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THE FAUNAL PHASES AND PALAEOECOLOGY OF OSTRACOD-MUSSEL  
BANDS IN THE COAL MEASURES OF THE NORTH OF ENGLAND

by

John Ernest Pollard, M.A., F.G.S.

A thesis submitted to the Faculty of Science  
in the University of Durham  
for the degree of  
Doctor of Philosophy

December 1962

VOLUME II - ILLUSTRATIONS



LIST OF FIGURES AND PLATES - VOLUME II

CHAPTER I	Page
Fig. 1.1. : The coalfields of the north of England .. ..	1
Fig. 1.2. : General succession of the Durham Coal Measures .	2
Fig. 1.3. : Comparative sections of Coal Measures of Cumberland - Midgeholme & Durham . .. ..	3
Fig. 1.4. : Locality map in Northumberland and Durham ..	4
Fig. 1.5.a. Legend of the lithologies on Figs.1.5.b - 1.7... .	5
Fig. 1.5.b. Vertical sections Longhurst to Ferryhill . ..	6
Fig. 1.6. : Vertical sections Hedley to Ryhope . .. ..	7
Fig. 1.7. : Vertical sections Chopwell to Eppleton .. ..	8
Fig. 1.8. : Lithofacies map of roof strata of Harvey Seam ..	9
Fig. 1.9. : Locality map - Cumberland .. .. .	10
Fig. 1.10. Comparison of ostracod-mussel bands, Cumberland, Midgeholme - Durham .. ..	11
Fig. 1.11.: Lithological successions of the Three Quarter boreholes .. .. .	12
Fig. 1.12.: Section of shale of the Claxheugh Shell Bed ..	12
 CHAPTER II	
Fig. 2.1. : Variation in <u>Carbonicola</u> in Hopkins' Band ..	13
Fig. 2.2. : Dimension graph of specimens of <u>C. oslancis</u> ..	14
Fig. 2.3. : Variation in <u>Anthracosia</u> in Hopkins' Band ..	15
Fig. 2.4. : Variation in <u>Naiadites</u> in Hopkins' Band . ..	16
Fig. 2.5. : Variation in <u>Anthraconaia</u> in Hopkins' Band ..	17

CHAPTER III

Fig. 3.1. :	Dimensions and areas of an ostracod carapace ..	18
Fig. 3.2. :	Morphology of an ostracod carapace .. ..	18
Fig. 3.3. :	Drawing of <u>Jonesina fastigiata</u> .. ..	19
Fig. 3.4. :	Drawing of <u>Geisina arcuata</u> .. ..	20
Fig. 3.5. :	The hinge structure of <u>G. arcuata</u> .. ..	21
Fig. 3.6. :	External and internal moulds of <u>G. arcuata</u> ..	21
Fig. 3.7. :	Height-length dimensions of <u>G. arcuata</u> .. ..	22
Fig. 3.8. :	Graph of median and posterior thickness in <u>G. arcuata</u> .. ..	22
Fig. 3.9. :	Graph of length and posterior thickness in <u>G. arcuata</u> .. ..	23
Fig. 3.10.:	Graph of H/L and TP/L ratios in <u>G. arcuata</u> ..	23
Fig. 3.11.:	Drawing of <u>Geisina subarcuata</u> .. ..	24
Fig. 3.12.:	Moults of <u>G. subarcuata</u> .. ..	25
Fig. 3.13.:	Drawing of <u>Carbonita cf. evelinae</u> .. ..	26
Fig. 3.14.:	Drawing of <u>C. cf. rankiniana</u> .. ..	27
Fig. 3.15.:	Height-length relationships in <u>C. rankiniana</u> ..	28
Fig. 3.16.:	Dimorphic forms of <u>C. humilis</u> .. ..	29
Fig. 3.17.:	Height-length relationships in <u>C. humilis</u> ..	30
Fig. 3.18.:	Drawing of <u>C. pungens</u> .. ..	30
Fig. 3.19.:	Drawing of <u>C. inflata</u> .. ..	31
Fig. 3.20.:	Height-length relationships in <u>C. inflata</u> .	32
Fig. 3.21.:	Drawing of <u>C. secans</u> .. ..	32
Fig. 3.22.:	Drawing of <u>C. concava</u> nom. nov. .. ..	33
Fig. 3.23.:	Records of ostracods from the Durham Coalfield..	34
Fig. 3.24.:	H/L population graph of ostracods of Hopkins' Band	35
Fig. 3.25.:	H/L population graph of <u>Carbonita</u> from Hylton ..	35

Fig. 3.26.:	H/L population graph of <u>Geisina subarcuata</u>			
	from Claxheugh .. .. .			36

CHAPTER IV

Fig. 4.1.:	Growth forms of <u>Microconchus (Spirorbis) pusillus</u>			37
Fig. 4.2.:	Internal moulds of <u>M. pusillus</u> .. .. .			37
Fig. 4.3.:	Internal features and wall structure of <u>M. pusillus</u> .. .. .			38
Fig. 4.4.:	Growth form and hosts of <u>M. pusillus</u> in the Hopkins' Band .. .. .			39
Fig. 4.5. :	<u>M. pusillus</u> on <u>Cordaites</u> in siltstones .. .. .			40
Fig. 4.6.:	Growth positions and feeding advantage .. .. .			40

CHAPTER V

Fig. 5.1.:	Key to faunal phase diagrams .. .. .			41
Fig. 5.2.:	Faunal phases of Hopkins Band at Bearpark .. .. .			42
Fig. 5.3.:	" " " " " " Whitworth .. .. .			43
Fig. 5.4.:	" " " " " " East Holywell .. .. .			44
Fig. 5.5.:	" " " " " " Bates, Blyth .. .. .			45
Fig. 5.6.:	" " " " " " Silksworth .. .. .			46
Fig. 5.7.:	" " " " " " Lanchester .. .. .			47
Fig. 5.8.:	Faunal distribution at Hedley Park .. .. .			48
Fig. 5.9.:	Faunal phases of the ThreeQuarter Band .. .. .			49

CHAPTER VI

Fig. 6.1.:	Petrographic features and X-ray data on the sediments of the Bearpark" type section" .. .. .			50
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## CHAPTER VII

- Fig. 7.1.: Typical defractometer traces of the various  
                  lithologies of the Bearpark " type section" . 51
- Fig. 7.2.: Correlation of X-ray and petrological data of the  
                  sediments of the Hopkins' Band at Bearpark .. 52
- Fig. 7.3.: Geochemical variation of certain elements and  
                  compounds in the sediments at Bearpark .. 53
- Fig. 7.4.: Stability fields of  $Fe_2CO_3$  and FeS in terms  
  of Eh and pH .. .. . 54
- Fig. 7.5.: Sedimentary associations in terms of Eh and pH . 55

## CHAPTER VIII

- Fig. 8.1.: Pattern of burial and preservation of  
  mussel shells .. .. 56
- Fig. 8.2.: Boron content and " salinity facies " of  
  Upper Carboniferous fossils .. .. 57

## CHAPTER IX

- Fig. 9.1.: Reconstruction of the ecological and depositional  
                  history of the Hopkins' Band at Bearpark .. 58
- Fig. 9.2.: Reconstruction of the changing sedimentary  
                  environments across the Durham Coalfield  
                  during the formation of the Hopkins' Band .. 59

## PLATES

- PLATE I : Specimens of Carbonicola from the Hopkins' Band . 60

PLATE II :	Specimens of <u>Carbōnicola</u> and <u>Anthracosia</u> from	
	the Hopkins' Band .. .. .	61
PLATE III:	Specimens of <u>Anthrasosia</u> from the Hopkins' Band..	62
PLATE IV :	Specimens of <u>Naiadites</u> from the Hopkins' Band ..	63
PLATE V :	Specimens of <u>Naiadites</u> and <u>Anthraconaia</u> from	
	the Hopkins' Band .. .. .	64
PLATE VI :	Mussels from the Three Quarter Seam horizon ..	65
PLATE VII:	<u>Geisina arcuata</u> from the Hopkins' Band ..	66
PLATE VIII:	Strata above the Harvey Seam at Whitworth and	
	shale section of the Claxheugh Shell Bed ..	67
PLATE IX :	Mudstone conglomerate and black shale, Whitworth	68
PLATE X :	Mudstone and siltstone above Harvey , Whitworth.	69
PLATE XI :	Mudstone conglomerate and black shale, Bates	
	and Bearpark .. .. .	70
PLATE XII:	Black silty shale at Bates, <u>Geisina</u> Band at	
	Eppleton .. .. .	71
PLATE XIII:	<u>Geisina</u> Band at Whitworth and Follonsby ..	72
PLATE XIV :	Grey shaley mudstone at Bearpark .. .. .	73
PLATE XV :	Grey mudstone and siliceous mudstone at Bearpark	74
PLATE XVI :	Laminated siltstones with borings at Bearpark..	75
PLATE XVII:	Carbonaceous cross-bedded sandstone from	
	Whitworth Opencast .. .. .	76

Figure 1.1. The coalfields of the four northern counties  
of England.

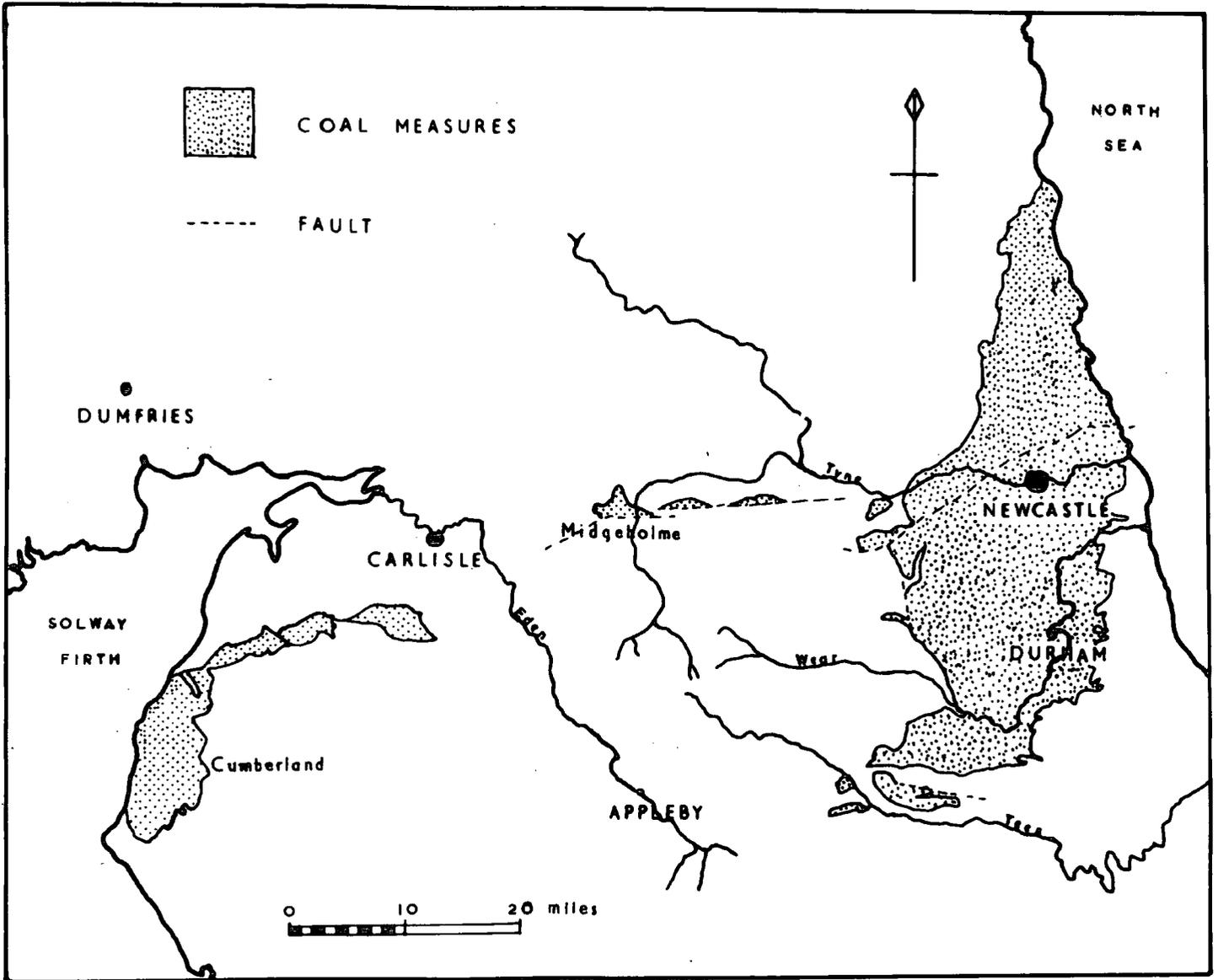


Figure 1.2. A generalised sequence of the Durham Coal Measures

# DURHAM

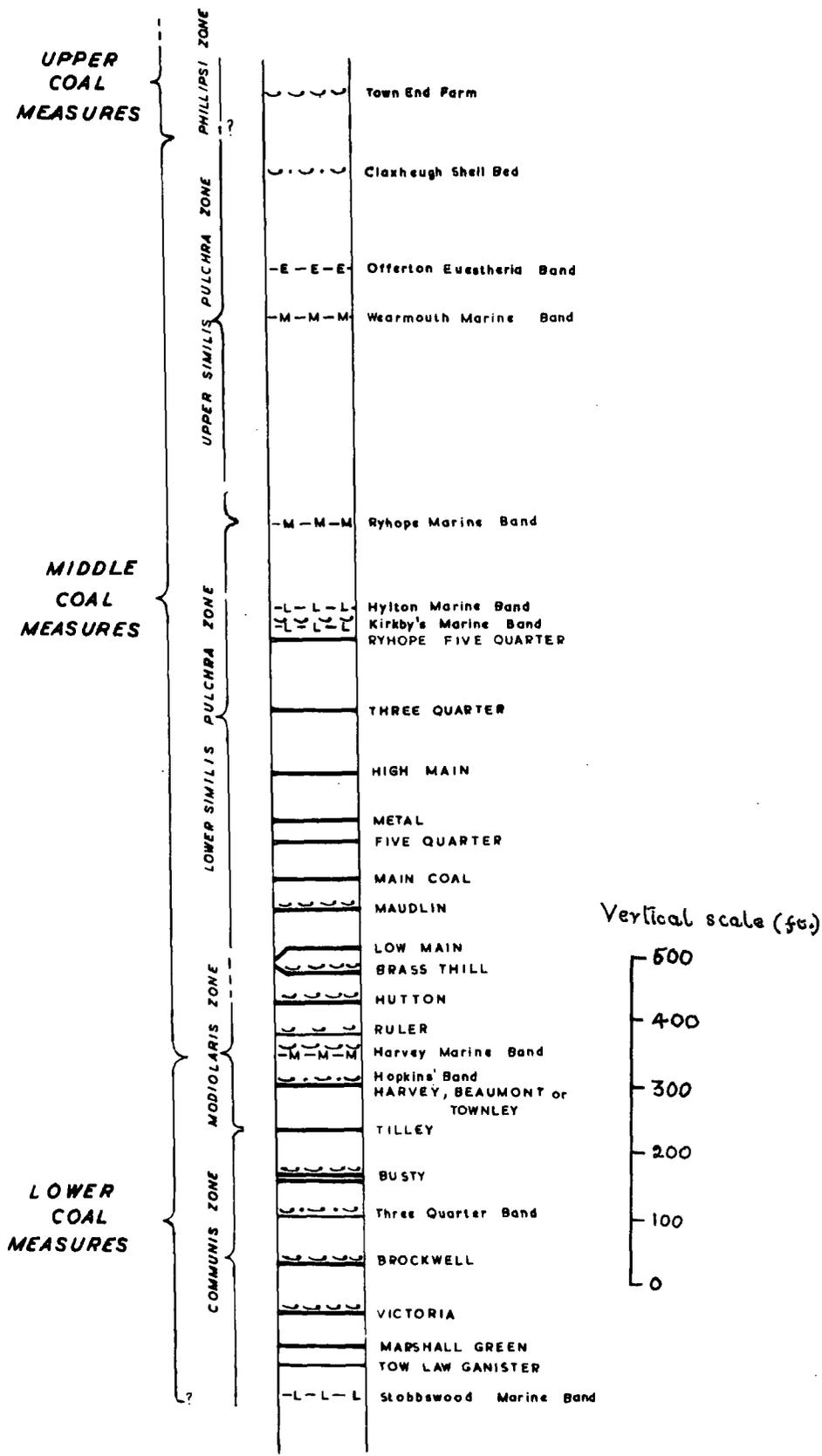


Figure 1.3. Comparative generalised sections of the coalfields  
of Cumberland, Midgeholme and Durham.

