edge, which indicates that it is not *Ct. bisati*. Demanet's plates (op. cit., pl. 6, figs. 1–3), although a little indistinct, appear to be very like *Ct. edalense* as collected above the grit on Slieve Anierin. At this level on Slieve Anierin *E. bisulcatum* does not occur, but Demanet (1941, p. 56) lists this species at four of the Nmlb localities. However, the single figure (pl. 5, fig. 15) of the form from this level is so poor that it is impossible to compare it with any of the Slieve Anierin specimens.

Posidonia aff. *P. wapanuckensis* is also recorded from many of the localities by Demanet, but is not figured from this level; it has previously been figured from P_2 beds (Demanet 1938, pp. 117–18, pl. 10, figs. 14–18). Demanet (1941, p. 81) comments that the specimens in Nmlb are far larger than the American ones and frequently difficult to distinguish from *P. corrugata*. This suggests that these specimens are the same as the forms from this level on Slieve Anierin described as *P. corrugata gigantea* subsp. nov. and *P. corrugata elongata* subsp. nov., and associated there with *Ct. edalense*.

Ramsbottom (1959, p. 405) believes that *Caneyella wapanuckensis* (Girty) from the Caney Shale of Oklahoma includes at least two species. In his opinion Girty's figure 9 (1909, pl. 3) is very like *Posidoniella variabilis*, and figs. 6, 7, and 11 (on the same plate) are all reminiscent of *Posidonia corrugata*. This tends to support the present contention that Demanet's specimens are probably incorrectly ascribed to *P.* aff. *wapanuckensis*.

Demanet (1941, p. 29) includes *A. tenuispirale* in his fauna but not in the lower Nmlb faunal and locality chart (pp. 55–56) and it is therefore presumed not to be a very prominent member of this fauna. This coincides with the evidence on Slieve Anierin where the species is seen only rarely beneath *E. bisulcatum leitrimense*, but becomes more abundant later.

Dimorphoceras sp. and *A. paucilobum* complete Demanet's goniatite fauna for this level. The latter has not been seen at this horizon on Slieve Anierin; specimens attributable to *Anthracoceras* are present but it is difficult to be sure of the species. *D. looneyi* occurs on Slieve Anierin at a horizon a little above the beds with *Ct. edalense*. The nautiloid and lamellibranch faunas given by Demanet are far larger than those on Slieve Anierin.

The fauna of the succeeding middle Nmlb or *C. nitidum* beds (of Demanet, but now *Ct. nitidus*) comes from 6–10 metres of fossiliferous beds at the base, which are succeeded by unfossiliferous strata. The fossils from the entire thickness are treated as one fauna so that it is impossible to make exact correlations with Slieve Anierin. *Ct. nitidus* is rare on Slieve Anierin, but the level at which it is abundant elsewhere is believed to be represented by *E. bisulcatum leitrimense*. From what is regarded as the same level in Germany Schmidt has described *E. bisulcatum varicata*, and Demanet has likewise described and figured this subspecies in Belgium (1941, pp. 138–9, pl. 5, figs. 16, 17). He describes it as having strong constrictions, about six in a whorl, and with seven ribs between them. This is obviously different from *leitrimense*, although the general aspect of Demanet's figures is rather like some of the less clearly preserved Slieve Anierin material.

Griffithides serotinus Demanet is recorded at locality Bioul 23, but appears to be distinct from *Weberides* cf. *W. shunnerensis* which occurs on Slieve Anierin. The trilobite level in Belgium is associated with *Ct. nitidus* and *E. bisulcatum varicata* and appears to be lower than the horizon on Slieve Anierin, which yields abundant *Ct. nititoides* and *E. rostratum* sp. nov. There is apparently no record of a *C. holmesi* fauna in Belgium nor have *C. cowlingense* or *C. subplicatum* been recorded.

Posidoniella variabilis is abundant in Belgium as on Slieve Anierin and the form included in Demanet's lists as *P. laevis* Brown is thought to be the same as *P. variabilis erecta* subsp. nov. *Posidonia corrugata* is not included in the lists given by Demanet but is very abundant on Slieve Anierin. *Posidonomya* aff. *P. wapanuckensis* is included, however (as in the lower Nmlb fauna), and the more correct designation of this form has already been discussed.

A. tenuispirale is abundant both in Belgium and on Slieve Anierin. It is very abundant just above *E. bisulcatum leitrimense* on Slieve Anierin, but higher in the succession it is replaced by *C. holmesi*. In Belgium it presumably occupies a similar position since it occurs with *Ct. nitidus*. Since there is no record of the succeeding *C. holmesi* fauna or the *Ct. nititoides*—*E. rostratum* band, it may be that the unfossiliferous beds which succeed the latter on Slieve Anierin are present at a lower level in Belgium.

The succeeding 'Nmlb supérieur' is characterized by *Nuculoceras nuculum* and is therefore higher in the sequence than any of the beds exposed on Slieve Anierin, but corresponds with the successions at other localities.

Dorlodot and Delépine (1930, pp. 57–58, pl. 1, figs. 1–5) figured specimens of *E. bisulcatum* from the Namur area; they are not like any of the Slieve Anierin forms, but as they are said to be associated with *N. nuculum*, *A. glabrum*, and *Ct. nitidus* (*Homoceras nitidum* of these authors) it seems likely that more than one form is included in this specific determination; also, since *N. nuculum* is referred to, some at least must occur at higher levels than any which are exposed on Slieve Anierin.

6. *North America*

There is evidence that there was open communication between the seas of western Europe and North America at least during uppermost Viséan and Lower Namurian times. Several American formations contain goniatite species that are very similar to those known in western Europe.

Miller and Youngquist (1948, p. 656) and Youngquist (1949, pp. 282–3) have claimed that faunal elements which are distinct in the European succession are found associated together in the Barnett Shale of Texas, the Caney Shale of Oklahoma, and the White Pine Shale of Nevada. Youngquist (op. cit., p. 282) states that *Eumorphoceras*, *Girtyoceras*, and *Goniatites* s.s. occur in direct association in the White Pine Shale. Gordon (1957) described goniatites from northern and eastern Alaska, and for the first time in North America recorded the genus *Sudeticeras* (*S. alaskae* Gordon). *G. crenistria* Phillips, *G*. cf. *G. granosus* Portlock and *Cravenoceras sp*. are also recorded but Gordon has no evidence to suggest an overlap of the ranges of *Goniatites* and *Cravenoceras*. The more obvious similarities between some of the species in the Slieve Anierin succession and those in American formations will be briefly outlined, but it seems impossible at present to establish accurate correlations based on the succession of faunas.

