MIDDLE JURASSIC OSTRACODA FROM THE GREY LIMESTONE SERIES, YORKSHIRE

BY

R. H. BATE

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By RAYMOND HOLMES BATE

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SYNOPSIS

The Middle Jurassic (Bajocian) Grey Limestone Series of Yorkshire is shown to have been deposited in a broad embayment, transgressing deltaic sediments of Bajocian age, and is here divided into two ostracod faunal zones : a lower zone of *Glyptocythere polita* and an upper zone of *G. scitula*, the type section being at Hundale Point. The zone of *G. polita* is present only towards the centre of the basin and represents the first phase of the marine transgression. The facies changes within the Series are produced by intermittently rising sea-level and the repeated southward extension of the northern delta. Shore-line sediments are also identified. Fourteen stratigraphical sections are described in detail. The period of marine deposition is considered to have taken place approximately during *sauzei* to *blagdeni* times and is thus in part at least equivalent to the Coronaten-Schichten of N.W. Germany. The ostracod fauna of the Grey Limestone Series is described for the first time. Four genera : *Caytonidea, Cloughtonella, Malzia* and *Mesocytheridea* are new. Sixteen new species and one new subspecies are also described. The palaeoecology of the ostracod fauna is briefly mentioned.

I INTRODUCTION AND ACKNOWLEDGEMENTS

In north-eastern England, the uppermost marine horizon of Bajocian age consists of a well developed succession of calcareous shales and sandy limestones known as the Grey Limestone Series or Scarborough Beds. The maximum thickness of this sequence occurs in the neighbourhood of Cloughton Wyke (62 feet) and Ravenscar (62 feet), the beds thinning to the north, south and west where they eventually pass

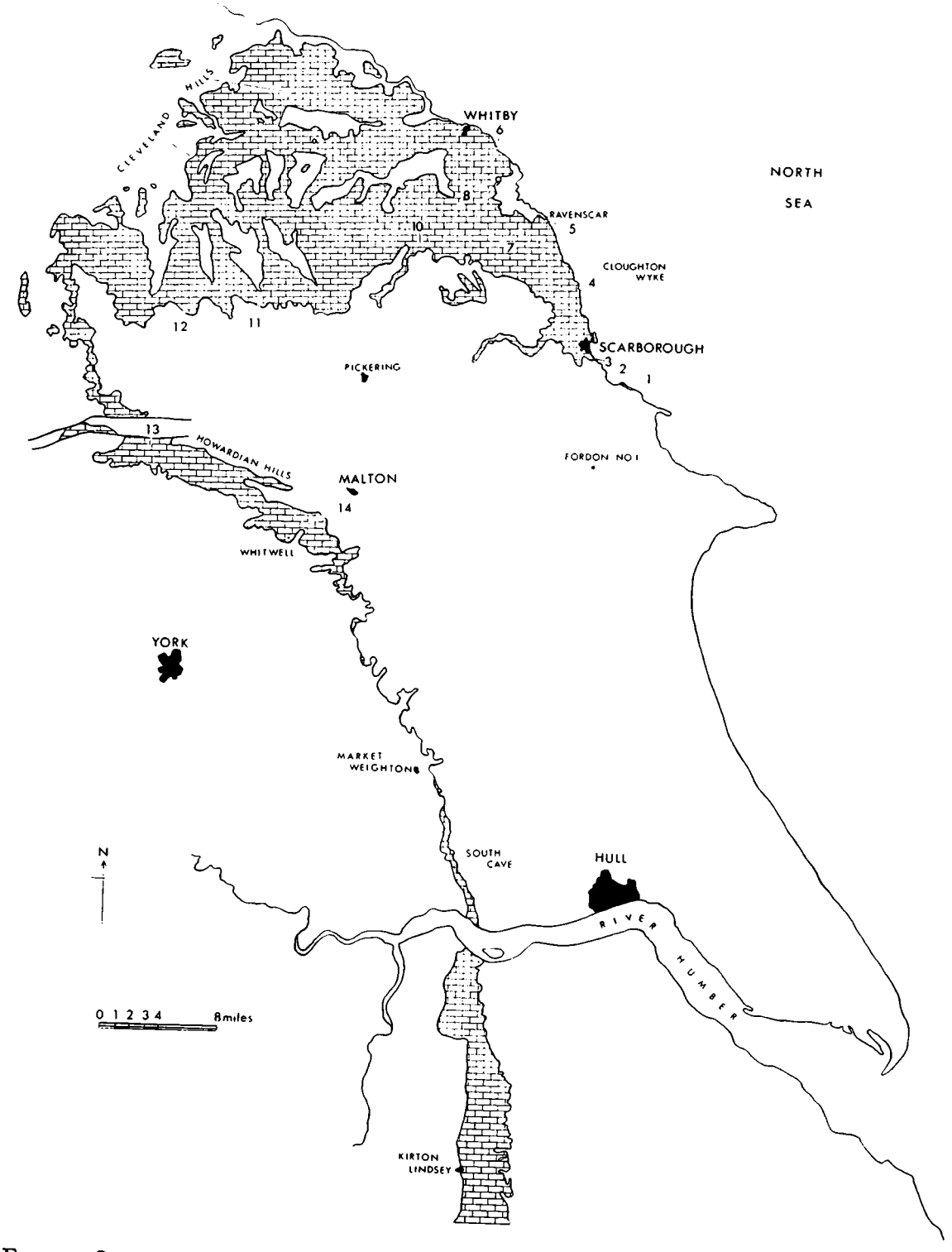


FIG. 1. Outcrop of Middle Jurassic Strata in N.E. England, with the localities and sections (1–14) mentioned in the text.

into arenaceous shore-line deposits. The open sea during this period lay to the east, occupying the site of the present day North Sea, whilst a delta lay to the north. Sediments equivalent in age to the Grey Limestone Series were also deposited in north-western Germany.

The dating of the Grey Limestone Series is difficult owing to the almost complete absence of ammonites : those which have been recorded (Fox-Strangways 1892 : 231 ; Buckman 1911 : 205–208 ; and Hemingway 1951 : 119)[1] indicate that part of the sequence at least belongs to the *Teloceras blagdeni* Subzone. As the ammonite zones are well known in north-western Germany, comparison of the ostracod faunas of the two regions should eventually offer a solution to this problem. At the moment, however, only two ostracods, present in the Grey Limestone Series have also been, recorded from Germany ; these are *Ljubimovella piriformis* Malz (1961 : 165, pl. 2, figs. 15–25) and *Fuhrbergiella* (*Praefuhrbergiella*) *horrida horrida* Brand & Malz (1962 : 19, pl. 4, figs. 33–37 ; pl. 5, fig. 46).

Ljubimovella piriformis has a range in Germany of *sauzei* to *blagdeni* Zones, with the type horizon being in the *sauzei* Zone. In Yorkshire this ostracod is restricted to the zone of *Glyptocythere scitula*, the upper zone from which the ammonites recorded from the Grey Limestone Series were most probably obtained. The ostracod *Fuhrbergiella* (*Praefuhrbergiella*) *horrida horrida* is recorded from the upper part of the Coronaten-Schichten (*romani* to *blagdeni* Zones) in Germany, whilst in Yorkshire it is

TABLE I

Generalised table of the Middle Jurassic stata in Yorkshire, north of Market Weighton

Strata	*Stage*
CORNBRASH (UPPER)	CALLOVIAN
UPPER DELTAIC SERIES	BATHONIAN
GREY LIMESTONE SERIES	BAJOCIAN
MIDDLE DELTAIC SERIES (UPPER)	
MILLEPORE SERIES	
MIDDLE DELTAIC SERIES (LOWER)	
ELLER BECK BED/HYDRAULIC LIMESTONE	
LOWER DELTAIC SERIES	
DOGGER	
LIAS	TOARCIAN

[1] The map reference for Monk's Walk Wood, Sneaton has been given with a misprint, and should read NZ/896086 (personal communication, Prof. Sylvester-Bradley).

FIG. 2. Sections 1–6 across the Yorkshire Basin.

largely restricted to the *G. scitula* zone, being found at only one locality in the *G. polita* Zone.

The Grey Limestone Series represents a period of deposition which appears to approximate with the Coronaten-Schichten of Germany although there is insufficient evidence to say how many of the German ammonite zones are represented in the Yorkshire sediments. It should be possible, however, to correlate the Grey Limestone Series with the German succession more precisely at a future date when the ostracod faunas are more fully known.

Fox-Strangways (1892 : 223) recorded the presence of lamellibranch casts within a 15 ft. bed of sandstone at Ravenscar. This is bed 17 of Section 5 (Text-fig. 2), which is the lower part of the Moor Grit (basal Upper Deltaic Series). The period of marine deposition was thus brought to a close by the infilling of the Yorkshire basin with deltaic sediments. The next marine transgression did not occur until Callovian times, it is, therefore, evident that the end of the Bajocian and the whole of the Bathonian is represented in Yorkshire by deltaic sediments of the Upper Deltaic Series.

The localities listed below are those at which the Grey Limestone Series has been examined at outcrop, the numbers corresponding with those in Text-fig. 1. Map references refer to the one-inch Ordnance Survey map of Great Britain (seventh series).

Coastal Exposures

1. Gristhorpe Bay, cliff section and foreshore, map reference TA/085842. A complete section, maximum thickness 15 ft. 6 in.
2. Cayton Bay, cliff section, map reference TA/082843. A complete section, maximum thickness 10 ft. 7 in.
3. White Nab, Scarborough, foreshore section, map reference TA/058865. Base below Low Water Mark, seen to 25 ft. 6 in.
4. Hundale Point, Cloughton Wyke, cliff and foreshore section, map reference TA/024949 to TA/027943. A complete section, maximum thickness 62 ft. 4 in.
5. Ravenscar, cliff section, map reference NZ/988012. A complete section, maximum thickness 62 ft. 4 in.

Inland Exposures

6. Hawsker, stream section at Hawsker Bottoms, map reference NZ/937079. Top of section not seen, 22 ft. 5 in.
7. Bloody Beck, stream section, map reference SE/945981 to SE/947982. A complete section, 29 ft. 4 in.
8. May Beck, stream section, map reference NZ/890015 to NZ/891019. Isolated exposures, base not seen, 14 ft. 9 in.
9. Ramsdale Beck, stream section NZ/925034. Upper part of Series only exposed, seen to 9 ft. 6 in.

10. Eller Beck, just downstream of road bridge, map reference SE/856984. Upper part of Series only, seen to 6 ft. 5 in.
11. Harland Beck, stream section, map reference SE/684914 to SE/686913. Incomplete section seen to 14 ft. 4 in.
12. Bogmire Gill, stream section, map reference SE/608905 to SE/609909. Almost a complete section, seen to 40 ft. 3 in.
13. Yearsley Moor, map reference SE/579754. A small quarry by the side of the Yearsley-Ampleforth road. Fauna indicates position of beds high up in the Grey Limestone Series, seen to 8 ft. 3 in.
14. Stonecliff Wood, Crambeck, map reference SE/744676, a small gully exposing 12 ft. 2 in. of sediment. Map reference SE/743676, section higher up the bank, above the York–Scarborough railway-line, exposing 5 ft. 8 in. of limestone. Map reference SE/740675 a 9 inch bed of limestone is exposed. All strata high up in the Grey Limestone Series.

Morphological terms used in the text are those introduced in vol. Q of the American Invertebrate Paleontology Treatise (Moore 1961), Sylvester-Bradley (1956) and Bate (1963).

The work embodied in this paper was largely conducted in the Geology Departments of Sheffield University and Leicester University. My sincere thanks go to Professors L. R. Moore and P. C. Sylvester-Bradley respectively, for the use of their departmental facilities. Grateful thanks are also due to the Department of Industrial and Scientific Research for a grant to finance this work. Dr. H. Malz, Senckenberg Museum, Frankfurt-am-Main and Dr. H. J. Oertli, S.N.P.A., Centre de Recherches, Pau (Basses-Pyr) also assisted with the loan of type and/or comparative material, for which they are gratefully acknowledged.

II STRATIGRAPHICAL SECTIONS

SECTION No. 1. Gristhorpe Bay (Text-fig. 2), exposure in south face of Yons Nab headland and on the foreshore at low tide. The section is complete and exposes 15 ft. 6 in. of sediment (G.L.S.).

Upper Deltaic Series

	ft.	*in.*
10. Yellow-grey sandstone (Moor Grit) with coaly lenses and grey sulphurous shale	30–40	0

Grey Limestone Series

9. Black, sulphur stained shale	4	0
8. Dark grey, ironstained shale	4	9
7. Mudstone	0	9
6. Black shale with indet. ostracods	1	4

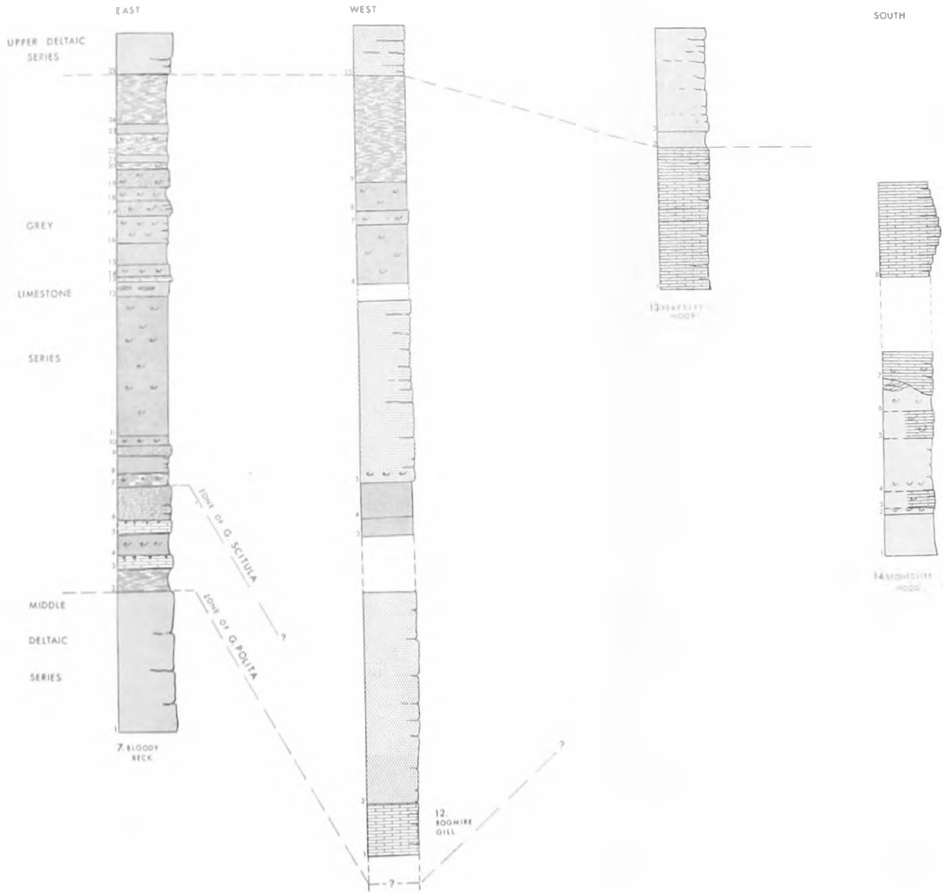


FIG. 4. Sections 7 and 12–14.

	ft.	in.
5. Fossiliferous mudstone with *Glyptocythere scitula*; *Vernoniella bajociana* and *Monoceratina scarboroughensis*	0	6
4. Black fossiliferous shale with a compact limy band at base. Lamillibranch *Gervillia scarburgensis* and Belemnites common. *Glyptocythere scitula*; *Praeschuleridea subtrigona intermedia*; *Vernoniella bajociana*; *Vernoniella* ? *caytonensis*; *Systenocythere ovata*; *Paracypris bajociana*; *Caytonidea faveolata*; *Fuhrbergiella* (*Praefurbergiella*) *horrida horrida* and *Pleurocythere* sp. . .	4	6

Middle Deltaic Series

3. Yellow sandstone, flaggy in part with carbonaceous bands .	4	10
2. Black Shale	0	5
1. Grey shale	7	0

SECTION No. 2. Cayton Bay (Text-fig. 2), exposure in north face of Yons Nab headland. This section is complete, but like Section No. 1 is liable to be cut into by washouts infilled with deltaic sandstone (Moor Grit). Up to 10 ft. 7 ins. of sediment (G.L.S.) exposed.

Upper Deltaic Series

8. Moor Grit.

Grey Limestone Series

7. Chocolate-brown to grey coloured shale with fragmentary shells .	1	5
6. Fossiliferous, chocolate-brown mudstone, variable in thickness. *Glyptocythere scitula*; *Vernoniella bajociana*; *Vernoniella* ? *caytonensis*; *Systenocythere ovata*; *Paracytheridea* ? *caytonensis*; *Progonocythere acuminata*; *Progonocythere yonsnabensis and Praeschuleridea subtrigona intermedia*	2 to 0	0 to 9
5. Grey fossiliferous shale with: *Glyptocythere scitula*; *Vernoniella bajociana*; *Fuhrbergiella* (*Praefuhrbergiella*) *horrida horrida*; *Monoceratina scarboroughensis*; *Praeschuleridea subtrigona intermedia*; *Progonocythere yonsnabensis* and *Caytonidea faveolata* .	2	0
4. Brown fossiliferous mudstone with: *Glyptocythere scitula* and *Vernoniella bajociana*	0	4
3. Grey shelly shale with: *Glyptocythere scitula*; *Vernoniella bajociana* and *Praeschuleridea subtrigona intermedia*.	2	9
2. Grey-black sulphurous shale	2	1

Middle Deltaic Series

1. Flaggy yellow sandstone.

SECTION No. 3. White Nab (Text-fig. 2), Scarborough. Exposure largely along the foreshore, cut out as a series of steps by the sea —well exposed and possibly almost complete, lowermost beds below Low Water Mark. 25 ft. 6 in. of marine sediment exposed.

	ft.	in.
Upper Deltaic Series		
18. Massive deltaic sandstone (Moor Grit) forming base of high cliffs.		
Grey Limestone Series		
17. Sandy shale passing into base of Moor Grit above	1	0
16. Fossiliferous, grey calcareous shale, partly ironstained. *Fuhrbergiella (Praefuhrbergiella) horrida horrida*	0	7
15. Fossiliferous shale with mudstone nodules. Internal casts, possibly of *Glyptocythere scitula* and *Praeschuleridea subtrigona intermedia*	0	8
14. Mudstone with *Glyptocythere scitula ; Vernoniella bajociana* and *Praeschuleridea subtrigona intermedia* .	0	4
13. Grey shale with ooliths	0	2
12. Grey to chocolate-brown fossiliferous shale with *Glyptocythere scitula ; Vernoniella bajociana* and *Praeschuleridea subtrigona intermedia*	1	0
11. Ironstained mudstone crowded with the lamellibranch *Gervillia scarburgensis*	0	5
10. Sandy limestone containing large specimens of *Gervillia scarburgensis Glyptocythere scitula* and *Praeschuleridea subtrigona intermedia*	1	5
9. Purplish-brown calcareous shale with *Glyptocythere scitula ; Vernoniella bajociana* and *Praeschuleridea subtrigona intermedia* .	1	0
8. Ironstained, sandy limestone. *Vernoniella bajociana* . . .	1	6
7. Fossiliferous grey shale with *Glyptocythere scitula ; Vernoniella bajociana ; Monoceratina scarboroughensis* and *Praeschuleridea subtrigona intermedia*	1	2
6. Calcareous shale with mudstone bed at top which varies from 0 in. to 9 in. in thickness	1	5
5. Massive, well bedded sandy limestone, fossiliferous though no microfauna so far obtained	6	7
4. Hard calcareous shale, almost an argillaceous limestone . .	1	6
3. Soft, grey fossiliferous shale. *Glyptocythere scitula ; Monoceratina scarboroughensis ; Fuhrbergiella (Praefuhrbergiella) horrida horrida* and *Praeschuleridea subtrigona intermedia*	1	0
2. Ironstained limestone	1	0
1. Grey sandy shale with large belemnites. *Glyptocythere scitula ; Vernoniella bajociana* and *Praeschuleridea subtrigona intermedia* seen to	4	0

SECTION No. 4. Hundale point (Text-fig. 2). A complete succession of these beds is exposed in the cliff face and along the foreshore, with a maximum thickness of 62 ft. 4 in.

	ft.	in.
Upper Deltaic Series		
32. Moor Grit—carbonaceous and more thinly bedded at base.		
Grey Limestone Series		
31. Grey, sandy and micaceous shale, ironstained . .	3	8
30. Dark grey sulphurous shale	1	7
29. Fossiliferous mudstone, variable in thickness, maximum	0	4
28. Grey shale, ironstained at base . . .	0 to 0	7 to 10
27. Chocolate-brown, fossiliferous shale	0	10
26. Grey calcareous shale, almost an argillaceous limestone. *Glyptocythere scitula ; Vernoniella bajociana ; Fuhrbergiella* (*Praefuhrbergiella*) *horrida horrida ; Praeschuleridea subtrigona intermedia*.	0	9
25. Chocolate-brown mudstone, shelly. *Glyptocythere scitula ; Vernoniella bajociana* and *Monoceratina scarboroughensis* . . .	0	4
24. Purplish brown, fossiliferous shale grading into bed 25. *Glyptocythere scitula ; Vernoniella bajociana ; Monoceratina scarboroughensis* and *Praeschuleridea subtrigona intermedia* . .	0	11
23. Grey shale becoming less fissile towards base. *Glyptocythere scitula ; Vernoniella bajociana ; Monoceratina scarboroughensis* and *Fuhrbergiella* (*Praefuhrbergiella*) *horrida horrida* . . .	4	0
22. Grey-black, very fossiliferous shale. Ostracod fauna at top of sequence : —*Glyptocythere scitula ; Monoceratina scarboroughensis ; Fuhrbergiella* (*Praefuhrbergiella*) *horrida horrida* and *Praeschuleridea subtrigona intermedia.*		
Fauna 7 ft. from base :— ostracods indet.		
Fauna 6 ft. from base :— *Ljubimovella piriformis.*		
Fauna 5 ft. from base :— *Glyptocythere scitula* and *Vernoniella bajociana.*		
Fauna 2 ft. from base :— *Monoceratina scarboroughensis ; Cloughtonella rugosa* and *Praeschuleridea subtrigona intermedia.*		
Fauna at base :— *Glyptocythere scitula ; Ljubimovella piriformis* and *Praeschuleridea subtrigona intermedia*	11	1
21. Calcareous shale. *Cloughtonella rugosa ; Fuhrbergiella* (*Praefuhrbergiella*) *horrida horrida ; Praeschuleridea subtrigona intermedia ; Monoceratina scarboroughensis ; Systenocythere ovata* and *Ljubimovella piriformis*.	1	0

	ft.	in.
20. Sandy limestone, very fossiliferous (*Trigona* sp. *Pholadomya* sp. etc.). *Glyptocythere scitula*	0	8
19. Calcareous, grey shale with macrofossils as for bed 20. *Glyptocythere scitula ; Fuhrbergiella* (*Praefuhrbergiella*) *horrida horrida ; Praeschuleridea subtrigona intermedia* and *Systenocythere ovata*	4	9
18. Grey sandy shale. *Systenocythere ovata*	1	11
17. Calcareous sandstone	1	5
16. Dark grey shale extensively burrowed by marine organisms—the burrows infilled with sand. Belemnites present—no microfossils	2 to 3	10 to 0
15. Hard calcareous shale. *Pentacrinus* ossicles common	1	2
14. Grey sandstone with *Pentacrinus* ossicles. The Crinoid Grit. Current bedded with ripple markings along the bedding planes. Worm burrows common. This bed grades upwards into bed 15. Foraminifera but no ostracods have been obtained from this bed	4 to 6	0 to 2
13. Grey shale	1	3
12. Purplish-brown mudstone with *Glyptocythere polita* and *Praeschuleridea subtrigona intermedia*	1	10
11. Limestone *Glyptocythere polita ; Malzia unicarinata* and *Praeschuleridea subtrigona intermedia*	1	3
10. Sandstone	0	9
9. Grey sandy shale. *Glyptocythere polita ; Malzia bicarinata* and *Praeschuleridea subtrigona intermedia*	2	2
8. Dark grey shale. *Glyptocythere polita ; Vernoniella bajociana ; Fuhrbergiella* (*Praefuhrbergiella*) *horrida horrida* and *Praeschuleridea subtrigona intermedia*	0	6
7. Grey mudstone. *Glyptocythere polita* in this bed, as in bed 12, occurs in extremely large numbers. Other members of the ostracod fauna are :— *Progonocythere acuminata ; Vernoniella bajociana* and *Praeschuleridea subtrigona intermedia*.	1	1
6. Grey shale. *Glyptocythere polita* and *Praeschuleridea subtrigona intermedia*	1	2
5. Grey calcareous sandstone. *Glyptocythere polita* and *Glyptocythere costata*	3	4
4. Sandy shale	2	0
3. Hard black shale	2	7

Middle Deltaic Series

2. Massive sandstone	11	7

	ft.	in.
1. Black shale . . . . . seen to	0	2

SECTION No. 5. Ravenscar (Text-fig. 2). As in the previous section, a complete sequence of marine strata is exposed, although the junction between the Grey Limestone Series and the Upper Deltaic Series is obscured by talus. The beds crop out high up in the steep cliff face, the Moor Grit of the Deltaic Series above capping the cliffs.

Upper Deltaic Series

17. Soft yellow, false bedded sandstone, about 15 ft. of which cap the cliffs at this point.

Grey Limestone Series

	ft.	in.
16. Reddish-brown, rather soft sandstone above which there is 3–4 ft. of sediment obscured by talus	1	10
15. Ochre coloured sandy shale	3	5
14. Ironstone with fossil casts	0	4
13. Ochre coloured sandy shale	4	0

12. Dark grey calcareous shale, fossiliferous throughout with shelly bands and nodules.

Fauna 27 ft. from base :— *Monoceratina scarboroughensis ; Ljubimovella piriformis ; Fuhrbergiella* (*Praefuhrbergiella*) *horrida horrida* and *Praeschuleridea subtrigona intermedia.*

Fauna 25 ft. from base :— indeterminate ostracods.

Fauna 21 ft. from base :— *Glyptocythere scitula ; Vernoniella bajociana* and *Monoceratina scarboroughensis.*

Fauna 19 ft. from base :— indet. internal casts.

Fauna 17 ft. from base :— indet. internal casts.

Fauna 15 ft. from base :— *Glyptocythere scitula ; Praeschuleridea subtrigona intermedia* and *Fuhrbergiella* (*Praefuhrbergiella*) *horrida horrida.*

Fauna 13 ft. from base in shelly band :— *Glyptocythere scitula.*

Fauna 11 ft. from base in shelly bed :— *Glyptocythere scitula* and *Ljubimovella piriformis.*

Fauna 6 ft. from base :— *Glyptocythere scitula ; Glyptocythere costata*?*; Ljubimovella piriformis ; Fuhrbergiella* (*Praefuhrbergiella*) *horrida horrida* and *Praeschuleridea subtrigona intermedia.*

	ft.	in.
In the shale sampled within the basal 4 ft. of shale, no microfauna has been so far obtained	30	7
11. Fossiliferous yellow sandstone with *Pentacrinus* ossicles. The Crinoid Grit	4	3

	ft.	in.
10. Light-grey, calcareous shale with abundant *Gervillia scarburgensis*. Fauna at top of bed :— *Malzia unicarinata ; Praeschuleridea subtrigona intermedia ; Glyptocythere costata* and *Vernoniella bajociana*. Fauna at base :— *Malzia unicarinata ; Malzia bicarinata ; Glyptocythere costata* and *Progonocythere acuminata* ?	2	3
9. Dark-grey, fossiliferous shale. *Glyptocythere polita* and *Malzia unicarinata*	1	9
8. Fossiliferous argillaceous limestone with *Gervillia scarburgensis*. *Glyptocythere polita ; Glyptocythere costata ; Malzia unicarinata ; Malzia bicarinata* and *Praeschuleridea subtrigona intermedia* .	0	4
7. Grey sandy shale. Fauna at top :— *Glyptocythere polita ; Malzia bicarinata ; Progonocythere acuminata* and *Praeschuleridea subtrigona intermedia*. Fauna at Base :— *Glyptocythere polita ; Vernoniella bajociana* and *Praeschuleridea subtrigona intermedia*.	2	6
6. Calcareous mudstone, almost an argillaceous limestone. *Glyptocythere polita ; Progonocythere acuminata* and *Praeschuleridea subtrigona intermedia*	1	2
5. Rubbly bed—same lithology as bed 4. *Glyptocythere polita* and *Praeschuleridea subtrigona intermedia*	0	7
4. Dark grey, massive, sandy limestone. *Glyptocythere polita* and *Praeschuleridea subtrigona intermedia*	2	0
3. Dark-grey shale extensively burrowed by marine organisms—the whole bed being a mixture of shale and sandstone. Large specimens of *Gervillia scarburgensis* present. *Glyptocythere polita* and *Praeschuleridea subtrigona intermedia* . . .	1	6
2. Grey-black, rather brittle shale—no microfauna .	1	10
Middle Deltaic Series		
1. Deltaic sandstone, massively bedded	6	10

SECTION No. 6. Hawsker (Text-fig. 2.). The thickness of the Grey Limestone Series has been considerably reduced and although the top of the succession is not exposed, the observed thickness of 22 ft. 5 in. cannot be far short of the total in this area.