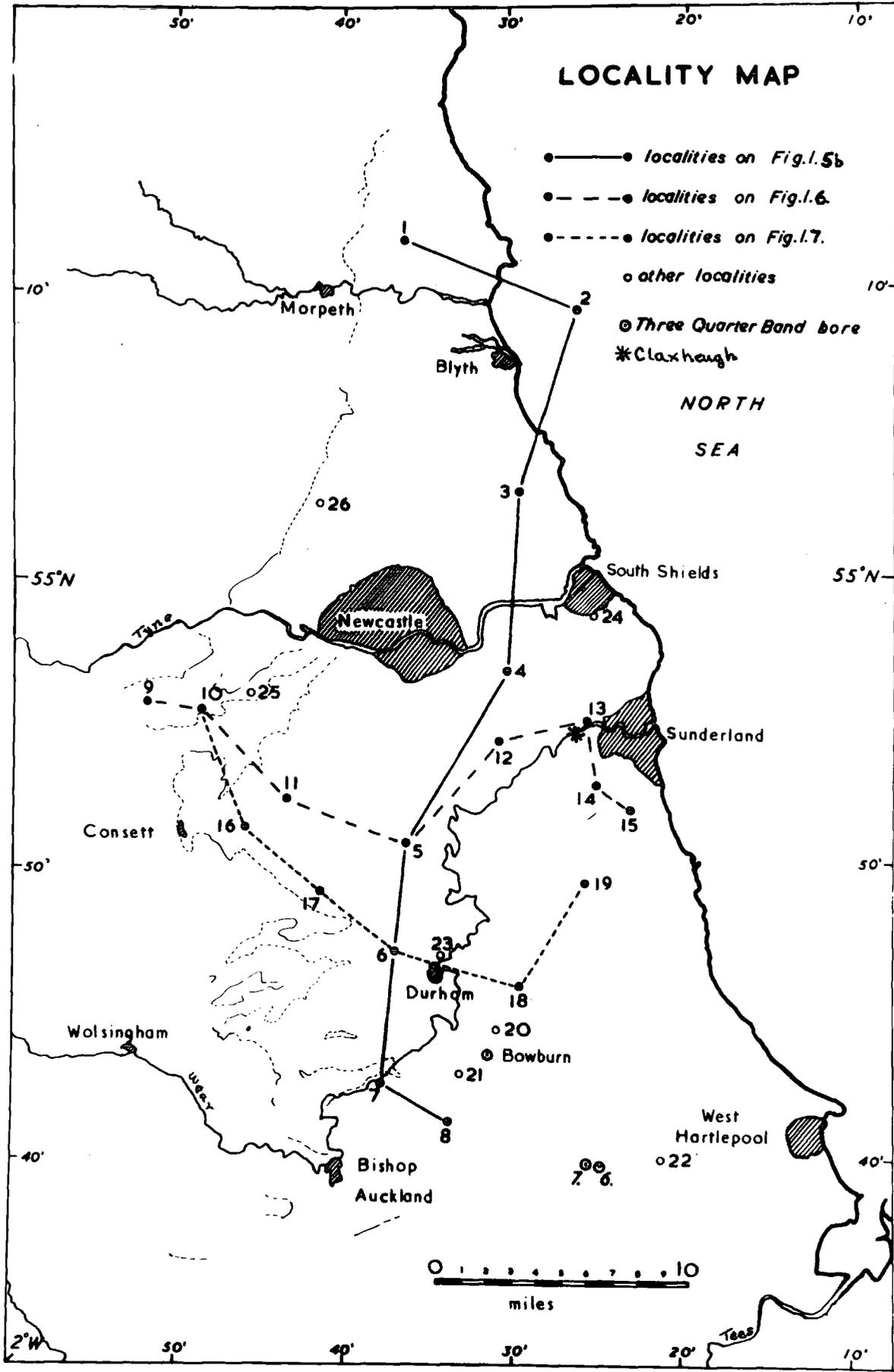


4.

Figure 1.4. Map of sampling localities of the strata of  
the Hopkins' Band and Three Quarter Band in  
Northumberland and Durham.

- Locality 1.- Longhurst Drift , Northumberland.  
2.-  $2\frac{1}{2}$  miles north-east of Bates Pit, Blyth.  
3.- Fenwick Pit, East Holywell, Northumberland.  
4.- Wardley No 1. Pit, Follonsby, Durham.  
5.- Pelton Colliery, Durham.  
6.- Bearpark Colliery, Durham.  
7.- Whitworth Opencast, Durham.  
8.- Dean and Chapter Pit, Ferryhill, Durham.  
9.- Hedley Park Drift, Northumberland.  
10- Chopwell East Drift, Durham.  
11.- Tanfield Lea Colliery, Durham.  
12.- Washington F & J Pit, Durham.  
13.- Hylton Colliery, Durham.  
14.- Silksworth Colliery, Durham.  
15.- Ryhope Colliery, Durham  
16.- Eden Colliery, Leadgate, Durham.  
17.- Lanchester drift, Durham.  
18.- Sherburn Hill Colliery, Durham.  
19.- Eppleton Colliery, Durham.  
20.- Bowburn Colliery, Durham.  
21.- Tuersdale Colliery, Durham.  
22.- Fishburn Colliery borehole 36.S.E.5.  
23.- Durham Main Colliery, ( disused), Durham.  
24.- Harton Colliery, South Shields, Durham.  
25.- Blaydon Burn Barlow Drift, Durham.  
26.- East Walbottle Colliery, Northumberland.  
6. Fishburn Borehole (6)., Durham  
7.- Fishburn Borehole (7)., Durham.

# LOCALITY MAP



- localities on Fig. 1.5b
- - - localities on Fig. 1.6
- - - - localities on Fig. 1.7
- other localities
- ⊙ Three Quarter Band bore
- \* Claxhaugh



Figure 1.5.a. The lithologies represented on the vertical sections on Figures 1.5.b., 1.6. and 1.7.

# LEGEND



Seatearth



Coal



Cannel coal



Cannel shale



Ankeritic mudstone conglomerate



Black shale



Grey shale



Grey mudstone



Grey mudstone with ironstone



Grey siliceous mudstone



Grey siltstone



Massive sandstone



Sandstone with plants



False bedded sandstone



Shale with ostracods



Mussel band

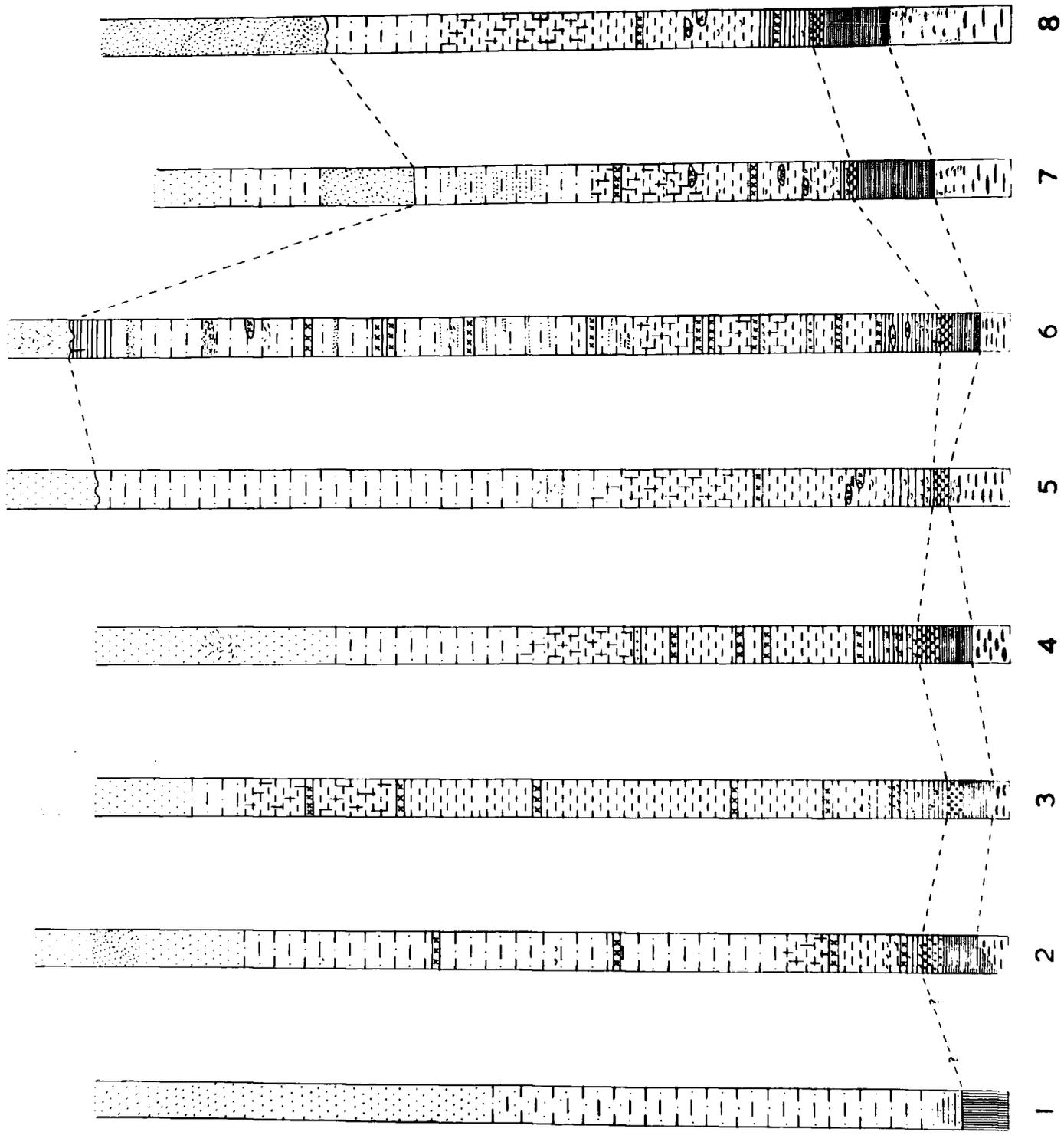


Fish band

Top of Harvey - Beaumont Seam

Figure 1.5.b. Vertical sections of the strata immediately above the Harvey - Beaumont Seam in an approximately north to south direction from Longhurst to Ferryhill. ( As on Figure 1.4.1 )  
( Base of the columns is the top of coal Seam )

5' 6" 5' 0" 4' 6" 4' 0" 3' 6" 3' 0" 2' 6" 2' 0" 1' 6" 1' 0" 6" 0"



8 7 6 5 4 3 2 1

7.

Figure 1.6. Vertical sections of strata immediately above the Townley-Harvey Seam in an approximately east-west direction , from Hedley Park to Ryhope ( Localities as on Figure 1.4)

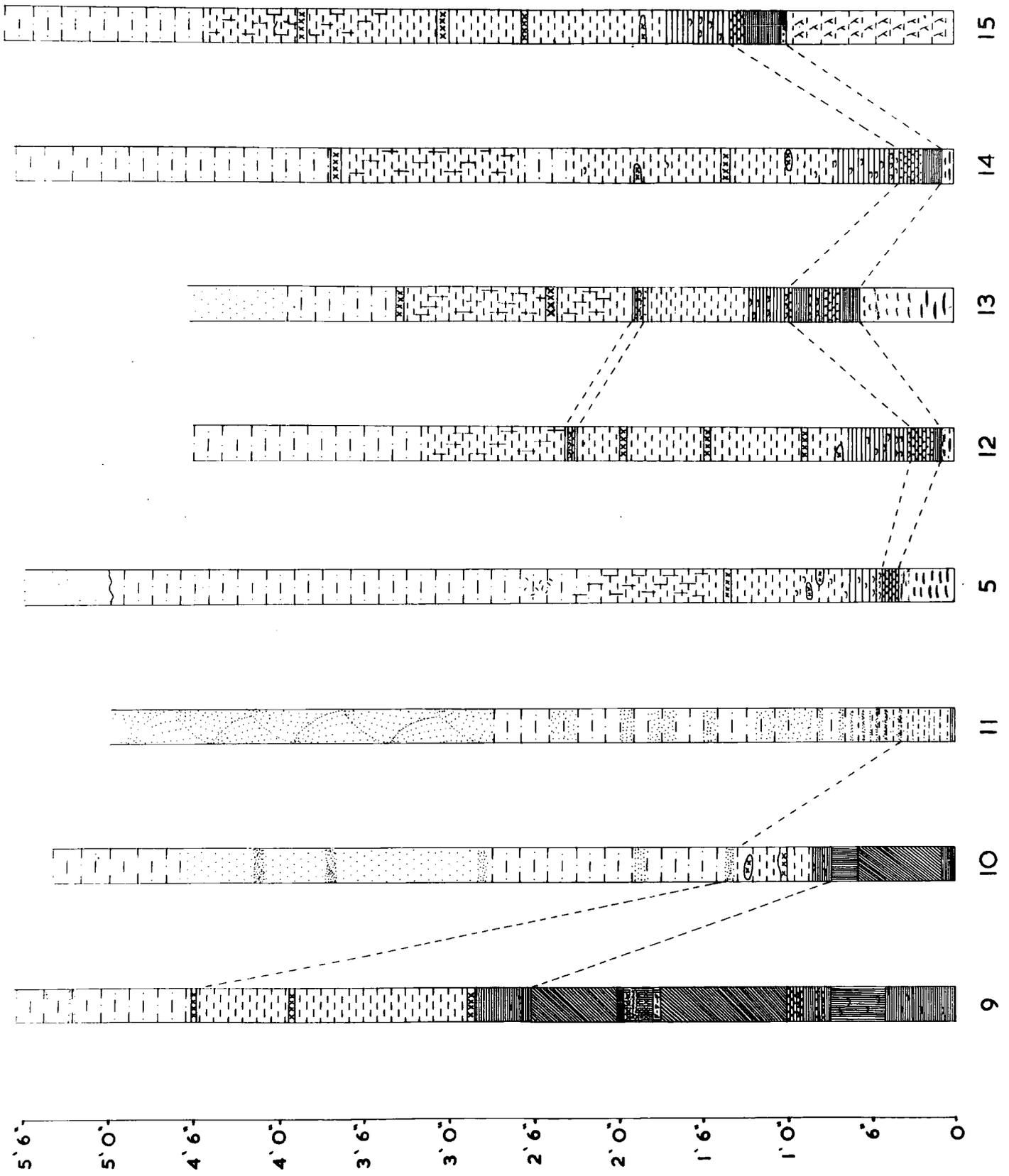


Figure 1.7. Vertical sections of strata immediately above the Townley-Harvey Seam in an approximately north-west to south-east direction, from Chopwell to Eppleton.  
( Localities as on Figure 1.4.)