The fauna of the Caney Shale of Oklahoma (over 1,000 feet thick) was described by Girty (1909), and is important as it includes the type material of *E. bisulcatum* Girty (1909, pp. 68–70, pl. 11, figs. 15–19*a*). The subspecies *erinense* and *ferrimontanum* from Slieve Anierin are both believed to be very close to *E. bisulcatum* s.s. In Ireland, England, Belgium, and Germany such forms appear to be typical of the lowest zone in E_2, that of *E. bisulcatum* s.s. The resemblance of *Caneyella wapanuckensis* (Girty) (1909, pp. 34–35, pl. 3, figs. 6–11) to at least two species, namely *Posidoniella variabilis* and *Posidonia corrugata*, has already been referred to. The former has been observed on Slieve Anierin throughout E_1 and E_2 deposits and in the lower P_2 beds, and the latter becomes abundant at about the middle of E_2. The genus *Caneyella* was erected on the abundant specimens of this lamellibranch in the shales, and species like *C. nasuta* (p. 37, pl. 3, figs. 12–14) appear to be very like *C. membranacea*, particularly fig. 14.

Adelphoceras meslerianum Girty was originally described from the Caney Shale but is now attributed to *Girtyoceras meslerianum*. This genus is not known to occur in the rather poor P_1–P_2 faunas of Slieve Anierin. Moore (1946, pp. 405–6, pl. 23, fig. 6) described GSM 72716 from a P_1a level in the Bowland Shales of the River Ribble, Dinckley, Lancashire, and was satisfied that there was no valid distinction between this specimen and GSM For.1867 (op. cit., pl. 23, fig. 3) collected from the Caney Shale.

Goniatites newsomi Smith from the Caney Shale (Girty 1909, pp. 62–63, pl. 12, figs. 11, 11*a*) also occurs on Slieve Anierin very near the top of P_2, and has been recorded by Moore (1936, p. 185, pl. 2, figs. 6, 12) from the Bowland Shales. The species was referred to the genus *Lyrogoniatites* by Miller and Furnish (1940, pp. 368–9), who erected a subspecies *L. newsomi georgiensis*, which differs from the typical *L. newsomi* in that the whorls are lower and broad and therefore the conch more nearly globular. In crushed shale material it is difficult to detect such a difference, but the close similarity of Moore's plates of the English material, the Slieve Anierin material, and the figures of the American form, whether *newsomi* or *georgiensis*, is convincing evidence of the close relationships of all these forms.

Padget (1953, pp. 22, 23) listed *Neoglyphioceras subcircularis* from the *G. granosus* zone of P_2. On Slieve Anierin only undoubted *G. granosus* has been collected but the former genus is known from America also and is listed by Miller and Furnish (1940, p. 361) as a form known from Oklahoma, Arkansas, Texas, P_2 of England, Ireland, Belgium, France, Germany, and also Morocco and northern Algeria. *Gastrioceras caneyanum* Girty is the genotype of *Paragoniatites* and is considered by Bisat (1955, p. 16) to be very close to *Neoglyphioceras*. There are therefore several forms from the Caney Shale which are known at specific levels in the succession of faunas established elsewhere.

The type specimens of *Leiorhynchus carboniferus polypleurus* come from the Moorefield Shale of Arkansas (Girty 1911) and are indistinguishable from those collected on Slieve Anierin about 3 feet below *G. granosus* at the base of P_2, and also forms figured and described by Demanet (1938, pp. 83–87, pl. 8, figs. 9–14). Demanet's figured specimens are from upper V3c, which is equivalent to P_2 in age. However, he records this species from the *E. pseudobilingue* zone, in which it has not been found on Slieve Anierin.

Girty (1911, pp. 103–4, pl. 14, fig. 4) identified one specimen from the Moorefield Shale as *E. bisulcatum;* only a single specimen, described as senile, was available. The identification was later amended to *Girtyoceras limatum* (Miller and Faber) by Miller and Furnish (1940, pp. 364–6, pl. 47, figs. 6–12). This form appears to be similar to *E. medusa* which occurs near the top of the *C. leion* zone on Slieve Anierin and above *E. pseudocoronula*, to which it is believed to be related.

Miller and Youngquist (1948, pp. 662–5) described examples of *E. bisulcatum* from the Barnett formation in central Texas. They also figured a new species, *E. plummeri* (op. cit., pp. 665–7, pl. 100, figs. 1–4, 20, 21), and compared it with the specimen (GSM 72603) figured by Moore (1946, pl. 22, fig. 3), which was associated with *N. nuculum* and collected from Samlesbury Bottoms, River Darwen, Lancs. There is no evidence for the *N. nuculum* zone on Slieve Anierin and no specimens of *Eumorphoceras* from the mountain appear to conform with *E. plummeri*, although *E. rostratum* sp. nov. displays certain points of similarity. *Girtyoceras meslerianum* (Girty) is also described from the Barnett formation, which, in terms of the European succession, apparently has species as widely separated as the base of P_1 and the *N. nuculum* zone, assuming that *E. plummeri* is correctly compared with the Samlesbury Bottoms material.

Gordon (1960, pp. 140–3) described a new genus, *Paracravenoceras*, from the Barnett Shale of Texas, and which also occurs rarely in the Caney Shale of Oklahoma. *P. ozarkense* is abundant in the Fayetteville Shale of Arkansas and *P. barnettense* is common in the Chainman Shale of Utah. The genus is said to be common in, and restricted to, the Lower *Eumorphoceras* zone. It has sinuous transverse growth lamellae in the young and a distinctive form of ventral lobe in the suture. Nothing resembling this genus has been seen on Slieve Anierin.

Another form which so far appears to be peculiar to America is *E. girtyi* Elias. It was attributed by Elias (1956, pp. 130–2, pl. 6, fig. 7) to an E_1 age, and described as possessing an intra-ventral carina and a reticulate pattern of striae on the ventro-lateral area. Nothing comparable occurs in E_1 on Slieve Anierin. However, the type is said to be associated with *E. plummeri*, which was originally likened by Miller and Youngquist (1948, pp. 665–7) to the forms associated with *N. nuculum* collected by Moore from Samlesbury Bottoms, Lancs. It is therefore difficult to know at which level any similar species might occur in the Slieve Anierin or other western European succession. Only a cross-section illustrates the original description by Elias, but material from the Redoak Hollow Formation of southern Oklahoma has been figured by Elias (1958, p. 32, pl. 3, figs. 10–13); unfortunately these figures do not shed any light on the problem.

One interesting connexion with American lamellibranch species has been established with the discovery of *Euchondria* aff. *E. levicula* in the highest faunal band on Slieve Anierin. Newell (*in litt.*, 1960) has confirmed the close similarity between the Slieve Anierin specimens and the described material from the Hushpuckney Shale of Iowa and the Labette Shale of Missouri.