Grey Limestone Series		
13. Well bedded grey sandstone, rather coarse grained, virtually a grit, which grades down into a chocolate-brown sandstone shelly in parts. Ostracods (*Glyptocythere scitula* ? and *Praeschuleridea subtrigona intermedia*) present though somewhat decalcified . . . . . seen to	5	2
12. Sandy limestone, crowded with shells towards the base—rather fissile on weathering. *Vernoniella* ? *caytonensis ; Systenocythere ovata* at base	2	5

	ft.	in.
11. Sandy and very fossiliferous chocolate-brown shale. *Southcavea microcellulosa; Praeschuleridea subtrigona intermedia; Eocytheropteron* ? sp.; *Glyptocythere scitula* ? and *Fuhrbergiella* (*Praefuhrbergiella*) *horrida horrida*	1	6
10. Chocolate-brown shale. *Glyptocythere scitula; Vernoniella bajociana* and *Praeschuleridea subtrigona intermedia*	1	8
9. Grey shale crowded with fossils at top. *Glyptocythere scitula* and *Vernoniella bajociana* at the top and *Glyptocythere scitula; Cloughtonella rugosa* and *Fuhrbergiella* (*Praefuhrbergiella*) *horrida horrida* at base	3	0
8. Grey shale with large nodules of limestone	2	0
7. Grey fossiliferous shale with *Glyptocythere scitula; Vernoniella bajociana; Fuhrbergiella* (*Praefuhrbergiella*) *horrida horrida; Ljubimovella piriformis; Systenocythere ovata; Progonocythere acuminata* and *Praeschuleridea subtrigona intermedia*	3	0
6. Calcareous sandstone, fossiliferous. No microfossils obtained. The Crinoid Grit of elsewhere	2	0
5. Dark-grey sandy shale, fossiliferous along bedding planes. Internal casts of *Glyptocythere* sp.	1	8

Middle Deltaic Series

4. Light-grey shale with sandstone lenses	0	8
3. Grey and white laminated sandy shale—sandstone lenses	2	1
2. Grey sandy shale with 1 ft. 1 in. lens of sandstone at top. Shale carbonaceous with plant remains	3	0
1. Grey sandstone . . . . . seen to	4	6

SECTION No. 7. Bloody Beck (Text-fig. 3). Of the inland exposures of the Grey Limestone Series, this is by far the best—it is complete and all beds are accessible along the course of the stream. 29 ft. 4 in. of marine sediment are developed here.

Upper Deltaic Series

25. Moor Grit—massively bedded sandstone forming the base of the Deltaic Series—flaggy towards base, grading into bed below.

Grey Limestone Series

24. Sandy, micaceous, dark-grey shale	2	10
23. Clay ironstone with specks of pyrite	0	7
22. Fossiliferous grey, sandy shale, no microfossils	1	2
21. Light-grey mudstone, very fossiliferous. *Glyptocythere scitula*	0	6

	ft.	in.
20. Fossiliferous grey sandy shale—internal casts of *Glyptocythere* ? sp. and *Vernoniella* ? sp. Beds 24–20 have suffered extensive decalcification—fresh material if possible to obtain would probably yield a larger fauna	0	4
19. Hard, grey, calcareous shale. Ostracods fragmentary and indeterminate	1	0
18. Grey calcareous shale, fossiliferous. *Glyptocythere scitula* and *Vernoniella bajociana*	0	9
17. Hard, grey, fossiliferous mudstone. *Glyptocythere scitula* and *Vernoniella bajociana*.	0	11
16. Hard, grey, calcareous shale—quite fossiliferous although the ostracod fauna appears to be restricted to the single species, *Vernoniella bajociana*	1	7
15. Grey, rather shelly shale, softer than bed 16. Ostracod fauna restricted to *Fuhrbergiella* (*Praefuhrbergiella*) *horrida horrida* .	1	4
14. Fossiliferous calcarous shale—poor ostrocod fauna. *Glyptocythere scitula* and *Praeschuleridea subtrigona intermedia* . . .	0	9
13. Hard, grey, calcareous shale/mudstone with sub-rounded quartz grains embedded particularly in upper part. *Glyptocythere scitula*	0	3
12. Sparsely fossiliferous shale with mudstone nodules. No ostracods recovered	0	10
11. Grey fossiliferous shale. Fauna at top :— indet. Fauna 3 ft. 8 in. from top :— *Glyptocythere scitula ; Systenocythere ovata* and a fragment of *Praeschuleridea subtrigona intermedia.* Fauna 6 ft. 6 in. from top :— *Glyptocythere scitula ; Vernoniella bajociana* and *Praeschuleridea subtrigona intermedia* . . .	8	0
10. Grey, very fossiliferous shale. *Cloughtonella rugosa* and *Praeschuleridea subtrigona intermedia*	0	7
9. Calcareous shale grading upwards into bed 10. It is, however, a much more resistant bed to weathering—fossiliferous. *Glyptocythere scitula ; Progonocythere acuminata* and ? *Southcavea microcellulosa*	0	7
8. Hard, grey shale, sparsely fossiliferous. *Fuhrbergiella* (*Praefuhrbergiella*) *horrida horrida* and indet. ostracod fragments .	1	0
7. Grey sandy shale, fossiliferous. *Mesocytheridea howardianensis ; Glyptocythere scitula* and *Malzia bicarinata*	0	10
6. Grey-black fossiliferous limestone becoming shaly towards base. Fauna at top in limestone :— *Glyptocythere polita* and *Glyptocythere scitula.* Fauna in shaly beds at the base consists entirely of *Glyptocythere polita* which occurs in enormous numbers . .	2	0

	ft.	in.
5. Well jointed, grey limestone. *Glyptocythere polita* and *Praeschuleridea subtrigona intermedia*	0	9
4. Grey, fossiliferous shale. *Glyptocythere polita ; Malzia unicarinata ; Progonocythere acuminata* and *Praeschuleridea subtrigona intermedia*.	1	4
3. Grey, well jointed, limestone. *Glyptocythere polita* and *Praeschuleridea subtrigona intermedia*	0	8
2. Grey sandy shale. *Glyptocythere polita* and *Praeschuleridea subtrigona intermedia*	1	3

Middle Deltaic Series

1. Massive sandstone, flaggy in places	seen to	8	0

SECTION No. 8. May Beck, stream section. Exposures poor and discontinuous, the ostracod fauna being almost entirely leached out. Section at NZ/890015.

Upper Deltaic Series

10. Moor Grit—flaggy at base	seen to	12	0

Grey Limestone Series

9. Sandy limestone. *Glyptocythere scitula* and ? *Fuhrbergiella* (*Praefuhrbergiella*) *horrida horrida*	seen to	2	9
8. Rubbly sandy bed with mudstone nodules		1	2
7. Grey, calcareous sandstone. *Praeschuleridea subtrigona intermedia*		1	1

Section at NZ/890017, about 100 yds. downstream.

6. Grey flaggy sandstone with fossil casts	seen to	1	0

Section at NZ/891019, about 100 yds. downstream.

5. Grey calcareous sandstone with fossil casts. This bed is probably more correctly a sandy limestone, leaching of the $CaCO_3$ reducing the bed to a sandstone. *Praeschuleridea subtrigona intermedia*		3	3
4. Purplish-red siltstone with decalcified shells. *Glyptocythere scitula* and *Vernoniella bajociana*		0	4
3. Grey sandstone with fucoid markings		0	7
2. Grey, brittle shale—ostracod internal casts		1	7
1. Light-grey shale with plant remains	seen to	3	0

SECTION No. 9. Ramsdale Beck, stream section. Only 9 ft. 6 in. of marine shale exposed in the left bank of the stream (facing downstream). Although macrofossils are present within the shale, all the microfauna has been leached away except for the occasional indeterminate internal cast.

	ft.	in.

SECTION No. 10. Eller Beck, stream section, exposing 6 ft. 5 in. of marine sediment in the right bank of the stream, below road bridge.

Grey Limestone Series

5. Dark grey shale—sandy and ironstained. Internal casts of *Glyptocythere* ? sp.	2	4
4. Calcareous mudstone with macrofossils. *Glyptocythere scitula* and *Praeschuleridea subtrigona intermedia*	1	2
3. Grey, sandy shale with a few fossils	0	9
2. Calcareous grey shale. This bed has a good calcareous cement and has not been so extensively decalcified. *Glyptocythere scitula ; Vernoniella bajociana* and *Praeschuleridea subtrigona intermedia*.	1	2
1. Dark grey shale, internal casts of *Glyptocythere* ? sp., and *Vernoniella bajociana* seen to	1	0

SECTION No. 11. Harland Beck, stream section in left bank in a disused bend of the stream just above the junction of the Harland Beck with the river Dove : 14 ft. 4 in. exposed.

Grey Limestone Series

7. Sandy shale. *Glyptocythere scitula ; Vernoniella bajociana* and *Praeschuleridea subtrigona intermedia* seen to	0	6
6. Grey, sandy limestone, fossiliferous along the bedding planes. *Praeschuleridea subtrigona intermedia*	2	8
5. Grey sandy shale with calcareous nodules	1	7
4. Massive bedded sandstone almost a grit, flaggy at base	5	3
3. Sandy shale	0	7
2. Dark-grey shale, almost a mudstone in appearance. Lamellibranch *Gervillia scarburgensis* common. *Glyptocythere scitula* and *Praeschuleridea subtrigona intermedia*	1	6
1. Dark-grey mudstone. *Glyptocythere scitula* and *Praeschuleridea subtrigona intermedia* seen to	2	3

SECTION No. 12. Bogmire Gill (Text-fig. 3), an almost complete stream section exposing some 40 ft. 3 in. of the Grey Limestone Series.

Upper Deltaic Series

10. Moor Grit—flaggy at base seen to	6	0

Grey Limestone Series

9. Grey sandy shale	6	1

	ft.	in.
8. Dark-grey ironstained shale with fossils. *Glyptocythere scitula* and *Vernoniella bajociana*	1	6
7. Grey-brown mudstone. *Glyptocythere scitula ; Vernoniella bajociana ; Progonocythere acuminata* and *Praeschuleridea subtrigona intermedia*	0	9
6. Dark-grey, fossiliferous shale. *Glyptocythere scitula* and *Vernoniella bajociana*	3	4
unexposed section approx. 2 ft.		
5. Flaggy yellow sandstone with fossil casts	10	6
4. Grey sandy shale .	2	1
3. Grey ironstained shale	1	0
unexposed section approx. 20 ft.		
2. Calcareous sandstone, known as the Crinoid Grit. Fossiliferous and false bedded. Ostracod internal casts, *Glyptocythere* ? sp. . .	10 to 12	0 to 0
1. Steel-grey, flinty limestone, ripple marked along bedded planes. Indeterminate ostracods . . . . . seen to	3	0

SECTION No. 13. (Text-fig. 3). A small, disused quarry on Yearsley Moor, exposing 8 ft. 3 in. of marine sediment.

	ft.	in.
Upper Deltaic Series		
3. Yellow, rather soft, flaggy sandstone with plant remains along bedding planes . . . . . seen to approx.	6	0
2. Yellow sandy bed with lenses of grey shale .	1	0
Grey Limestone Series		
1. Buff coloured sandy limestone, weathers to a sandstone—fossiliferous.		
Fauna approx. 3 ft. 6 in. from the base :— *Glyptocythere scitula ; Praeschuleridea subtrigona intermedia ; Mesocytheridea howardianensis ; Fuhrbergiella* (*Praefuhrbergiella*) *horrida horrida* and *Systenocythere ovata.*	8	3

SECTION No. 14. (Text-fig. 3). Three isolated sections within the Grey Limestone Series, exposed in Stonecliff Wood, above the York–Scarborough railway-line. Altogether a maximum of 20 ft. 1 in. of sediment is exposed.

	ft.	in.
Grey Limestone Series		
8. Sandy, fossiliferous limestone exposed at map reference SE/743676. Fauna at top of section :— *Eocytheropteron* ? sp. ; *Southcavea microcellulosa* and *Praeschuleridea subtrigona intermedia.* Fauna 3 ft. 8 in. from base :— *Southcavea microcellulosa ; Praeschuleridea subtrigona intermedia ; Glyptocythere scitula ; Mesocytheridea howardianensis and Fuhrbergiella* (*Praefuhrbergiella*) *horrida horrida.* Fauna 1 ft. 6 in. from base includes all those listed above, with the exception of *Fuhrbergiella* (*Praefuhrbergiella*) *horrida horrida* . .	5	8
Section at SE/744676 :—		
7. Grey limestone weathering to orange-red sandstone containing fossil casts. This bed is largely decalcified at outcrop .	1 to 2	4 to 6
6. Yellow sand, false bedded at top. Fossil casts	1	7
5. Limestone, impersistent laterally, being replaced by yellow sand. *Glyptocythere scitula ; Eocytheropteron* ? sp. ; *Praeschuleridea subtrigona intermedia* and *Southcavea microcellulosa* . . .	1	8
4. Soft yellow sandstone—easily weathers to a sand—fossil casts common in lower part	3	0
3. Shelly limestone, impersistent and replaced laterally by sand. *Glyptocythere scitula* and *Southcavea microcellulusa* .	0	8
2. Reddish-brown sand with fossil casts . . .	0	4
1. Coarse silver sand . . seen to	2	5
Section at SE/740675 :—		
2. Grey limestone. *Praeschuleridea subtrigona intermedia ; Mesocytheridea howardianensis ; Glyptocythere scitula* and *Vernoniella bajociana.* This bed is possibly at a slightly lower horizon than those listed in the two sections above . . .	0	9
1. Yellow sandstone seen to	1	6

III STRATIGRAPHY

During Middle Jurassic times an important axis of downwarping, the Cleveland Axis, extended approximately east-west through the centre of the Yorkshire Basin, cutting the present coastline somewhere about Ravenscar (Text-fig. 1). This axis of movement played an important role during the deposition of the Grey Limestone Series.

The Grey Limestone Series or Scarborough Beds are well exposed along the coast as far north as Whitby where the outcrop turns inland. In the northern part of the Yorkshire basin, the Cleveland Hills (Text-fig. 4), the outcrops are generally represented by expanses of coarse calcareous grit known as the Crinoid Grit. Down the western part of the outcrop, exposures are sometimes good but incomplete ; the most complete inland exposures are found towards the centre of the basin in stream sections.

Fox-Strangways (1892 : 236) was the first to subdivide this marine series on lithological terms. His divisions consisted of an upper shale division, a middle sandstone division and a lower limestone division. This arrangement was continued by Richardson (1911). However, the subdivision of the Grey Limestone Series in this way, although basically correct, is a simplification of what really takes place. In fact failure to recognize facies changes resulted in Arkell (1933 : 221) making the following statement " Although the exact horizons of the ammonites recorded from the Scarborough or Grey Limestone are not known, it may be presumed that most if not all came from the lowest or limestone division ". The impure limestones developed in the Scarborough district belong to the upper shale division. The lower so called limestone division is not exposed at Scarborough and may not, in fact, extend as far south. As many of the ammonites recorded come from Scarborough, it is clear that they must come from the upper division. The examination of the ostracod faunas brought out this fact and at the same time made it possible to correlate the various sections more precisely than would have been possible on purely lithological evidence.

The division of the Grey Limestone Series on lithological evidence is here abandoned, instead two ostracod zones are recognized : a lower zone of *Glyptocythere polita* and an upper zone of *Glyptocythere scitula*, the type section for both being taken at Hundale Point—see Section 4.

Glyptocythere scitula Zone

The ostracod fauna associated with the index ostracod of this zone is more varied than that of the lower zone and possesses several species which are restricted in their geographical distribution. The typical faunal assemblage of this zone is as follows:—

> *Glyptocythere scitula ; Vernoniella bajociana ; Monoceratina scarboroughensis ; Fuhrbergiella* (*Praefuhrbergiella*) *horrida horrida ; Ljubimovella piriformis ; Systenocythere ovata* and *Praeschuleridea subtrigona intermedia.*

Of this fauna *P. subtrigona intermedia* ranges throughout the entire Grey Limestone strata and is not indicative of either zone. The two ostracods *Vernoniella bajociana* and *Fuhrbergiella* (*P.*) *horrida horrida* are similarly found to occur in sediments below this zone, but they are relatively uncommon at the lower horizon and are not considered to be characteristic there.

A number of ostracods, restricted to this zone, have a limited geographic distribution, the palaeoecological considerations of which will be dealt with later. These are :— *Cloughtonella rugosa ; Cytheropteron ? yonsnabensis ; Caytonidea faveolata ;*

Mesocytheridea howardianensis ; Vernoniella ? caytonensis ; Paracytheridea ? caytonensis ; Progonocythere yonsnabensis and *Southcavea microcellulosa.*

The ostracod *Progonocythere acuminata* is present in this zone, but is equally, if not more so, as common in the lower zone of *G. polita* and is of little value stratigraphically.

Glyptocythere polita Zone

The diagnostic fauna of this zone is :— *G. polita, G. costata ; Malzia unicarinata* and *M. bicarinata.* As mentioned above (see also Text-fig. 24), several ostracods are present in both zones and need not be listed again. The above assemblage is characteristic of and restricted to this lower part of the Grey Limestone Series.

In all cases the junction between the zone of *G. polita* and *G. scitula* is clear-cut. There is a very slight overlap of one or two species in some cases, but this is relatively insignificant, and where observed limited to a few feet of strata only. A few species, however, as mentioned above are not restricted to either zone, but range throughout the complete succession (Text-fig. 24).

Along the coast the most southerly exposure of the Grey Limestone Series is in Gristhorpe Bay. Here the beds rapidly thicken to the observed maximum of 15 ft. 6 in. at the north of the Bay in Yons Nab headland (Section 1, Text-fig. 2). The marine sediments consist entirely of calcareous shales and mudstones both here and on the other side of the headland in Cayton Bay (Section 2, Text-fig. 2) where a maximum of 10 ft. 7 in. was observed. In this area the basal sandstone of the Upper Deltaic Series (here a rather incipient lateral equivalent of the massive Moor Grit further north) cuts down into the marine sediments as a number of well exposed washouts. These have been described and figured by Black (1928).

At White Nab, Scarborough, the Series is again exposed (Section 3, Text-fig. 2) and has increased to an exposed maximum of 25 ft. 6 in. The shales are rather more strongly calcareous, and impure sandy limestones are developed. The ostracod fauna throughout the sequence, as in the previous two sections, is indicative of the *G. scitula* zone. It is possible that the lower zone of *G. polita* may be present under the sea. However this part of the section is never exposed even at low tide and must remain not proven for the present.

North of Scarborough, at Hundale Point, Cloughton, the marine strata attain their maximum development of 62 ft. 4 in. (Section 4, Text-fig. 2). This is exactly the same thickness of sediment as measured for the Grey Limestone Series a few miles further north at Ravenscar (Section 5, Text-fig. 2). In both cases there is a very thick development of calcareous shale in the upper part, tending to be arenaceous at the top of Hundale, whilst at Ravenscar a bed of sandstone is developed. At Hundale there is still a remnant of the sandy limestone of the White Nab succession, present towards the lower part of the shale sequence. This limestone is not represented at Ravenscar. At both localities the shale beds are followed by a thick bed of calcareous sandstone in which *Pentacrinus* ossicles are plentiful. This is the Crinoid Grit which is more typically developed further north. The ostracod fauna of the shale beds is indicative of the *G. scitula* Zone. No ostracods have been obtained

from the calcareous sandstone (Crinoid Grit) and it is taken to belong to the *G. scitula* Zone. As all the sediments below this bed at Hundale and Ravenscar belong to the *G. polita* Zone, the bed is here, a good marker horizon.

The strata belonging to the *G. polita* Zone here reach their maximum development and consist of calcareous and sandy shales, some impure limestones and calcareous sandstones. Some mudstones are also present and these invariably are crowded with the ostracod *Glyptocythere polita*.

Just south of Whitby the outcrop of the Grey Limestone Series turns inland away from the coast. However, an excellent exposure has been obtained in a stream section at Hawsker, or more precisely, Hawsker Bottoms (Section 6, Text-fig. 2). According to the section described by Fox-Strangways (1892 : 237) only 6 ft. 4 in. of sediment at the top of the section is unexposed at the present time. In this section the upper shale horizon, so well developed at Hundale and Ravenscar, is much thinner and a thick bed of fossiliferous sandstone and a bed of sandy limestone are introduced at the top. The sandstone is almost certainly laterally equivalent to bed 16 present at the top of the shale horizon at Ravenscar, but here much more massive in character. The lateral equivalent of the Crinoid Grit (bed 6) is not very strongly developed here and beds possibly belonging to the *G. polita* Zone are very much reduced in thickness. The shale bed which probably represents this horizon (bed 5) has only produced extensively decalcified internal casts of *Glyptocythere* sp., so that conclusive evidence is at the moment lacking. Stratigraphically, however, there is good reason to consider bed 5 as representing the *G. polita* Zone with beds 6–13 belonging to the *G. scitula* Zone.

To the north and west of Whitby the marine sediments of the Series are poorly exposed and appear to consist almost entirely of coarse grained fossiliferous grits in which *Pentacrinus* ossicles are common. This lithofacies has been named the Crinoid Grit (Richardson 1911 : 195 and 197) and is laterally equivalent not only to the calcareous sandstone containing *Pentacrinus* ossicles at Hundale and Ravenscar but to practically the whole of the *G. scitula* Zone. However, shale and limestone horizons are still to be found in this northern area but are definitely subordinate to the arenaceous facies.

Towards the centre of the depositional basin the Grey Limestone Series continues to exhibit a wide variety of lithofacies. At the Bloody Beck stream section (Section 7, Text-fig. 3) calcareous shales and mudstones predominate with some impure limestones coming in towards the base in the zone of *G. polita*. The Crinoid Grit appears to be absent here and the junction of the two ostracod zones falls between beds 6 and 7. Only a few miles to the north-west the majority of the sediments exposed in the May Beck section (Section 8) are quite arenaceous. In the west at Bogmire Gill (Section 12, Text-fig. 3) a large part of the section is again arenaceous and the Crinoid Grit (bed 2) is well developed and shows strong false bedding. The sediments in the Harland Beck section (Section 11) are also predominantly arenaceous. Apart from the Bloody Beck section where beds of *G. polita* age definitely occur, the only possible exposure of these beds is at Bogmire Gill where a flinty ripple marked limestone is probably to be correlated with this zone. So far no ostracods have been extracted

from this lithology in a recognizable form. The basal limestone at Bogmire Gill was seen to be 3 feet, and is probably not very much thicker. The *G. polita* Zone at Bloody Beck is 6 feet in thickness. Not only does this zone diminish considerably in thickness north and south away from the Hundale/Ravenscar area but it also thins westwards. The probable area covered by sediments of the *G. polita* Zone is shown in Text-fig 4.

The most westerly outcrop of the Grey Limestone Series runs north/south through the Howardian Hills and consists of strongly arenaceous limestones interbedded with pure sand. In many cases decalcification of the limestone has resulted in the production of beds of sand. No complete section is exposed. Section 13 (Text-fig. 3) on Yearsley Moor exposes 8 ft. 3 in. of sandy limestone overlain by yellow sandstone of the Upper Deltaic Series. Further south at Stonecliff Wood, near Whitwell a

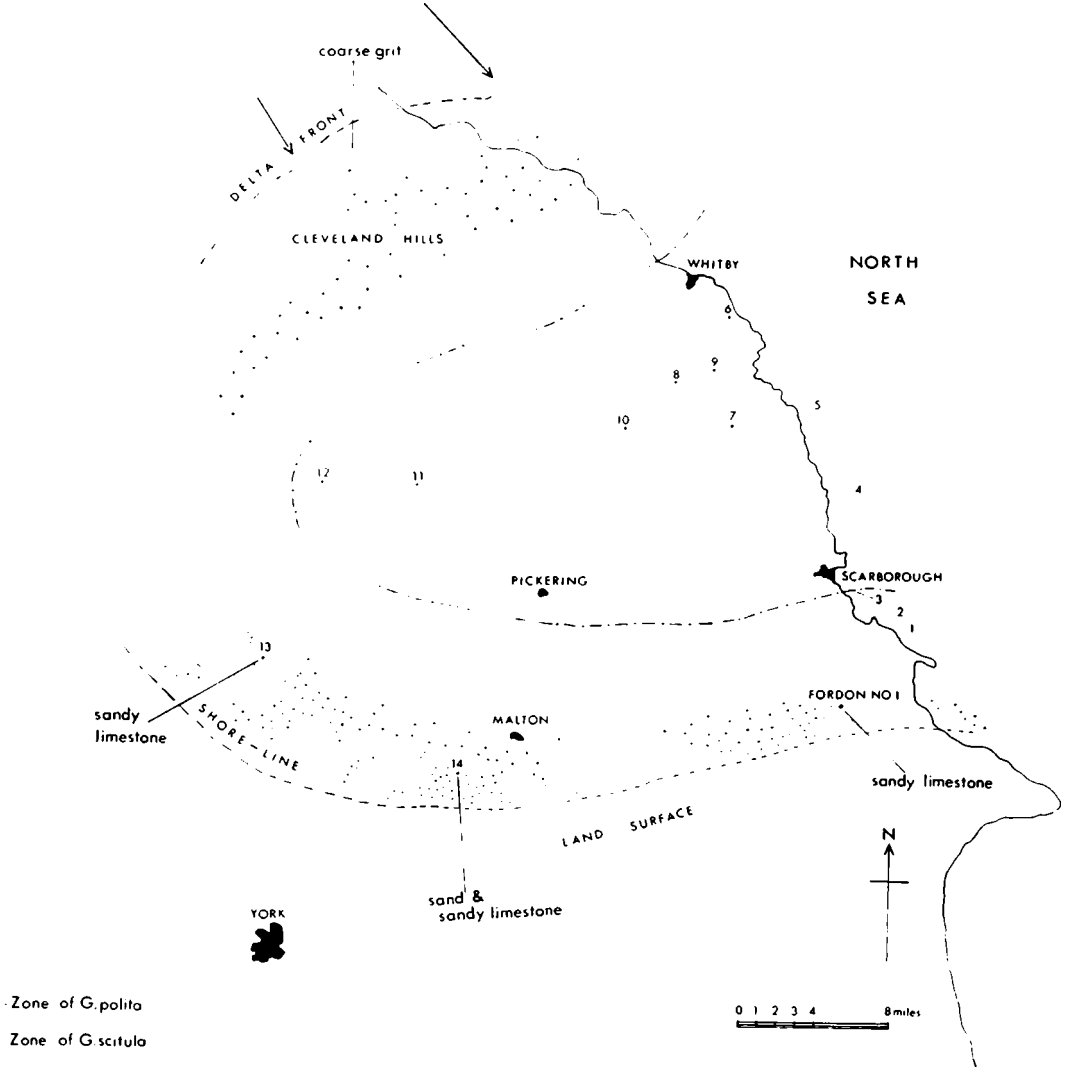


FIG. 4. Plan view of the marine basin during the deposition of the Grey Limestone Series, showing the probable maximum extent of the two faunal zones.

rather more complete section is exposed (Section 14, Text-fig. 3). Here sandy limestones are seen to be not only interbedded with false-bedded sand but are also observed to pass laterally into red sandstone or sand. This strongly arenaceous facies of the Grey Limestone Series is also present in the east, south of Gristhorpe Bay. Here, however, not exposed at the surface. The Fordon No. 1 borehole proved 5 feet of sandy limestone with belemnites (Falcon & Kent 1960 : 27). This facies is, therefore, continued around the western and southern perimeters of the Yorkshire basin whilst coarse grits are present along the northern edge. The shales and impure limestones are the major development towards the east and centre of the basin.