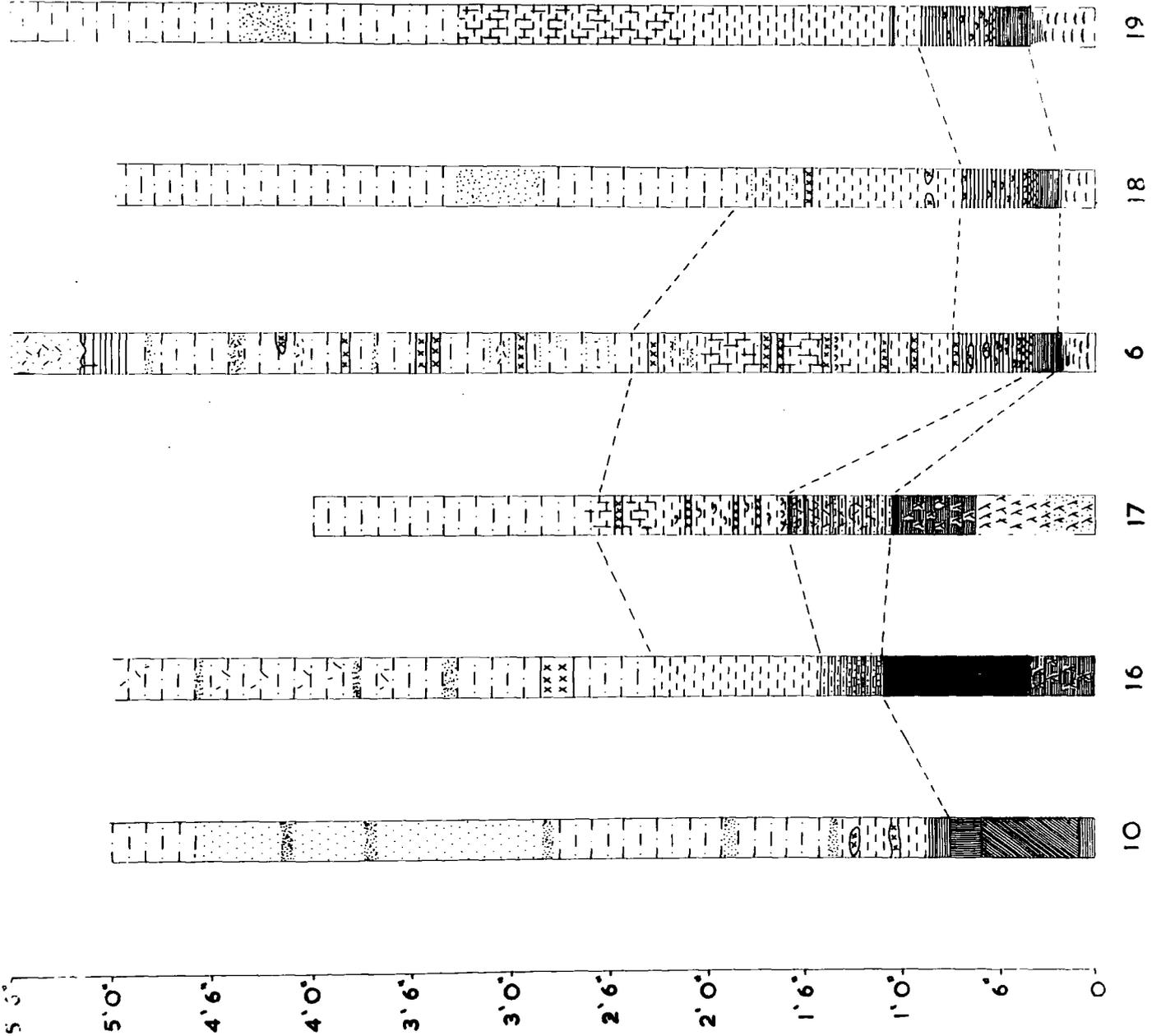


Figure 1.8. Lithofacies map of the 3ft. of roof strata of the Harvey-Beaumont Seam in Northumberland and Durham.

( The information for this map has been derived from the sampling localities of Figure 1.4. and examination of 130 borehole records. )

# LITHOFACIES MAP

## LEGEND



Sandstone



Siltstone with plants



Shales and mudstones with ostracods  
Hopkins' Band



Black shales with scattered mussels



Cannel shale and coal  
with ostracods



Seam outcrop

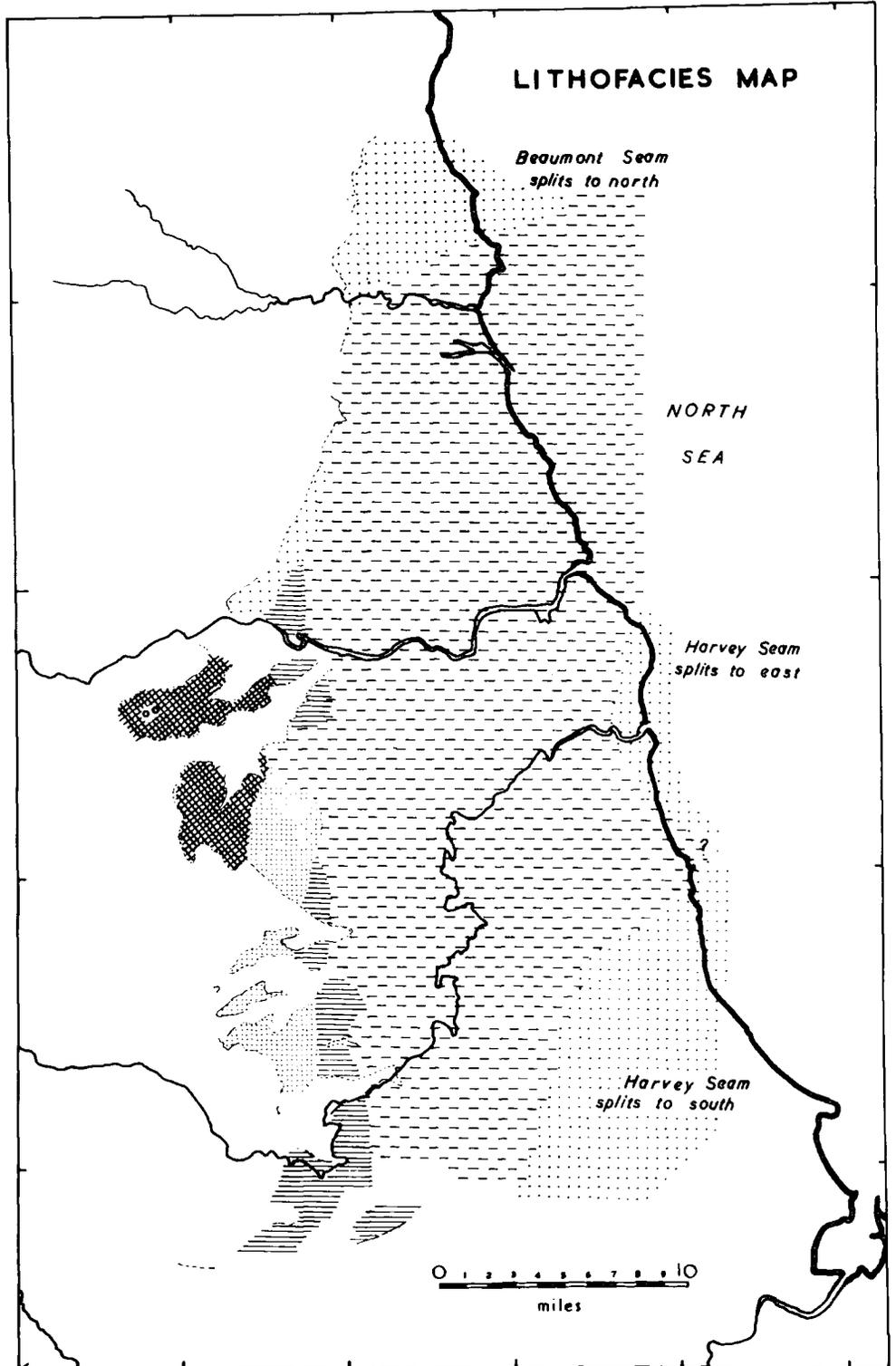


Figure 1.9. Map showing the sampling localities of the ostracod-mussel band above the Eighteen Inch Seam of Cumberland.

- Locality A. ♀ Nelson Park Pit (disused), Broughton Moor  
B. - Hennow Hall Opencast Site, Cumberland.  
C. - Borehole nr. Branthwaite, Cumberland.  
D. - Risehow No 10. underground borehole, Risehow  
Colliery, Maryport, Cumberland.  
E. - Crosby NO. 6. borehole, Crosby, Cumberland.  
F. - Crosby No. 7. borehole, Crosby, Cumberland.  
G. - Bullgill Station, Cumberland. ( Ostracod-  
mussel band above Little Main Seam.)

The numbered boreholes are those given by Taylor and Calver (1961)

# LOCALITY MAP CUMBERLAND

⊙ borehole record - Taylor & Calver 1961

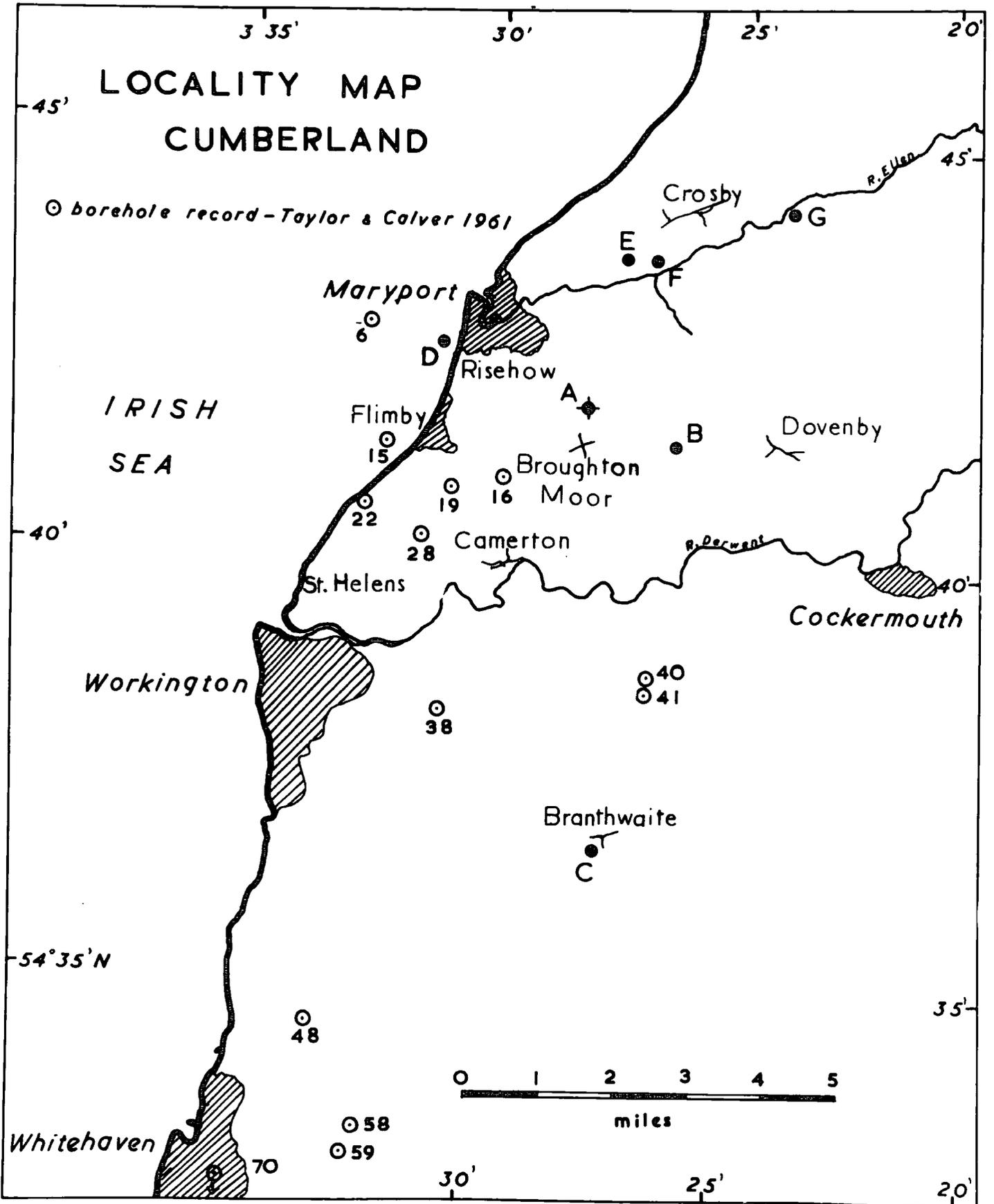


Figure 1.10. Comparative sections of ostracod-mussel bands equivalent to the Hopkins' Band in Cumberland, Midgeholme and Durham.  
( Lithologies represented as on Figure 1.5.a.)