7. *Morocco*

Delépine (1941) described some Namurian goniatites from Morocco, including (p. 79) a very small specimen (unfortunately not figured) which he tentatively assigned to *E. bisulcatum*. He also described and figured (op. cit., p. 77, pl. 6, figs. 4–7) *C. nitidum* (Phillips); the specimen illustrated in fig. 4 was collected with *N. nuculum* and *A. glabrum*. Judging from the plate the ornament appears to be rather fine and hairlike, and not like the normal asymmetrical lirae of typical *Ct. nitidus*. Figs. 5–7 are too poor for comparative purposes.

C. africanum Delépine (op. cit., pp. 75–76, pl. 6, figs. 1–3) appears to be a form which in its somewhat evolute aspect suggests *C. holmesi*. Hudson (1941, p. 282) has commented on the wide distribution of the *Cravenoceras* group to which this species belongs in the *Eumorphoceras* beds of Europe, North Africa, and North America, and also that some of the species described from America may in fact be synonyms of the European species. Delépine also refers to the resemblance of *C. africanum* to *C. holmesi* and *C. cowlingense*. There is certainly a resemblance to the specimens of *C. holmesi* from Slieve Anierin and to those figured from Arnsberg by Schmidt (1934, p. 449, fig. 40).

Conclusion

As more evidence becomes available a remarkable picture of the extent of the Namurian goniatite faunas emerges and the great similarity of specimens from locations geographically far removed from each other is striking. Local geographical variants obviously occur. *E. bisulcatum*, for example, both from E_2a levels on Slieve Anierin and from similar levels in England, is very close to *E. bisulcatum* s.s. from the Caney Shale, and yet these forms are not quite the same. Similarly, amongst the lamellibranchs, *Euchondria* aff. *E. levicula* is very close to the American forms, but is not quite the same.

These differences, however, are fine ones and the overall picture is of a basic population which is remarkably uniform over a very wide area. The appearance of trilobites at specific levels in the succession both in western Ireland, England (Pace Gate Beck, the Alport boring, and in the Edale Valley), and in Silesia, is also striking proof of the widespread nature of certain horizons. The geographical extent and remarkable abundance of the *Posidonia corrugata* group is also a feature of this part of the succession. *P. becheri* was often extremely abundant in P_1 times but the success and vigour of the *corrugata* group surpassed it both in time range and range of variation. In E_1 only *Caneyella* approached it in abundance but above E_1 this genus is no longer seen.

This widespread uniformity of the goniatite-lamellibranch faunas is not confined to the narrow time range with which this work has been concerned. The foundations of all such studies were firmly laid by Bisat (1928, pl. 6) for the whole of the Namurian and now the correlations established by him are being endorsed and amplified in greater detail both vertically and horizontally.

As methods of illustrating specimens improve, it becomes increasingly obvious that although language and other national difficulties may often obscure the true features of the specimens and lead to varying interpretations, often of the same species, good well-reproduced photographs smooth out such difficulties and bear silent witness to the widespread nature of these goniatite and lamellibranch species, and may truly be a more accurate substitute for the actual specimens than words alone.

APPENDIX

1. *Fossiliferous localities on Slieve Anierin*

a. *West of Slieve Anierin*

LEITRIM 20(16) (text-fig. 3)

1. North bank of stream 500 yds. west of Glen Bridge; best material 3–4 ft. above stream level. *Eumorphoceras medusa*, *Pseudamusium praetenuis*. E_1a.
2. South bank of stream 450 yds. east of Glen Bridge. 10 ft. section of friable shales. *Coelacanthus sp.* E_1a.

LEITRIM 20(12) (text-fig. 3)

1. At un-named bridge on Dowra track 1,600 yds. north of Glen Bridge; calcareous mudstone at stream level; *Sudeticeras* cf. *S. newtonense*. Basal 3 ft. of the overlying 10-ft. section of papery shales yield *Caneyella membranacea*, *C. membranacea horizontalis* subsp. nov. High P_2.
2. 15 ft. shale section in stream, with prominent hard band. High P_2.

b. *North of Slieve Anierin; Stony River*

LEITRIM 20(8) (text-fig. 2)

1. 25-ft. shale section 100 yds. upstream from point where 500-ft. contour crosses the Stony River; at base *Obliquipecten costatus* sp. nov., *C. leion*, *Eumorphoceras* cf. *E. sp.* form *A* Moore. E_1a.
2. 40-ft. section 100 yds. east of 1; shales at base yield *Pseudamusium praetenuis*, *E. medusa*, *Kazakhoceras sp.* E_1a.
3. 50-ft. section of friable dark-grey shales on south bank near point where 600-ft. contour crosses Stony River; fauna collected on scree includes *Posidonia corrugata*, *P. trapezoedra*, *Pseudamusium sp.*, *Kazakhoceras sp.* Similar fauna collected *in situ* on opposite side in gully higher up hillside. E_1a.

LEITRIM 21(5) (text-fig. 2)

1. Right bank 250 yds. upstream from confluence of 1st tributary; 25-ft. section; lower reaches barren, but fallen shales yield *P. corrugata*, *P. trapezoedra*, *Kazakhoceras sp.* Low E_1b.

2. Few yds. upstream from 1; band *in situ*; solid beds at base yield *P. corrugata*, *P. trapezoedra*, *Kazakhoceras sp.*, *Eumorphoceras* cf. *E. angustum*. Low E_1b.
3. 200 yds. downstream from confluence of 2nd tributary; hard black shales 3 ft. above stream. *P. corrugata*, *P. trapezoedra*, *Kazakhoceras sp.* Low E_1b.
4. 150 yds. downstream from confluence of 2nd tributary; 20-ft. section; lowest 2–4 ft. yield *E. pseudobilingue* s.s., *P. corrugata*, *P. trapezoedra*, *Chaenocardiola footii;* succeeding 6 in. yield different fauna, *E. pseudobilingue C*, *C. footii*, *P. corrugata*. Low E_1b. Opposite this section fallen blocks from upper part of section yield *C. membranacea*, *K. scaliger*, *Cravenoceras* aff. *C. malhamense*. E_1c.
5. First north bank section upstream from confluence of 2nd tributary; 3 ft. of papery shales above a hard calcareous mudstone yield *C. membranacea*, *K. scaliger*, *C.* aff. *C. malhamense*. E_1c.
6. 150 yds. upstream from 5 on left bank; 10-ft. section. *Cravenoceras sp.*, *Chaenocardiola footii*. E_1c.
7. 100 yds. upstream from 6; hard shales at base. *Posidonia lamellosa*. E_2a.
8. North bank 175 yds. downstream from confluence of 3rd tributary; 15–20 ft. of thicker bedded shales (overlying friable unfossiliferous black shales), forming high continuous sections on either side of valley until 3rd tributary. *P. lamellosa*, *P. corrugata*, *C. footii*, *Cravenoceras cowlingense*, *E. bisulcatum grassingtonense*. E_2a.
9. At confluence of 3rd tributary; same beds and fauna as at 8, but at stream level.
10. Right bank of 3rd tributary 220 yds. upstream from confluence; 4 ft. 6 in. of fossiliferous shales exposed at top of section. *E. bisulcatum erinense* subsp. nov., *E. bisulcatum ferrimontanum* subsp. nov. (much less common), *K. scaliger*, *Anthracoceras glabrum*, *Cravenoceras* cf. *C. gairense*, *P. corrugata*, *P. corrugata elongata* subsp. nov., *C. footii*, *Dunbarella* aff. *D. elegans*, *Pseudamusium sp.*, *Stroboceras subsulcatus*, crinoidal debris. High E_2a.
11. Right bank of Stony River 300 yds. upstream from confluence of 3rd tributary and along the river to the grit escarpment; 4 ft. of shales at stream level with *E. bisulcatum ferrimontanum* subsp. nov., *K. scaliger*, *Cravenoceras* cf. *C. gairense*, *C. footii*, *P. corrugata*, *P. corrugata elongata* subsp. nov., *Dunbarella* aff. *D. elegans*, *Dunbarella sp.*, *Pseudamusium sp.*, *Stroboceras subsulcatus*, crinoidal debris. High E_2a.