IV CONCLUSIONS

The Grey Limestone Series of north-east England is considered to represent the marine deposits of a broad embayment which cut into the deltaic sediments in Middle Jurassic times.

The transgression of the sea at this point was the result of downwarping along the Cleveland Axis, the lowermost beds of the Series (zone of *Glyptocythere polita*) being deposited only towards the centre of the basin (Text-fig. 4). The higher beds (zone of *Glyptocythere scitula*) extend over a wider area and in part rest directly upon deltaic sediments. The probable maximum extent of these higher beds is indicated in Text-fig. 4.

That deposition of the marine sediments occurred in shallow water is evidenced by the presence of ripple markings, false bedding, worm burrows etc. The macrofauna is also generally indicative of shallow water conditions, which, together with a possible lowering of the salinity close to a delta may explain the almost complete absence of ammonites. The shore-line of the Series is indicated by the change in facies to a very sandy limestone and even to pure sand around the south and western boundaries of the outcrop. To the north, the whole series is more coarsely arenaceous, the detrital material being brought in by the delta. The present day perimeter of the Grey Limestone Series outcrop approximates closely to the original shore-line.

As shown in Text-fig. 5, there are two prominent sandstone horizons which extend across the basin. Each reflects the influence of the northern delta. A third sandstone, the deltaic Moor Grit brings the period of marine deposition to a close. This type of sedimentation with marine shales and limestones interfingered by marine deposited deltaic sandstones is suggestive of intermittently rising sea-level, see Dunbar & Rodgers (1958 : 85, text-fig. 35*c*).

The ostracod fauna is typically shallow water benthos and in the majority of species present, appears to be largely independent of bottom facies. There is, however, a typical shore-line fauna consisting of :— *Southcavea microcellulosa ; Mesocytheridea howardianensis ; Praeschuleridea subtrigona intermedia* and *Glyptocythere scitula.* A number of other species such as *Vernoniella bajociana ; Systenocythere ovata* and *Fuhrbergiella* (*P.*) *horrida horrida* also occur in this very sandy shore-line facies, although they are only poorly represented. Towards the centre of the basin in slightly deeper water, the characteristic fauna consists of (in the *G. scitula* Zone) :— *Glyptocythere scitula ; Vernoniella bajociana ; Monoceratina scarboroughensis ;*

Ljubimovella piriformis ; Praeschuleridea subtrigona intermedia ; Cloughtonella rugosa ; Systenocythere ovata and *Fuhrbergiella* (*P.*) *horrida horrida.* A number of other species such as *Caytonidea faveolata ; Vernoniella* ? *caytonensis ; Paracytheridea* ? *caytonensis* and *Progonocythere yonsnabensis* also occur but are rather restricted in their geographical range, reflecting an environment most probably restricted to the Cayton Bay region. The ostracod *Progonocythere acuminata* is only sporadically present at this horizon. In the *G. polita* Zone the fauna appears to have lived in a

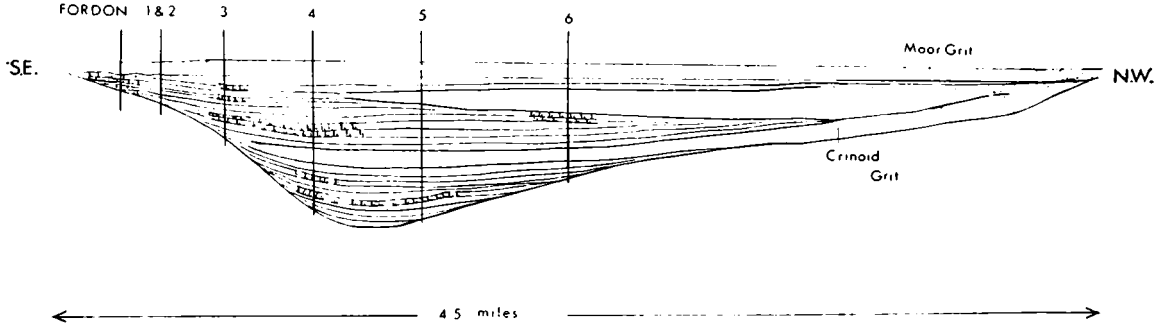


FIG. 5. Section across the Yorkshire Basin showing the facies changes of the Grey Limestone Series. Sections 1–6 are indicated together with information from the Fordon bore-hole. Vertical scale exaggerated.

similar environment, with regard to bottom sediment and depth of water, as the above and consists of the following :— *Glyptocythere polita ; G. costata ; Malzia bicarinata ; M. unicarinata ; Progonocythere acuminata* and *Praeschuleridea subtrigona intermedia. Vernoniella bajociana* occurs in the upper part of this zone whilst *Fuhrbergiella* (*P.*) *horrida horrida* has only been recorded from a single locality. No definite shore-line fauna has been identified in this lower zone, due, no doubt to lack of exposures, although the ostracod *Mesocytheridea howardianensis* occurs in sandy shale at the base of the *G. scitula* Zone in the Bloody Beck section, whilst a little higher up in the same section there is a single specimen possibly belonging to *Southcavea microcellulosa.* The presence of these ostracods here may indicate a shallowing of the water or a change in environment to their liking. It is not possible, however, to draw any further conclusions at this stage.

V SYSTEMATIC DESCRIPTIONS

Subclass *OSTRACODA* Latreille 1806

Order PODOCOPIDA Müller 1894

Suborder PODOCOPINA Sars 1866

Superfamily **CYPRIDACEA** Baird 1845

Family **PARACYPRIDIDAE** Sars, 1923

Genus ***PARACYPRIS*** Sars 1866

Paracypris bajociana Bate

For complete synonymy see Bate 1964 : 9.

REMARKS. *Paracypris bajociana* has been recorded from the Lincolnshire Limestone and from the Cave, Whitwell and Millepore Oolites of N.E. England (Bate 1963, 1963*a* and 1964). Plumhoff (1963 : 18) records this species from beds of *discites* age and younger from Noith Germany.

The only occurrence within the Grey Limestone Series is at the base of the Gristhorpe Bay sequence where two specimens have been found.

Superfamily **CYTHERACEA** Baird 1850

Family **BYTHOCYTHERIDAE** Sars 1926

Genus ***MONOCERATINA*** Roth 1928

Monoceratina scarboroughensis sp. nov.

(Pl. 1, figs. 1–12)

DIAGNOSIS. *Monoceratina*, with finely punctate, subquadrate to elongate carapace, slightly constricted just anterior of mid-dorsal region.

HOLOTYPE. Io.1711, top of bed 22, Hundale Point, Cloughton.

PARATYPES. Io.1712–23, from top and base of bed 22 and bed 25, Hundale Point ; bed 5, Cayton Bay and bed 12 (21 ft. and 27 ft. from base), Ravenscar.

DESCRIPTION. *Carapace* subquadrate in outline, slightly constricted just anterior of mid-dorsal region, the more elongate dimorphs are considered to be the males. Greatest length of carapace through mid-point ; greatest height in anterior or posterior third ; greatest width in posterior third. The shallow constriction (sulcus) does not extend below mid-point, the ventro-lateral part of the carapace being noticeably swollen, particularly postero-ventrally. Dorsal margin straight with distinct, rounded cardinal angles. Ventral margin incurved medially ; anterior rounded ; posterior triangular with a short, straight or slightly concave postero-dorsal slope and a long, convex postero-ventral slope. Shell surface finely ornamented with small, round puncta, arranged in longitudinal rows in the male dimorph. Valves almost equivalve : mid-ventrally the left valve slightly overlaps the right, whilst dorsally the right valve overlaps the left, the degree of overlap increasing towards the posterior cardinal angle. *Muscle scars* consist of a subvertical row of four rectangular adductor scars and two antero-dorsal scars situated below mid-length and below the shallow sulcus. *Hinge* in the left valve consists of the slightly downset mid-dorsal edge of the valve acting as a hinge-bar ; not seen in the right valve, but presumably consisting of a simple dorsal groove for the articulation of the left valve hinge. *Duplicature* not clearly seen, though there appears to be a narrow anterior vestibule developed in one paratype (Io.1716).

Dimensions

Holotype Io.1711, female carapace (Pl. 1, figs. 1–3), length 0·61 mm. ; height 0·32 mm. ; width 0·25 mm.

Io.1719, female right valve, length 0·60 mm. ; height 0·35 mm. Io.1720, female left valve (Pl. 1, fig. 12), length 0·55 mm. ; height 0·33 mm. Io.1721, male carapace (Pl. 1, figs. 9–11), length 0·70 mm. ; height 0·32 mm. ; width 0·27 mm. Io.1722, female carapace, length 0·52 mm. ; height 0·27 mm. ; width 0·22 mm. Io.1723, female carapace (Pl. 1, figs. 4–8), length 0·57 mm. ; height 0·31 mm. ; width 0·23 mm.

REMARKS. *Monoceratina scarboroughensis* differs from all previously named species in outline (greatest length being through mid-point and not dorsal of mid-point as in the majority of cases), surface ornamentation of fine puncta coupled with the presence of dimorphism.

Family **PROGONOCYTHERIDAE** Sylvester-Bradley 1948

Subfamily **PROGONOCYTHERINAE** Sylvester-Bradley 1948

Genus ***CAYTONIDEA*** nov.

DIAGNOSIS. Progonocytherinae, oval-rectangular in outline with well rounded anterior and posterior margins. Low eye swelling situated at anterior cardinal angle. Cardinal angles prominent, broadly rounded. Hinge antimerodont. Muscle scars consist of subvertical row of four adductor scars, rounded antero-dorsal antennal scar and rounded antero-ventral mandibular scar. Radial pore canals long, straight, few in number. Left valve larger than right.

TYPE SPECIES. *Caytonidea faveolata* sp. nov.

REMARKS. Only a single species can be placed in the genus at the present time and this is typified by a strongly reticulate ornament. The possession of a well rounded oval-rectangular carapace with an antimerodont hinge, type A muscle scar arrangement and a distinct eye swelling identifies the genus *Caytonidea* from all other cytheracean genera. The genus (feminine) is named after the type locality, Cayton Bay.

Caytonidea faveolata sp. nov.

(Pl. 1, figs. 13–14 ; Pl. 2, figs. 1–10 ; Text-figs. 6, 7)

DIAGNOSIS. *Caytonidea*, with strongly reticulate ornament of 5–6 sided pits.

HOLOTYPE. Io. 1831, bed 5, Cayton Bay.

PARATYPES. Io.1832–35, horizon and locality as above and from bed 4, Gristhorpe Bay.

FIG. 6. Hinge of right valve, *Caytonidea faveolata* sp. nov. Paratype, Io.1832, approx. ×190.

DESCRIPTION. *Carapace* oval-subrectangular in outline with well rounded anterior and posterior margins, slightly concave mid-dorsal margin and antero-medially incurved ventral margin. The carapace is constricted slightly in the mid-dorsal region, and is noticeably swollen in the postero-dorsal region. Greatest length of carpace through mid-point, greatest height in the anterior third, greatest width in the posterior third. Shell surface ornamented by prominent 5–6 sided pits. Ventrally the reticulate ornament is somewhat subdued and is dominated by a series of longitudinal ridges. A low, smooth, *eye swelling* is situated at the anterior cardinal angle. *Left valve* larger than the right which it over-laps along the ventral margin and slightly

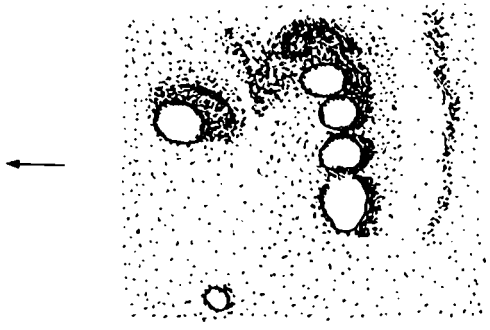


FIG. 7. Muscle scars, *Caytonidea faveolata* sp. nov. Paratype, Io.1833, approx. ×250.

in the region of the anterior cardinal angle. *Hinge* antimerodont, seen only in the right valve: 4 anterior and 5 posterior teeth observed; median groove long and locellate. *Duplicature* of moderate width, the inner margin and line of concrescence coinciding. *Radial pore canals* long, straight and widely spaced, 7 observed anteriorly. *Muscle scars* with rounded antero-dorsal antennal scar (Type A).

Dimensions

Holotype Io.1831, carapace (Pl. 2, figs. 1–4), length 0·56 mm.; height 0·33 mm.; width 0·30 mm.

Io.1834, carapace (Pl. 1, figs. 13, 14; Pl. 2, figs. 5, 6), length 0·65 mm.; height 0·37 mm.; width 0·33 mm. Io.1835, carapace length 0·56 mm.; height 0·34 mm.; width 0·27 mm.

REMARKS. Externally similar to *Southcavea reticulata* Bate (1964: 27, pl. 10, figs. 3–14; pl. 11, figs. 1–4), *Caytonidea faveolata* differs in the presence of an eye swelling, type A muscle scar arrangement as against type D, and in being less convex in dorsal view. The reticulate ornament of *S. reticulata* differs markedly from that of *C. faveolata* in the presence of strong punctation inside the shallow pits.

Genus ***CLOUGHTONELLA*** nov.

DIAGNOSIS. Progonocytherinae with subquadrate carapace, virtually parallel-sided in dorsal view. Ventero-lateral border convex projecting downwards and

outwards in type species. Dorsal margin of larger left valve concave with upstanding cardinal angles. Posterior traingular; anterior rounded with narrow marginal border. Hinge antimerodont. Duplicature of moderate width, inner margin and line of concrescence coinciding. Radial pore canals straight, few in number, widely spaced. Muscle scars not observed.

TYPE SPECIES. *Cloughtonella rugosa* sp. nov.

REMARKS. *Cloughtonella* is very close to *Aulacocythere* Bate (1963 : 198) from which it probably evolved. The general morphological features of these two genera suggest a very close relationship. However, *Cloughtonella* can be distinguished by the absence of the horseshoe-shaped swelling of *Aulacocythere* and does not possess an eye swelling.

At present only a single species can be definitely assigned to the genus : *Cloughtonella rugosa* sp. nov. However, the ostracod *Procytheridea hoffmani* Brand (1961 : 159, pl. 1, figs. 1–8) is possibly congeneric although tending to be more oval in side view, with the dorsal margin of the left valve broadly convex, passing down to the extreme posterior without any break at the cardinal angle. The dorsal margin of the left valve, male dimorph, may be slightly concave, however. *P. hoffmanni* does not appear to belong to the genus *Micropneumatocythere* Bate (1963*a* : 29), to which many of the European procytherids belong, nor is it a true *Procytheridea* Peterson (1954 : 171) which is a much more posteriorly acuminate genus. It is here tentatively considered to be congeneric with *C. rugosa*. The specimens of *Procytheridea hoffmanni* examined here were obtained from a sample of the *romani* Schichten, South Hannover, sent to me by Dr. F. Plumhoff, Erdöl A. G., Wietze krs. Celle. The known range of *P. hoffmanni* is *romani* to *blagdeni* Zones, that of *C. rugosa* uncertain because of the almost complete absence of an ammonite fauna, but probably just below *blagdeni* Zone.

The genus *Cloughtonella* (feminine) is named after the type locality Hundale Point, Cloughton Wyke.

Cloughtonella rugosa sp. nov.

(Pl. 3, figs. 1–13 ; Text-figs. 8, 9)

DIAGNOSIS. *Cloughtonella*, with small subquadrate carapace. Dorsal margin medially concave in left valve. Ornamentation consists of prominent diagonal, rather irregular median ridge extending from postero-dorsal to antero-ventral region. Weak longitudinal ridges occur on either side of diagonal ridge. Ventro-lateral border of valves project slightly outwards and downwards, with longitudinal groove above, particularly prominent in male dimorphs. Hinge antimerodont. Muscle scars and radial pore canals not seen.

HOLOTYPE. Io.2118, base bed 22, Hunsdale Point, Cloughton Wyke.

PARATYPES. Io.2119–36, horizon and locality as above and from horizon 2 ft. from base of bed 22, Hundale Point ; from bed 10, Bloody Beck and from base of bed 10, Hawsker.

DESCRIPTION. *Carapace* subquadrate in outline, more elongate in the male dimorphs. Greatest length of carapace extends through mid-point whilst the greatest height is in the anterior third. Greatest width in the posterior third, although there is only a slight increase in width posteriorly when compared with the width in the anterior part of the carapace. This is clearly seen in dorsal view, the carapace tending to be almost parallel-sided. Anterior broadly rounded, posterior triangular. Posterior marginal border narrow ; anterior border broad, directed obliquely back towards anterior cardinal angle. Dorsal margin concave in the left valve, convex in the right. Cardinal angles prominent in both valves. Ventral margin tends to be straight, the central part of the ventral surface being flattened, overhung on either side by the convex ventro-lateral margins, which in some specimens tend to project slightly outwards although not sufficiently developed to be termed alate. Left valve larger than the right which it overlaps along the ventral margin and strongly overreaches along the dorsal margin. Terminally the left slightly overreaches the right with the possible exception of at the extreme posterior where there is no overreach or

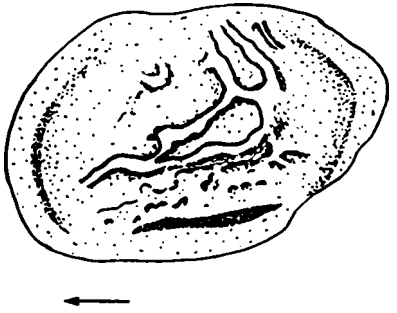


FIG. 8. Left side, female carapace, *Cloughtonella rugosa* sp. nov. Holotype, Io.2118, approx. ×85.

overlap. Shell surface ornamented by a series of low ridges, the dominant ridge running obliquely across the carapace from the postero-dorsal region to the antero-ventral region. This oblique ridge is rather irregular in outline and is bounded on either side by short, also irregular ridges which tend to be lateral below the main diagonal ridge and vertical above. Just above the ventro-lateral margin, which in some specimens also bears lateral ridges, there appears to be a shallow groove which gives the ventro-lateral extension of the carapace a pinched-up appearance particularly noticeable in the male dimorphs. The intensity of the ornamentation varies in each specimen but generally the impression given is of a wrinkled carapace. The ventral surface is ornamented by 3–4 longitudinal ridges on each valve. *Hinge* antimerodont. In the left valve the terminal sockets are separated by a short median ridge above which the shell slopes upwards to the dorsal margin. As a result there is virtually no accommodation groove developed. In the right valve only the anterior dentate element has been observed, bearing some 5–6 teeth. The median groove is poorly developed in the material examined but appears to be loculate. Inner margin and line of concrescence coincide, the *duplicature* being of moderate width. Radial pore canals almost imperceptible but can be made out as being short, straight and few in number. *Muscle scars* not observed.

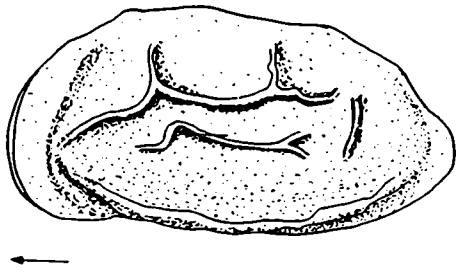


FIG. 9. Left side, male carapace, *Cloughtonella rugosa* sp. nov. Paratype, Io.2119, approx. ×95.

Dimensions

Holotype, Io.2118, female carapace (Pl. 3, figs. 1–4 ; Text-fig. 8), length 0·53 mm. ; height 0·34 mm. ; width 0·28 mm.

Io.2119, male carapace (Pl. 3, figs. 5–7 ; Text-fig. 9), length 0·55 mm. ; height 0·28 mm. ; width 0·26 mm. Io.2120, male carapace (Pl. 3, figs. 12, 13), length 0·61 mm. ; height 0·33 mm. ; width 0·26 mm. Io.2121, female left valve (Pl. 3, fig. 11), length 0·48 mm. ; height 0·32 mm. Io.2134, male carapace (Pl. 3, fig. 10), length 0·54 mm. ; height 0·29 mm. ; width 0·22 mm. Io.2135, female carapace (Pl. 3, figs. 8, 9), length 0·51 mm. ; height 0·32 mm. ; width 0·26 mm. Io.2136, male right valve, length 0·60 mm. ; height 0·29 mm.

REMARKS. *Cloughtonella rugosa* is close to the genus *Aulacocythere* in outline but as mentioned under remarks for the genus does not possess the generic characters of the latter. The present species is also close to *Procytheridea hoffmanni* Brand, which can, however, be distinguished by the strongly arched dorsal margin in the left valve ; presence of a definite accommodation groove and in the more positive ornamentation. The two species are probably congeneric however.

Genus ***FUHRBERGIELLA*** Brand & Malz 1962.

Subgenus ***PRAEFUHRBERGIELLA*** Brand & Malz 1962

Fuhrbergiella (*Praefuhrbergiella*) *horrida* Brand & Malz.

REMARKS. Brand & Malz (1962 : 19) described a new subgenus *Praefuhrbergiella* with *Fuhrbergiella* (*P.*) *horrida* as type species. Two subspecies were introduced : *Fuhrbergiella* (*P.*) *horrida horrida* having a range of *romani* to *blagdeni* Zones and *Fuhrbergiella* (*P.*) *horrida bicostata* typically developed in the Sonninien-Schichten (*sowerbyi* to *grandis* Zones) but also occurring in the Coronaten-Schichten (*pinguis* Zone). The subspecies recorded here from the Grey Limestone Series is *Fuhrbergiella* (*P.*) *horrida horrida*.

Fuhrbergiella* (*Praefuhrbergiella*) *horrida horrida Brand & Malz

(Pl. 4, figs. 1–12)

1962. *Fuhrbergiella* (*Praefuhrbergiella*) *horrida horrida* Brand & Malz : 19, pl. 4, figs. 33–37 ; pl. 5, fig. 46.

1962. *Fuhrbergiella* (*Praefuhrbergiella*) *horrida horrida* Brand & Malz : Simon & Bartenstein : 141, pl. 20, fig. 32 ; table 9.

MATERIAL. Seventy-two specimens examined from the Grey Limestone Series, of which the following have been registered in the British Museum collections: Io.2109–17.

DESCRIPTION. *Carapace* subquadrate narrowing towards the posterior. Sexual dimorphism indicated by the presence of more elongate dimorphs, considered to be the males. Greatest length through mid-point; greatest height in the anterior third; greatest width in the posterior third. Shell surface strongly reticulate, the reticulae in adults being extended into thin lamellae. Postero-dorsally a keel-like extension of the carapace projects above the dorsal margin of the valve bending down at about mid-point to die out close to the anterior margin below mid-length. Along the ventral surface a ridge is developed which turns upwards anteriorly towards an anterior vertical ridge which bounds the broad, flattened anterior border, to die out below the prominent *eye node*. The latter is situated just below the prominent, well rounded anterior cardinal angle. A short ventro-lateral ridge may be present above the ventral ridge in some specimens. Posterior marginal border also well developed. Anterior and posterior margins may possess short spines. Left valve larger than the right which it overlaps along the ventral margin and over-reaches along the antero-dorsal and postero-dorsal slopes. *Hinge* antimerodont with strongly loculate terminal sockets in the left valve and a long denticulate median bar. Accommodation groove poorly developed. In the right valve the hinge consists of some 8 anterior teeth and approximately 7 posterior teeth. Median groove poorly preserved in the present material. Inner margin and line of concrescence coincide, the *duplicature* both anteriorly and posteriorly being quite broad. *Radial pore canals* long, straight and widely spaced; 8–9 anteriorly and 4 posteriorly. The *selvage* forms a prominent ridge around the free margin, outside of which there is a narrow *flange* developed around the anterior margin and along the ventral margin. Only the 4 oval adductor scars have been seen in the present material, the anterior muscle scars not being preserved.

Dimensions

Io.2109, female left valve (Pl. 4, figs. 1–3), length 0·78 mm.; height 0·45 mm. Io.2110, female carapace (Pl. 4, figs. 11, 12), length 0·68 mm.; height 0·37 mm.; width 0·38 mm. Io.2111, male carapace (Pl. 4, figs. 6–9), length 0·74 mm.; height 0·37 mm.; width 0·37 mm. Io.2115, female left valve, length 0·61 mm.; height 0·35 mm. Io.2116, female right valve (Pl. 4, figs. 4, 5), length 0·75 mm.; height 0·40 mm. Io.2217, female right valve (Pl. 4, fig. 10), length 0·73 mm.; height 0·38 mm.

REMARKS. All the specimens of *Fuhrbergiella* present within the Grey Limestone Series are here referred to *Fuhrbergiella* (*Praefuhrbergiella*) *horrida horrida* although in some cases the presence of a short ventro-lateral ridge indicates some affinity with the subspecies *F.* (*P.*) *horrida bicostata* Brand & Malz (1962 : 21, pl. 4, figs. 38–40). The variation observed is here, however, restricted to the subspecies *F.* (*P.*) *horrida horrida*.

Genus *GLYPTOCYTHERE* Brand & Malz 1962

Glyptocythere costata sp. nov.

(Pl. 5, figs. 1–7)

DIAGNOSIS. *Glyptocythere* with subquadrate, posteriorly tapered carapace. Ornamented medially by branching transverse ridges radiating outwards from dorsal margin; ventro-laterally by single longitudinal ridge and ventrally by second longitudinal ridge.

HOLOTYPE. Io.1775, base bed 10, Ravenscar.

PARATYPES. Io.1776–82, from top and base of bed 10, and from bed 8, Ravenscar.

DESCRIPTION. *Carapace* subquadrate, tapering towards the narrowly triangular posterior. Elongate dimorphs indicate the presence of males within the population. The shell surface is strongly ornamented by irregular, branching transverse ridges which radiate downwards from the dorsal margin of the valve and by two prominent longitudinal ridges. The uppermost ridge extends along the ventro-lateral part of the carapace whilst the lower ridge, being an increased development of one of the finer longitudinal ridges which occur on the ventro-lateral and ventral surfaces, is ventral in position and in some specimens forms a prominent ventral keel. Anterior and posterior with narrow marginal border. Left valve larger than the right which it overlaps along the ventral margin and overreaches around the anterior margin, in the region of the anterior cardinal angle and along the postero-dorsal slope. Greatest length through mid-point; greatest height in the anterior third; greatest width in the posterior third. Anterior broadly rounded, posterior narrow, triangular, with short, concave, postero-dorsal slope and convex postero-ventral slope. Ventral margin incurved medially. Dorsal margin strongly convex in the right valve concave in the left. A low *eye swelling* is suggested in the right valve only, elongate in outline and situated below the anterior cardinal angle. Internal characters not observed.

Dimensions

Holotype, Io.1775, female carapace (Pl. 5, figs. 1–4), length 0·65 mm.; height 0·40 mm.; width 0·37 mm.