CUMBERLAND

MIDGEHOLME

DURHAM

Crosby No.7

Lambley No.14

Bearpark

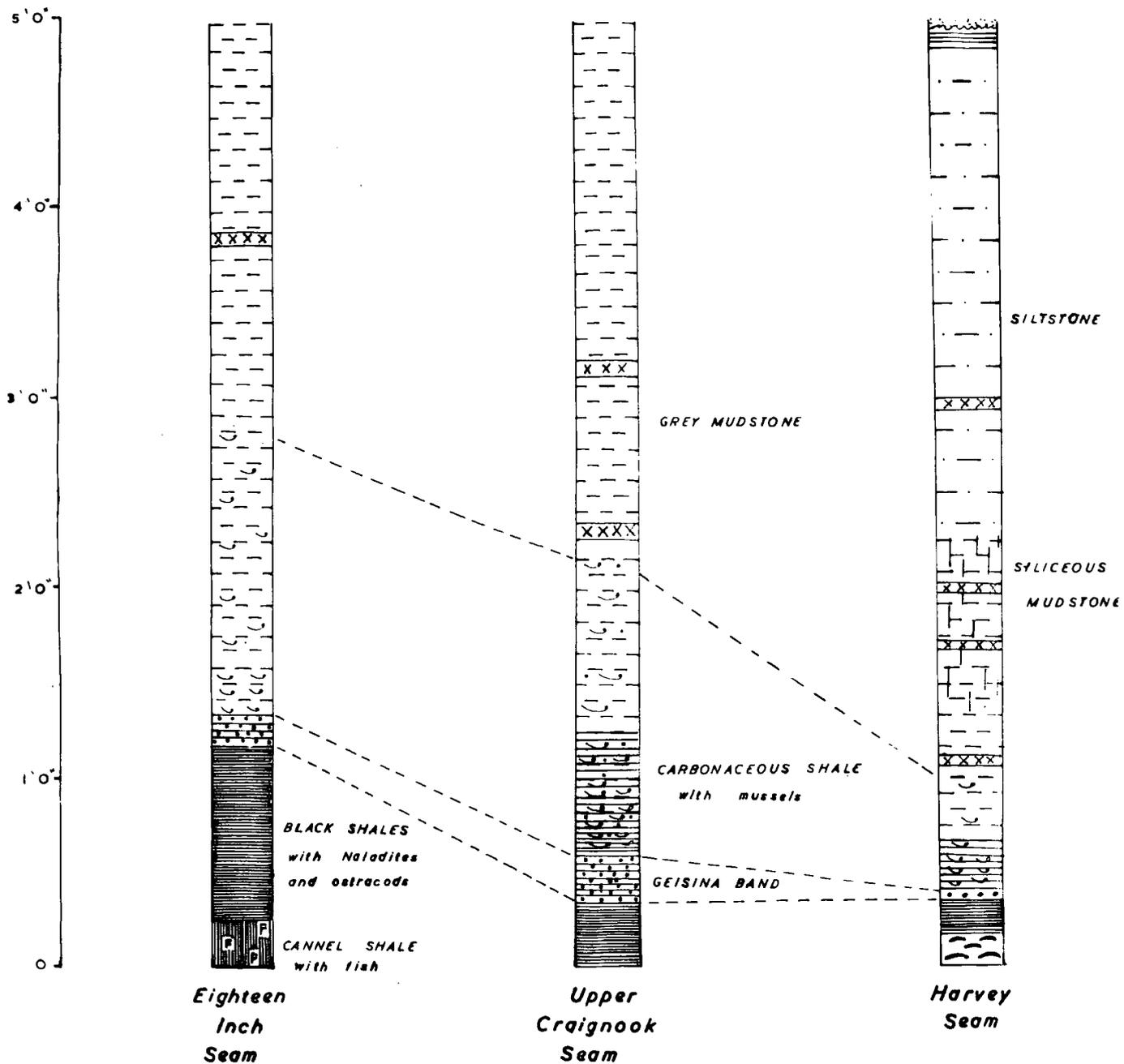


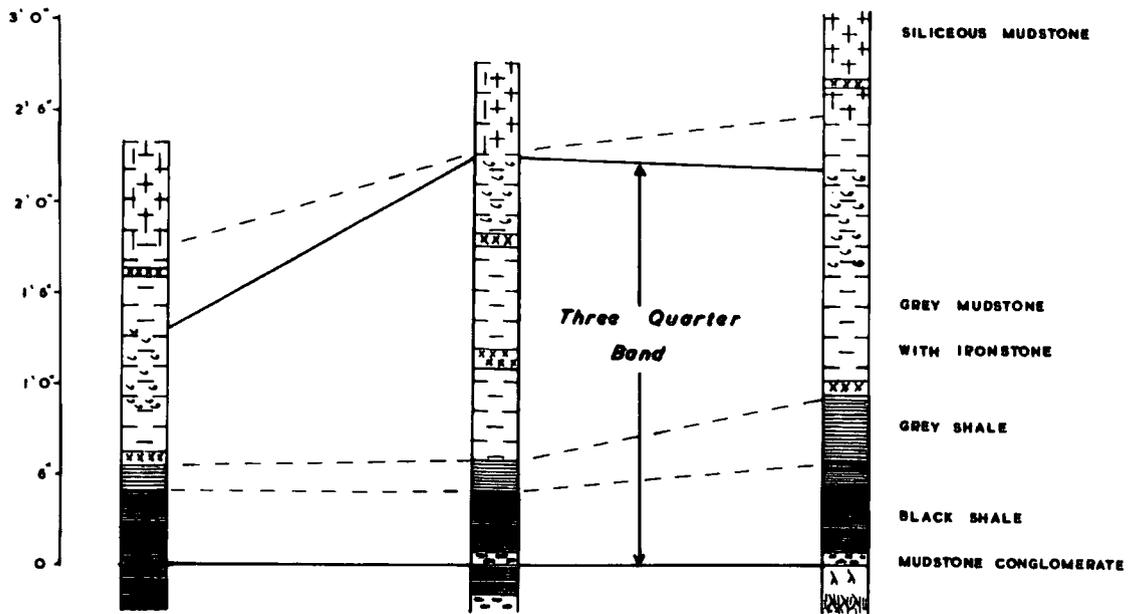
Figure 1.11. Comparative sections of the Three Quarter  
Band boreholes.

Figure 1.12. The vertical section of the Claxheugh Shell  
Bed, north bank of River Wear, opposite  
Claxheugh Rocks, North Hylton, Sunderland,  
County Durham.

Bowburn

Fishburn 7

Fishburn 6



**Section of CLAXHEUGH SHELL BED**

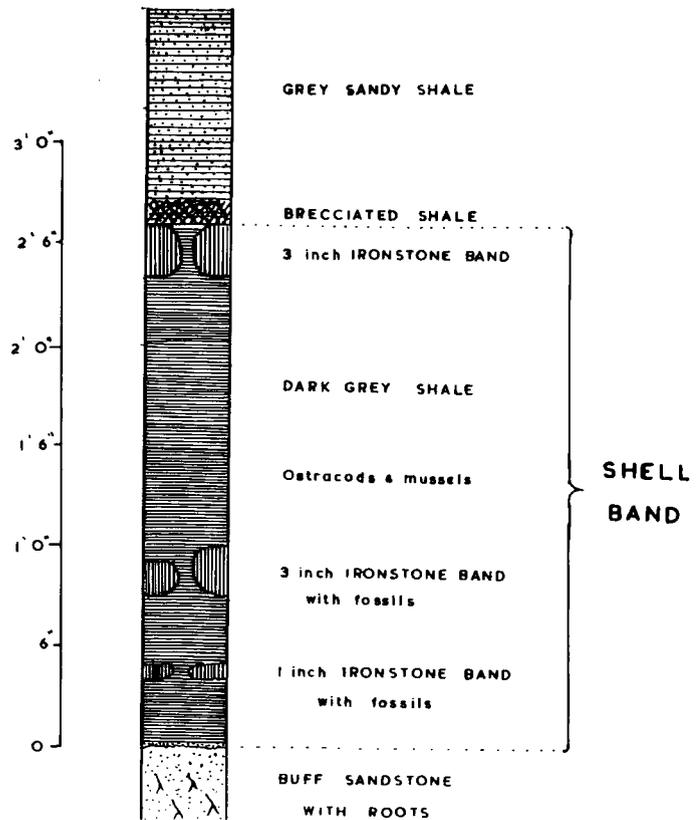


Figure 2.1. Variation in the genus Carbonicola in the Hopkins' Band. Form a is C. venusta , l- C. oslancis , j & i - C. embletoni, f -C. cf. oslancis , n & o- C. cf. bipennis , u - C. pectorata , p & q- C. cf. communis , and r - C. cf. rhomboidalis.

( The underlined specimens are figured on Plates I & II. The localities of the mussels are various so this is not a true community pictogram. )

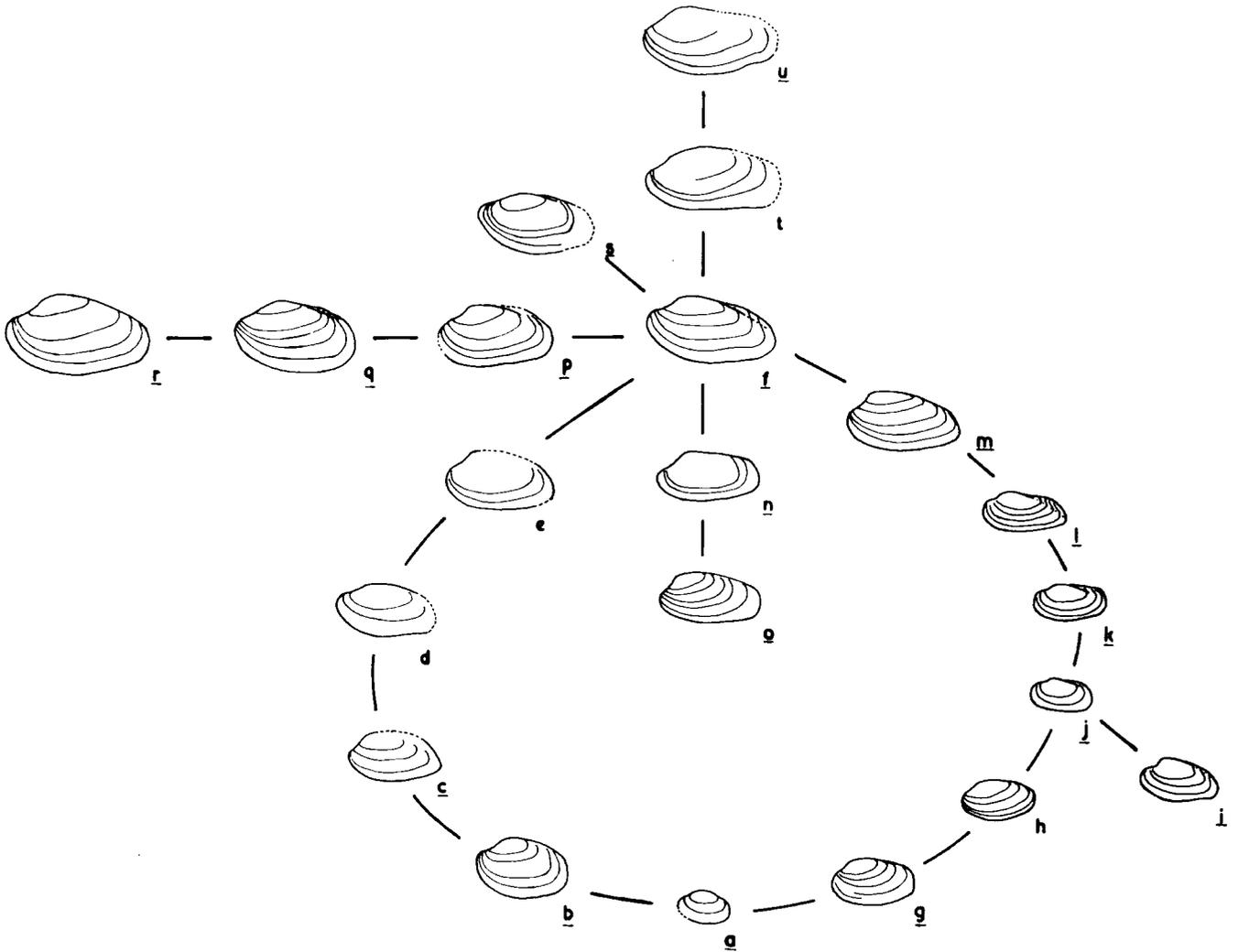


Figure 2.2. Graph of the dimension ratios of Carbonicola  
oslancis and related species.

A/L = ratio anterior to length.

H/L = ratio height to length.

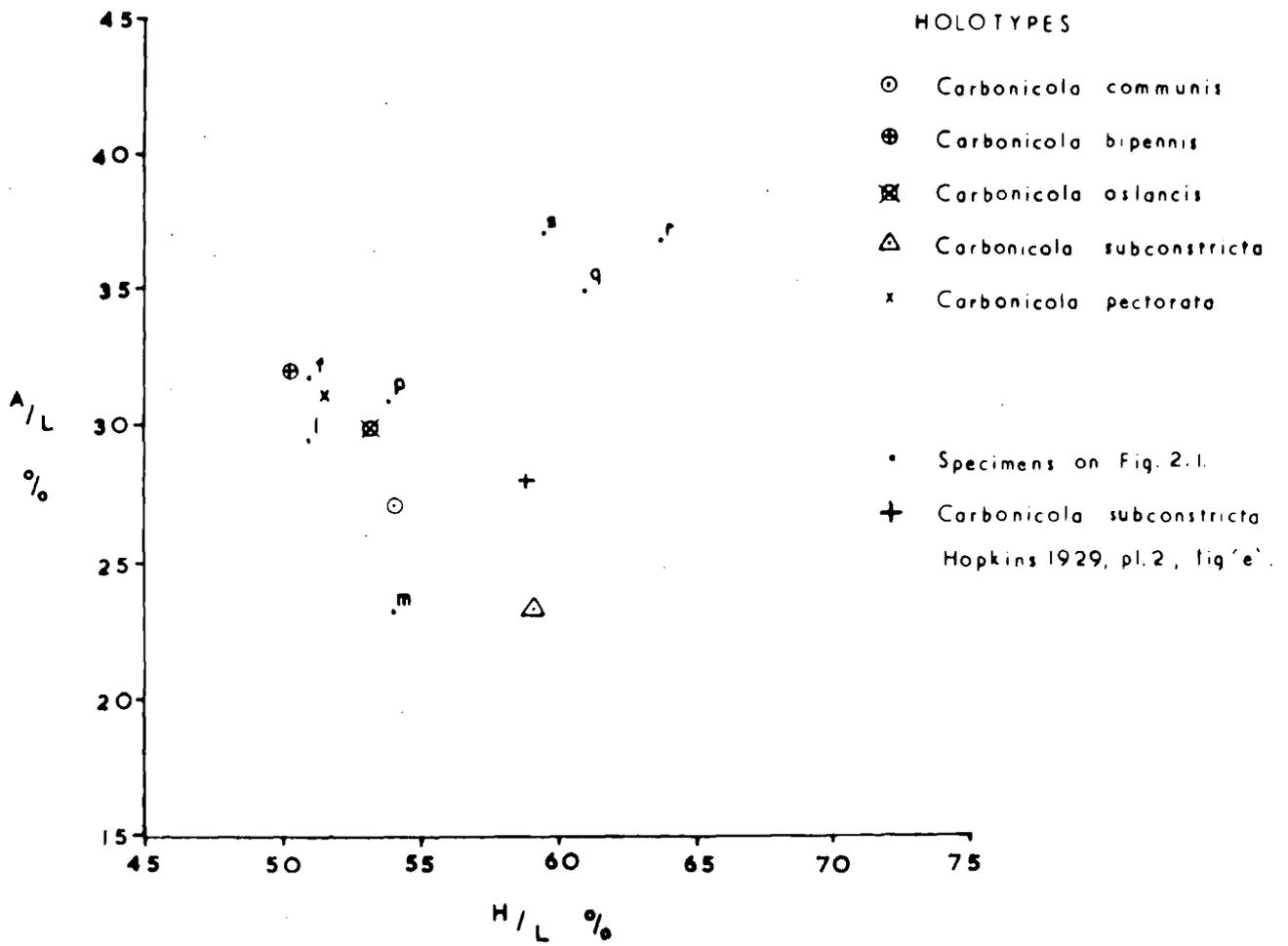


Figure 2.3. Variation in the genus Anthracosia in the Hopkins' Band. N - A. regularis , L & K - A. cf. ovum , I - A. cf. aquilina, and A - A. cf. retrotracta ( Underlined specimens are figured on Plates II & III. Not a community pictogram, localities various. )