c. *South-east of Slieve Anierin*

LEITRIM 21(14) (text-fig. 3)

Doherty Stream East

1. In western tributary 10 yds. west of 2; 5 ft. of sandy shales. *Chaenocardiola footii*. High E_1b.
2. In western tributary above fork at 3; *P. corrugata*, *P. trapezoedra*. Low E_1b.
3. Bed of stream at fork, and in both banks of eastern tributary for about 5 ft. from stream bed. *Eumorphoceras* cf. *E. angustum*, *Kazakhoceras sp.*, *P. corrugata*, *P. trapezoedra*. Low E_1b.
4. In eastern tributary above fork; 20 ft. of shales; at base *C. footii*, *P. corrugata*. Low E_1b.
5. North bank a few yds. before fork; 2 ft. of shales exposed 6–8 ft. above stream. Fauna as at 3. Low E_1b.
6. North-east bank; 30 ft. high section of shales, top 10 ft. inaccessible. At about 20 ft. from base, *E. medusa*, *Pseudamusium praetenuis*, *P. trapezoedra*, *Kazakhoceras sp.* At about 10 ft. from base, *P. trapezoedra*, *P. corrugata*, *Kazakhoceras sp.* E_1a.
7. South-west bank 20 yds. upstream from 6; 4–6 ft. of shales. *E. medusa*, *Pseudamusium praetenuis*, ? *Stroboceras sp.* E_1a.
8. South-west bank 100 yds. upstream from 9, and a few yards beyond the last field boundary; 6-ft. section; soft mudstone 3–4 ft. above stream with *E. pseudocoronula*, *E. rota*, *C. leion*, *Kazakhoceras sp.* E_1a.
9. North-east bank about 380 yds. upstream from BM 931·0; 8 ft. of thinly leaved black shales. *Caneyella membranacea*, *C. membranacea horizontalis* subsp. nov., *Sudeticeras sp.* High P_2.
10. South-west bank about 300 yds. upstream from BM 931·0. P_1.
11. South-west bank at bend in stream 120 yds. upstream from 12; sandstones with occasional thin sandy shales. *Chonetes sp.*, *Dunbarella sp.*, *Leiorhynchus sp.*, obscure *Goniatites sp.* P_1.
12. Section upstream from BM 931·0; upstream from massive calcareous horizon on lip of upper waterfall, a few yds. above waterfall at 13; alternations of friable shales and calcareous mudstones; 3 ft. of mudstones on north-east bank yield *P. becheri*, obscure *Goniatites* cf. *G. striatus* group, *Orbiculoidea sp.*, ? worm burrows, *Mourlonia striata*. P_1.

13. To north of bridge (BM 931·0), 250 yds. along track to north-east from road to old coal level from the Ballinamore road; 2 ft. of calcareous mudstone overlying 3 ft. massive limestone yields *P. becheri*, *Goniatites* cf. *G. striatus* group, ? worm tubes, indet. brachiopods. P_1.
14. Stream section 40 yds. south-east of bridge; 6 in. mudstone underlying 3 ft. black limestone forming a small waterfall yields *Goniatites* cf. *G. striatus* group, crinoidal debris, abundant worm burrows. P_1.
15. Stream section 75 yds. south-east of bridge; mudstone band near base of 6-ft. section. *Goniatites* cf. *G. striatus* group, indet. gastropods. P_1.

Doherty Stream West

16. Long overgrown exposure under right bank of tributary 350 yds. south of BM 1249·8; *C. leion*. E_1a.
17. 20 yds. upstream from 18; 1 ft. of shales with *Dunbarella sp.* and *P. becheri* overlying 9 in. mudstone with *P. becheri*. P_1.
18. Few yds. upstream from 19; hard band at 19 near base of section. *P. becheri*. P_1.
19. Few yds. upstream from 20; 4–5 ft. of mudstone with *P. becheri;* in middle of section is harder horizon with *Productus sp.* P_1.
20. Stream sections at bridge where track south-west from BM 986·1 crosses stream near ruined cottages on 900-ft. contour; below bridge, 40 ft. of black bituminous limestone; above bridge, 4 ft. of mudstones with *P. becheri* dominant overlying 18 in. massive limestone, and then 2 ft. of mudstones with *P. becheri* and very abundant worm tubes. P_1.

d. *South of Slieve Anierin: Aghagrania River and tributaries*

LEITRIM 23(8). Aghagrania River (text-fig. 4)

1. West bank 150 yds. north-north-west of Aghagrania Bridge; black limestone with *Dunbarella* aff. *D. elegans*. P_1.
2. East bank 8 yds. upstream from 3; 1 ft. of shale. *P. becheri*, *G. striatus* s.l., *D.* aff. *D. elegans*, *Mourlonia striata*. P_1.
3. East bank at stream level 100 yds. north of Aghagrania Bridge, just beyond stepping-stones; shales yield *Goniatites* aff. *G. falcatus*, *P. becheri*, *D.* aff. *D. elegans*. P_1.
4. East bank at stream level 30 yds. upstream from 5, and separated from latter by calcareous mudstone horizon; 1–2 ft. of shale with *Goniatites striatus* s.l., *Archaeocidaris urii*, indet. pleurotomariid gastropod. P_1.
5. East bank at stream level just north of Aghagrania Bridge; 1 ft. of shale with *G. striatus* s.l., *Chonetes sp.* P_1.
6. West bank 60 yds. south of Aghagrania Bridge, below house on east bank; 4 ft. mudstones. *Thrincoceras* cf. *T. hibernicum*, orthoconic nautiloids, crinoidal debris, indet. pleurotomariid gastropod. P_1.
7. North-west bank 150 yds. south-west of Aghagrania Bridge; 2–3 ft. of mudstone overlying massive limestone horizon yields *Thrincoceras* cf. *T. hibernicum*, *P. becheri*, *Productus sp.*, indet. brachiopods, orthoconic nautiloids. P_1.
8. South-east bank opposite 7. Same fauna. P_1.