Io.1776, female right valve (Pl. 5, fig. 7), length 0·62 mm.; height 0·35 mm. Io.1777, female carapace, length 0·60 mm.; height 0·38 mm.; width 0·36 mm. Io.1780, male carapace, length 0·80 mm.; height 0·43 mm.; width 0·42 mm. Io.1782, male carapace (Pl. 5, figs. 5, 6), length (broken) 0·59 mm.; height 0·34 mm.; width 0·32 mm.

REMARKS. So far this species has only been found in sediments of the Grey Limestone Series as exposed at Ravenscar. *Glyptocythere costata* resembles *Glyptocythere dorsicostata* Brand & Malz (1962*a*: 145, pl. 21, fig. 10, table 9) although it differs in being smaller with a more pronounced posterior taper and in the absence of the dorso-median ridge which characterizes the latter. *G. costata* is also close to

Progonocythere juglandica (Jones, 1884), Sylvester-Bradley (1948 : 193, pl. 12, figs. 5, 6, pl. 13, fig. 8 ; text-fig. 4) to which it could be ancestral. *G. costata*, however, differs in being smaller and in the possession of strong longitudinal ridges in the ventral and ventro-lateral regions. [It is here considered that the species *Progonocythere juglandica* should be assigned to the genus *Glyptocythere*, to which it bears greater relationship than to *Progonocythere*. This will, however, be discussed in more detail in a subsequent paper.]

Glyptocythere polita sp. nov.

(Pl. 5, figs. 8–11 ; Pl. 6, figs. 1–9)

DIAGNOSIS. *Glyptocythere* with subquadrate/subtriangular carapace. Shell surface smooth with occasional wrinkles in dorso-median part. Downwardly projected ventro-lateral margin may be extended into thin keel, particularly in female dimorph.

HOLOTYPE. Io.1724, bed 7, Hundale Point, Cloughton.

PARATYPES. Io.1725–49 and Io.2210, beds, 7 and 8, Hundale Point, Cloughton ; beds 6, 7 and 9 Ravenscar and bed 6 Bloody Beck.

DESCRIPTION. *Carapace* subquadrate to subtriangular in outline with strong sexual dimorphism : the males being much more elongate in outline and quite strongly convex in dorsal view. Greatest length of carapace through mid-point with the greatest height in the anterior third. Greatest width just behind valve middle. Left valve larger than the right which it overlaps along the ventral margin and overreaches in the region of the antero-, and postero-dorsal slopes and slightly around the anterior margin. Shell surface smooth with a shallow median sulcus marking the position of the adductor muscle scars. Occasionally there is apparent a slight wrinkling of the dorso-median part of the carapace, but this is rarely well developed. *Normal pore canals* are large, circular and prominently displayed over the valve surface. The ventral surface of each valve is strongly ornamented with longitudinal ridges some of which may be bifurcate, about 4–6 per valve, the outermost being situated along the convex ventro-lateral extension of the carapace and may be developed as a thin, blade-like keel. One or two weaker longitudinal ridges may occur outside this keel on the ventro-lateral part of the carapace. The keel, when developed appears to be restricted to the female dimorphs, being little more than a well developed ridge in the males. Anterior margin of carapace broadly rounded with flattened marginal border. Posterior triangular with marginal border, concave postero-dorsal slope, almost straight in the male, and convex postero-ventral slope. Ventral margin medially incurved, sweeping upwards posteriorly in female dimorph. Ventro-lateral margin extended below ventral surface, also sweeping strongly upwards posteriorly in the female dimorph. Dorsal margin medially concave in the left valve with prominent cardinal angles ; in the right valve medially convex, although the strong median convexity noticeable here is really dorso-median in position. *Hinge* entomodont : left valve with terminal loculate sockets and a strongly dentate median bar, especially so antero-medially. Accommodation groove virtually absent. Right

valve hinge complementary to the left. Hinge in juveniles antimerodont. *Muscle scars* consist of a subvertical row of 4 oval adductor scars with (as seen in a single specimen) a crescent-shaped antero-dorsal antennal scar. Mandibular scar not observed. This muscle scar type is placed in type A (Bate 1963 : 181) rather than type B. Inner margin and line of concrescence coincide the *duplicature* being of moderate width. *Radial pore canals* straight and widely spaced, approximately 9 anteriorly and 4 posteriorly. Anteriorly a narrow *flange* may be developed outside the *selvage* but is rarely preserved.

Dimensions

Holotype, Io.1724, female carapace (Pl. 6, figs. 1–4), length 0·84 mm. height 0·52 mm. ; width 0·47 mm.

Io.1725, male carapace (Pl. 6, figs. 5–8), length 1·18 mm. ; height 0·53 mm. ; width 0·55 mm. Io.1736, female carapace (Pl. 5, fig. 10), length 0·71 mm. ; height 0·46 mm. ; width 43 mm. Io.1737, female carapace (Pl. 6, fig. 9), length 0·85 mm. ; height 0·54 mm. ; width 0·45 mm. Io.1738, female left valve (Pl. 5, fig. 9), length 0·82 mm. ; height 0·49 mm. Io.1739, female right valve, length 0·77 mm. ; height 0·46 mm. Io.1741, female left valve (Pl. 5, fig. 11), length 0·72 mm. ; height 0·46 mm. Io.1742, male carapace, length 1·00 mm. ; height 0·50 mm. ; width 0·51 mm. Io.1743, female carapace (Pl. 5, fig. 8), length 0·93 mm. ; height 0·56 mm. ; width 0·48 mm. Io.1744, female carapace, length 0·71 mm. ; height 0·45 mm. ; width 0·37 mm.

REMARKS. In general appearance *Glyptocythere polita* is similar to *Progonocythere acuminata* sp. nov., although it is not so strongly tapered posteriorly. The main differences between these two species are to be found in the dorsal margin, that of *P. acuminata* being straight and not convex as in *G. polita*. The dorsal margin of the left valve is also almost straight, or may be slightly concave, but not strongly so as in the present species. The much straighter dorsal margin of species of *Progonocythere* and the strongly convex dorsal development of the right valve in species of *Glyptocythere* serve to distinguish the species of these respective genera.

Glyptocythere scitula sp. nov.

(Pl. 7, figs. 1–13 ; Pl. 8, figs. 1–9 ; Pl. 9, figs. 1–4 ; Text-fig. 10)

DIAGNOSIS. Squat, subquadrate to elongate *Glyptocythere* with strong branching and anastomosing ridges, radiating from dorsal margin. Ventro-lateral and ventral surfaces ornamented with longitudinal ridges, some of which bend upwards antero-ventrally. All ridges with rounded surfaces. Internal characters as for genus.

HOLOTYPE. Io.1750, bed 5, Cayton Bay section.

PARATYPES. Io.1751–74, from bed 5 Cayton Bay ; bed 5, Gristhorpe Bay ; beds 17 and 18, Bloody Beck ; 6 ft. from base and 15 ft. from base bed 12, Ravenscar and from bed 10, Hawsker.

DESCRIPTION. *Carapace* subquadrate in the female dimorph, elongate in the male.

Greatest length through mid-point ; greatest height in the anterior third. Greatest width in the posterior third. Carapace strongly convex in dorsal view, slightly constricted medially. Anterior and posterior with flattened marginal borders. Left valve larger than the right which it overlaps most strongly mid-ventrally and overreaches along the anterior, posterior and dorsal margins. The degree of overreach is most strongly developed mid-dorsally. Anterior margin broadly rounded ; posterior triangular with concave postero-dorsal slope and convex postero-ventral slope. Ventral margin medially incurved ; dorsal margin strongly concave in the left valve convex in the right. The dorsal margin in the left valve besides projecting above that of the right valve is also very much thicker, almost keel-like. Ornamentation of carapace strongly developed and consists of transverse ridges which radiate outwards and downward from the dorsal margin, branching and anastomosing to produce a coarse reticulate pattern. The ridges are rounded and not lamellate. Ventro-lateral part of carapace strongly convex and ornamented by approximately 4 longitudinal ridges. The same number of longitudinal ridges also occur along the ventral surface of each valve. The ventro-lateral ridges tend to turn upwards antero-ventrally. In some specimens the ornament is only poorly developed, here the very large, circular *normal pore canals* are particularly evident, widely scattered over the shell surface. *Hinge* entomodont : left valve with terminal loculate sockets and a strongly dentate median bar of which the anterior part is more coarsely dentate. Accommodation groove virtually absent, the valve sloping upwards to the dorsal margin from the base of the median bar. In the right valve 6 anterior and 6 posterior teeth are developed. Median groove expanded anteriorly, strongly loculate. *Muscle scars* (Type A) consist of a subvertical row of 4 oval adductor scars, a small round,

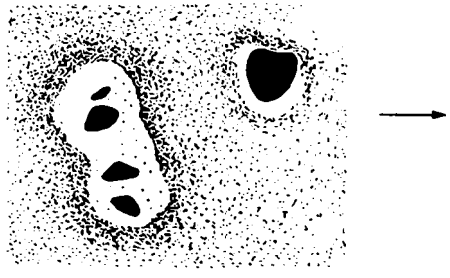


FIG. 10. Muscle scars, *Glyptocythere scitula* sp. nov. Female paratype, Io.1770, approx. ×300.

antero-dorsal antennal scar and a much larger rounded antero-ventral mandibular scar which appears as a rosette of several smaller scars. Inner margin and line of concrescence coincide the *duplicature* being of moderate width. *Radial pore canals* long, straight, 9 anteriorly and 4 posteriorly. A narrow *flange* may be present around the anterior margin outside the *selvage*, whilst in the right valve a short ventral " lip " occurs just below the ventral incurvature of the valve.

Dimensions

Holotype, Io.1750, female carapace (Pl. 8, figs. 1–4), length 0·72 mm.; height 0·47 mm.; width 0·43 mm.

Io. 1751, male left valve (Pl. 7, figs. 11, 12), length 0·82 mm.; height 0·45 mm. Io. 1752, female carapace (Pl. 8, figs. 6–9), length 0·77 mm.; height 0·50 mm.; width 0·47 mm. Io.1753, male carapace (Pl. 9, figs. 1–4), length 0·93 mm.; height 0·54 mm.; width 0·52 mm. Io.1754, female left valve (Pl. 8, fig. 5), length 0·75 mm.; height 0·48 mm. Io.1756, female right valve, length 0·63 mm.; height 0·36 mm. Io. 1760, female right valve (Pl. 7, figs. 1, 7), length (broken) 0·72 mm.; height 0·40 mm. Io.1768, female right valve (Pl. 7, figs. 4, 6, 10), length 0·60 mm.; height 0·35 mm. Io.1769, female left valve (Pl. 7, figs. 5, 9), length 0·61 mm.; height 0·37 mm. Io.1771, female right valve (Pl. 7, figs. 3, 8), length 0·68 mm.; height 0·37 mm. Io.1772, male right valve (Pl. 7, fig. 13), length 0·82 mm.; height 0·40 mm. Io.1773, female left valve, length 0·82 mm.; height 0·48 mm.

REMARKS. *Glyptocythere scitula* although smaller than *Glyptocythere tuberodentina* Brand & Malz (1962*a*: 143, pl. 21, figs. 11, 12; table 9) is similar in general appearance. The two species may, however, be distinguished by the ornamentation which in *G. tuberodentina* consists essentially of a reticulate ornament on the lateral surface with prominent longitudinal ridges ventrolaterally. Both the longitudinal ridges and the ridges which comprise the reticulations are thin and lamellate. In *G. scitula* the ornament as described consists of radiating transverse ridges which produce a coarse reticulation on branching and anastomosing. In this species the longitudinal ridges and the transverse ridges are rounded, contrasting strongly with the lamellate ridges of *G. tuberodentina*.

The known range of *G. tuberodentina* is from the middle of the *acris* Zone to the top of the *friederici-augusti* Zone of the Parkinsoni-Schichten. The range of *G. scitula* is more difficult to give precisely but probably does not occur higher than the *blagdeni* Zone of the Coronaten-Schichten.

Genus ***MALZIA*** nov.

Named after Dr. Heinz Malz of the Senckenberg Museum, Frankfurt-am-Main, Germany.

DIAGNOSIS. Progonocytherinae with subquadrate carapace, tapering to posterior. Anterior and posterior with flattened marginal borders. Ventro-lateral part of carapace extended into one or two keel-like projections. Low eye swelling developed at anterior cardinal angle. Species may be dimorphic. Hinge entomodont. Radial pore canals long and straight, approximately 8 anteriorly, 3 posteriorly. Muscle scars as for subfamily (Type A).

TYPE SPECIES. *Malzia bicarinata* sp. nov.

REMARKS. The genus *Malzia* (feminine) is erected here with two species: *M. bicarinata* having two ventro-lateral keel-like extensions and *M. unicarinata* sp. nov., having but a single valvular extension. It is considered that *Malzia* has a position

transitory between *Progonocythere* Sylvester-Bradley (1948 : 189) and *Marslatourella* Malz (1959: 19). This is suggested by the general similarity of carapace outline, muscle scars and radial pore canals present in all three. *Progonocythere* has a strong entomodont hinge and only a faint suggestion of an eye swelling. In *Marslatourella* the hinge is antimerodont and a strong eye tubercle is developed. At the same time prominent ventro-lateral outgrowths of the carapace occur. *Malzia* possesses a hinge which can be considered as entomodont, a low eye swelling and ventro-lateral outgrowths of the carapace. It appears, therefore, that the development of ventro-lateral outgrowths coupled with a change from an entomodont to an antimerodont hinge and the development of an eye tubercle results in the appearance in the Bathonian of the genus *Marslatourella*. This evolutionary series commences in the Bajocian with the genus *Progonocythere* an offshoot of which produces *Malzia*. This second lineage then continues giving rise to *Marslatourella*.

The genus *Marslatourella* described by Malz from the Bathonian of France (Mars-la Tour and Boulonnais) and Germany (Eichberg) is also common in the Bathonian sediments of England. Species of this genus will be described in forthcoming publications.

Malzia bicarinata sp. nov.

(Pl. 9, figs. 5–8 ; Pl. 10, figs. 1–3 ; Text-figs. 11–14)

DIAGNOSIS. *Malzia* with two, short, well developed ventro-lateral keels. Internal details as for genus.

HOLOTYPE. Io.1797, bed 9, Ravenscar section.

PARATYPES. Io.1798–1800, beds 7 and 8, Ravenscar and bed 7, Bloody Beck.

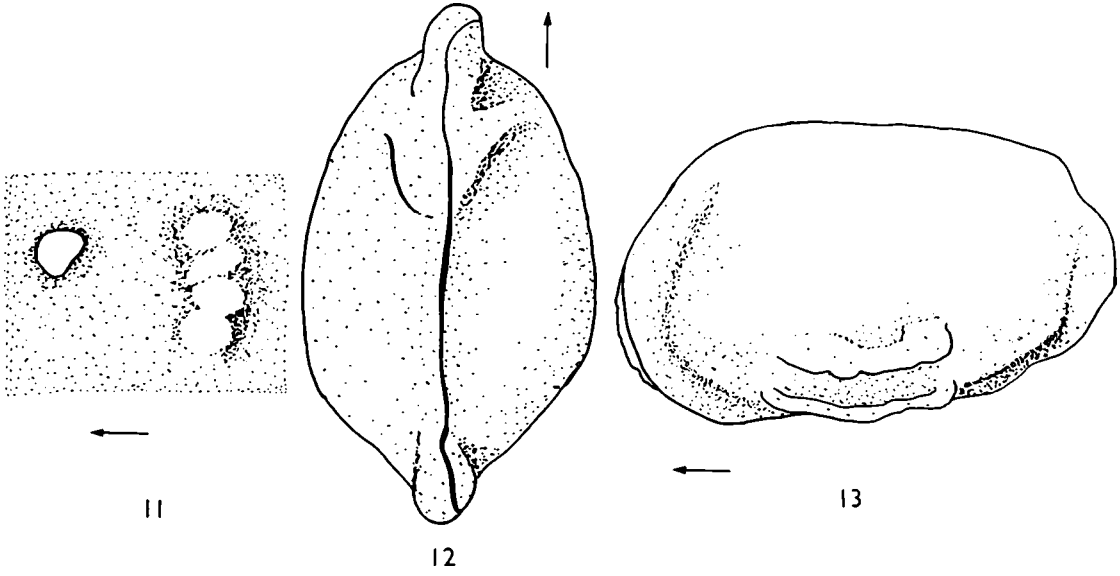


FIG. 11. Muscle scars. *Malzia bicarinata* sp. nov. Paratype, Io.1800, approx. ×290.

FIGS. 12–13. Dorsal and left views, complete carapace *Malzia bicarinata* sp. nov. Holotype, Io.1797, approx. ×85.

DESCRIPTION. *Carapace* subquadrate in outline with straight or very slightly convex dorsal margin. Cardinal angles well developed. Anterior rounded; posterior triangular with concave postero-dorsal slope and convex postero-ventral slope. Ventral margin medially incurved. Anterior and posterior with flattened marginal borders. Shell surface laterally smooth with two, stubby keels developed, the uppermost of which tends to project slightly outwards, particularly noticeable in dorsal view. Ventral surface may be smooth or possess two longitudinal ridges on each valve. A low *eye swelling* is situated just below the anterior cardinal angle, particularly noticeable in the right valve. Greatest length of carapace through mid-point; greatest height in the anterior third; greatest width in the posterior third. Left valve larger than the right which it overlaps mid-ventrally and slightly over-reaches around the posterior and along the dorsal margin. *Hinge* entomodont, only seen in the left valve where the terminal loculate sockets are separated by a dentate median bar the dentition of which increases in coarseness towards the anterior. Accommodation groove narrow, elongate. *Muscle scars* (Type A), the antennal scar being round and antero-dorsal in position. Mandibular scar not seen. *Radial pore canals* straight and simple: approximately 8 anteriorly and 3 posteriorly. *Duplicature* in completely seen in present material. *Selvage* prominent external to which there is a narrow *flange* developed around the anterior margin and along the ventral margin.

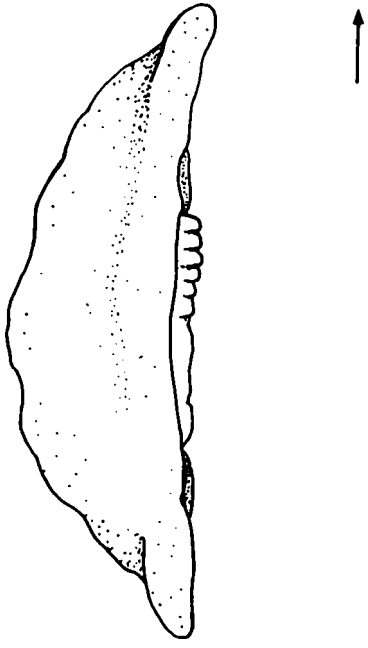


FIG. 14. Dorsal view, left valve hinge, *Malzia bicarinata* sp. nov. Paratype, Io.1799, approx. ×105.

Dimensions

Holotype, Io.1797, carapace (Pl. 9, figs. 5–8; Text-figs. 12–13), length 0·70 mm.; height 0·43 mm.; width 0·41 mm.

Io.1798, carapace (Pl. 10, fig. 1), length 0·69 mm. ; height 0·43 mm. ; width 0·38 mm. Io.1799, left valve (Pl. 10, figs. 2, 3 ; Text-fig. 14), length 0·70 mm. ; height 0·43 mm.

REMARKS. *Malzia bicarinata* cannot easily be confused with *Marslatourella exposita* Malz (1959 : 20, text-figs. 1–4), lacking the prominent eye tubercle and antimerodont type hinge of the latter. It is, however, sufficiently close as to be considered ancestral to *M. exposita*. The present species differs from species of *Progonocythere* in the development of ventro-lateral outgrowths of the carapace and in the development of an eye swelling. Although some species of *Progonocythere* may show the development of an eye swelling it is not so prominent as in *Malzia* although even here it is hardly a dominant feature of the carapace.

Malzia unicarinata sp. nov.

(Pl. 10, figs. 4–10 ; Pl. 11, fig. 1–4 ; Text-fig. 15)

DIAGNOSIS. *Malzia*, with single ventro-lateral keel. Dimorphic.

HOLOTYPE. Io.1801, bed 9, Ravenscar section.

PARATYPES. Io.1802–6, beds 8 and 10, Ravenscar and bed 4, Bloody Beck.

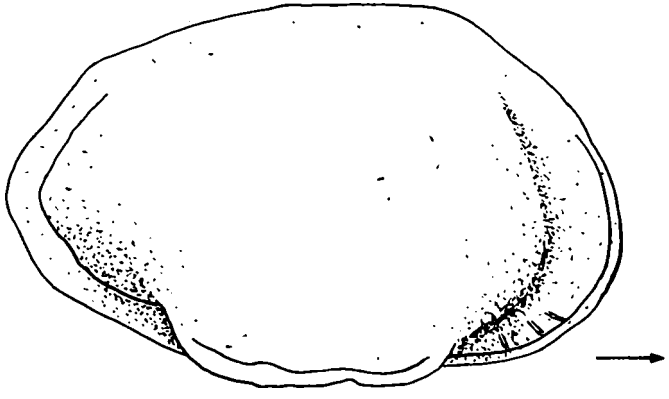


FIG. 15. Right side, female carapace, *Malzia unicarinata* sp. nov. Holotype, Io.1801, approx. ×105.

DESCRIPTION. *Carapace* subquadrate in outline in the female dimorphs, elongate in the male. Ventro-lateral part of carapace convex, extended as a short, rather stubby keel. Greatest length through mid-point ; greatest height in the anterior third ; greatest width in the posterior third. Shell surface punctate. Anterior broadly rounded ; posterior broadly triangular with concave postero-dorsal slope and convex postero-ventral slope. Ventral margin medially incurved. Dorsal margin very slightly convex in the female, straight in the male although slightly concave just behind the anterior cardinal angle. Cardinal angles prominent, the anterior angle being broadly rounded with the posterior angle tending to be more acute. Anterior and posterior margins with well defined borders. *Eye swelling* elongate in

outline situated below the anterior cardinal angle, more prominently developed in the male dimorph. Left valve larger than the right which it overlaps mid-ventrally and overreaches along the remaining part of the ventral margin and along the dorsal margin. Internal details not seen. *Radial pore canals* as seen from the exterior straight and widely spaced, approximately 8 anteriorly and 3 posteriorly. A narrow *flange* extends around the anterior margin and although not clearly seen probably also along the ventral margin.

Dimensions

Holotype Io.1801, female carapace (Pl. 10, figs. 4–8 ; Text-fig. 15), length 0·71 mm. ; height 0·42 mm. ; width 0·41 mm.

Io.1802, female carapace (Pl. 10, figs. 9, 10), length 0·73 mm. ; height 0·44 mm. ; width 0·43 mm. Io.1804, female carapace, length 0·75 mm. ; height 0·46 mm. ; width 0·43 mm. Io.1806, male carapace (Pl. 11, figs. 1–4), length 0·85 mm. ; height 0·45 mm. ; width 0·44 mm.

REMARKS. *Malzia unicarinata* is distinguished easily from *M. bicarinata* by the possession of but a single ventro-lateral keel. The male dimorph of *M. unicarinata* is, however, similar to *Progonocythere acuminata* sp. nov., from which it can be identified by the mid-laterally swollen, strongly convex carapace, a feature which characterizes species of this genus, and by the possession of a short stubby keel.

Genus ***PROGONOCYTHERE*** Sylvester-Bradley 1948

Progonocythere acuminata sp. nov.

(Pl. 11, figs. 5–10 ; Pl. 12, figs. 1–4)

DIAGNOSIS. *Progonocythere* with posteriorly acuminate carapace. Ventro-lateral margin convex with knife-edge keel developed in some specimens. Lateral surface smooth, though may possess faint transverse furrows medially. Low eye swelling at anterior cardinal angle. Ventral surface with longitudinal ridges in region of ventro-lateral overhang. Anterior with well developed border.

HOLOTYPE. Io.1783, bed 7, Hundale Point, Cloughton.

PARATYPES. Io.1784–91, bed 7, Hundale Point ; bed 6, Cayton Bay ; bed 7, Bogmire Gill ; top bed 7, Ravenscar and bed 10, Hawsker.

DESCRIPTION. *Carapace* elongate, tapering strongly towards the sharply acuminate posterior. Sexual dimorphism not apparent. The ventro-lateral border of the carapace is extended below the ventral surface and generally possesses a thin, knife-edge keel, developed from one of the longitudinal ridges which extend along the undersurface of the ventro-lateral part of the carapace, remainder of ventral surface smooth. The ventro-lateral margin of the carapace sweeps obliquely upwards just behind valve middle. Shell surface smooth, although weak transverse furrows may be observed in some specimens in the mid-lateral area. *Normal pore canals* often well developed, large and circular, widely scattered over the carapace. Greatest length

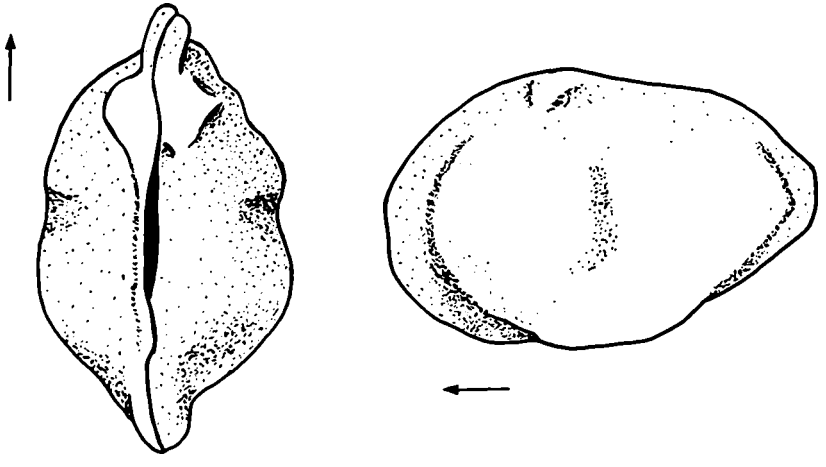
through mid-point ; greatest height in the anterior third ; greatest width at or just behind middle. A shallow, indistinct sulcus, medially situated marks the position of the adductor *muscle scars*. Anterior broadly rounded with a distinct marginal border ; posterior narrow, acuminate with a short, concave postero-dorsal slope and a convex postero-ventral slope. Ventral margin broadly concave. Dorsal margin slightly convex in the right valve slightly concave medially in the left. Cardinal angles prominent. Below the anterior cardinal angle an oblique swelling, separated off from the convex part of the carapace below by an oblique groove, is suggestive of an eye swelling. Left valve larger than the right which it overlaps along the ventral margin and overreaches along the dorsal margin and around the anterior. The left valve may also overreach the right along the postero-dorsal slope but not at the extreme posterior. *Hinge* poorly seen in a single individual (left valve) where the terminal sockets are separated by a median groove which can be made out as dentate. Accommodation groove elongate, deep. *Duplicature* appears to be of moderate width, but imperfectly seen. Other internal details not observed.

Dimensions

Holotype, Io.1783, carapace (Pl. 12, figs. 1–4), length 0·80 mm. ; height 0·49 mm. ; width 0·38 mm.

Io.1784, left valve, length 0·71 mm. ; height 0·41 mm. Io.1786, left valve (Pl. 11, figs. 7, 8), length 0·60 mm. ; height 0·36 mm. Io.1787, carapace (Pl. 11, figs. 9, 10), length 0·69 mm. ; height 0·41 mm. ; width 0·34 mm. Io.1789, carapace (Pl. 11, figs. 5, 6), length 0·73 mm. ; height 0·41 mm. ; width 0·36 mm. Io.1791, right valve, length 0·71 mm. ; height 0·36 mm.

REMARKS. The similarity of *P. acuminata* to the male dimorph of *Malzia unicarinata* has already been discussed and need not be gone into again. The male dimorph of *Progonocythere yonsnabensis* sp. nov. also bears some resemblance to the



FIGS. 16–17. Dorsal and left views, female carapace, *Progonocythere yonsnabensis* sp. nov. Holotype, Io. 1792, approx. ×95.

present species although it can be readily distinguished by its much smaller size and by the distinct median sulcus not present to such an extent here.