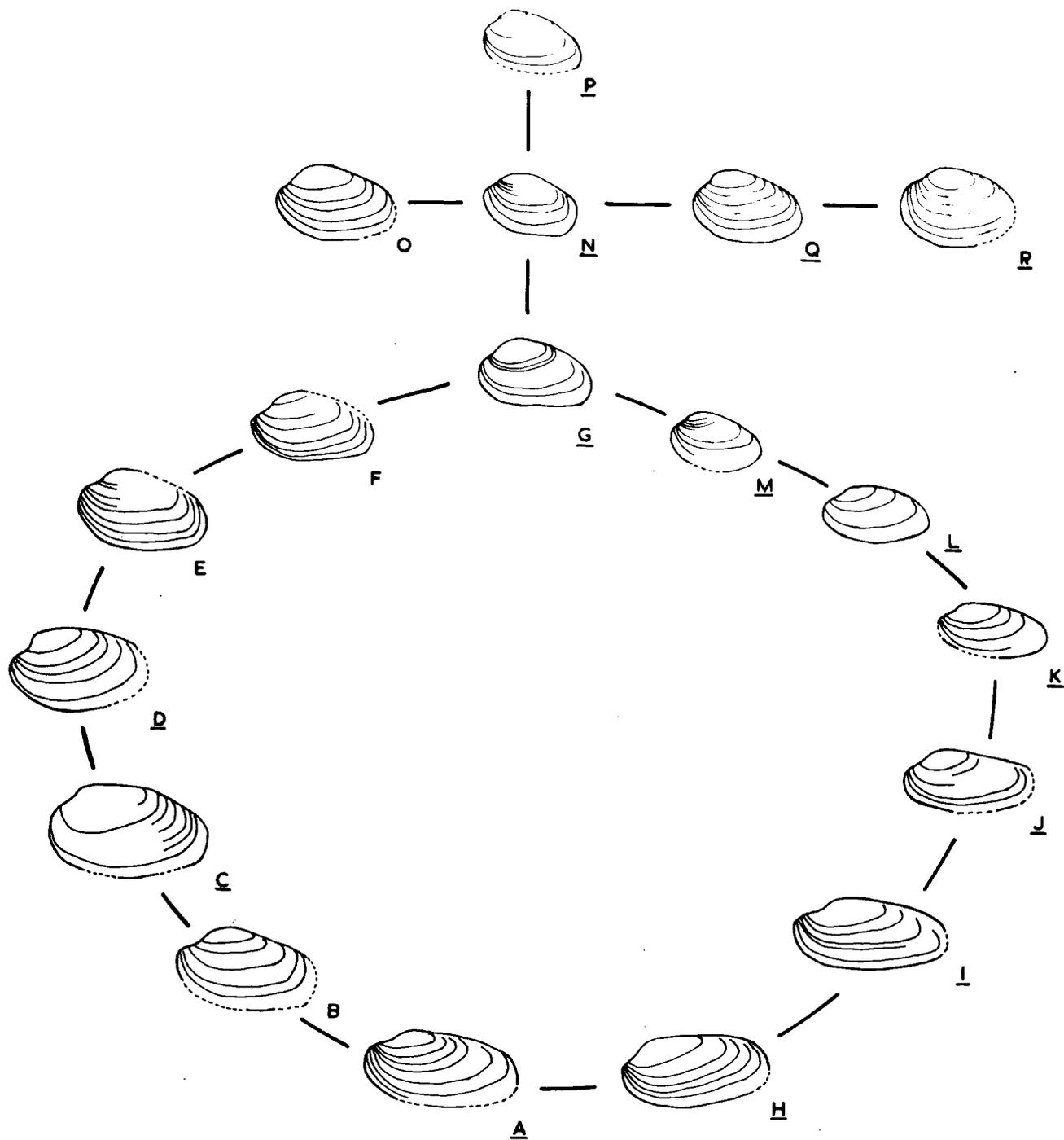


Figure 2.4. Variation in the genus Naiadites in the  
Hopkins' Band. i- N. cf. triangularis,  
iii - N. productus, viii - N. cf. subtruncatus,  
ix - N. cf. quadratus , xi - N. cf. carinatus  
xii - N. cf. flexuosus .

( Underlined specimens are figured on Plates

IV & V. )

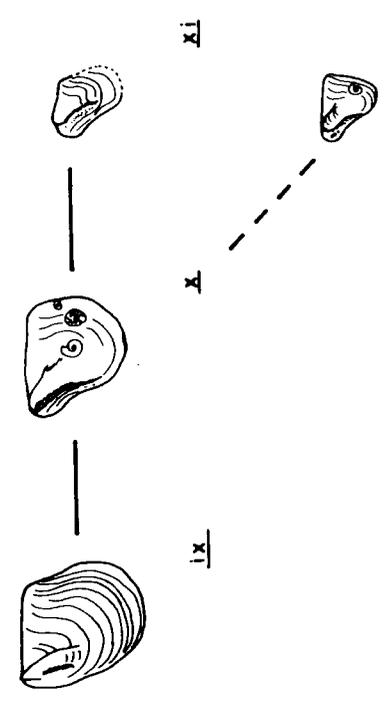
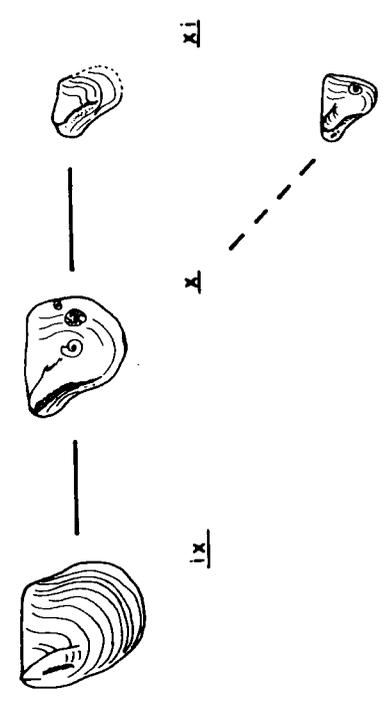


Figure 2.5. Variation in the genus Anthraconama in the Hopkins' Band. Form Z - A. cf. curtata ,  
Y - A. modiolaris , U - A. williamsøni ,  
and V - A. cf. fugax.  
(Underlined specimens are figured on Plate V )

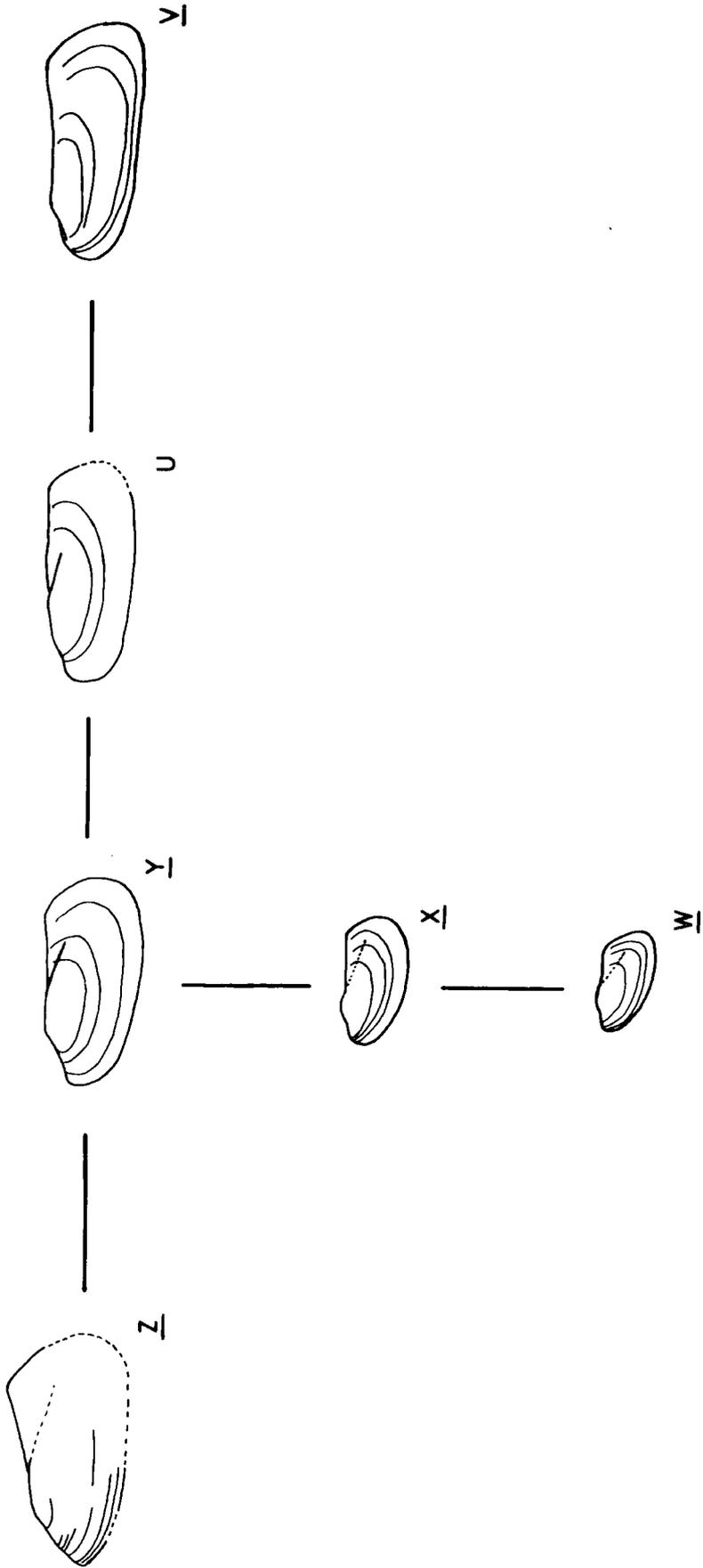
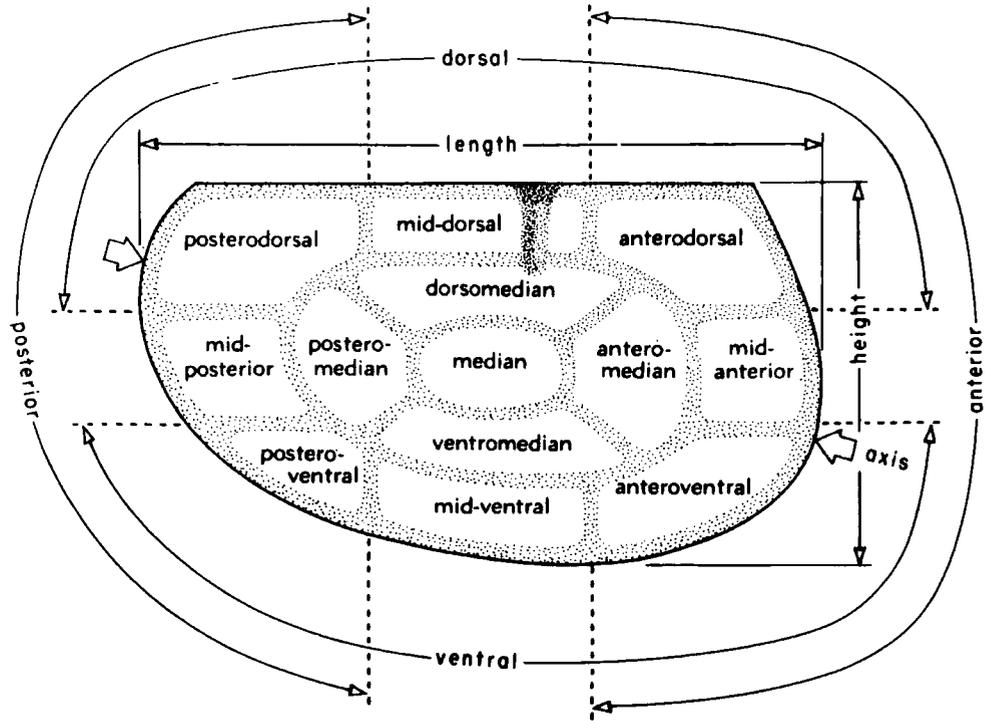


Figure 3.1. Nomenclature of the areas on the lateral surface and features relating to orientation and dimensions of a straight backed ostracod. Right valve. ( After Moore et al 1961, fig. 18. )

Figure 3.2. Carapace nomenclature of a typical straight backed ostracod.  
( After Moore et al 1961, fig.16. )