LEITRIM 23(4) (text-fig. 4)

1. At bridge over western branch of 1st tributary, 130 yds. to north of fork; large slabs of dark grey shale. *E. pseudobilingue* s.s., *P. corrugata*. Low E_1b.
2. 20 ft. shale section in 1st tributary, 500 yds. upstream from confluence. *P. trapezoedra*, *E. medusa sinuosum*. E_1a.
3. West bank of 1st tributary, 450 yds. upstream from confluence; 15 ft. section. *P. trapezoedra*. E_1a.
4. 10 ft. section 50 yds. north of 5; fauna from stream level to 6 ft. *C. membranacea horizontalis* subsp. nov., *Kazakhoceras sp.* E_1a.
5. West bank of 1st tributary, 350 yds. upstream from confluence; 20 ft. shales; at 15 ft. from base *C. leion*, *P. corrugata*, *P. trapezoedra*, *Kazakhoceras sp.*, *E. medusa*. E_1a.
6. East bank opposite 7, but at slightly lower horizon; highest material collected at 8 ft. above stream level, with *E. pseudobilingue A*, *C. leion*; at 5 ft. *C. leion*, *E.* cf. *E. pseudocoronula;* at 4 ft. *C. leion*. E_1a.

7. West bank of 1st tributary 250 yds. above confluence; 3 ft. of shales at about 10 ft. above stream bed. *E. pseudobilingue A*, *C. leion*. E_1a.
8. West bank of 1st tributary 200 yds. above confluence; 3-ft. shale section. *Obliquipecten costatus* sp. nov., *C. leion*, *E. pseudocoronula*. E_1a.
9. East bank 25 yds. downstream from 8; collection 3 ft. from top of 8-ft. high shale section overlying calcareous mudstone. *C. leion*, *O. costatus* sp. nov. E_1a.
10. Narrow ravine in 3rd tributary 150 yds. north of confluence, just south of waterfall over calcareous band; friable shales with *C. leion*, *O. costatus* sp. nov. E_1a.
11. Narrow ravine 50 yds. south of 10; shales at base with *O. costatus* sp. nov. E_1a.
12. South bank of Aghagrania River 30 yds. downstream from confluence of 3rd tributary; 2 ft. of shales with P. *corrugata*, *Pseudamusium praetenuis*. E_1a.
13. South bank 160 yds. upstream from confluence of 2nd tributary; 4 ft. shales. *P. corrugata*, *C. membranacea horizontalis* subsp. nov., *Kazakhoceras sp.* P_2.
14. South bank 40 yds. upstream from confluence of 2nd tributary; 15 ft. shales; at base *C. membranacea*, *C. membranacea horizontalis* subsp. nov., *Sudeticeras sp.*; few yds. to east a soft clay-like band a few ft. above base yielded *P. corrugata*. P_2.
15. South bank of Aghagrania River between 1st and 2nd tributaries; 20 ft. shale section; collections from 3 levels—(1) 6 ft. from base, west side, *P. corrugata*, *Kazakhoceras sp.*; (2) 10 ft. from base, *C. membranacea horizontalis* subsp. nov.; (3) 15 ft. from base, *Chonetes sp.*, *Lingula* cf. *L. parallela*, *P. corrugata*, *Obliquipecten costatus* sp. nov., trilobite remains. (1) and (2) P_2, (3) probably E_1a. Scree material, not *in situ*, in front of section yielded *E. pseudocoronula*, *C. leion*. E_1a.
16. South bank between 1st and 2nd tributaries; shales 3 ft. 6 in. above stream level, *Lyrogoniatites newsomi georgiensis*, *C. membranacea*; at base calcareous mudstone with imperfect brachiopods. P_2.
17. 480 yds. north-north-west of Aghagrania Bridge, on east of track, and 40 ft. above stream; 6–8 ft. of friable shales, *Pseudamusium praetenuis*, *P. corrugata*, *Chonetes sp.*, trilobite remains; soft clayey band in centre of section, *P. corrugata*, *Kazakhoceras sp.*, *C. membranacea horizontalis* subsp. nov. P_2.
18. East side of stream at lower horizon than 17; 5–6 ft. of shales. *Dunbarella* aff. *D. elegans*, *Sudeticeras sp.*, *Coleolus sp.* P_2.
19. 450 yds. north-north-west of Aghagrania Bridge; 30-ft. section in westerly loop of stream; collection from 3 levels—(1) 3 ft. from base, *Leiorhynchus carboniferus polypleurus*; (2) 6 ft. from base, *G. granosus*, *Sudeticeras* cf. *S. crenistriatum*, *Coleolus namurcensis*; (3) 20 ft. from base, *Sudeticeras sp.*, *G. granosus*, *C. namurcensis*, *Kazakhoceras sp.*, *Orthoceras* cf. *O. calamus* de Koninck, *Dunbarella* aff. *D. elegans*, *C. membranacea*, *C. membranacea horizontalis* subsp. nov., *P. corrugata*, *Chaenocardiola bisati* sp. nov. P_2.
20. 350 yds. north-north-west of Aghagrania Bridge; rich goniatite band in soft mudstone. *Sudeticeras* cf. *S. crenistriatum*, *Thrincoceras* cf. *T. hibernicum*, *C. namurcensis*, *Productus sp.*, *Mourlonia striata*. P_1.

LEITRIM 24(1) (text-fig. 4)

1. West bank 100 yds. north of farmhouse, near point where 800-ft. contour crosses river; 3 ft. shales about 6 ft. above stream. *E. pseudocoronula*, *E. pseudobilingue A*, *E. rota*, *C. leion*, *P. praetenuis*, *Chaenocardiola bisati* sp. nov., *C. membranacea horizontalis* subsp. nov., *Kazakhoceras sp.* E_1a.
2. Embayment on south side of river about 100 yds. north-north-east of right-angled bend in road; 6 ft. of thin-bedded decalcified sandy rocks with obscure brachiopods. P_2.
3. North bank 400 yds. west-south-west of right-angled bend in road; 6 ft. of decalcified beds; obscure brachiopod moulds only. P_2.
4. South bank 1,100 yds. upstream from confluence of 3rd tributary; thin-bedded arenaceous limestone with crinoidal remains. P_2.
5. South bank 500 yds. from confluence of 3rd tributary; upper 2 ft. limestone bed in soft black shales yields *Productus sp.* and indet. brachiopods. P_2.
6. South bank 330 yds. upstream from confluence of 3rd tributary. *G. granosus*, *Sudeticeras* cf. *S. crenistriatum*, indet. brachiopods. P_2.
7. North bank 300 yds. upstream from confluence of 3rd tributary; 3 ft. shales. *Sudeticeras sp.*, *P corrugata*, *Pseudamusium sp.* P_2.
8. North bank 250 yds. upstream from confluence of 3rd tributary; 15–20 ft. shale section on east side at 8 ft. from base yields *C. membranacea horizontalis* subsp. nov.; at base on western side *Chonetes*

sp., *Sudeticeras sp.*, *Leiorhynchus sp.*, *P. corrugata;* 3 ft. above base, *Sudeticeras sp.*, *Coleolus namurcensis;* 9 ft. above base, *Sudeticeras sp.*, *P. corrugata*. P_2.