Progonocythere yonsnabensis sp. nov.

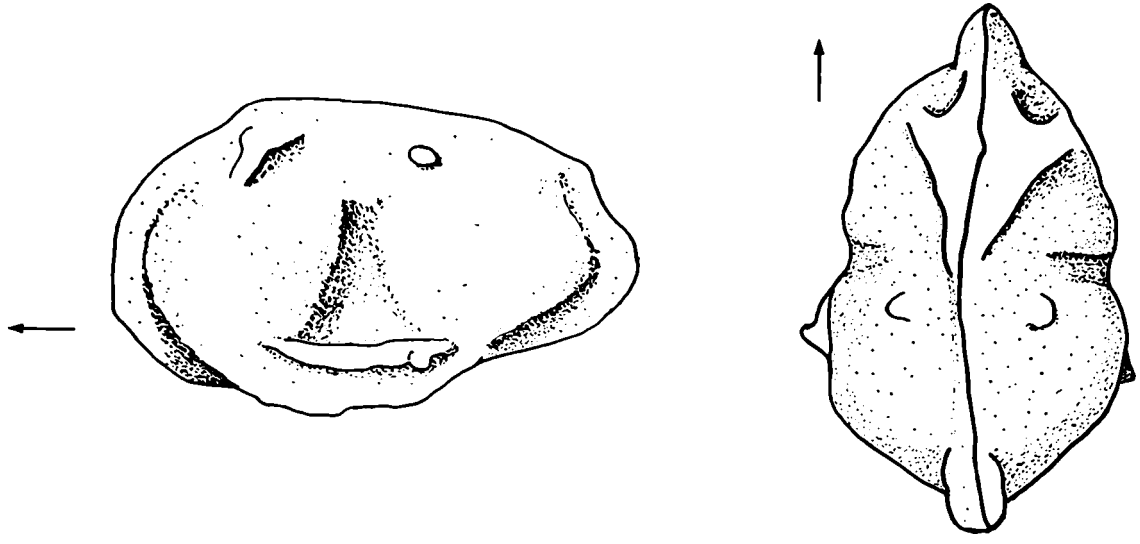
(Pl. 12, figs. 5–14 ; Pl. 13, figs. 1–4 ; Text-figs. 16–19)

DIAGNOSIS. Small progonocytherid with distinct median sulcus. Eye swelling prominent. Ventro-lateral margin extended into ventral keel. Shell surface punctate.

HOLOTYPE. Io.1792, bed 5, Cayton Bay section.

PARATYPES. Io.1793–96, horizon and locality as above.

DESCRIPTION. *Carapace* small, subquadrate ; elongate in the male dimorph. Greatest length through mid-point ; greatest height in the anterior third ; greatest width in the posterior third. As seen in dorsal view a shallow sulcus divides the carapace into an anterior and a posterior half. This sulcus is more strongly developed in the female. Ventro-lateral margin strongly convex, extended ventrally into a prominent keel. In a single male specimen there is a second, short keel dorsal to the first and terminating in a small node. Almost directly above this node a second node is situated dorso-medially on each valve of the carapace posterior to the median sulcus. In all other respects this specimen is identical to the others. Dorsal margin strongly convex in the left valve, slightly convex in the right. Anterior rounded with a short, obliquely convex antero-dorsal slope. Posterior triangular : postero-dorsal slope concave ; postero-ventral slope convex. Ventral margin medially incurved. Cardinal angles prominent, the posterior angle being the more strongly angled of the two, anterior angle tending to be broadly rounded. A prominent oval



FIGS. 18–19. Left and dorsal views, male carapace, *Progonocythere yonsnabensis* sp. nov., showing development of second keel and tubercles. Paratype, Io.1795, approx. ×95.

eye swelling is situated below the anterior cardinal angle. Anterior and posterior marginal borders distinct. Shell surface punctate. Left valve larger than the right which it overlaps mid-ventrally and overreaches postero-ventrally, postero-dorsally and antero-dorsally. Mid-dorsally the left valve is strongly projected above the right. There is little or no overreach around the anterior margin. Internal characters not observed for this species.

Dimensions

Holotype, Io.1792, female carapace (Pl. 12, figs. 5–8 ; Text-figs. 16–17), length 0·54 mm. ; height 0·32 mm. ; width 0·30 mm.

Io.1793, male carapace (Pl. 12, figs. 11–14), length 0·57 mm. ; height 0·34 mm. ; width 0·31 mm. Io.1794, female carapace (Pl. 12, figs. 9, 10), length 0·60 mm. ; height 0·36 mm. ; width 0·35 mm. Io.1795, male carapace (Pl. 13, figs. 1–4 ; Text-figs. 18–19), length 0·63 mm. ; height 0·36 mm. ; width 0·35 mm.

REMARKS. The single specimen (Io.1795) mentioned in the description, possessing two ventro-lateral keels and two lateral nodes is considered to be simply an extreme variant of the present species. Possibly this morphological variation may have been brought about by changes in the salinity of the water. Morphologically the possession of two lateral keels results in this specimen having some resemblance to *Malzia bicarinata*, although it can be distinguished by the possession of a prominent median sulcus and a very much smaller adult size.

The species *Progonocythere yonsnabensis* more closely resembles *Progonocythere cristata* Bate (1963 : 191, pl. 4, figs. 5–15 ; pl. 5, figs. 1–6) than any other ostracod. It is, however more strongly sulcate, possesses a more prominent eye swelling and is very much smaller.

Subfamily **PLEUROCYTHERINAE** Mandelstam 1960

Genus ***PLEUROCYTHERE*** Triebel 1951

Pleurocythere sp.

(Pl. 13, fig. 5)

REMARKS. A single left valve belonging to the genus *Pleurocythere* but not readily assignable to any known species is here recorded from the Gristhorpe Bay section, bed 4. The ornamentation of the valve consists of a longitudinal ventro-lateral ridge, an oblique median ridge and a short diagonal ridge which is situated below the anterior cardinal angle. This short ridge V's downwards, connected by a short ridge at the apex of the V to the median ridge. The dorsal end of the diagonal ridge terminates in an eye swelling. Shell surface between the ridges strongly reticulate.

Dimensions. Io.1836, left valve (Pl. 13, fig. 5), length 0·80 mm. ; height 0·35 mm.

Family **CYTHERIDEIDAE** Sars 1925

Subfamily **CYTHERIDEINAE** Sars 1925

Genus ***VERNONIELLA*** Oertli 1957

REMARKS. The genus as diagnosed by Oertli (1957 : 659) possesses either a hemimerodont or antimerodont type hinge, and is considered to be without any strong ornamentation. Two species are here placed in *Vernoniella* : *V. bajociana* sp. nov., a smooth form possessing an antimerodont hinge and the strongly ornamented *V.* ? *caytonensis* sp. nov. There is, however, some uncertainty concerning the generic designation of the last named species.

Vernoniella bajociana sp. nov.

(Pl. 13, figs. 6–11 ; Pl. 14, figs. 1–13)

DIAGNOSIS. *Vernoniella* with subquadrate carapace, elongate in male dimorphs. Shell surface finely punctate. Anterior and posterior margins with narrow marginal borders. Hinge antimerodont. Radial pore canals long, straight, approximately 10–11 anteriorly, 4–5 posteriorly.

HOLOTYPE. Io.1807, bed 23, Hundale Point, Cloughton.

PARATYPES. Io.1808–30 and Io.2988, bed 5, Cayton Bay ; beds 7, 8, 23 and 25, Hundale Point ; bed 12, Ravenscar and beds 9 and 10, Hawsker.

DESCRIPTION. *Carapace* subquadrate to subtriangular in the female dimorph, elongate in the male. Shell surface punctate. Ventral surface may possess weak longitudinal ridges. In the dorso-median part of the carapace the valve is slightly constricted and here may exhibit weak, transverse furrowing. Greatest length of carapace through mid-point ; greatest height in the anterior third ; greatest width in the posterior third, although there is here only a slight increase over the width in the anterior third. Carapace appears compressed in dorsal view, almost parallel-sided. Dorsal margin medially concave in the left valve (both dimorphs), convex in the right. Cardinal angles in both valves prominent : anterior angle broadly rounded, posterior angle sharply angled and situated at extreme posterior of the carapace. Ventral margin medially incurved. Ventral surface overhung slightly by the convex ventrolateral margin. The incurving of the ventral surface produces, particularly in the male, an enlarged anterior portion of the carapace as seen in lateral view. Anterior broadly rounded with marginal border which is separated off from the convex lateral part of the carapace by a marginal groove. Posterior broadly triangular with a steeply angled, straight or slightly convex postero-dorsal slope and a convex postero-ventral slope. Left valve larger than the right which it overlaps along the ventral and postero-ventral margins and overreaches around the anterior margin and along the postero-dorsal slope. Mid-dorsally the convex dorsal margin of the right valve projects above the left. *Hinge* antimerodont : left valve with terminal loculate sockets and a strong denticulate median bar. No accommodation groove. Right valve with 6 terminal teeth, dorsally bifid and an elongate, finely locellate median groove. *Muscle scars* (Type B?) with a subvertical row of 4 oval adductor scars, a rounded antero-ventral mandibular scar which as seen in one individual is composed of a rosette of several small scars and an antero-dorsal antennal scar which is cloverleaf in shape. The antennal scar appears to be formed by the fusion of at least three

scars which together form a clover-leaf pattern, or may appear rounded. Between the antennal scar and the dorsal adductor scar there is a large depression which is the mandibular support spot. This muscle scar arrangement is tentatively placed as Type B. Inner margin and line of concrescence coincide, the *duplicature* being of moderate width. Radial pore canals straight, approximately 10–11 anteriorly and 4–5 posteriorly. Outside the *selvage* in the right valve a *flange* is developed around the anterior margin, extending back along the ventral margin, where it expands opposite the ventral incurvature into a broad " lip ".

Dimensions

Holotype, Io.1807, female carapace (Pl. 13, figs. 6–9), length 0·67 mm. ; height 0·38 mm. ; width 0·30 mm.

Io. 1808, female carapace (Pl. 13, figs. 10, 11), length 0·66 mm. ; height 0·37 mm. width 0·26 mm. Io.1812, female left valve, length 0·69 mm. ; height 0·44 mm. Io.1814, male carapace (Pl. 14, figs. 1–4), length 0·84 mm. ; height 0·43 mm. ; width 0·29 mm. Io.1816, female carapace, length 0·61 mm. ; height 0·34 mm. ; width 0·28 mm. Io.1818, female left valve (Pl. 14, figs. 5–9), length 0·48 mm. ; height 0·31 mm. Io.1819, female right valve (Pl. 14, figs. 10, 12, 13), length 0·65 mm. ; height 0·37 mm. Io.1821, male carapace, length 0·68 mm. ; height 0·37 mm. ; width 0·28.

REMARKS. *Vernoniella bajociana* is similar in general external appearance to *V. sequana* Oertli (1957 : 659, pl. 3, figs. 70–85) but has an antimerodont instead of a hemimerodont hinge, and also lacks the accommodation groove which is present in *V. sequana*. *V. bajociana* has a distinct marginal border, a feature not present in Oertli's species.

Vernoniella* ? *caytonensis sp. nov.

(Pl. 15, figs. 1–9)

DIAGNOSIS. *Vernoniella* ? with elongate, posteriorly acuminate carapace. Shell surface strongly ornamented by 4–5 longitudinal ridges arranged in broad, inverted V. Two to three obliquely transverse ridges occur anterior to these. Anterior and posterior with distinct marginal borders. Normal pore canals prominent.

HOLOTYPE. Io.1855, bed 6, Cayton Bay section.

PARATYPES. Io.1856–69, bed 4, Gristhorpe Bay ; bed 6 Cayton Bay and bed 11, Hawsker.

DESCRIPTION. *Carapace* elongate tapering towards the narrowly rounded posterior. Greatest length through mid-point ; greatest height in the anterior third ; greatest width in the posterior third. In dorsal view the carapace is slightly constricted medially. Anterior broadly rounded ; posterior narrowly rounded with steeply angled, convex postero-dorsal slope and convex postero-ventral slope. Dorsal margin in the right valve medially convex, in the left valve thickened and medially concave. Cardinal angles prominent ; the anterior angle being broadly

rounded, posterior angle more acute, situated at extreme posterior of carapace. Anterior and posterior with distinct marginal borders. Ventral margin medially incurved. Shell surface strongly ornamented by 4–5 longitudinal ridges arranged in a broad inverted V, the lowermost being almost straight. These ridges are situated on the strongly convex part of the carapace which is cut off posteriorly by the posterior border and anteriorly by an oblique groove running just behind and below the anterior cardinal angle. In front of this groove there are 2–3 obliquely transverse ridges which antero-ventrally bend back to extend along the ventro-lateral and ventral surfaces where weak longitudinal ridges may be made out. *Normal pore canals* distinctly seen along the ventral surface where they are large and circular, elsewhere tending to be masked by lateral ornamentation. Left valve larger than the right which it overlaps along the ventral margin and overreaches in the region of the antero-dorsal and postero-dorsal slope. *Hinge* incompletely seen : right valve with the terminal elements consisting of approximately 6 dorsally bifid teeth. Median groove obscured by matrix. Left valve hinge not seen. Inner margin and line of concrescence appear to coincide. *Radial pore canals* long, straight and widely spaced, approximately 8 anteriorly and 3–4 posteriorly. Below the ventral incurvature in the right valve an elongate " lip " is developed.

Dimensions

Holotype, Io.1855, carapace (Pl. 15, figs. 1–4), length 0·63 mm. ; height 0·33 mm. ; width 0·30 mm.

Io.1857, right valve (Pl. 15, figs. 8, 9), length 0·66 mm. ; height 0·33 mm. Io.1858, carapace (Pl. 15, figs. 5–7), length 0·66 mm. ; height 0·37 mm. ; width 0·32 mm.

REMARKS. In outline this species approaches *Vernoniella* and as a result has been placed tentatively in that genus. It is, however, a strongly ornamented form whose hinge and muscle scars are as yet unknown.

Vernoniella ? caytonensis resembles the male dimorph of *Eocytheridea carinata* Bate (1964 : 18, pl. 5, figs. 5–8) primarily because of the similarity of ornament although it is easily distinguishable by the more prominent posterior cardinal angle, the not so strongly tapered carapace, and by the more strongly pronounced marginal borders.

Genus ***LJUBIMOVELLA*** Malz 1961

Ljubimovella piriformis Malz

(Pl. 15, figs. 10–13 ; Pl. 16, figs. 1, 2)

1949. Ostracod 96 Brand : 337, pl. 10 (fauna 2), fig. 4, pl. 14.
1961. *Ljubimovella piriformis* Malz : 165, pl. 2, figs. 15–25 ; text-figs. 2–3.
1962. *Ljubimovella piriformis* Malz : Brand & Fahrion : 134, pl. 20, fig. 33 ; table 9.

MATERIAL. Twenty-three specimens examined from the Grey Limestone Series, of which the following have been registered in the British Museum collections : Io.2103–08.

DESCRIPTION. *Carapace* piriform, very much enlarged in the anterior third, in which region it attains maximum height. Greatest length below mid-point ; greatest width at, or in front of valve centre. A strong, downwardly projected spine is developed at the postero-ventral angle whilst a much shorter spine may also be present on the lower half of the anterior margin. Shell surface smooth except for the ventral surface where a number of fine longitudinal striae occur. *Normal pore canals* circular and widely scattered over the surface. Dorsal margin slightly concave medially ; cardinal angles broadly rounded, although the posterior angle may be acute. Ventral margin with a strong median incurvature. Anterior broadly rounded ; posterior obliquely rounded with a relatively long, convex postero-dorsal slope and a short, almost vertical but slightly convex postero-ventral slope which terminates in the prominent posterior spine. Left valve larger than the right which it overlaps along the ventral margin. Along the antero-dorsal and postero-dorsal slopes the left valve tends to overreach the right, whilst mid-dorsally the right valve overreaches the left. *Hinge* hemimerodont : left valve without an accommodation groove ; right valve with smooth median groove and terminal dentate elements. *Muscle scars* not clearly seen. Inner margin and line of concrescence coincide. *Radial pore canals* short and widest at their base, 5 in number antero-ventrally and 5 postero-ventrally, of which the lowermost passes down through the centre of the posterior spine. A well developed *flange* extends around the anterior margin and along the ventral margin in the right valve, not observed in the left valve probably because of the preservation of the material.

Dimensions

Io.2103, carapace, length 0·69 mm. ; height 0·34 mm. ; width 0·31 mm. Io.2106, carapace (Pl. 16, figs. 1, 2), length 0·75 mm. ; height 0·40 mm. ; width 0·32 mm. Io.2107, juv, carapace (Pl. 15, figs. 10, 11), length 0·44 mm. ; height 0·25 mm. ; width 0·22 mm. Io.2108, right valve (Pl. 15, figs. 12, 13), length 0·72 mm. ; height 0·37 mm.

REMARKS. The single juvenile specimen observed of this species exhibits a much enlarged anterior half of the carapace. It would appear that in subsequent instars of the species there is a proportionately greater increase in the posterior part of the carapace, a process almost certainly related to the development of the reproductive organs as the animal reaches maturity.

Family **SCHULERIDEIDAE** Mandelstam 1959
Subfamily **SCHULERIDEINAE** Mandelstam 1959
Genus ***MESOCYTHERIDEA*** nov.

DIAGNOSIS. Schulerideinae with oval/subquadrate carapace. Central part of valve strongly cut off from remainder of carapace by oblique groove below the anterior and posterior cardinal angles, particularly well developed in right valve. Dorso-median part of right valve strongly projected above dorsal margin. Hinge anti-

merodont with anterior socket of left valve cutting back into median bar. Radial pore canals long, slightly curved, 10 anteriorly, 4 posteriorly. Inner margin and line of concrescence coincident. Muscle scars (Type C) as for family. Left valve larger than right.

TYPE SPECIES. *Mesocytheridea howardianensis* sp. nov.

REMARKS. The genus (feminine) is close to *Eocytheridea* Bate (1963*a* : 35) from which it has probably evolved. *Mesocytheridea* is distinguishable from *Eocytheridea* by the presence of a strongly antimerodont hinge and a slight reduction in the number of anterior radial pore canals (10 as against 14) which tend to be straighter. The species *Eocytheridea carinata* Bate (1964 : 18, pl. 4, figs. 6–11 ; pl. 5, figs. 1–8) is very close to this genus but has a hemimerodont hinge and the radial pore canals are slightly more curved.

Mesocytheridea howardianensis sp. nov.

(Pl. 16, figs. 3–11 ; Pl. 17, figs. 1–3 ; Text-figs. 20, 21)

DIAGNOSIS. *Mesocytheridea* with oval/subquadrate carapace, convex in dorsal view. Ornamentation consists of some 5–6 low, broad ridges arranged in an inverted V. The lowermost, ventro-lateral ridges are longitudinal, thereby forming base to V. Ornamentation never strong, may be almost completely lacking, when shell appears smooth. Shell surface with prominent, circular, normal pore canals. Hinge, muscle scars, radial pore canals as for genus. Left valve larger than right. Species dimorphic.

HOLOTYPE. Io.1870, bed 2, Stonecliff Wood, locality SE/740675.

PARATYPES. Io.1871–81, horizon and locality as above and 1 ft. 6 in. and 3 ft. 8 in. from base bed 8, Stonecliff Wood, locality SE/743676.

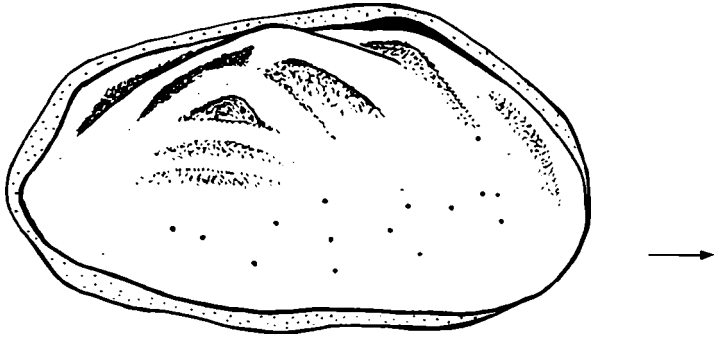


FIG. 20. Right view, female carapace, *Mesocytheridea howardianensis* sp. nov. Holotype, Io.1870, approx. ×93.

DESCRIPTION. *Carapace* oval/subquadrate, the male dimorphs being more elongate in outline. Greatest length through mid-point ; greatest height in the anterior third ; greatest width in the posterior third. Dorsal margin medially concave in the left valve with well rounded cardinal angles. In the male dimorph the dorso-median

part of the left valve tends to project slightly above the dorsal margin, but not so strongly as in the right valve. Cardinal angles in the right valve more acute than in the left. Ventral margin medially incurved, convex in the posterior half where the carapace appears to be noticeably swollen. Anterior rounded with oblique, straight or slightly convex antero-dorsal slope. Posterior narrowly rounded with convex postero-dorsal and postero-ventral slopes. Narrow, convex, anterior and posterior marginal borders are separated from the lateral part of the carapace by a marginal groove. Dorsal margin of the left valve noticeably thickened. Shell surface with something like 5–6 low, rather poorly developed ridges which are arranged in the form of an inverted V, the apex of which reaches the dorsal margin, more noticeably developed in the right valve. Several of the lower, ventro-lateral ridges are straight and form a base to the inverted V. A strong diagonal groove separates the central part of the valve from the terminal parts, particularly in the right valve. The anterior groove extends diagonally below the anterior cardinal angle whilst the posterior groove extends below the posterior angle. A transverse ridge extends from the anterior cardinal angle towards the antero-ventral angle. Remainder of shell surface punctate, although a few very minor ridges may connect some of the antero-dorsal ridges. The degree with which the ornamentation is developed varies with each individual, but is often so poorly represented that the specimen appears smooth.

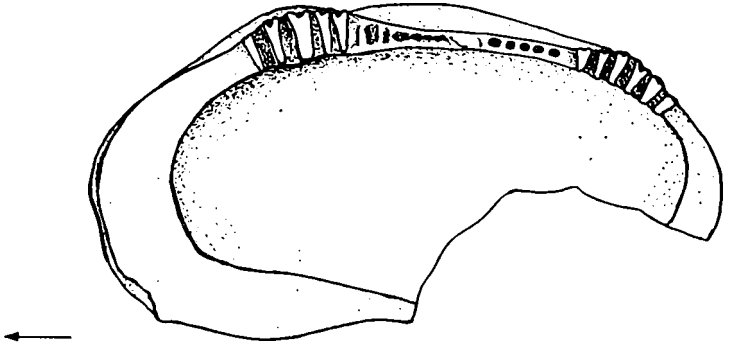


FIG. 21. Internal view, right valve showing hinge, *Mesocytheridea howardianensis* sp. nov. Paratype, Io. 1879, approx. ×95.

In all cases the *normal pore canals* which are large and circular, are prominently displayed over the shell surface. Left valve larger than the right which it overlaps along the ventral margin and overreaches practically everywhere else apart from mid-dorsally where the two valves are drawn apart. *Hinge* antimerodont: left valve with elongate terminal loculate sockets separated by a strong, denticulate median bar. The anterior socket, and to some extent the posterior socket also, tends to cut back into the median bar. There is virtually no accommodation groove. In the right valve the median groove is quite strongly locellate, whilst terminally there are 5 anterior and 7 posterior teeth, all dorsally bifid and well developed. *Muscle scars* (Type C) consist of a slightly crescentic row of 4 oval adductor scars with an antero-median, round, antennal scar. No mandibular scar observed. Inner margin and

line of concrescence coincide, *duplicature* being quite broad. *Radial pore canals* long and widely spaced, some straight others slightly curved ; 10 anteriorly and 4 posteriorly.

Dimensions

Holotype, Io.1870, female carapace (Pl. 16, figs. 3–6 ; Text-fig. 20), length 0·73 mm. ; height 0·43 mm. ; width 0·38 mm.

Io.1871, female right valve (Pl. 16, fig. 9, Pl. 17, figs. 2, 3), length 0·71 mm. ; height 0·37 mm. Io.1872, male left valve (Pl. 17, fig. 1), length 0·93 mm. ; height 0·47 mm. Io.1875, female left valve (Pl. 16, fig. 11), length 0·76 mm. ; height 0·44 mm. Io.1877, male right valve, length 0·71 mm. ; height 0·36 mm. Io.1879, male right valve (Pl. 16, figs. 8, 10), length 0·78 mm. ; height 0·41 mm. Io.1881, female left valve (Pl. 16, fig. 7), length 0·71 mm. ; height 0·41 mm.

REMARKS. This is a much larger species than *Eocytheridea carinata* with which it bears some resemblance, although in *M. howardianensis* the ornamentation tends to be much weaker and the presence of a strong antimerodont hinge and a slight reduction in the number of radial pore canals help to distinguish the two species. The majority of the specimens examined come from the uppermost beds of the Grey Limestone Series as exposed along the western shore-line. However a population belonging to this species has been found at the base of the Series in the Bloody Beck section. The specimens here are generally smaller, no males having been found and are very poorly ornamented. They are not, however, considered to be sufficiently distinct as to be separated specifically.

Genus ***PRAESCHULERIDEA*** Bate 1963

Praeschuleridea subtrigona (Jones & Sherborn 1888)

SYNONYMY. See Bate (1964 : 22).

REMARKS. Two subspecies of *P. subtrigona* have been recognized : *P. subtrigona subtrigona* having a size range of up to 0·56 mm. in the female dimorph and 0·58 mm. in the male ; and *P. subtrigona magna* where the range extends to 0·73 mm. for the female and 0·83 mm. for the male. Within the Grey Limestone Series, however, there is a third subspecies having a maximum size of about 0·68 mm. for the female and 0·77 mm.–0·82 mm. for the male. There are also a number of minor morphological details which help to distinguish this third subspecies. As all the specimens examined from the Grey Limestone Series fall into this intermediate range the subspecies *Praeschuleridea subtrigona intermedia* subsp. nov. has been erected to account for them.

Praeschuleridea subtrigona intermedia subsp. nov.

(Pl. 17, figs. 4–10 ; Pl. 18, figs. 1–9)

DIAGNOSIS. A subspecies of *Praeschuleridea subtrigona* in which adult female is of the order of 0·68 mm. and male is 0·77 mm. to 0·82 mm. Carapace subtrigonal,

punctate. Posterior dorsal margin virtually straight, sloping strongly to posterior. Anterior dorsal margin long, obliquely convex. Posterior with steeply inclined, convex postero-ventral slope. Anterior with narrow marginal border; posterior border poorly developed.

HOLOTYPE. Io.1837, bed 7, Hundale Point, Cloughton.

PARATYPES. Io.1838–54, bed 4, Gristhorpe Bay; bed 12, White Nab, Scarborough; bed 7 & base bed 22, Hundale Point and bed 2 Stonecliff Wood, locality SE/740675.

DESCRIPTION. *Carapace* subtrigonal in outline, more elongate in the male dimorph. Shell surface finely punctate. *Normal pore canals* fairly large, circular, evenly scattered over carapace. A very low *eye swelling* may be seen on the right valve, female dimorph and slightly more strongly developed in the right valve of the male, situated below the anterior cardinal angle, not observed in the left valve of either dimorph. Greatest length passes through mid-point; greatest height and width approximately at centre of carapace. A narrow marginal border delimited along its inner side by a marginal groove extends around the anterior margin, only poorly developed around the posterior. Left valve larger than the right which it overlaps along the ventral margin and overreaches elsewhere around the carapace. Dorsal margin " umbonate " the highest point being just about at valve centre, the dorsal margin sloping steeply away from this point to the anterior and posterior. Anteriorly the dorsal margin is broadly convex and passes into the anterior margin without a break. Posteriorly the dorsal margin is steeply angled, straight or very slightly convex. Posterior cardinal angle more prominently developed than the anterior angle. Posterior rounded-triangular with a short postero-dorsal slope which is convex in the left valve and straight in the right. Postero-ventral slope longer, convex and tending to be obliquely angled away from the ventral margin. Anterior uniformly rounded. Ventral margin antero-medially incurved, medially convex. *Hinge* paleohemimerodont; left valve with terminal loculate sockets and a short median bar (longer in the male dimorph) across which there is a narrow groove connecting the terminal sockets. Accommodation groove broad and shelf-like. Right valve with strongly dentate terminal elements, not clearly seen in the present material. *Muscle scars* (Type C) with rounded anteromedian antennal scar. Inner margin and line of concrescence coincide; *duplicature* of moderate width. Anterior *radial pore canals* slightly curved and in some specimens appearing to thicken slightly towards the outer termination; 12–16 observed in the present material.