*Crustacea—Ostracoda*



*Shell Morphology—External Features*

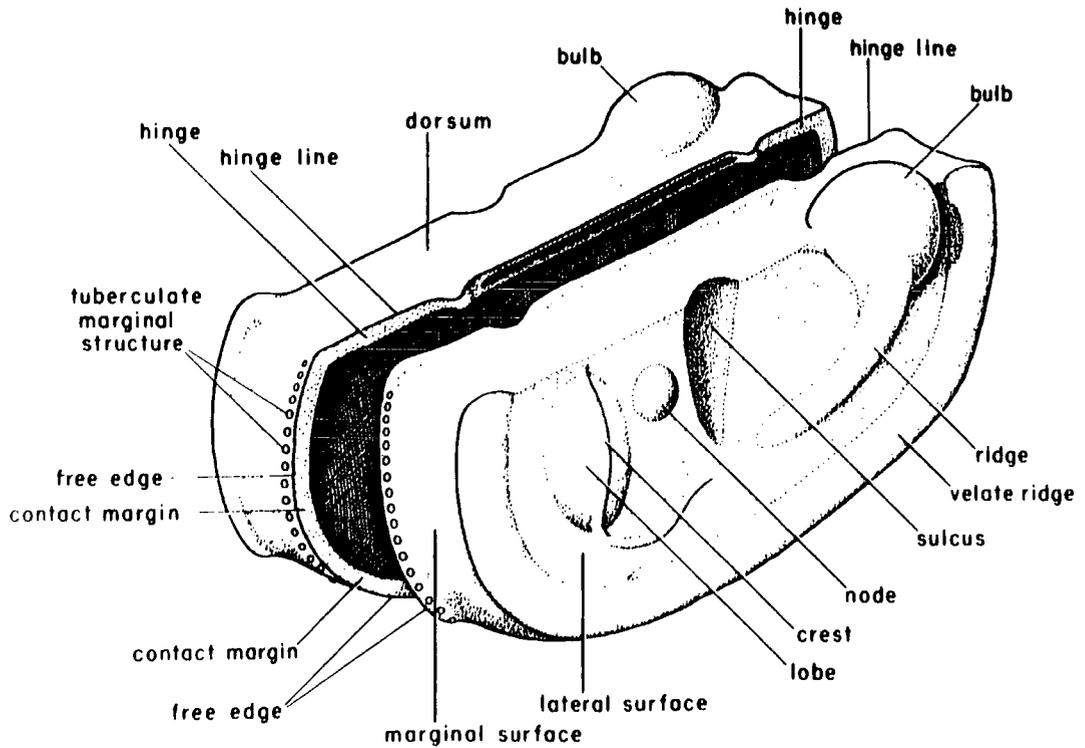
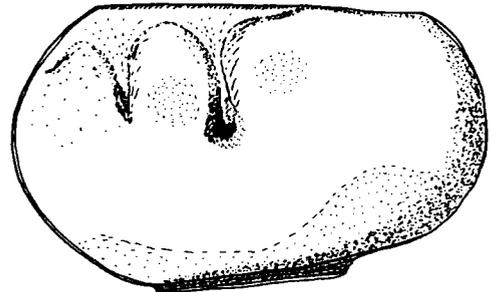
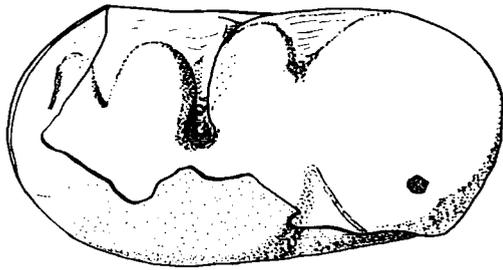


Figure 3.3. Line drawings of the lectotypes of Jonesina  
fastigiata Jones and Kirkby, x 73. approx.  
Specimens with British Museum numbers.

Jonesina fastigiata Jones and Kirkby

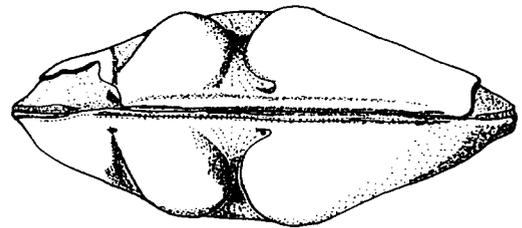
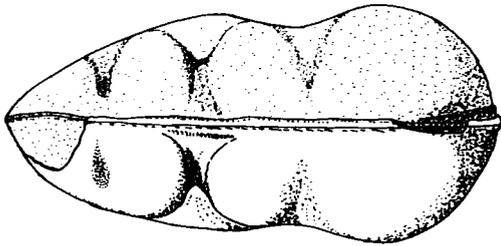
Female B.M. I1774

Male B.M. In 32496



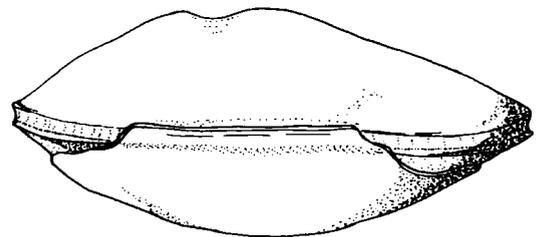
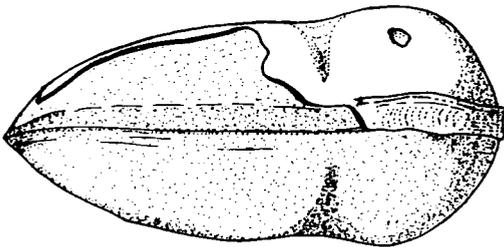
left valve

left valve



dorsal view

dorsal view

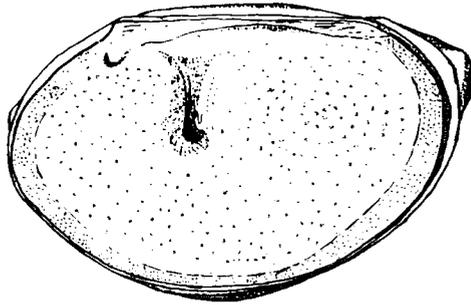


ventral view

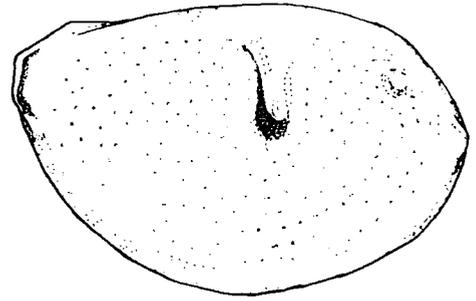
ventral view

Figure 3.4. Line drawings of the lectotype of Geisina  
arcuata Bean. x 50. approx. adult female.  
The interior view of the right valve of  
female is a specimen from above the Flockton  
Coal of Yorkshire and not the lectotype.

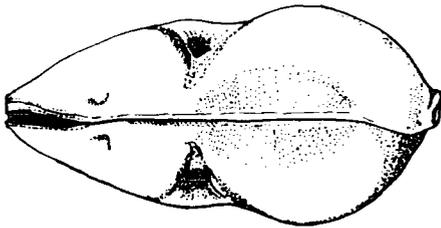
Geisina arcuata Bean



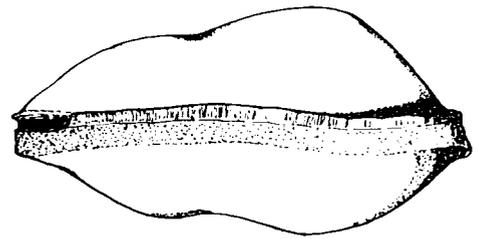
left valve



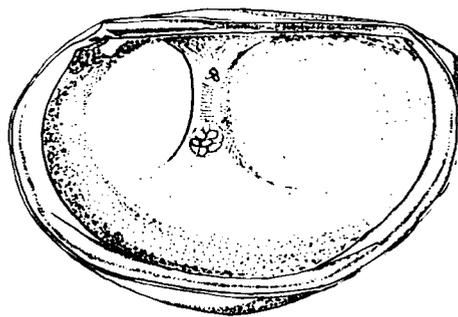
right valve



dorsal view



ventral view

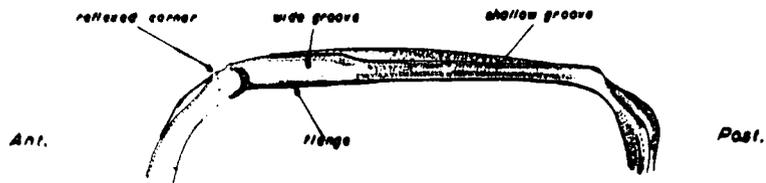


interior right valve

Figure 3.5. The hinge of Geisina arcuata Bean. x 65 approx.  
The full hinge is drawn from the Flockton specimen of Fig. 3.4. while the transverse sections are reconstructed from sectioned specimens in the Geisina Band of Durham. (Plate XIII, figs. 1 & 2)

Figure 3.6. External and internal moulds of dimorphic adult specimens of Geisina arcuata Bean, from the Geisina Band at Eppleton Colliery, Co. Durham. x 40 approx.

Hinge of Geisinga arcuata — right valve



Transverse section of hinge



Dorsal outlines of Geisinga arcuata

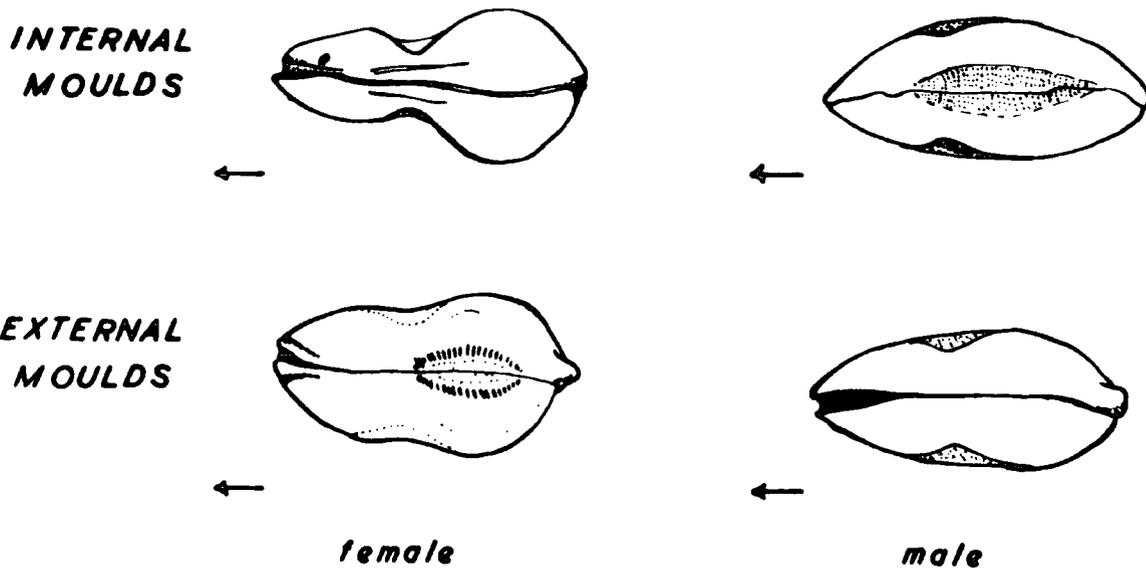
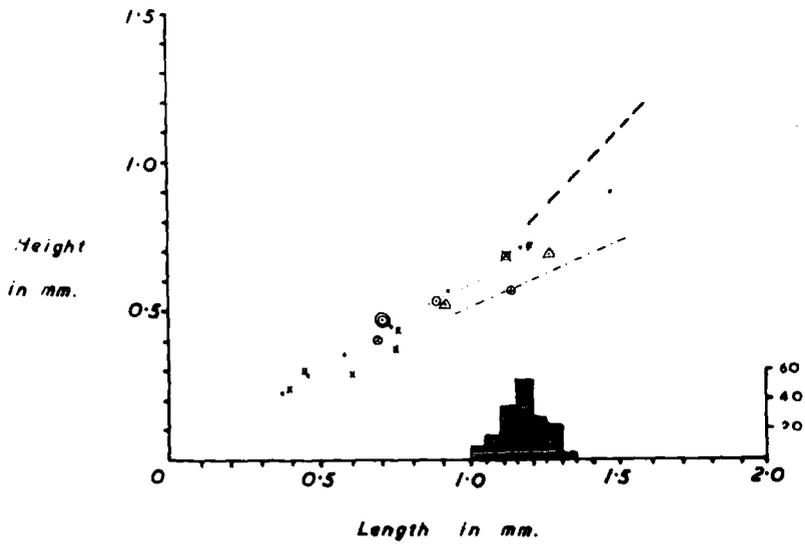


Figure 3.7. Graph of the height and length dimensions of Geisina arcuata Bean and related species. Eppleton specimens and other authors.

Figure 3.8. Frequency graph of the ratio of median to posterior thickness in 180 specimens of Geisina arcuata , from Eppleton Colliery, Co. Durham.



Geisina arcuata

- Mean of 170 Epplaton specimens & moult.
- Moults - Marple 1952
- Knight 1928
- Harlton 1927
- ⊙ Kummerow 1953
- △ Kummerow 1949
- Geisina subarcuata Jones
- ✕ Geisina robusta Kummerow

Range of dimensions

- ..... G. arcuata Krempe & Grebe 1955
- G. arcuata Latham 1933
- G. robusta Krempe & Grebe 1955

Geisina arcuata

Relationship of median to posterior thickness

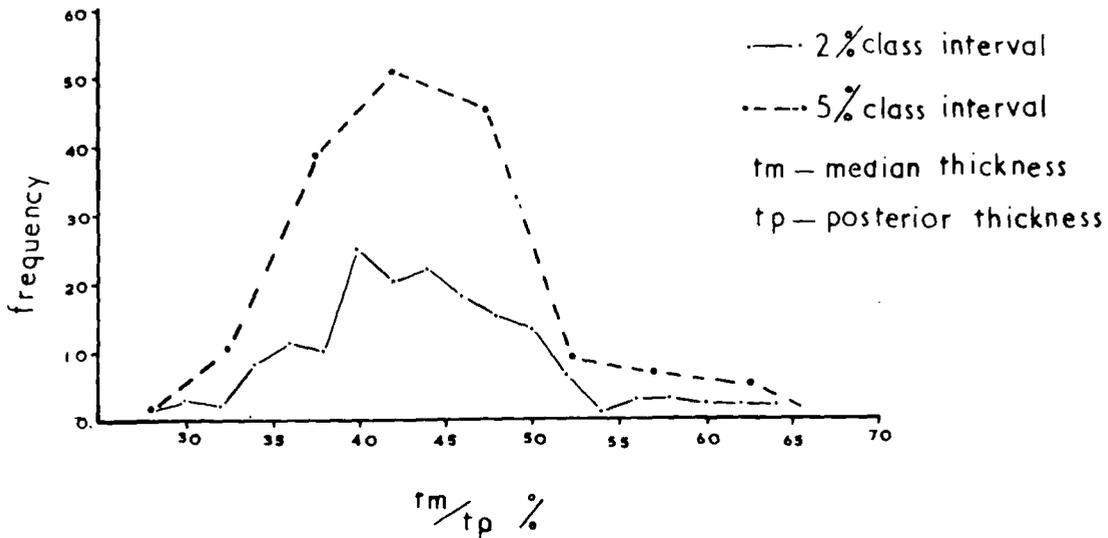
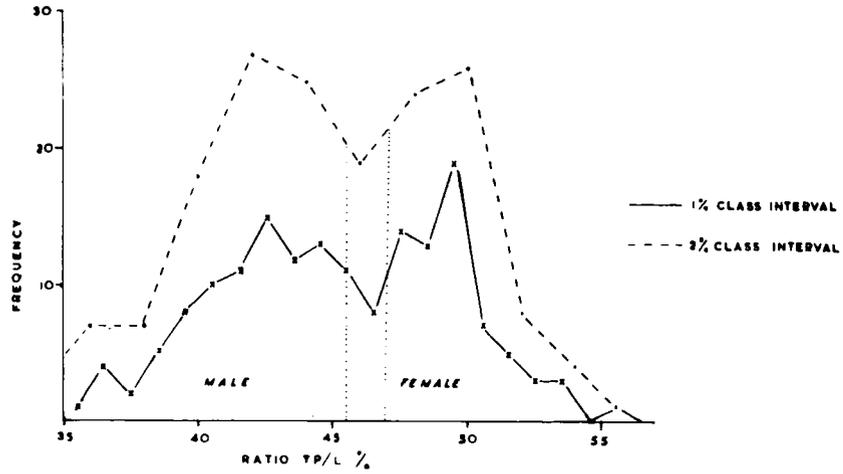


Figure 3.9. Frequency graph of the ratio of posterior thickness (TP) to length (L) in 180 specimens of Geisina arcuata , from Eppleton, Co. Durham.