9. South bank 230 yds. upstream from confluence of 3rd tributary; 6 ft. black shales. *G. granosus*, *Sudeticeras sp.*, *C. membranacea*, *C. membranacea horizontalis* subsp. nov., *Obliquipecten costatus* sp. nov., *Dunbarella* aff. *D. elegans*. P_2.
10. North bank 200 yds. upstream from confluence of 3rd tributary; 6 ft. shale section; near base, *P. corrugata*, *Sudeticeras sp.* P_2.

LEITRIM 21(13) (text-fig. 3)

4. East side of Aghagrania River, 780 yds. east from BM 1163·1, 100 yds. upstream from 6; 2 ft. of hard fossiliferous shales overlain by 4 ft. of friable unfossiliferous shales. *E. bisulcatum ferrimontanum* subsp. nov., *Kazakhoceras scaliger*, *Cravenoceras* cf. *C. gairense*, *P. corrugata*, *P. corrugata elongata* subsp. nov., *Chaenocardiola footii*, *Dunbarella* aff. *D. elegans*, *Stroboceras subsulcatus*, *Pseudamusium sp.*, crinoidal debris. High E_2a.
5. Western valley side 50 yds. beyond last field boundary and 650 yds. east of BM 1163·1; 6 ft. of slabby shales resting on friable unfossiliferous shales; fauna as at 6. Low E_2a.
6. East bank 750 yds. east of BM 1163·1; 16 ft. of shales (underlying 20 ft. of friable unfossiliferous shales) with *Cravenoceras cowlingense*, *E. bisulcatum grassingtonense*, *C. footii*, ?*Dimorphoceras sp.*, *Posidonia lamellosa*, *Stroboceras subsulcatus*, plant remains. Low E_2a.
7. 15-ft. shale section on west bank 950 yds. north of right-angled bend in road; lower 6 ft. with *C. membranacea*, *Chaenocardiola footii*, *Cravenoceras* aff. *C. malhamense*, *K. scaliger*, *Actinopteria persulcata*. E_1c.
8. West bank just above waterfall near point where 1,000-ft. contour crosses stream; 15 ft. of sandy shales; at base *P. corrugata*, *C. footii*, *E. pseudobilingue C*, *Cycloceras purvesi*. High E_1b.
9. West side of waterfall 850 yds. north of right-angled bend in road; 6 ft. of shales. *P. corrugata*, *P. trapezoedra*, *Eumorphoceras* cf. *E. angustum*, *Kazakhoceras sp.* Low E_1b.
10. East side of waterfall at 9, high in bank; 8 ft. of shales; same fauna. Low E_1b.

LEITRIM 20(16) (text-fig. 3)

3. Western branch of 1st tributary 360 yds. north of fork; 3-ft. shale section, upper 2 ft. sparsely fossiliferous. Probably E_1c.
4. Shale sections in both banks below house, 30 yds. south of 3. Probably E_1c.

e. *Top of Slieve Anierin* (*above grit*)

LEITRIM 21(9) (text-fig. 3)

1 to 14. Several small valley-like exposures, varying in height from 10 to 30 ft.; only 13 has a stream (headwaters of Stony River). Basal beds in valleys 1 to 10 are in shales with *Ct. edalense*, *P. corrugata*, *Cravenoceras* cf. *C. subplicatum*. Basal beds at 11 are at a higher level and yield *Dimorphoceras sp.*, those at 12 *P. corrugata*, and at 13 *C. holmesi* and *C.* cf. *C. subplicatum*. E_2b1.

15. Valley 150 yds. north-east of 16, and 400 yds. south-east of trig. stn. 1,628 ft.; lower exposure of hard shales at top of 15 ft. scree yields *Ct.* cf. *Ct. bisati*, *Cravenoceras sp.*, *P. corrugata;* larger 30 ft. shale exposure upstream, at base *C.* cf. *C. subplicatum*, *Ct. bisati*. E_2b1.
16. Small exposure of shales in hillside, 400 yds. south-south-east of trig. stn. 1,628 ft. *A. tenuispirale*. E_2b2.
17. Outcrop 300 yds. north-west of valley 1 (L21(9)26). Lower horizon with *Ct. edalense*, *C.* cf. *C. cowlingense*, *P. corrugata*. E_2b1. Higher horizon (at about same level as 18) with *P. corrugata*, *A. tenuispirale*. E_2b2.
18. Small shale outcrop 150 yds. north-west of Valley 1 (L21(9)26). *P. corrugata*, *Anthracoceras sp.* E_2b2.
19. 150 yds. north-east of L21(13)3; fauna at lower level *P. corrugata*, *Posidoniella variabilis*, *Dimorphoceras sp.;* at higher level *E. bisulcatum leitrimense* subsp. nov., *P. corrugata*, *Cravenoceratoides sp.* (with asymmetrical lirae). E_2b2.
20. 50 yds. north-west of bend in grit escarpment, at bottom of narrow corridor overlain by thick peat; large slabs of fossiliferous shale overlying friable unfossiliferous shales. *Ct. edalense*, *Ct. bisati*, *P. corrugata elongata* subsp. nov. E_2b1.
21. South-west side of wide valley with small stream 120 yds. north of 20; scree makes collecting difficult. *Cravenoceras holmesi* occurs sparsely below *E. bisulcatum leitrimense* subsp. nov. Also

occurring *A. tenuispirale*, *P. variabilis*, *P. variabilis erecta* subsp. nov., *Dimorphoceras sp.*, *P. corrugata*, *P. corrugata elongata* subsp. nov. E_2b2.