Dimensions

Holotype, Io.1837, female carapace (Pl. 17, figs. 4–6), length 0·64 mm.; height 0·40 mm.; width 0·32 mm.

Io.1838, male carapace, length 0·82 mm.; height 0·45 mm.; width 0·37 mm. Io.1839, male carapace (Pl. 18, figs. 1–3), length 0·77 mm.; height 0·43 mm.; width 0·33 mm. Io.1840, female carapace (Pl. 17, figs. 7–10), length 0·62 mm.; height 0·41 mm.; width 0·32 mm. Io.1843, female right valve (Pl. 18, fig. 9), length 0·60

mm. ; height 0·34 mm. Io.1846, female left valve (Pl. 18, figs. 6, 7), length 0·61 mm. ; height 0·43 mm.

REMARKS. Apart from the variations in size range between the three subspecies of *Praeschuleridea subtrigona* there are also a number of additional characters by which the subspecies may be distinguished. The first of these characters concerns the angularity of the carapace which in the female dimorph of *intermedia* is very close to that of the type subspecies, the dorsal margin sloping strongly away from the region of greatest height. If anything, however, the posterior half of the dorsal margin is more elongate and not so steeply sloping as in *subtrigona subtrigona*. The dorsal margin in *magna* appears more uniformly convex on either side of the region of greatest height, contrasting with the almost straight posterior part in the other two subspecies. Posteriorly there are slight differences in all three: triangular in *subtrigona subtrigona* ; rounded in *magna* and bluntly flattened in *intermedia* where the postero-ventral slope although convex appears to flatten out slightly on approaching the extreme posterior. Actually the posterior margin of *intermedia* is closer to that of *magna* than to *subtrigona subtrigona*. The male dimorph of *intermedia* may be equivalent in size to that of *magna*—there however, it is the male of the last named species which shows the greater degree of angularity, being more noticeably " umbonate " than *intermedia*.

The conditions pertaining in north-eastern England during Middle Jurassic times appear to have offered a number of environments inhabited by a subspecies of *Praeschuleridea subtrigona* each population being characterized by a variation in size range. *Praeschuleridea subtrigona subtrigona* inhabited the marine waters of the shallow oolitic sea which covered Lincolnshire during Bajocian times. The northern extension of this sea lapped against the Yorkshire delta and provided a changed environment in which the subspecies *P. s. magna* developed. Higher up in the succession, the Yorkshire delta was still influencing the sedimentation of the Bajocian and throughout the entire marine embayment which spread over N.E. Yorkshire the population that existed was of *P. s. intermedia*.

Family **CYTHERURIDAE** Müller 1894

Genus ***EOCYTHEROPTERON*** Alexander 1933

Eocytheropteron ? sp.

(Pl. 18, figs. 10–13 ; Pl. 19, figs. 1–4)

REMARKS. Four complete carapaces of a species externally resembling the genus *Eocytheropteron* have been obtained from beds high up in the Grey Limestone Series. Two male carapaces (Io.1910–11) have been obtained from bed 8, Stonecliff Wood section whilst a single female carapace (Io.2102) has been obtained from bed 5 of the same section. From bed 11, Hawsker, a further female carapace (Io.1909) has been found. The carapace is elongate-oval in side view with the ventro-lateral margin strongly convex and overhanging the ventral surface, especially so in the female dimorph. A short caudal process is developed and the greatest length of the cara-

pace extends through mid-point. Shell surface with a very faint reticulation. A shallow sulcus is present at about valve centre in the female, slightly anterior to this in the male. Left valve larger than the right. Internal details not known although some radial pore canals can be made out externally in the antero-ventral area where they appear to be straight and widely spaced. This species is close to *Cytheropteron* (*Cytheropteron*) *purum* Schmidt (1954 : 88, pl. 6, figs. 3–6 ; pl. 7, figs. 25–29) although somewhat smaller and may be further distinguished by the more elongate and posteriorly tapering carapace of the female dimorph which in *C.* (*C.*) *purum* is shorter in comparison.

Io.1909, female carapace (Pl. 19, figs. 1–4), length 0·47 mm. ; height 0·26 mm. ; width 0·26 mm. Io.1911, male carapace (Pl. 18, figs. 10–13), length 0·53 mm. ; height 0·26 mm. width 0·28 mm.

Genus ***PARACYTHERIDEA*** Müller 1894

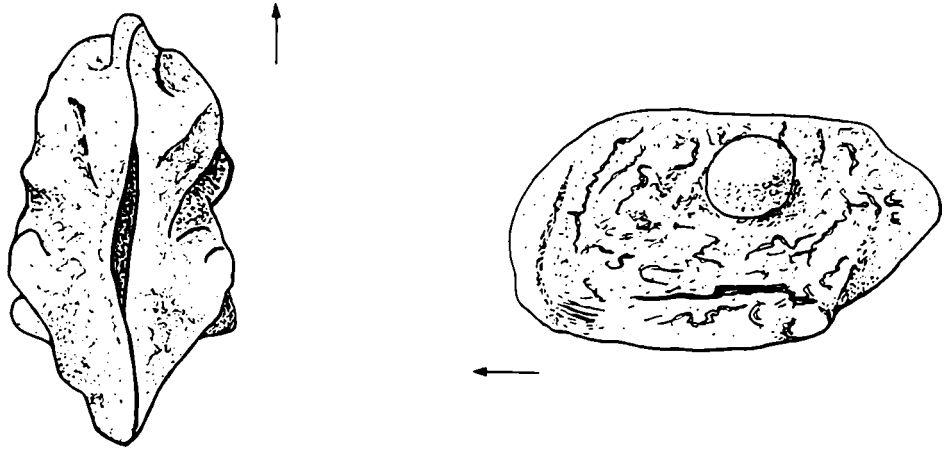
Paracytheridea? caytonensis sp. nov.

(Pl. 19, figs. 5–16 ; Text-figs. 22, 23)

DIAGNOSIS. *Paracytheridea* ? with backwardly projected ala terminating in prominent node. A second node is situated dorso-medially on lateral surface of valve, just behind median sulcus. Shell surface reticulate. Anterior and posterior with flattened marginal borders. Left valve larger than right. Species dimorphic.

HOLOTYPE. Io.2137, bed 6, Cayton Bay Section.

PARATYPES. Io.2138–42, horizon and locality as above.



FIGS. 22–23. Dorsal and left views, female carapace, *Paracytheridea* ? *caytonensis* sp. nov. Holotype, Io.2137, approx. × 105.

DESCRIPTION. *Carapace* subquadrate in side view with a prominent, backwardly projected ala at the tip of which is situated an oval node-like swelling. Above and slightly in front of this swelling a much larger node is situated on the lateral surface of the valve. In front of this circular node a transverse median sulcus is present

which appears to curve under the lateral node. An oblique groove extending from the dorsal margin, below the anterior cardinal angle, extends down to the antero-ventral part of the valve where it turns back to extend along the dorsal side of the ventro-lateral ala. Shell surface rather coarsely reticulate, including the surface of the two nodes. An *eye swelling* is situated just below the anterior cardinal angle. Anteriorly and posteriorly the marginal borders are flattened, the convex lateral part of the carapace not extending right up to the margins. Ventral surface with approximately 5 longitudinal ridges to each valve. Sexual dimorphism indicated by the presence of an elongate specimen considered to be the male. Greatest length of carapace passes through mid-point ; greatest height in the anterior third ; greatest width in the posterior third. Dorsal margin slightly concave in the left valve, convex in the right. Anterior margin rounded with oblique, convex, antero-dorsal slope. Posterior triangular, extended into a caudal process, especially in the female. Postero-dorsal slope strongly concave, postero-ventral slope strongly convex. Ventral margin medially incurved. Cardinal angles prominent ; anterior angle broadly rounded ; posterior angle more acute. Left valve larger than the right which it overlaps along the ventral margin and slightly at the cardinal angles. Elsewhere the left valve overreaches the right, apart from along the dorsal margin where the valves diverge. Internal characters not seen.

Dimensions

Holotype, Io.2137, female carapace (Pl. 19, figs. 5–8 ; Text-figs. 22, 23), length 0·45 mm. ; height 0·26 mm. ; width 0·25 mm.

Io.2138, male carapace (Pl. 19, figs. 13–16), length 0·54 mm. ; height 0·25 mm. ; width 0·23 mm. Io.2140, female carapace (Pl. 19, figs. 9–12), length 0·43 mm. ; height 0·25 mm. ; width (broken) 0·22 mm.

REMARKS. Only six specimens of this species have been found and these all occur in the same bed and represent a single population. Owing to the lack of knowledge concerning the internal details of this ostracod the generic designation is given with a query, although on general external morphology there is good reason to place this species into *Paracytheridea*. Superficially there is some resemblance between *P.* ? *caytonensis* and *Cytheropteron* (*Cytheropteron*) *bispinosum crassum* Schmidt (1954 : 87, pl. 7, figs. 23–24) although in the last named ostracod the ventro-lateral alar projection is not backwardly directed as in *P.* ? *caytonensis* and also lacks the characteristic nodes of that species.

Family **PROTOCYTHERIDAE** Ljubimova 1955

Subfamily **KIRTONELLINAE** Bate 1963

Genus ***SOUTHCAVEA*** Bate 1964

Southcavea microcellulosa sp. nov.

(Pl. 20, figs. 1–13 ; Pl. 21, figs. 1–4)

DIAGNOSIS. *Southcavea* with oval-subquadrate carapace and coarse reticulate

ornament. Pits produced by reticulate ornament 4–6 sided, internally strongly punctate. Hinge antimerodont. Species dimorphic.

HOLOTYPE. Io.1882, bed 5, Stonecliff Wood section.

PARATYPES. Io.1883–99, beds 3, 5 & 8, Stonecliff Wood and bed 11, Hawsker.

DESCRIPTION. *Carapace* oval-subquadrate in outline, more elongate in the male dimorph. Posteriorly tapered in the female. Greatest length through mid-point; greatest height in the anterior third; greatest width just behind valve centre. Dorsal margin in the left valve slightly concave medially with broadly rounded cardinal angles, in the right valve slightly convex, cardinal angles somewhat more acute. Anterior broadly rounded; posterior more narrowly rounded with convex postero-dorsal and postero-ventral slopes in the left valve, and a concave postero-dorsal and convex postero-ventral slope in the right. Ventral margin medially incurved. Ventro-lateral margin convex. Anterior without a marginal border, whilst posteriorly there is a very narrow, flattened border. Left valve larger than the right which it overlaps mid-ventrally, at the cardinal angles and along the postero-dorsal slope. Antero-ventrally, postero-ventrally and antero-dorsally the left valve overreaches the right. Shell surface strongly reticulate, the 4–6 sided pits produced being strongly punctate. This degree of punctation in many cases has resulted in the pits themselves being subdivided by secondary ridges—this development appears to be more characteristic of the ventro-lateral areas of the carapace. Ventral surface strongly ornamented by longitudinal ridges. *Normal pore canals* few in number and widely scattered over the carapace, although because of the ornamentation only clearly seen along the ventral surface. *Hinge* antimerodont: left valve with terminal sockets separated by a finely denticulate median bar. The accommodation groove is elongate and shelf-like. Right valve with 5 bifid, posterior teeth, exact number anteriorly not known but appears to be more than 5. Median groove elongate and finely locellate. Inner margin and line of concrescence coincide, *duplicature* of moderate width. *Radial pore canals* straight, simple and widely spaced, approximately 8 anteriorly, at least 4 posteriorly. *Muscle scars* (Type D?): adductor scars an oblique row of 4 scars with an antero-ventral mandibular scar and an antero-dorsal antennal scar which may be heart-shaped, but not so definitely V-shaped as in other species of this genus. A narrow *flange* has been observed in the right valve extending around the anterior margin and along the ventral margin.

Dimensions

Holotype, Io.1882, male carapace (Pl. 20, figs. 1–4), length 0·67 mm.; height 0·36 mm.; width 0·38 mm.

Io.1883, female carapace (Pl. 20, figs. 5–8), length 0·60 mm.; height 0·36 mm.; width 0·37 mm. Io. 1886, female right valve (Pl. 20, figs. 9, 10), length (broken) 0·60 mm.; height 0·34 mm. Io.1888, male carapace (Pl. 21, figs. 1–4), length 0·77 mm.; height 0·41 mm.; width 0·46 mm.; Io.1891, female carapace, length 0·65 mm.; height 0·36 mm.; width 0·36 mm. Io.1893, female carapace, length 0·54 mm.; height 0·30 mm.; width 0·31 mm.

REMARKS. *Southcavea microcellulosa* is a much more elongate ostracod than *Southcavea reticulata* Bate (1964 : 27, pl. 10, figs. 3–14 ; pl. 11, figs. 1–4) with which it might be confused, and also has a much finer ornamentation. *S. microcellulosa* appears to be virtually restricted to the sandy shore-line facies along the western outcrop of the Grey Limestone Series with the exception of a single female carapace found in bed 11, Hawsker. However, even at Hawsker in the east it is doubtful whether the northern coast-line was very far away.

Genus ***SYSTENOCYTHERE*** Bate 1963

Systenocythere ovata sp. nov.

(Pl. 21, figs. 5–12)

DIAGNOSIS. *Systenocythere* with ovoid carapace showing a strong reticulate ornamentation when well preserved, but generally only possessing ornamentation of longitudinal ridges on ventro-lateral and ventral surfaces. Internal characters as for genus.

HOLOTYPE. Io.1900, bed 7, Hawsker.

PARATYPES. Io.1901–8, bed 4, Gristhorpe Bay ; bed 6, Cayton Bay ; beds 19 and 22, Hundale Point, Cloughton ; beds 7 and 12, Hawsker and bed 1, Yearsley Moor.

DESCRIPTION. *Carapace* ovoid in side view, tapering posteriorly. Greatest length through mid-point ; greatest height in the anterior third ; greatest width in the posterior third. Dorsal margin convex in both valves ; cardinal angles rounded. Anterior rounded with oblique, convex, antero-dorsal slope. Posterior narrowly rounded with convex postero-dorsal and postero-ventral slopes in the left valve and concave postero-dorsal and convex postero-ventral slopes in the right valve. Ventral margin medially incurved. Ventro-lateral margin convex, overhanging the ventral surface in side view. Anterior and posterior with flattened marginal borders. Left valve larger than the right which it overlaps most strongly mid-ventrally, from which point, along the ventral margin the left valve progressively overreaches the right. The left valve also overreaches the right along the antero- and postero-dorsal slopes. Shell surface may be either strongly reticulate or only noticeably ornamented along the ventro-lateral and ventral surfaces with longitudinal ridges. Fairly large *normal pore canals* may be seen, depending on preservation, widely scattered over the carapace. *Hinge* merodont, not fully determinable. Right valve with 5 anterior teeth and possibly 5 posterior teeth ; median groove long and very narrow, it is difficult to state precisely whether this groove is smooth or locellate because of the preservation of the material. Hinge poorly preserved in the left valve : Accommodation groove of moderate width situated above the median bar which cannot be identified as being either smooth or denticulate. *Muscle scars* (Type D) consist of a subvertical row of 4 oval adductor scars with an oval anteroventral mandibular scar and a V-shaped antero-dorsal antennal scar. Inner margin and line of concrescence coincide, the *duplicature* being of moderate width. Approximately 8 anterior and 3

posterior *radial pore canals* may be distinguished, these appear to be straight and widely spaced. A narrow *flange* widening opposite the ventral incurvature, extends

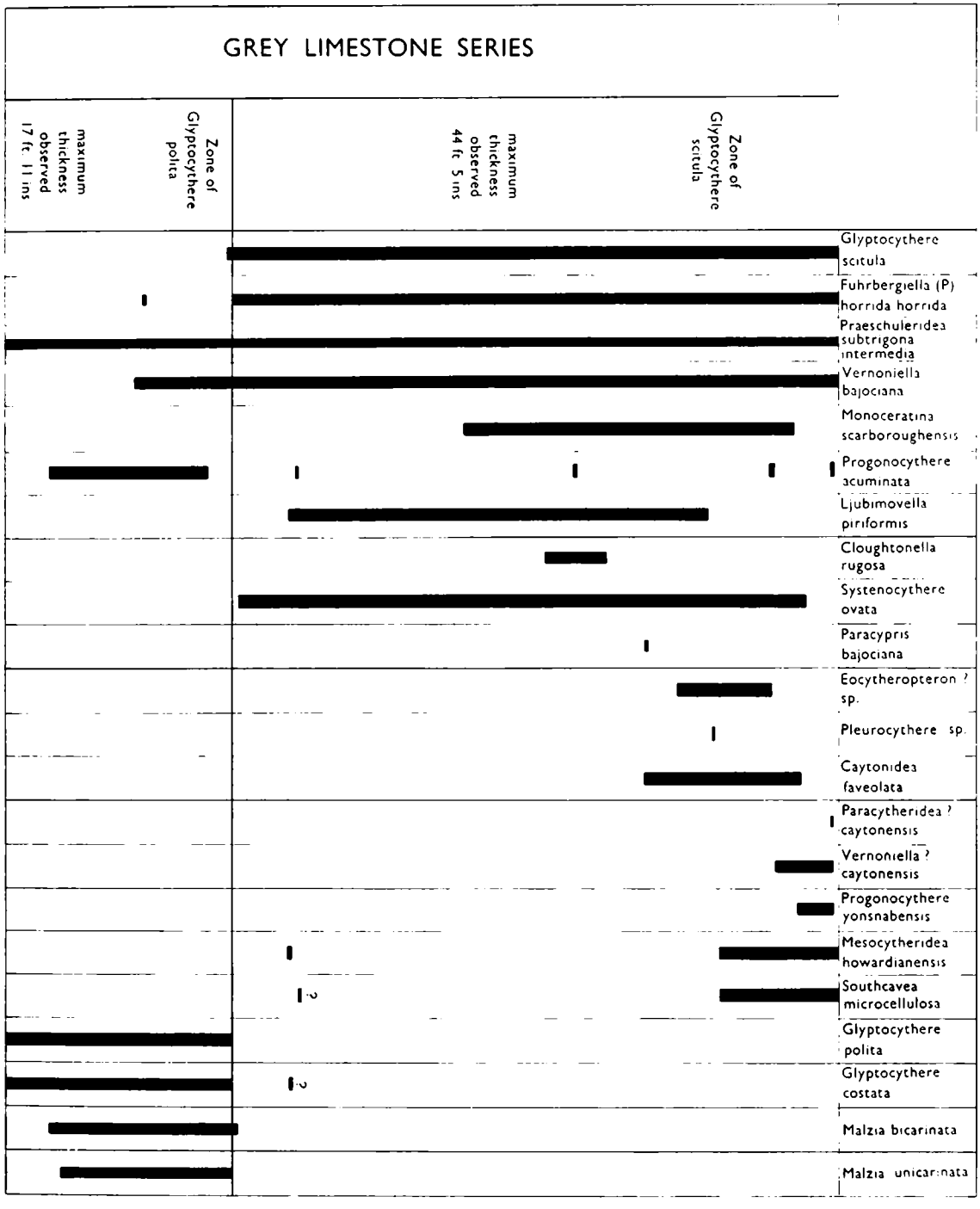


FIG. 24. Range table of the Grey Limestone Series Ostracoda.

along the ventral margin of the right valve and possibly also extends around the anterior margin. A flange has not been observed in the left valve.

Dimensions

Holotype, Io.1900, carapace (Pl. 21, figs. 5–8), length 0·70 mm. ; height 0·44 mm. ; width 0·37 mm.

Io.1901, left valve, length 0·66 mm. ; height 0·39 mm. Io.1903, left valve (Pl. 21, fig. 12), length 0·60 mm. ; height 0·36 mm. Io.1904, right valve, length 0·48 mm. ; height 0·28 mm. Io.1907, right valve (Pl. 21, figs. 9–11), length 0·60 mm. ; height 0·34 mm.

REMARKS. *Systenocythere ovata* is similar in outline to the female dimorph of *S. exilofasciata* Bate (1963 : 212, pl. 14, figs. 7–10 ; pl. 15, figs. 1–4), the type species, although it differs in not being so noticeably acuminate posteriorly and, when preservation permits, in being strongly reticulate.

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EXPLANATION OF PLATES

All the specimens illustrated are now in the Department of Palaeontology, British Museum (Natural History). All photographs, taken by the author, ×85 unless otherwise indicated.

PLATE 1

Monoceratina scarboroughensis sp. nov. p. 99.

FIGS. 1–3, 12. Bed 22, Hundale Point.

FIGS. 4–11. Bed 5, Cayton Bay.

FIGS. 1–3. Right, left and ventral views, female carapace. Holotype, Io.1711.
FIG. 4. Muscle scars, female carapace. Paratype, Io.1723, ×310.
FIGS. 5–8. Right, left, dorsal and ventral views, female carapace. Paratype, Io.1723.
FIGS. 9–11. Left, dorsal and ventral views, male carapace. Paratype, Io.1721.
FIG. 12. Internal view, female left valve. Paratype, Io.1720.

Caytonidea faveolata gen. et sp. nov. p. 100.

Specimen from bed 4, Gristhorpe Bay.

FIGS. 13, 14. Right, left, views, carapace. Paratype, Io.1834.

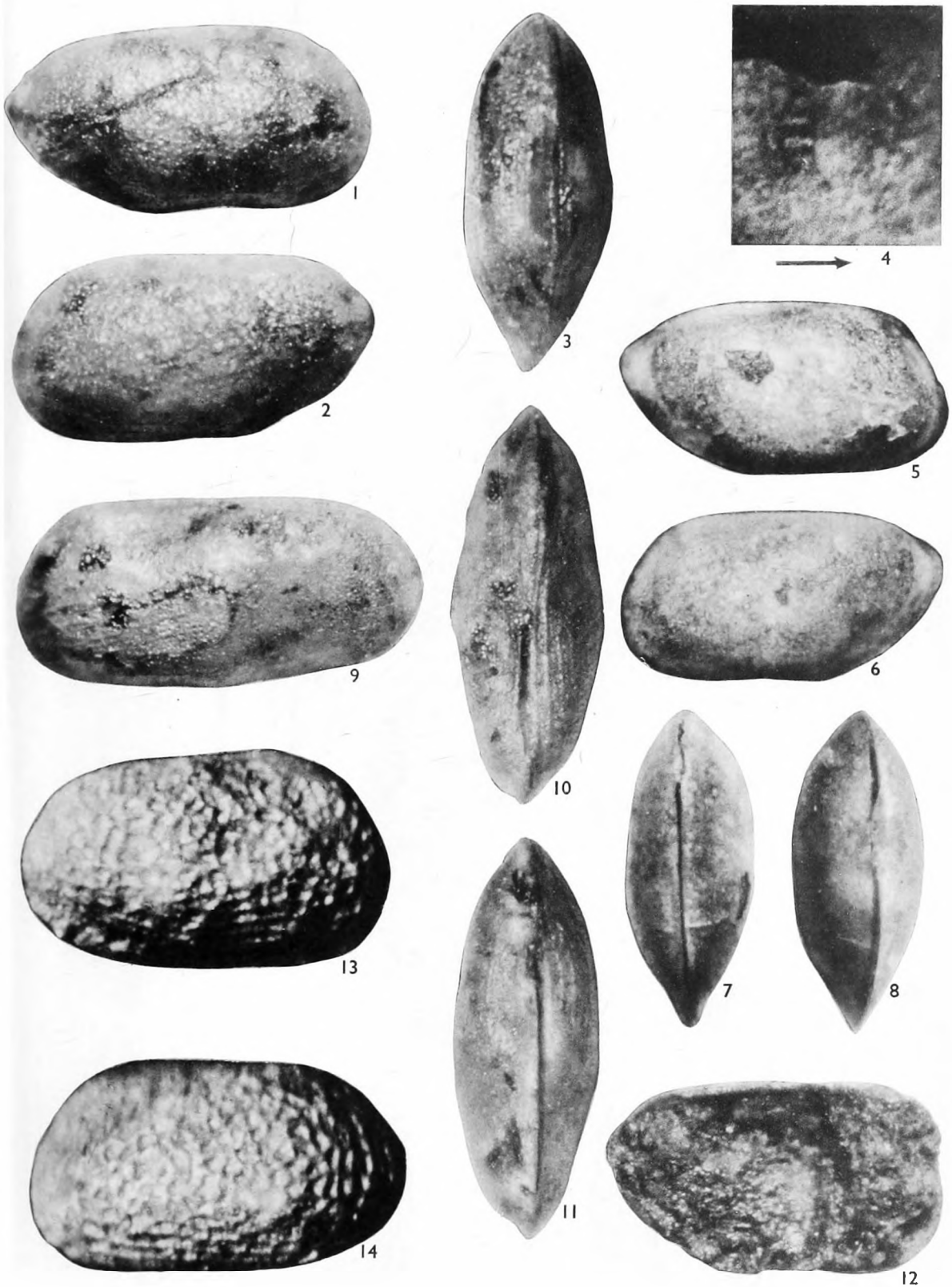
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PLATE 2

Caytonidea faveolata gen. et sp. nov. p. 100

FIGS. 1–4, 7–10. Bed 5, Cayton Bay.

FIGS. 5, 6. Bed 4, Gristhorpe Bay.

FIGS. 1–4. Right, left, dorsal and ventral views, carapace. Holotype, Io.1831.
FIGS. 5, 6. Dorsal and ventral views, carapace. Paratype, Io.1834.
FIGS. 7, 8. Dorsal and lateral views of right valve hinge., Paratype, Io.1832, ×95.
FIGS. 9, 10. Internal views of right valve fragment to show muscle scars and anterior radial pore canals. Paratype, Io.1833.


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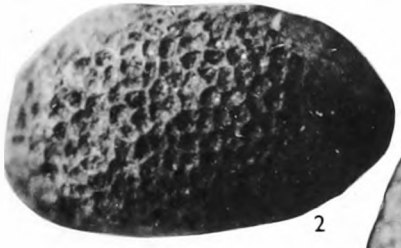
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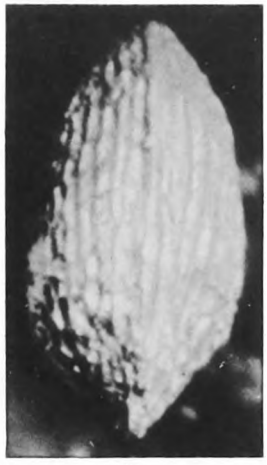
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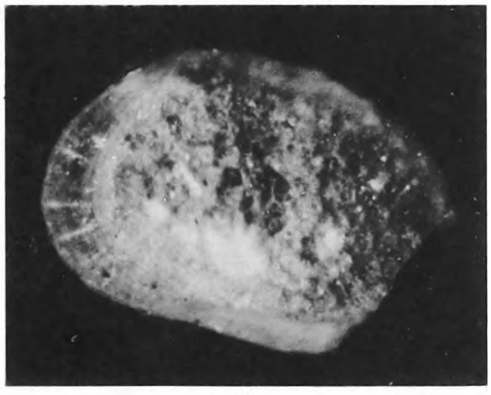
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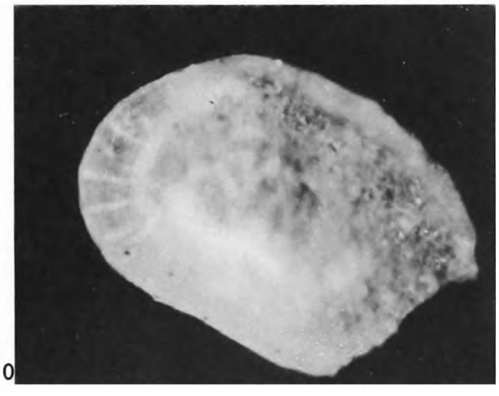
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PLATE 3

Cloughtonella rugosa gen. et sp. nov. p. 102

FIGS. 1–7, 11–13. Bed 22, Hundale Point, Cloughton.