Figure 3.10. Distribution graph of the ratio posterior thickness to length and height to length for 180 specimens of Geisina arcuata , from Eppleton, Co. Durham.

*Relationship of length to posterior thickness in Gelsina arcuata*



*Correlation of sex and form ratio*

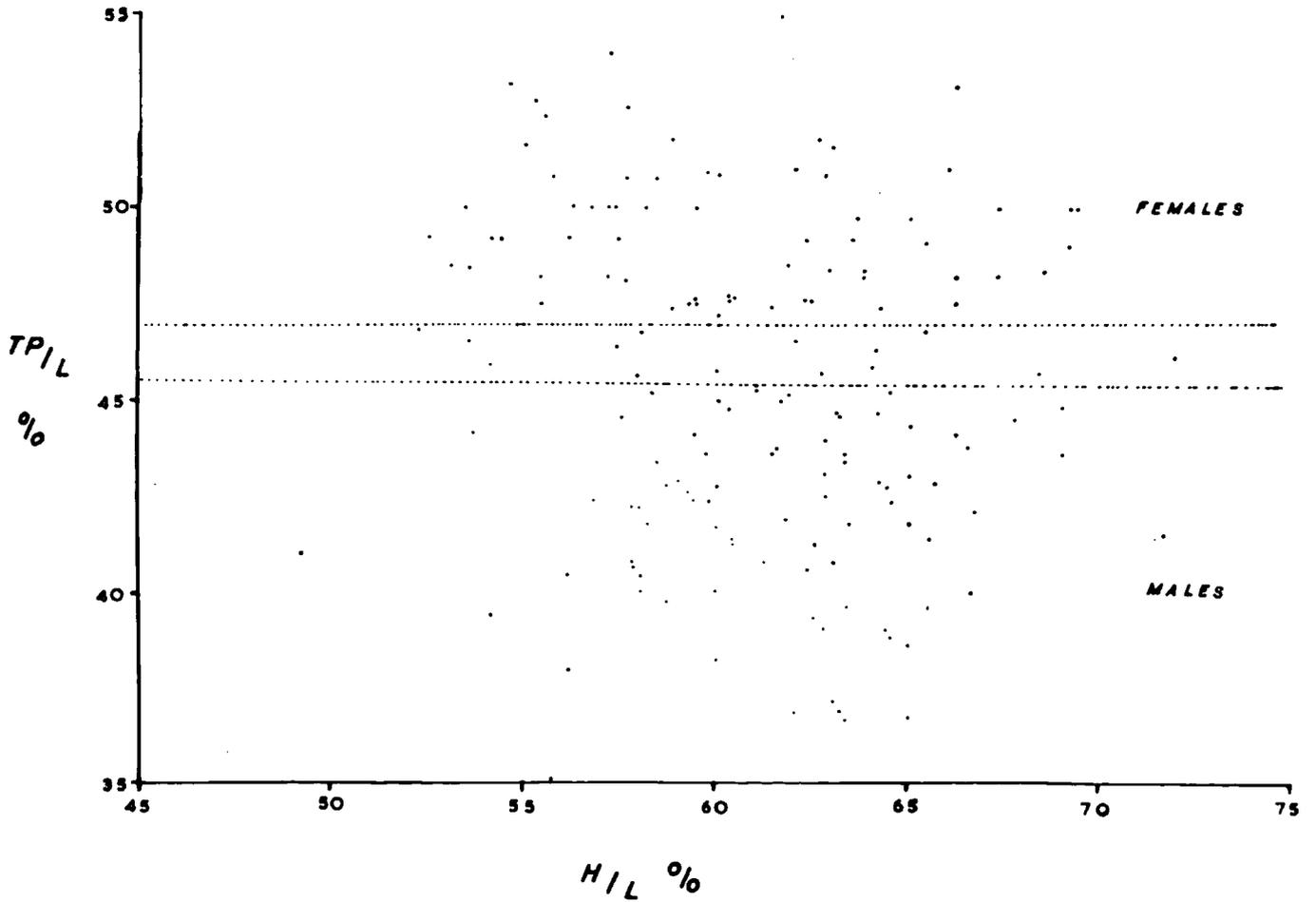
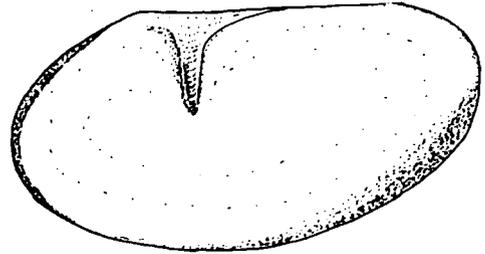
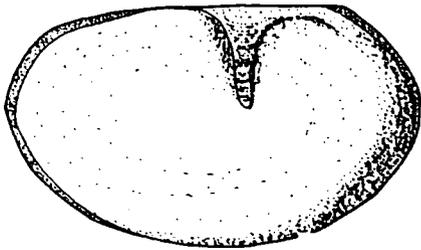


Figure 3.11. Line drawings of Geisina subarcuata Jones, x 40 approx  
Figs. a & b are Neotypes in Durham Palaeontology  
Collections, specimens c & d are in personal  
collections. All the specimens are from the  
Claxheugh Shell Bed , North Hylton , Sunderland,  
Co. Durham.

Geisina subarcuata Jones

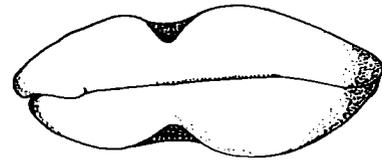
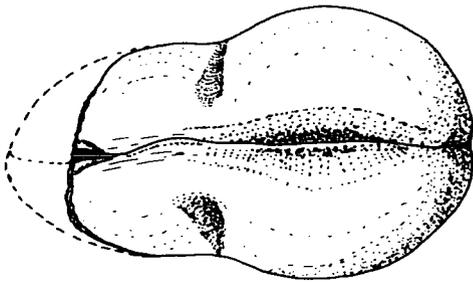
Female

Male



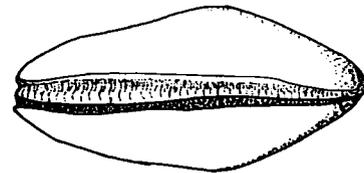
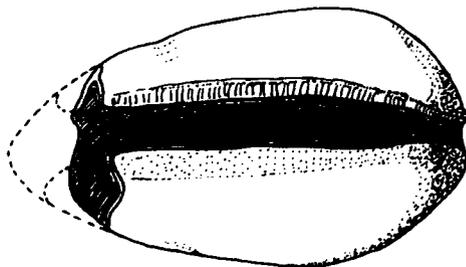
a. right valve

b. left valve



c. dorsal view

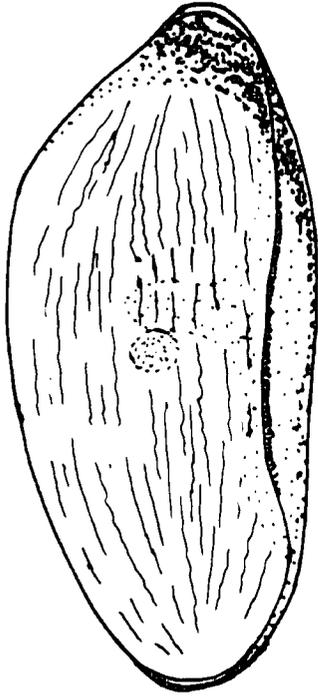
d. dorsal view young male



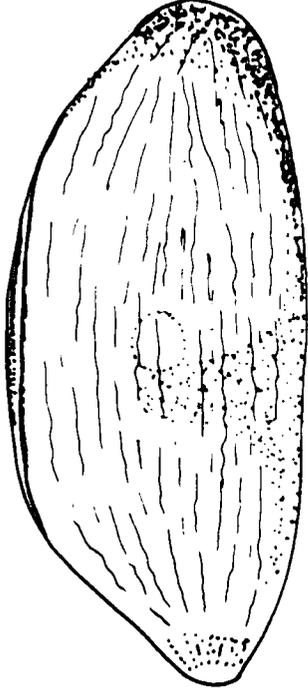
e. ventral view

f. ventral view young male

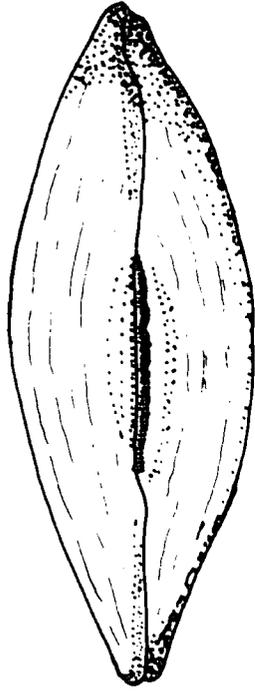
Carbonita c.f. evelinae



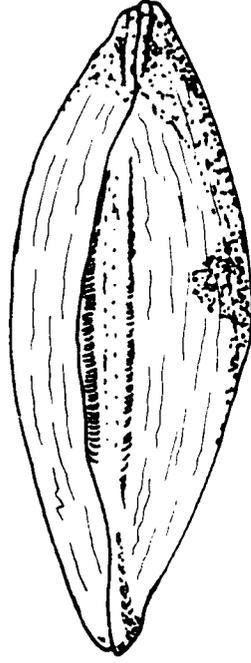
left valve



right valve



dorsal view

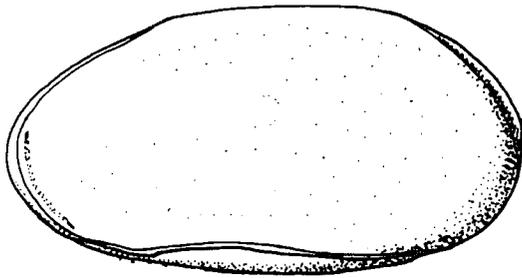


ventral view

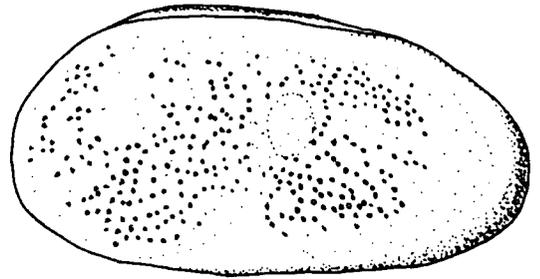


Figure 3.14. Line drawing of Carbonita cf. rankiniana Jones and Kirkby. x 70 approx. The four external views are of a specimen from above the Flockton Coal of Yorkshire and the internal mould from the Geisina Band at Ryhope Colliery, Co. Durham.

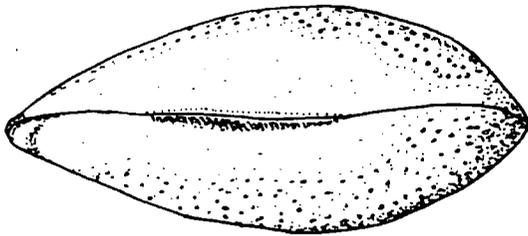
Carbonita c.f. rankiniana



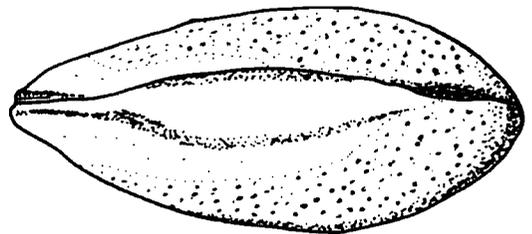
*left valve*



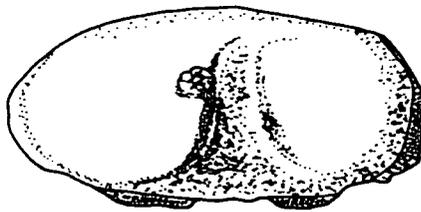
*right valve*



*dorsal view*



*ventral view*

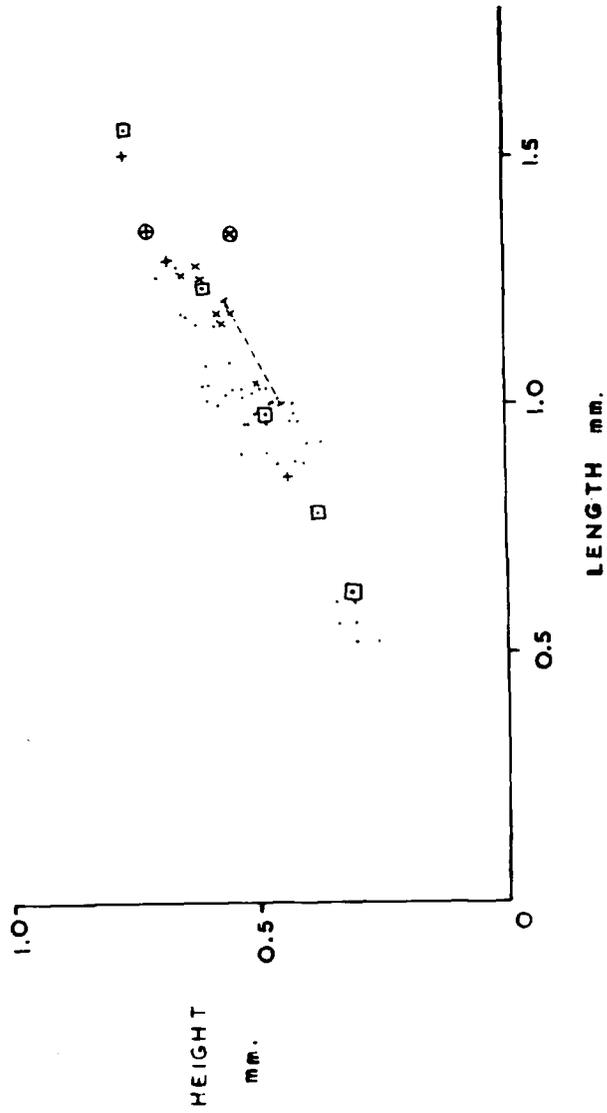


*internal mould*

Figure 3.15. Graph of height and length relationships in Carbonita cf. rankiniana and related species.