22. 75 yds. north-east of 21 and 200 yds. north-east of bend in grit escarpment; higher beds than at 20, but not as high as those at 21. *P. corrugata*, *Posidoniella variabilis erecta* subsp. nov. E_2b1.
23. Valley 4, the most south-easterly of four prominent valleys, and containing the most complete succession E_2b1 to 3; the lowest beds (corresponding to the first fossiliferous beds above the grit at 20) contain *Ct. edalense*, *Ct. bisati*, *P. corrugata elongata* subsp. nov., and *P. corrugata*, E_2b1. (See Table 2.)
24. Valley 3; basal beds seen are in a rich band of *E. bisulcatum leitrimense* subsp. nov.; thereafter succession as in Valley 4, but collecting easier. E_2b2 to 3. (See Table 2.)
25. Valley 2; highest faunal band, with *Ct. nititoides*, *E. rostratum* sp. nov., &c., overlain by unfossiliferous shales and then flagstones. E_2b3.
26. Valley 1; *Ct. nititoides* horizon exposed about 15 ft. above stream; overlying succession as in Valleys 3 and 4. E_2b3.
27. Deep east-west valley with stream, 650 yds. south of trig. stn. 1,628 ft. Basal beds in horizon of *E. bisulcatum leitrimense* subsp. nov., E_2b2. The *Ct. nititoides* horizon occurs at the eastern end, E_2b3.
28. East-west valley containing small stream 600 yds. south of trig. stn. 1,628 ft. Basal beds in *leitrimense* horizon, E_2b2; exposures end before *Ct. nititoides* band.
29. Small dry east-west valley 75 yds. north of 28; 20 ft. of shales with *A. tenuispirale*, *P. corrugata*, *C. holmesi*, *P. variabilis erecta* subsp. nov.; succession starts above *leitrimense* level and does not reach the *Ct. nititoides* band. E_2b2.

LEITRIM 21(13) (text-fig. 3)

1. Hillside exposure 100 yds. east of Valley 4 (L21(9)23); 2 ft. of shales with *Dimorphoceras* (*Paradimorphoceras*) cf. *D. looneyi*, *P. corrugata*. E_2b1.
2. Several small shale exposures in hillside 150 yds. east of 1; *Ct. edalense*, *P. corrugata elongata* subsp. nov. E_2b1.
3. Long valley with tiny stream ¼ mile east of Valley 4 (L21(9)23), and exposing slightly lower beds; at entrance 20 ft. of beds are overlain by 6–8 ft. of shales with *Ct. edalense*, *P. corrugata*, *P. corrugata elongata* subsp. nov.; higher 8–10 ft. of shales contain *P. corrugata*, *Cravenoceras* cf. *C. subplicatum*. E_2b1.

2. *New specimen and locality numbers for Yates (1961)*

	Yates (1961)	*New*		*Yates (1961)*	*New*
(*a*) *Specimens*:					
E. medusa	St. Ri. 2.23	7018	*E. medusa*	Agh. 8.1	7027
	St. Ri. 2.26	7019	*sinuosum*	Agh. 8.2	7028
	Doh. 6B.10	7020		Agh. 8.4	7029
		7021 counterpart		Agh. 8.10	7030
	Doh. 6B.14	7022		St. Ri. 2.22a	7031
	St. Ri. 2.24	7023	*E. rota*	Agh. 21.3	7012
		7024 counterpart		Doh. 50.1	7013
	Doh. 6B.7	7025		Agh. 21.4	7014
	St. Ri. 2.25	7026			
(*b*) *Localities*:					
E. medusa	Doh. 6	L21(14)6	*E. rota*	Agh. 21	L24(1)1
	St. Ri. 2	L20(8)2		Doh. 50	L21(14)8
E. medusa	Agh. 8	L23(4)2			
sinuosum	St. Ri. 2	L20(8)2			
(*c*) *Explanation of Plate 6*:					
E. medusa	Doh. 6B.10	7020	*E. medusa*	Agh. 8.1	7027
	St. Ri. 2.23	7018	*sinuosum*	Agh. 8.2	7028
E. pseudo-coronula	Agh. 21.3	7213	*E. rota*	Agh. 21.3	7012
				Doh. 50.1	7013

3. *Notes on preservation*

Goniatites. The goniatites are most commonly preserved as external moulds or impressions from which plasticine replicas showing the original external aspect of the fossils can easily be made. In a true internal mould of a goniatite there should be sutures visible as, for example, in many of the sutured internal moulds described by Currie (1954) and also in most of the material collected by Moore from various localities in England and Ireland and deposited at the Geological Survey Museum.

The specimens in shale from Slieve Anierin, however, have been preserved under far less favourable conditions and sutures are scarcely ever preserved. Frequently only the long living chamber is clearly visible, so that the internal mould does not reveal any sutures. The term internal mould is used, with the proviso that the specimens usually lack the sutures of true internal moulds. The internal moulds would show the minor features on the internal surface of the shell in reversed or negative relief. But at the same time they would also show, due to the thinness of the shell itself (and in apparent contradiction of the strict definition of the term mould), the major structural features of the shell, e.g. strong ribs, ventro-lateral ridges and furrows, in positive relief. It is also possible occasionally for some of the finer features of the test, seen in reverse in the external moulds or impressions, to be impressed to a certain extent onto the unsutured internal mould. The same phenomenon is seen also in some of the lamellibranchs.

The constrictions seen in such a species as *Eumorphoceras pseudocoronula*, although more prominent on the internal moulds, are also visible on the exterior of the test. In the external impressions the constrictions are seen in reverse as ridges. On the internal moulds they are more strongly defined and seen as strong furrows. In some goniatites, however, the constrictions are entirely due to an internal thickening of the shell and not visible externally. The specimens of *Goniatites granosus* collected from P_2 show constrictions very strongly on the internal moulds but they are not visible on the outside of the shell.

Lamellibranchs. As with goniatites external moulds or impressions are common but in several genera internal moulds are equally abundant. After death and the subsequent decay of the soft parts it would be natural for the valves to part and for internal moulds to be formed. Many specimens of the genus *Euchondria*, for example, show the multiple ligament pits along the dorsal margin and must therefore be internal moulds. There is an added complication in these specimens in that although they are basically internal moulds the external ornament of the valve has to a certain extent been impressed on to the internal mould during the compaction of the sediment. This method of preservation is not unknown, as Newell (1937, pl. 19, fig. 1) figures similarly preserved valves from America and uses the term 'subinternal mould'. The same process may also have happened occasionally in other genera; for example, the ornament in both *Pseudamusium* and *Obliquipecten* often has a curiously muted aspect, which may be due to its impression onto a presumably smooth internal mould.

Trilobites. In the case of *Weberides* from the highest faunal band, some of the pygidia are preserved as external moulds or impressions of the dorsal surface of the exoskeleton and therefore show the convex rim as a depression surrounding the pleurae, which are in reversed relief. However, other pygidia are obviously moulds of the ventral surface of the exoskeleton, since they show surrounding the pleurae (which are in apparent positive relief) a concave area which bears fine striations parallel with the margin; this is in fact a mould of the convex doublure.