FIGS. 8–10. Bed 10, Bloody Beck.

FIGS. 1–4. Right, left, dorsal and ventral views, female carapace. Holotype, Io.2118.
FIGS. 5–7. Ventral, right and left views, male carapace. Paratype, Io.2119.
FIGS. 8, 9. Left and right views, female carapace. Paratype, Io.2135.
FIG. 10. Left view, showing large normal pore canals, male carapace. Paratype, Io.2134.
FIG. 11. Dorsal view of hinge, female left valve. Paratype, Io.2121.
FIGS. 12, 13. Right and left views, male carapace. Paratype, Io.2120.


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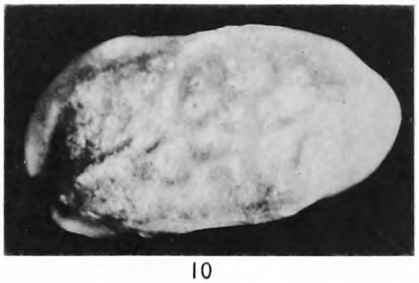
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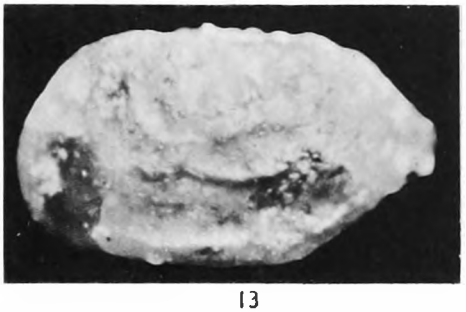
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PLATE 4

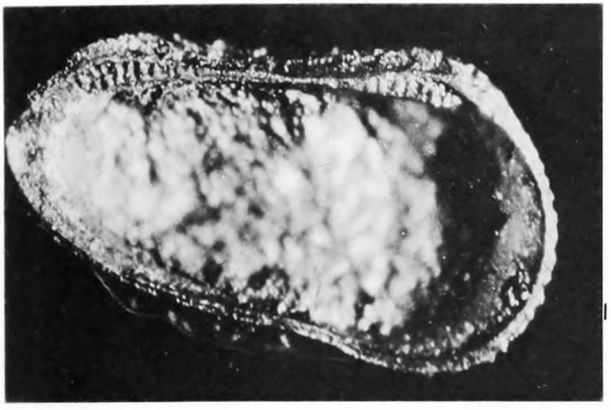
Fuhrbergiella (Praefuhrbergiella) horrida horrida Brand & Malz p. 104

FIGS. 1–3. Bed 5, Cayton Bay.

FIGS. 4, 5, 10. Bed 6, Cayton Bay.

FIGS. 6–9, 11, 12. Bed 23, Hundale Point, Cloughton.

FIGS. 1–3. Internal, external and dorsal views, female left valve, Io.2109.
FIGS. 4, 5. External and dorsal views, female right valve, Io.2116.
FIGS. 6–9. Dorsal, left, right and ventral views, male carapace, Io.2111.
FIG. 10. External view, female right valve showing anterior and posterior radial pore canals, Io.2117.
FIGS. 11, 12. Dorsal and right views, female carapace, Io. 2110.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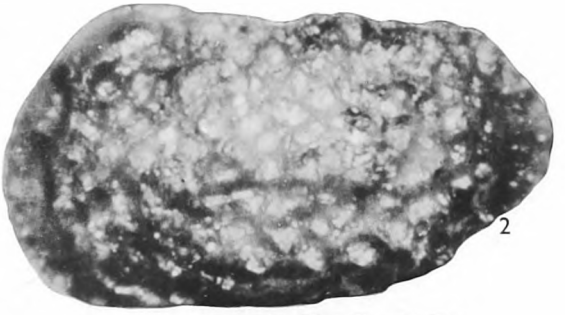
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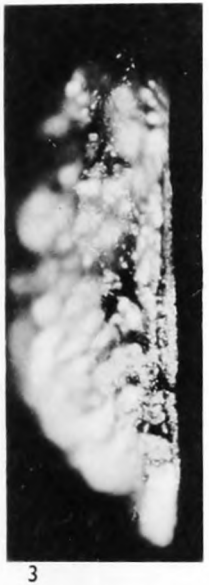
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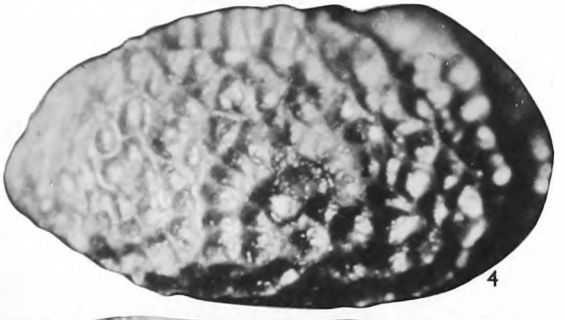
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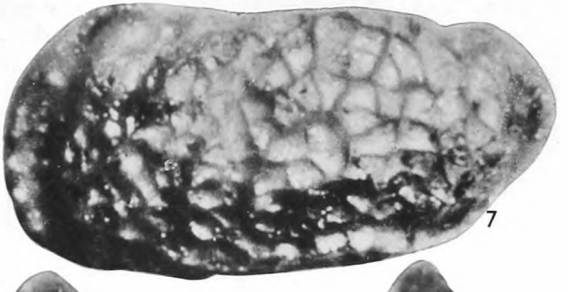
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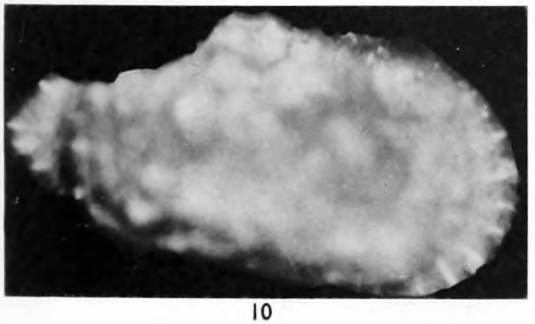
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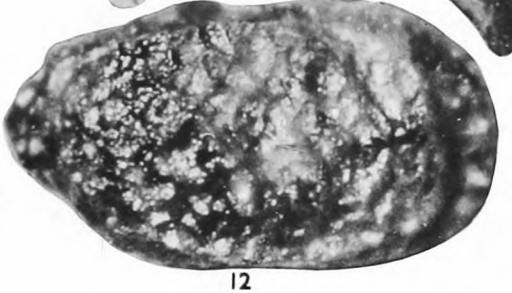
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PLATE 5

Glyptocythere costata sp. nov. p. 106

FIGS. 1–4, 7. Bed 10, Ravenscar.

FIGS. 5, 6. Bed 8, Ravenscar.

FIGS. 1–4. Right, left, dorsal and ventral views, female carapace. Holotype, Io.1775.
FIGS. 5, 6. Right and left views, male carapace. Paratype, Io.1782.
FIG. 7. Female right valve. Paratype, Io.1776.

Glyptocythere polita sp. nov. p. 107

FIG. 8. Bed 6, Bloody Beck.

FIG. 9. Bed 7, Ravenscar.

FIG. 10. Bed 7, Hundale Point, Cloughton.

FIG. 11. Bed 9, Ravenscar.

FIG. 8. Right view, female carapace. Paratype, Io.1743.
FIG. 9. Internal view, female left valve. Paratype, Io.1738, ×70.
FIG. 10. Right view, female carapace, showing normal pore canals. Paratype, Io.1736, ×70.
FIG. 11. Dorsal view of hinge, female left valve. Paratype, Io.1741.


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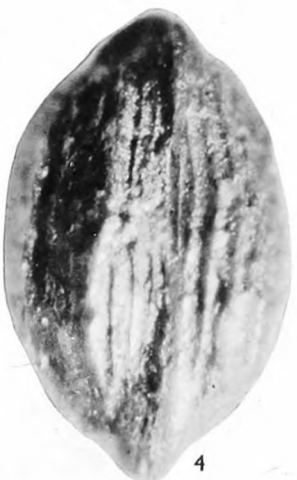
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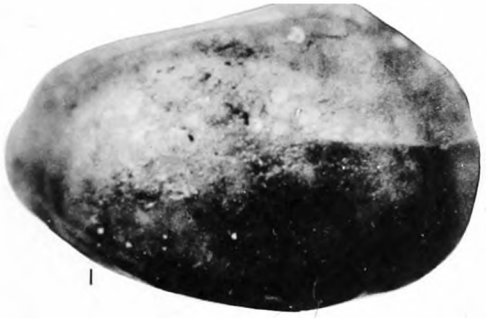
PLATE 6

Glyptocythere polita sp. nov. p. 107

FIGS. 1–8. Bed 7, Hundale Point, Cloughton.

FIG. 9. Bed 8, Hundale Point, Cloughton.

FIGS. 1–4. Right, left, dorsal and ventral views, female carapace. Holotype, Io.1724, ×70.
FIGS. 5–8. Right, left, dorsal and ventral views, male carapace. Paratype, Io.1725, ×70.
FIG. 9. Muscle scars, female left valve. Paratype, Io.1737, ×150.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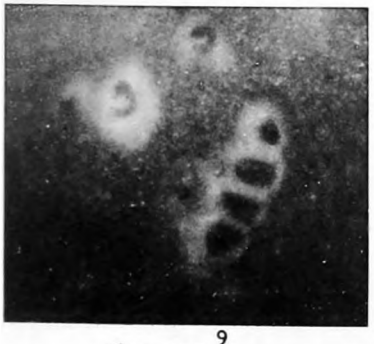
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PLATE 7

Glyptocythere scitula sp. nov. p. 108

FIGS. 1, 7. Bed 10, Hawsker.

FIGS. 2–6, 8–10. Bed 12, Ravenscar.

FIGS. 11, 12. Bed 5, Cayton Bay.

FIG. 13. Bed 5, Gristhorpe Bay.

FIGS. 1, 7. Internal and dorsal views, female right valve. Paratype, Io.1760.

FIG. 2. Muscle scars. Note antero-ventral mandibular scar, which is a rosette of several. smaller scars. Broken female right valve. Paratype, Io.1774, ×150.

FIGS. 3, 8. Muscle scars (×125) and anterior radial pore canals (×90), female right valve. Paratype, Io. 1771.

FIGS. 4, 6, 10. Internal view, showing radial pore canals, and two dorsal views of hinge, female right valve. Paratype, Io.1768.

FIGS. 5, 9. Dorsal views of hinge, female left valve. Paratype, Io.1769.

FIGS. 11, 12. External and internal views, male left valve. Paratype, Io.1751.

FIG. 13. External view, male right valve. Paratype, Io.1772.

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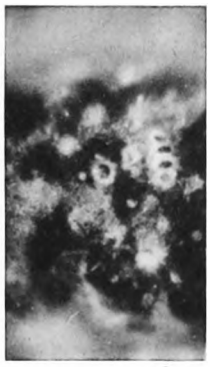

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PLATE 8

Glyptocythere scitula sp. nov. p. 108

FIGS. 1–5. Bed 5, Cayton Bay.

FIGS. 6–9. Bed 10, Hawsker.

FIGS. 1–4. Left, right, dorsal and ventral views, female carapace. Holotype, Io.1750.
FIG. 5. External view, female left valve. Paratype, Io.1754.
FIGS. 6–9. Left, right, dorsal and ventral views, female carapace. Paratype, Io.1752.

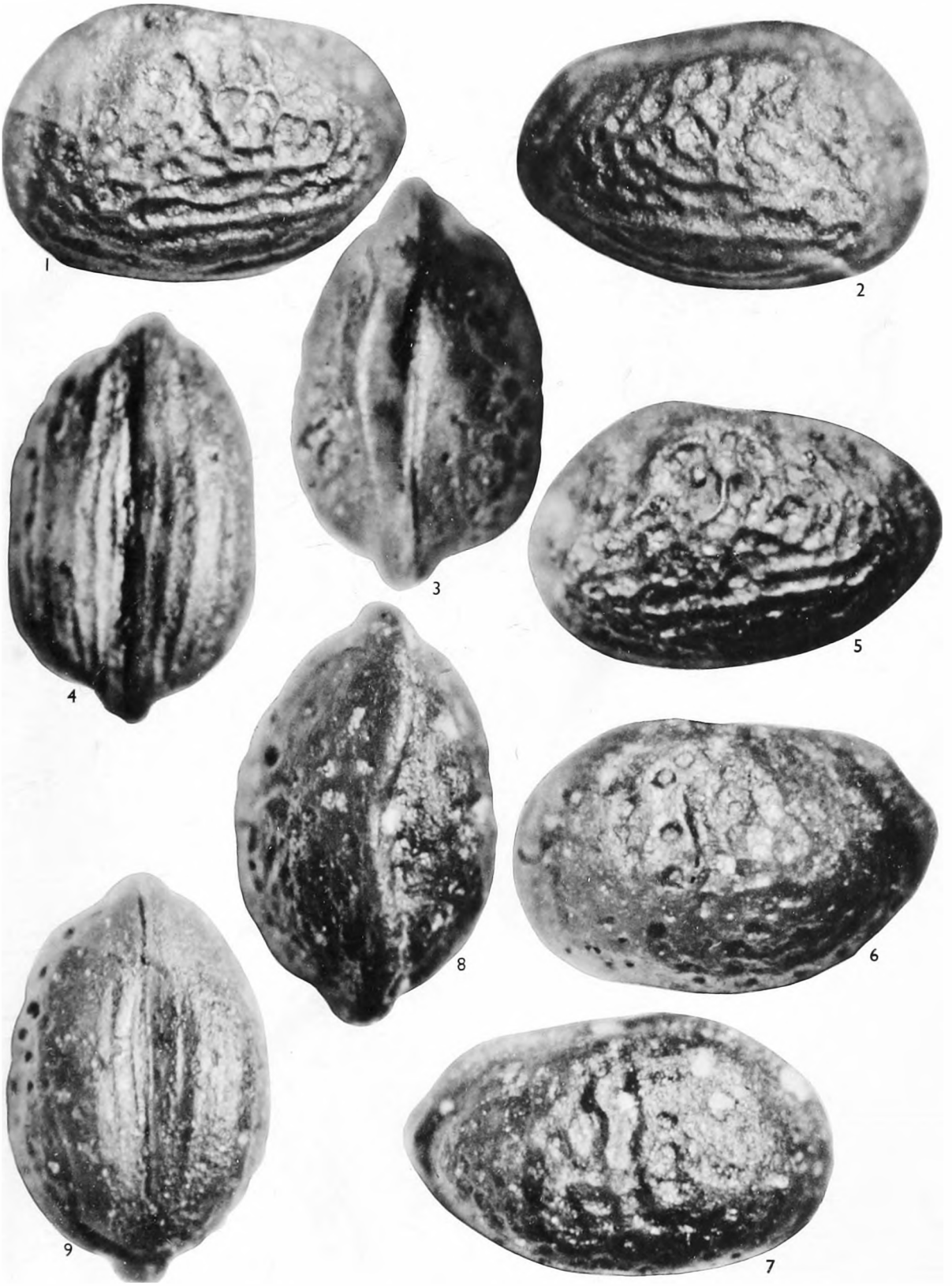
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PLATE 9

Glyptocythere scitula sp. nov. p. 108

Specimen from bed 10, Hawsker.

FIGS. 1–4. Left, right, dorsal and ventral views, male carapace. Paratype, Io.1753.

Malzia bicarinata gen. et sp. nov. p. 111

Specimen from bed 9, Ravenscar.

FIGS. 5–8. Left, right, dorsal and ventral views. Holotype, Io.1797.

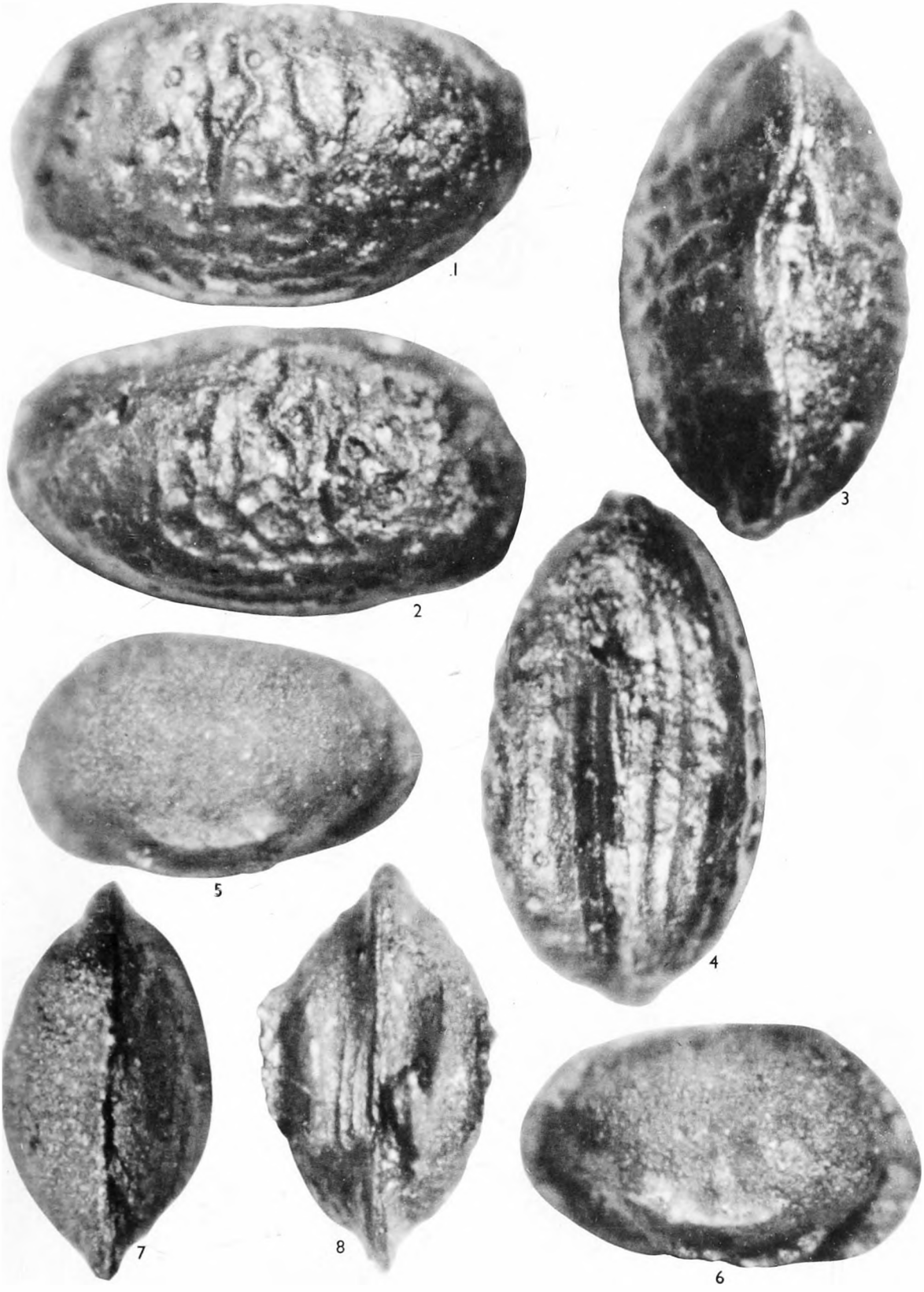
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PLATE 10

Malzia bicarinata gen. et sp. nov. p. 111.

FIG. 1. Bed 8, Ravenscar.

FIGS. 2, 3. Bed 7, Ravenscar.

FIG. 1. Left side, carapace. Paratype, Io.1798.
FIGS. 2, 3. Internal view and dorsal view (×100) left valve. Paratype, Io.1799.

Malzia unicarinata gen. et sp. nov. p. 113.

FIGS. 4–8. Bed 9, Ravenscar.

FIGS. 9, 10. Bed 8, Ravenscar.

FIGS. 4–7. Left, right, dorsal and ventral views, female carapace. Holotype, Io.1801.
FIG. 8. Right view of female carapace to show radial pore canals. Holotype, Io.1801.
FIGS. 9, 10. Left and right views, female carapace. Paratype, Io.1802.


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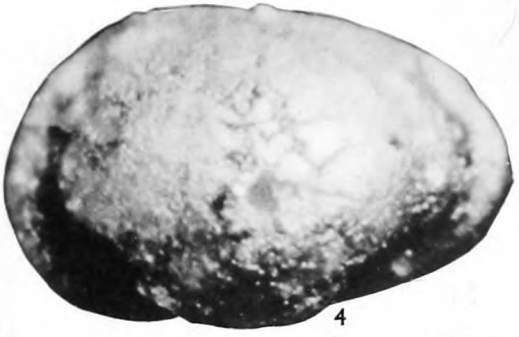
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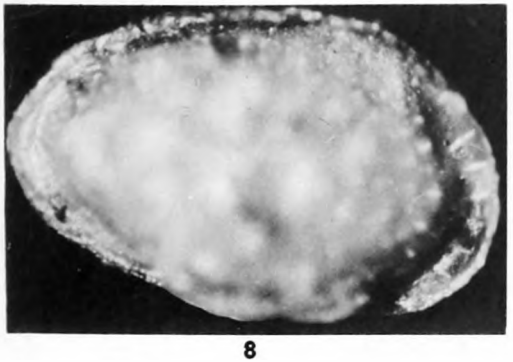
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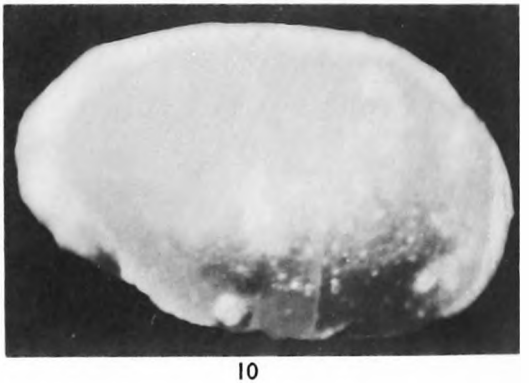
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PLATE 11

Malzia unicarinata gen. et sp. nov. p. 113.

Specimen from bed 10, Ravenscar.

FIGS. 1–4. Left, right, dorsal and ventral views, male carapace. Paratype, Io.1806.

Progonocythere acuminata sp. nov. p. 114.

FIGS. 5, 6. Bed 7, Ravenscar.

FIGS. 7–10. Bed 6, Cayton Bay.

FIGS. 5, 6. Left and right views, carapace. Paratype, Io.1789.
FIGS. 7, 8. External and internal views, left valve. Paratype, Io.1786.
FIGS. 9, 10. Right and left views, carapace. Paratype, Io.1787.


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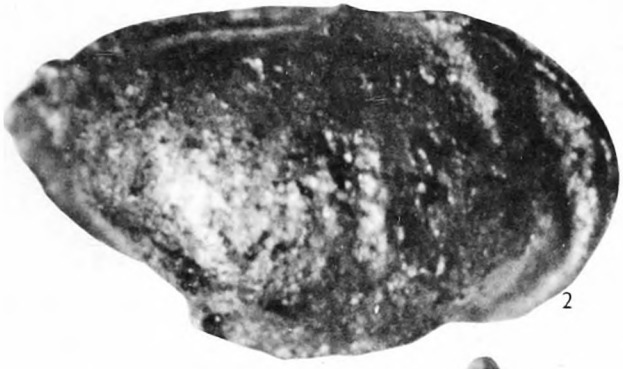
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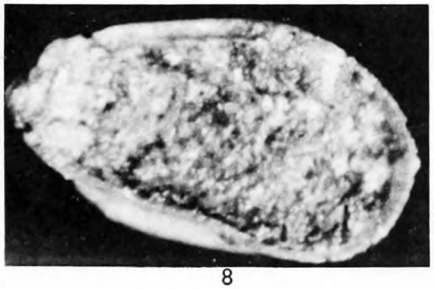
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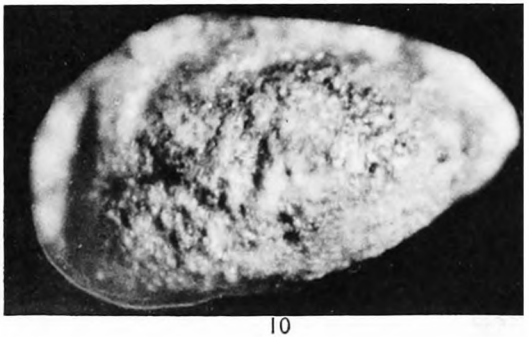
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PLATE 12

Progonocythere acuminata sp. nov. p. 114.

Specimen from bed 7, Hundale Point, Cloughton.

FIGS. 1–4. Left, right, dorsal and ventral views, carapace. Holotype, Io.1783.

Progonocythere yonsnabensis sp. nov. p. 116.

All specimens from bed 5, Cayton Bay.

FIGS. 5–8. Left, right, dorsal and ventral views, female carapace. Holotype, Io.1792.
FIGS. 9, 10. Left and right views, female carapace. Paratype, Io.1794.
FIGS. 11–14. Left, right, dorsal and ventral views, male carapace. Paratype, Io.1793.

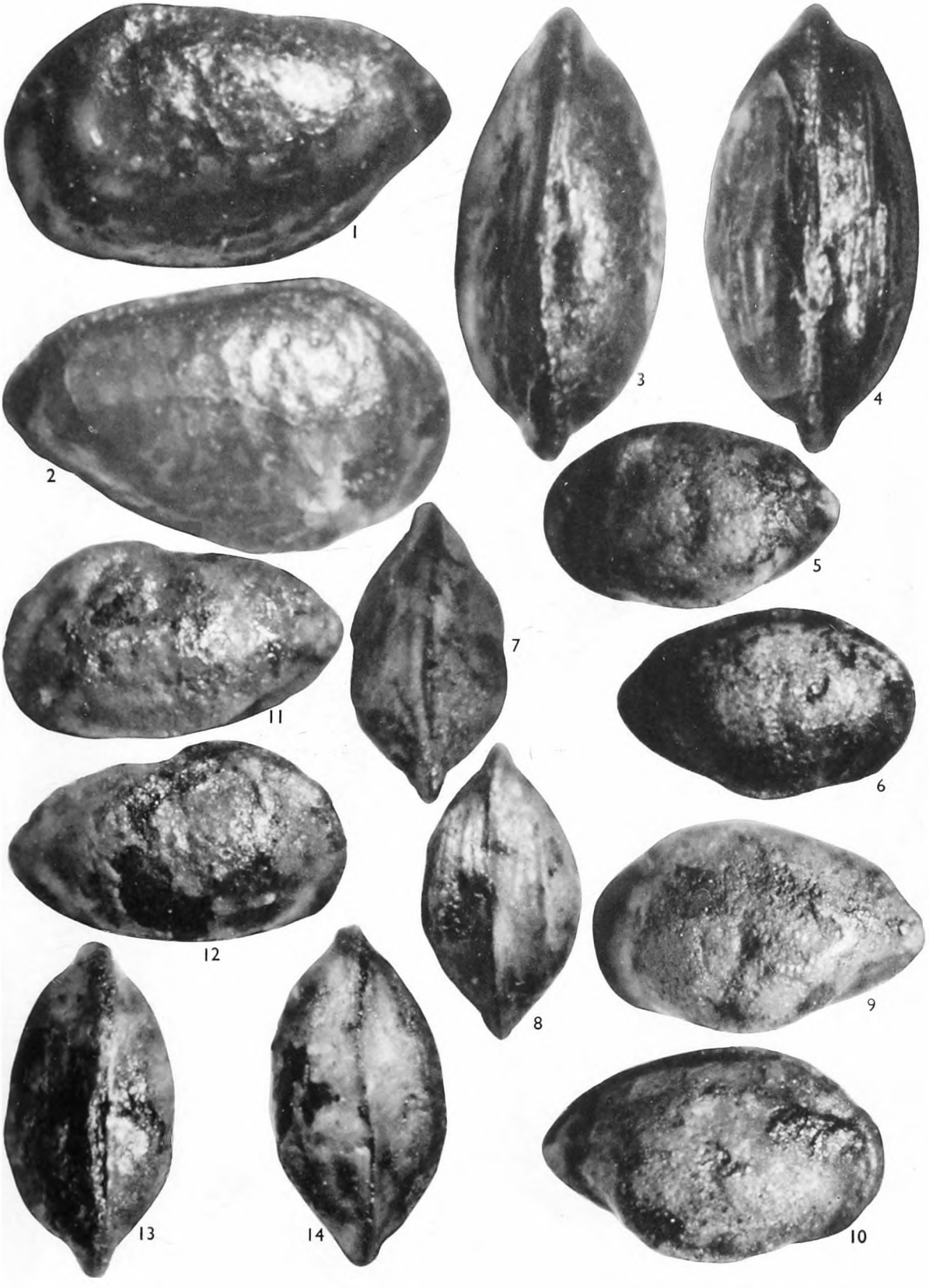
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PLATE 13

Progonocythere yonsnghensis sp. nov. p. 116.