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London, S.W. 7

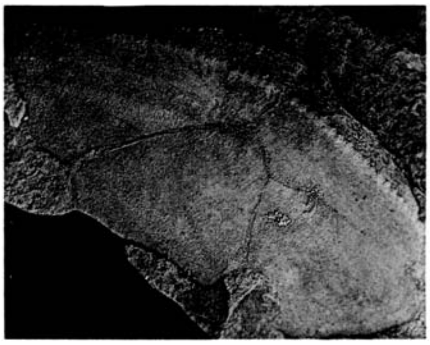
Manuscript received 22 November 1961

1 × 3·5

2 × 4

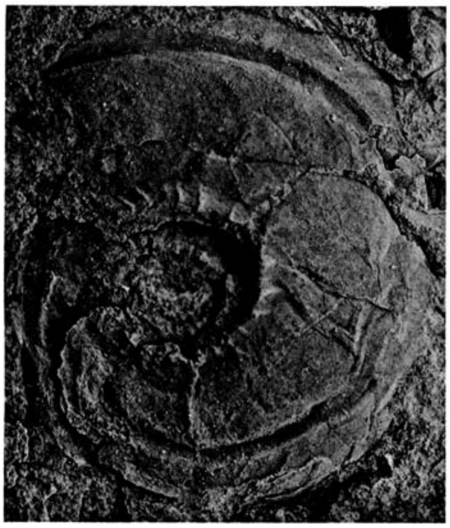
3 × 3·6

4 × 3·6



5 × 2

YATES, Namurian goniatites



1 × 5·5

3 × 5·3

2 × 6

4 × 7

6 × 4

5 × 4

YATES, Namurian goniatites

1 × 4·3

2 × 4

4 × 5·3

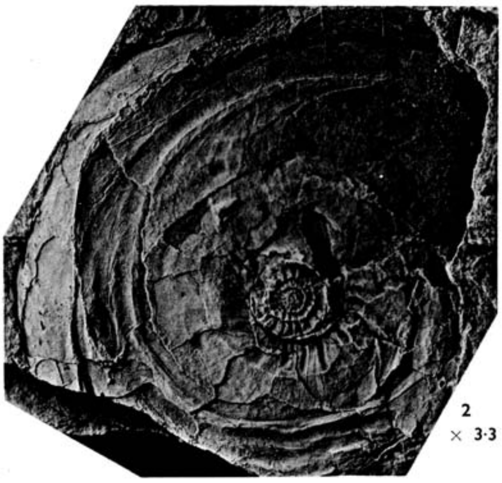
5 × 9·4

3 × 4·25

6 × 3

YATES, Namurian goniatites

1 × 3·75



2 × 3·3

3 × 5

5 × 8

6 × 4·75

4 × 4·75

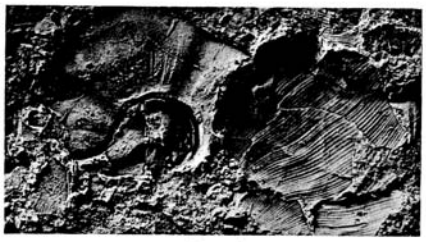
7 × 3·75

YATES, Namurian goniatites

1 × 3·8

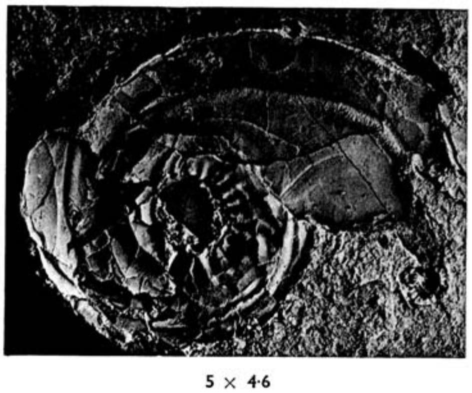
2 × 3·5

3 × 6



6 × 4

4 × 3



5 × 4·6

YATES, Namurian goniatites

1 × 5·25

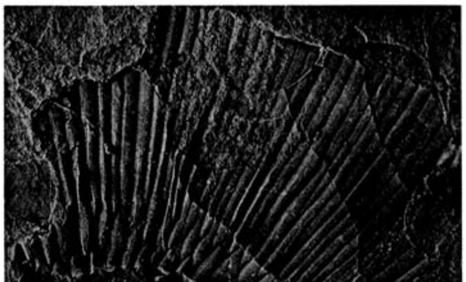
2 × 5

3 × 4·5

4 × 3·5

7 × 6·5

5 × 5·3



6 × 4

YATES, Namurian goniatites and lamellibranchs

1 × 4·25

2 × 5

3 × 16

4 × 3·3

5 × 5

YATES, Namurian goniatites

1 × 7·25

4 × 20

3 × 4

2 × 6

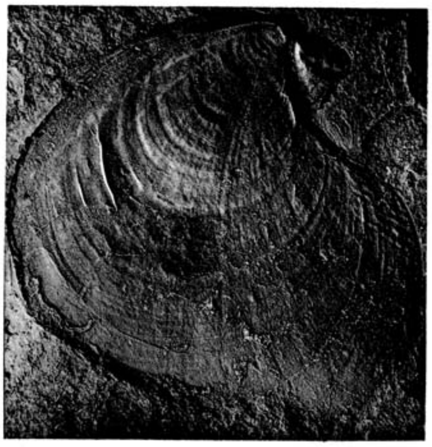
5 × 6·5

YATES, Namurian lamellibranchs and goniatites

2 × 5·3

1 × 20

4 × 7



3 × 2

YATES, Namurian lamellibranchs and goniatites

1 × 7

2 × 2·8

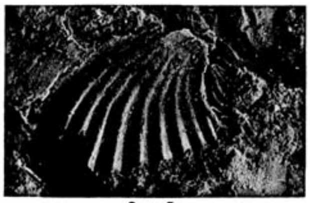
3 × 3

4 × 4

5 × 4

YATES, Namurian lamellibranchs

1 × 4·5



2 × 5

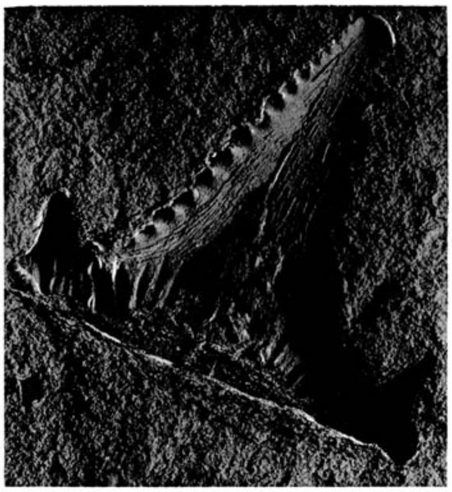
3 × 3·5

4 × 6

5 × 5

YATES, Namurian lamellibranchs

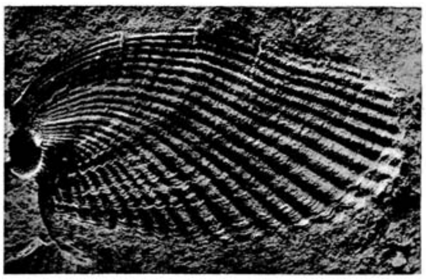
1 × 7



4 × 4

2 × 6

5 × 3.3



3 × 6·5

YATES, Namurian fossils