Specimen from bed 5, Cayton Bay.

FIGS. 1–4. Left, right, dorsal and ventral views, male carapace, showing development of two lateral keels and nodes. Paratype, Io.1795.

Pleurocythere sp. p. 117.

Specimen from bed 4, Gristhorpe Bay.

FIG. 5. External view, left valve, Io.1836.

Vernoniella bajociana sp. nov. p. 118.

Specimens from bed 23, Hundale Point, Cloughton.

FIGS. 6–9. Left, right, dorsal and ventral views, female carapace. Holotype, Io.1807.
FIGS. 10, 11. Right and left views, female carapace. Paratype, Io.1808.


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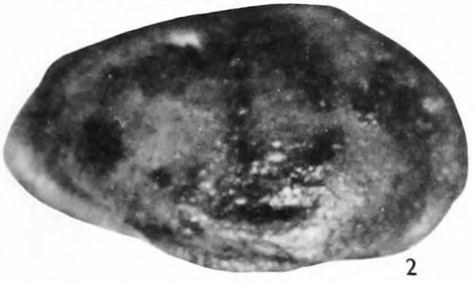
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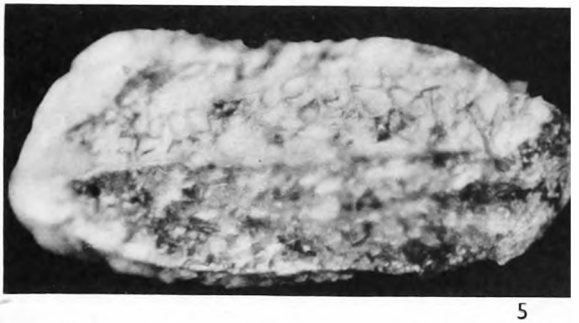
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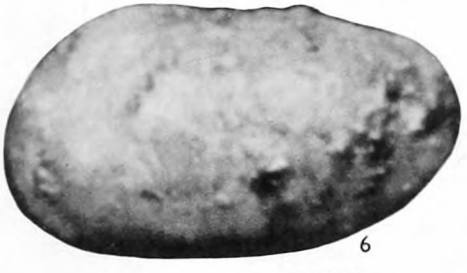
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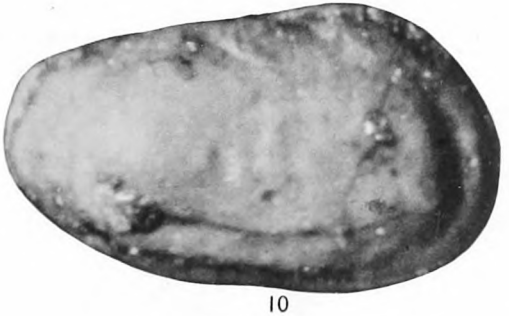
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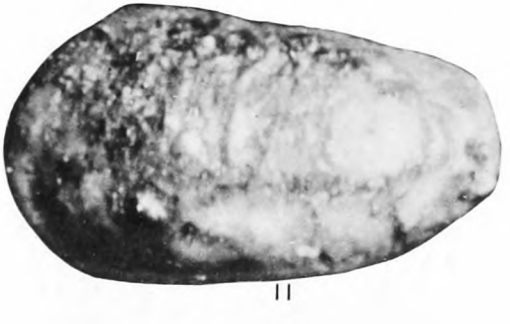
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PLATE 14

Vernoniella bajociana sp. nov. p. 118.

FIGS. 1–4. Bed 7, Hundale Point, Cloughton.

FIGS. 5–10, 12, 13. Bed 12, Ravenscar.

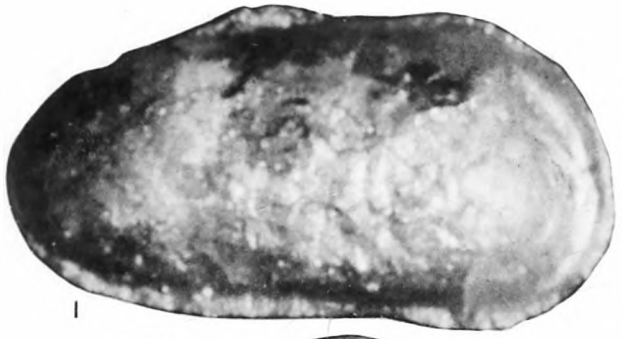
FIG. 11. Bed 9, Hawsker.

FIGS. 1–4. Right, left, dorsal and ventral views, male carapace. Paratype, Io.1814.

FIGS. 5–9. 5, anterior radial pore canals (×140); 6, dorsal view of hinge; 7, internal view to show boring of shell by marine organism; 8, lateral view of hinge; 9, internal view to show radial pore canals. Female left valve. Paratype Io.1818.

FIGS. 10, 12, 13. Muscle scars (×180) showing composite antennal scar, dorsal view of hinge (×95) and internal view of male right valve. Paratype, Io.1819.

FIG. 11. Muscle scars, fragment of female right valve. Paratype, Io.1813, ×110.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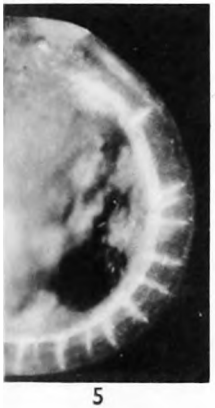
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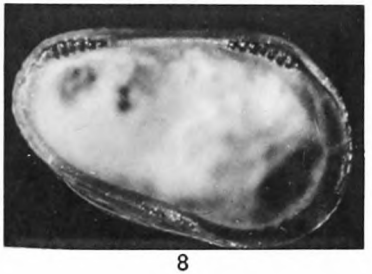
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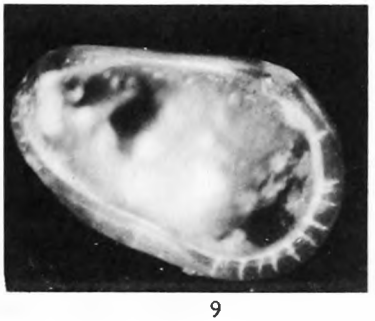
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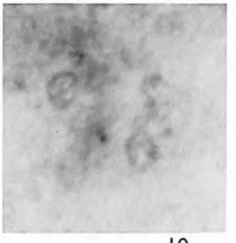
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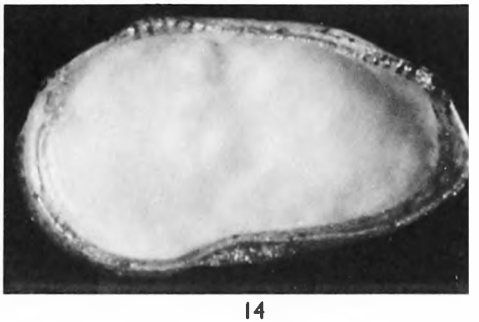
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PLATE 15

Vernoniella caytonensis sp. nov. p. 119.

All specimens from bed 6, Cayton Bay.

FIGS. 1–4. Left, right, dorsal and ventral views, carapace. Holotype, Io.1855.
FIGS. 5–7. Right, left and ventral views, carapace. Paratype, Io.1858.
FIGS. 8, 9. Dorsal and internal views, right valve. Paratype, Io.1857.

Ljubimovella piriformis Malz p. 120.

FIGS. 10, 11. Bed 22, Hundale Point, Cloughton.

FIGS. 12, 13. Bed 12, Ravenscar.

FIGS. 10, 11. Left and right sides, juvenile carapace. Io.2107.
FIGS. 12, 13. Internal and external views, right valve. Io.2108.


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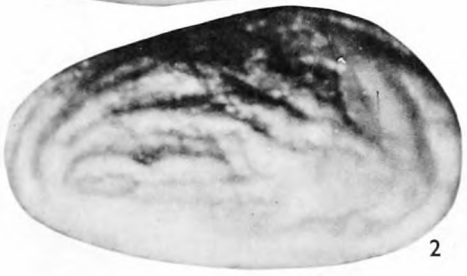
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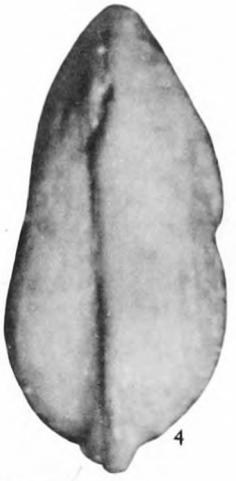
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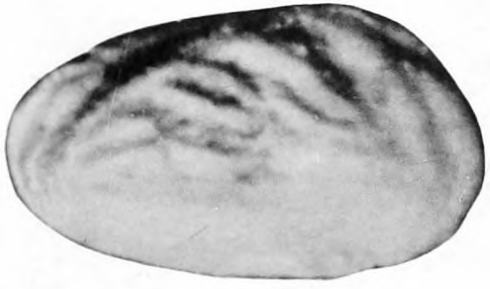
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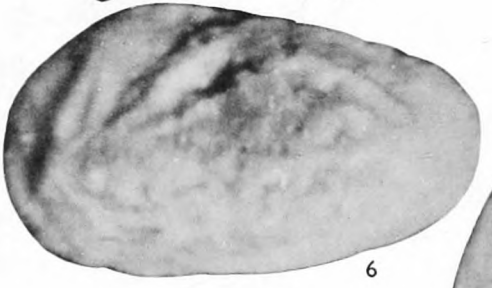
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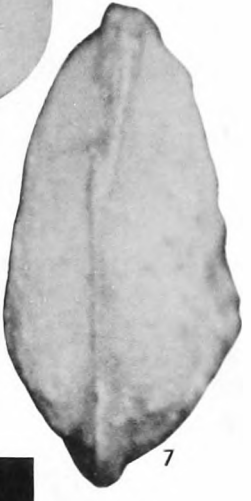
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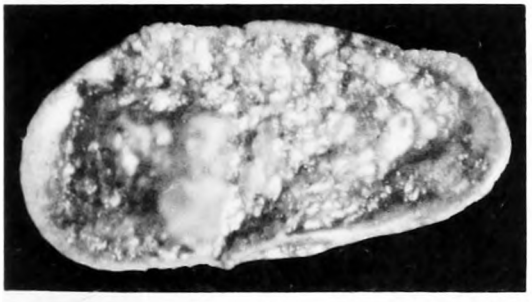
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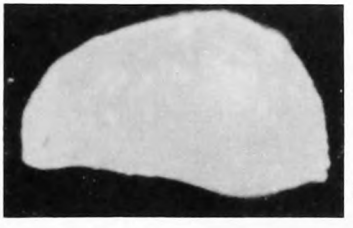
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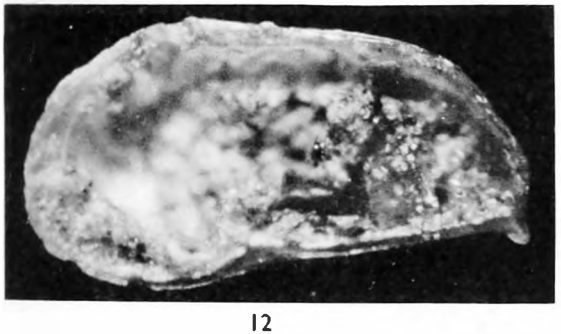
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PLATE 16

Ljubimovella piriformis Malz. p. 120.

Specimen from bed 7, Hawsker.

FIGS. 1, 2. Left and right sides, adult carapace. Io.2106.

Mesocytheridea howardianensis gen. et sp. nov. p. 122.

FIGS. 3–6, 9, 11. Bed 2, Stonecliff Wood.

FIG. 7. Bed 7, Bloody Beck.

FIGS. 8, 10. Bed 8, Stonecliff Wood.

FIGS. 3–6. Right, left, dorsal and ventral views, female carapace. Holotype, Io.1870.
FIG. 7. Dorsal view hinge, female left valve. Paratype, Io.1881.
FIGS. 8, 10. Dorsal and internal views, male right valve. Paratype, Io.1879.
FIG. 9. Dorsal view, female right valve. Paratype, Io.1871.
FIG. 11. Internal view, female left valve, showing anterior socket cutting back into the median bar. Paratype, Io.1875.

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PLATE 17

Mesocytheridea howardianensis gen. et sp. nov. p. 122.

Specimens from bed 2, Stonecliff Wood.

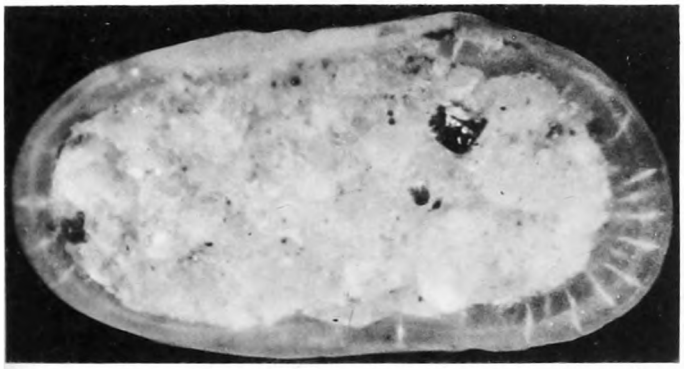
FIG. 1. Internal view, showing radial pore canals, male left valve. Paratype, Io. 1872.
FIGS. 2, 3. Internal views to show hinge and radial pore canals, female right valve. Paratype, Io.1871.

Praeschuleridea subtrigona intermedia subsp. nov. p. 124.

FIGS. 4–6. Bed 7, Hundale Point, Cloughton.

FIGS. 7–10. Bed 2, Stonecliff Wood.

FIGS. 4–6. Left, right and dorsal views, female carapace. Holotype, Io.1837.
FIGS. 7–10. Ventral, dorsal, right and left views, female carapace. Paratype, Io.1840.



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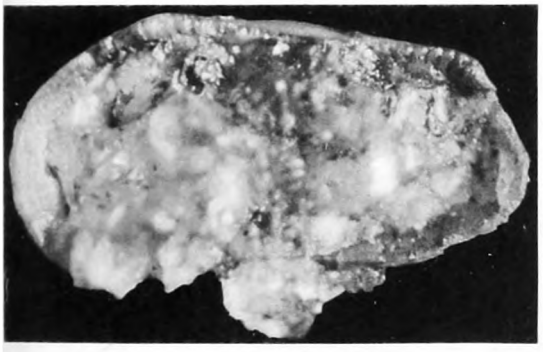

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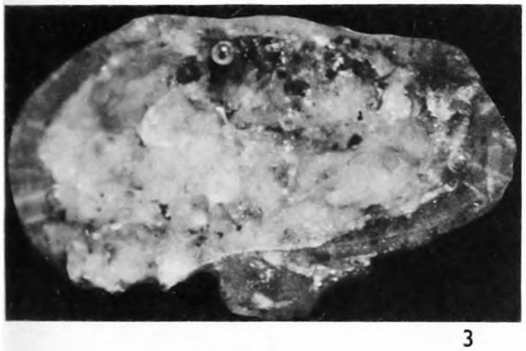

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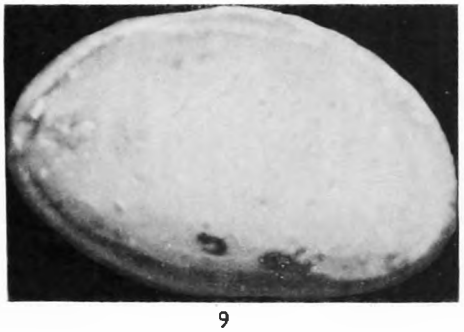

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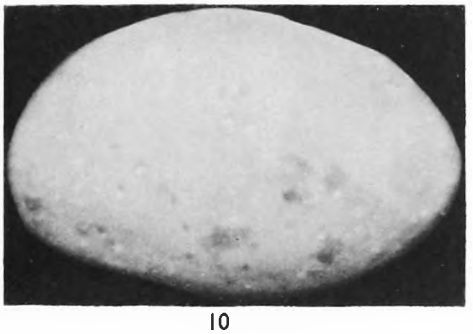

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PLATE 18

Praeschulerida subtrigona intermedia subsp. nov. p. 124.

FIGS. 1–3. Bed 7, Hundale Point, Cloughton.

FIGS. 4, 5, 8, 9. Bed 2, Stonecliff Wood.

FIGS. 6, 7. Bed 4, Gristhorpe Bay.

FIGS. 1–3. Left, right and ventral views, male carapace. Paratype, Io.1839.
FIG. 4. Muscle scars from internal cast. Paratype, Io.1844, ×180.
FIG. 5. Anterior radial pore canals, right valve fragment. Paratype, Io.1841, ×135.
FIGS. 6, 7. Dorsal and internal views to show hinge, female left valve. Paratype, Io.1846.
FIG. 8. Right side to show normal and radial pore canals, female carapace. Paratype, Io. 1842.
FIG. 9. Dorsal view of hinge, female right valve. Paratype, Io.1843.

Eocytheropteron ? sp. p. 126.

Specimen from bed 8, Stonecliff Wood.

FIGS. 10–13. Ventral, left, right and dorsal views, male carapace. Io.1911.

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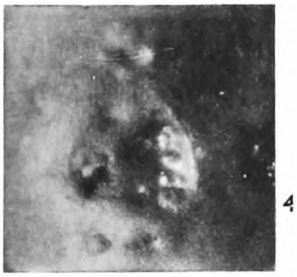

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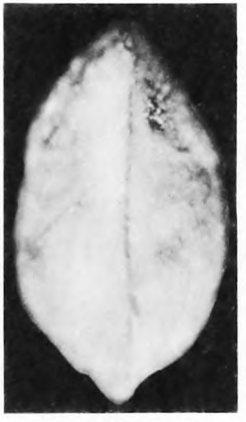

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PLATE 19

Eocytheropteron ? sp. p. 126.

Specimen from bed 11, Hawsker.

FIGS. 1–4. Right, left, dorsal and ventral views, female carapace. Io.1909.

Paracytheridea ? ***caytonensis*** sp. nov. p. 127.

All specimens from bed 6, Cayton Bay.

FIGS. 5–8. Dorsal, ventral, left and right views, female carapace. Holotype, Io.2137.
FIGS. 9–12. Right, left, dorsal and ventral views, female carapace. Paratype, Io.2140.
FIGS. 13–16. Right, left, dorsal and ventral views, male carapace. Paratype, Io.2138.


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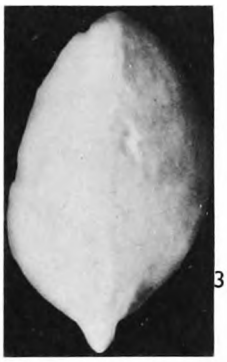
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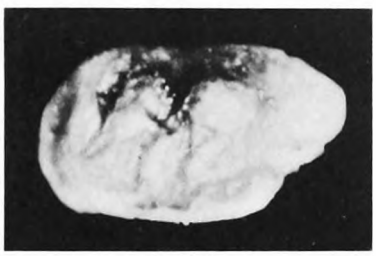
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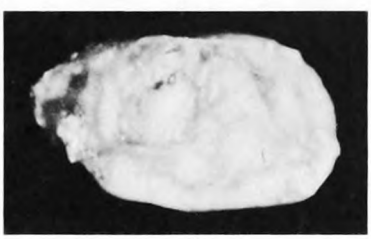
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PLATE 20

Southcavea microcellulosa sp. nov. p. 128.

FIGS. 1–8, 11–13. Bed 5, Stonecliff Wood.

FIGS. 9, 10. Bed 3, Stonecliff Wood.

FIGS. 1–4. Left, right, dorsal and ventral views, male carapace. Holotype, Io.1882.

FIGS. 5–8. Left, right, ventral and dorsal views, female carapace. Paratype, Io.1883.

FIGS. 9, 10. Dorsal view of hinge and muscle scars ($\times 120$), female right valve. Paratype, Io.1886.

FIGS. 11–13. Dorsal view of hinge and internal views showing hinge and radial pore canals, female right valve. Paratype, Io.1885.

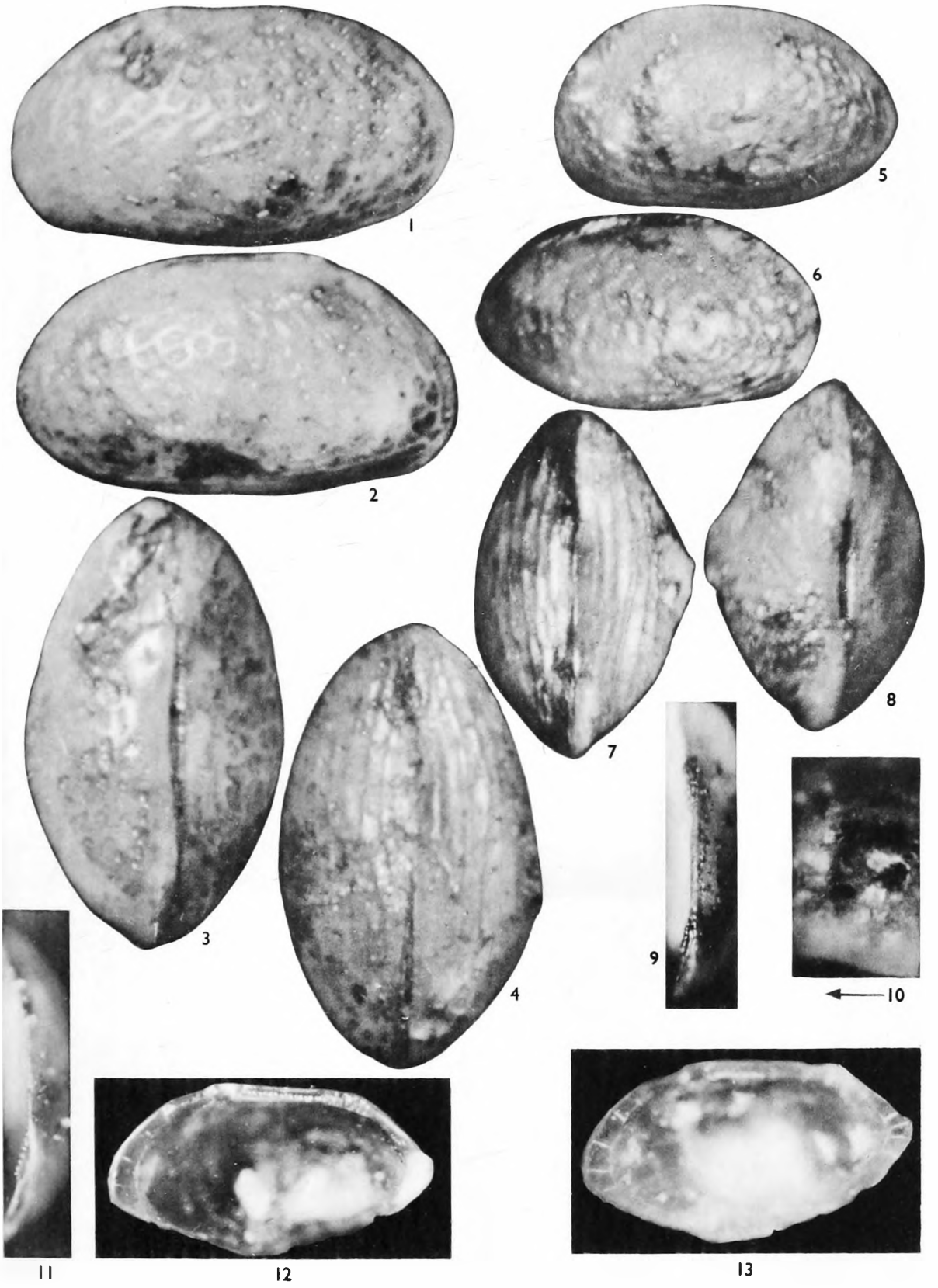
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PLATE 21

Southcavea microcellulosa sp. nov. p. 128.

Specimen from bed 8, Stonecliff Wood.

FIGS. 1–4. Right, left, dorsal and ventral views, male carapace. Paratype, Io.1888.

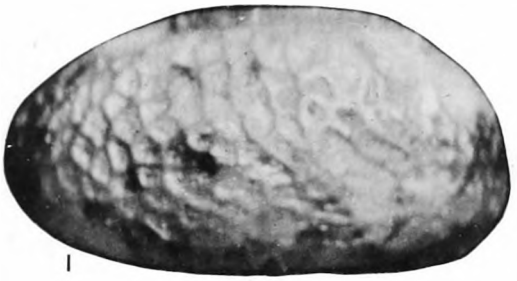
Systenocythere ovata sp. nov. p. 130.

FIGS. 5–8. Bed 7, Hawsker.

FIGS. 9–11. Bed 6, Cayton Bay.

FIG. 12. Bed 4, Cayton Bay.

FIGS. 5–8. Right, left, dorsal and ventral views, carapace. Holotype, Io.1900.
FIGS. 9–11. External, internal and dorsal views, right valve. Paratype, Io.1907.
FIG. 12. Muscle scars, note V-shaped antennal scar, left valve. Paratype, Io.1903, ×240.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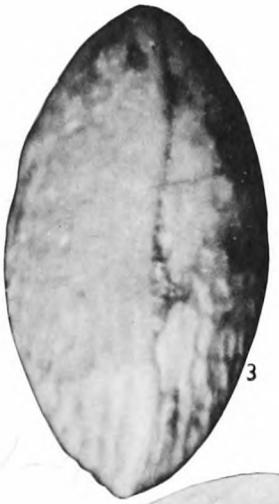
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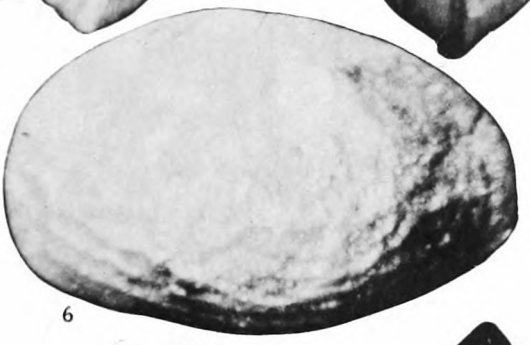
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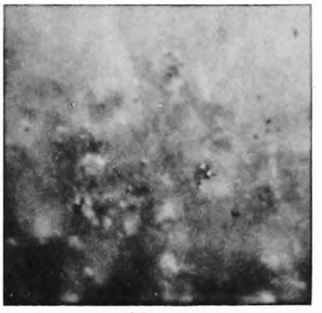
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