CARBONITA RANKINIANA

- HOPKINS BAND SPECIMENS
- ◻ MOULTS (PRZIBRAM FACTOR)
- x FLOCKTON SPECIMENS
- DIMENSIONS OF LATHAM 1932
- + C. AGNES KEMPE & GREBE 1955
- ⊕ C. SALTERIANA COOPER 1946
- ⊗ .. .. JONES & KIRKBY 1890



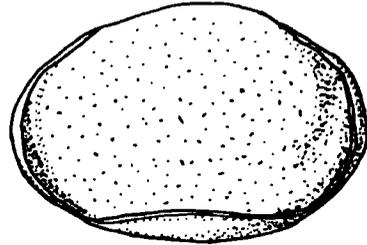
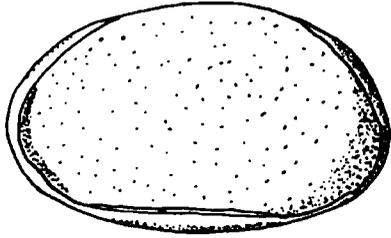
9

Figure 3.16. Line drawings of dimorphic forms of Carbonita  
humilis. x 63 approx. The figured specimens are  
neotypes, locality and numbers as recorded in  
the specific description.

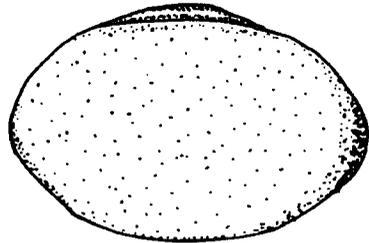
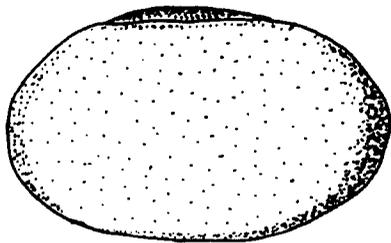
Carbonita humilis

Male

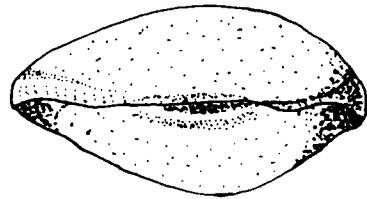
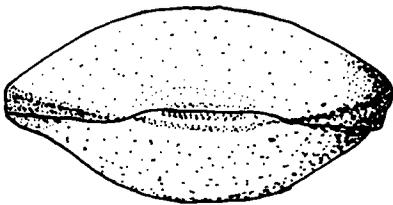
Female



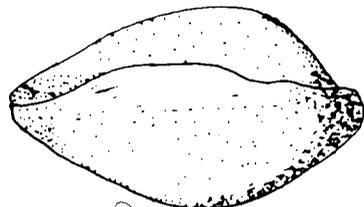
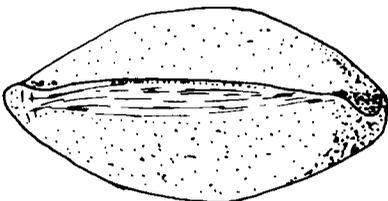
left valve



right valve



dorsal view

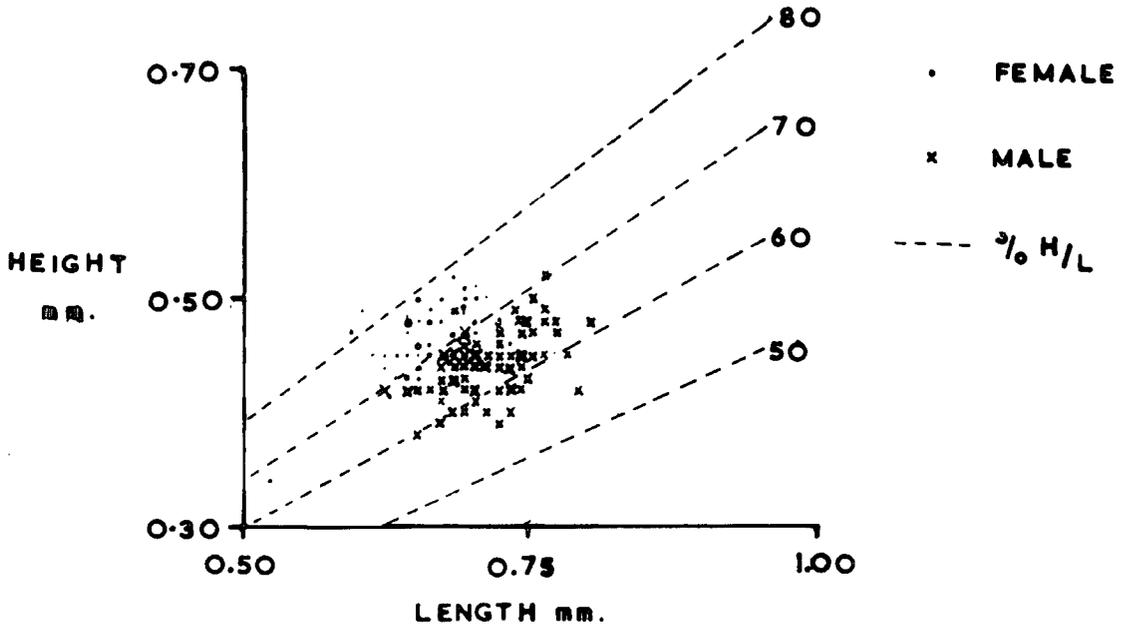


ventral view

Figure 3.17. Graph showing dimorphism in terms of height-length ratio in a population of Carbonita humilis from the Geisina Band at Silksworth, Co. Durham.

Figure 3.18. Line drawing of Carbonita pungens Jones and Kirkby., This specimen is from the black shale at Bearpark, BP. 105 series. x 38 approx.

DIMORPHISM IN CARBONITA HUMILIS FROM SILKSWORTH



Carbonita pungens

internal moulds

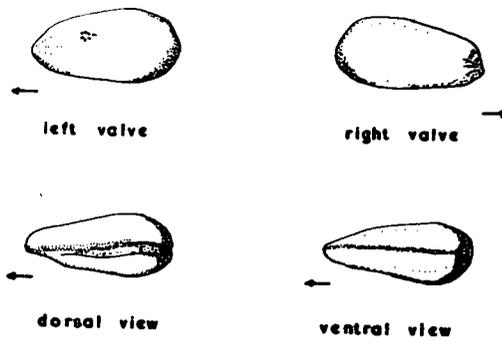
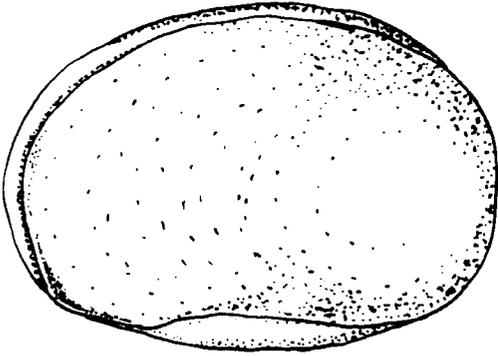
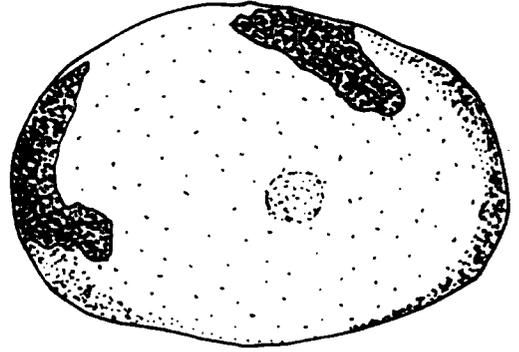


Figure 3.19. Line drawing of Carbonita inflata Jones and Kirkby, from the Geisina Band at Hylton Colliery, Co. Durham. x 67 approx.

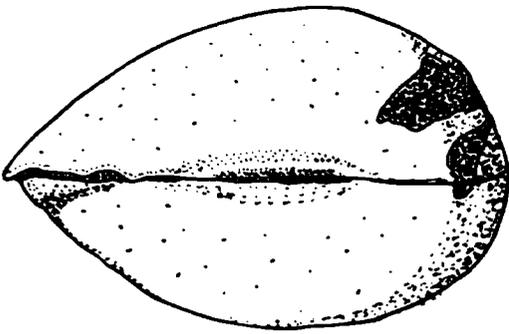
Carbonita    inflata



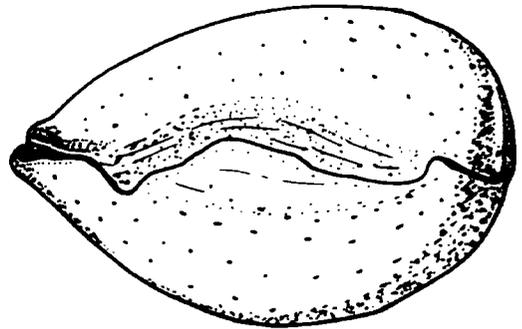
left valve



right valve



dorsal view



ventral view

Figure 3.20. Graph of height - length relationships in Carbonita inflata and synonomous species.  
( After Cooper 1946, fig.32, but redrawn with additions and corrections. )

Figure 3.21. Line drawing of the internal mould of the left valve of Carbonita secans Jones and Kirkby from the black shale at Bearpark, BP. 105 series . x 60 approx.

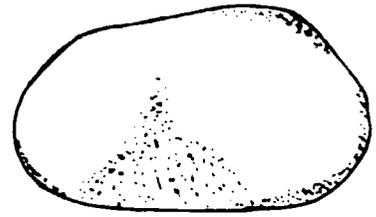


Figure 3.22. Line drawing of the internal mould of Carbonita  
concava Vangerow. nom. nov. x 85 approx.

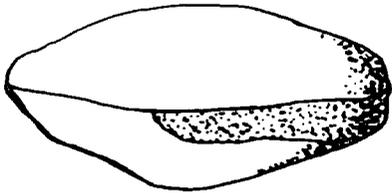
The specimen on the left is slide (11).10. and  
on the right slide (11). 11. Both specimens came  
from the grey mudstone above the Geisina Band at  
Bearpark.

Carbonita concaua

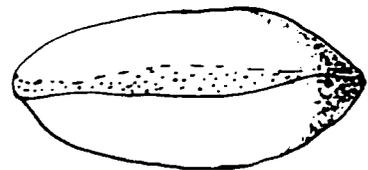
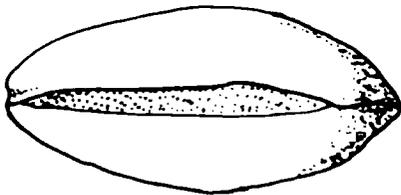
*internal moulds*



left valve



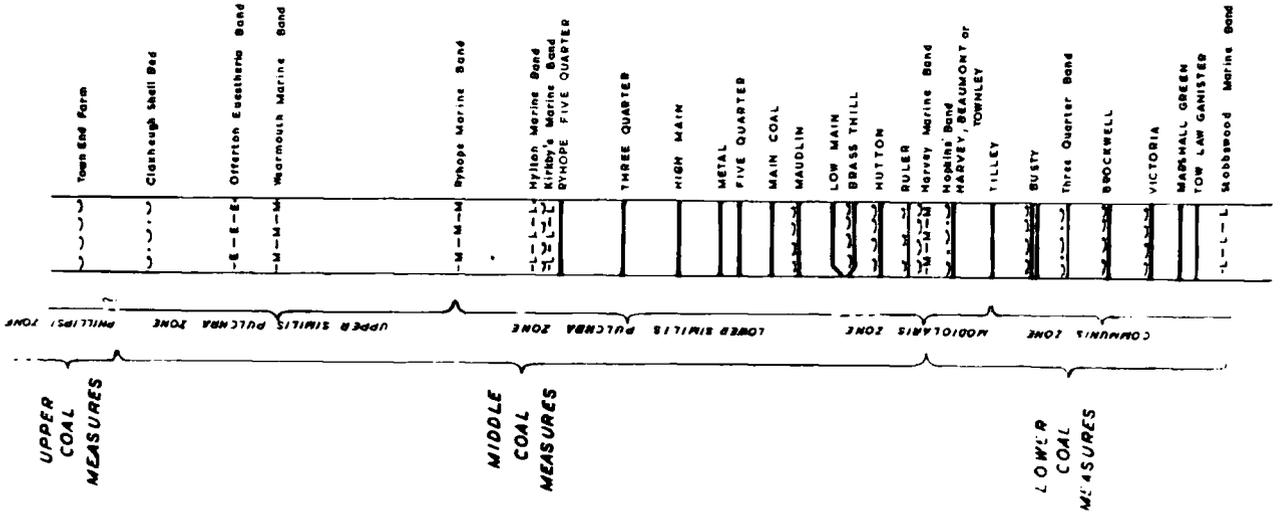
dorsal view



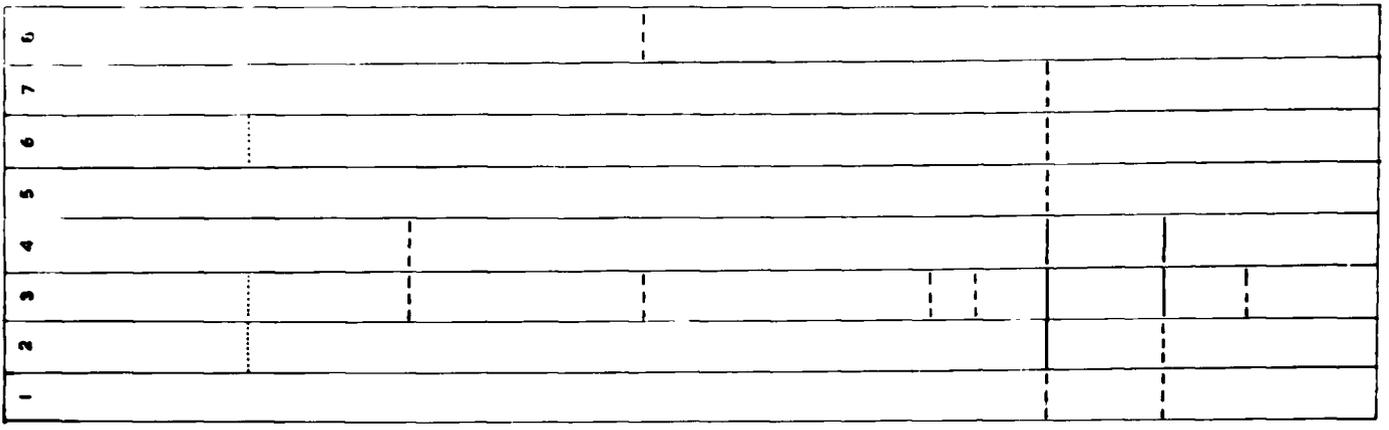
ventral view

Figure 3.23. Stratigraphical horizons and species of ostracods recorded from the Durham Coal Measures. The authorities for some of these records are given in the text.

DURHAM



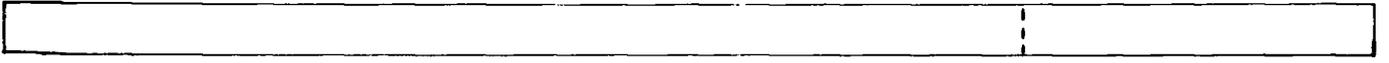
Carbonita



Geisina



Hollinella



Geisina

- 1-G. arcuata
- 2-G. subarcuata

Carbonita

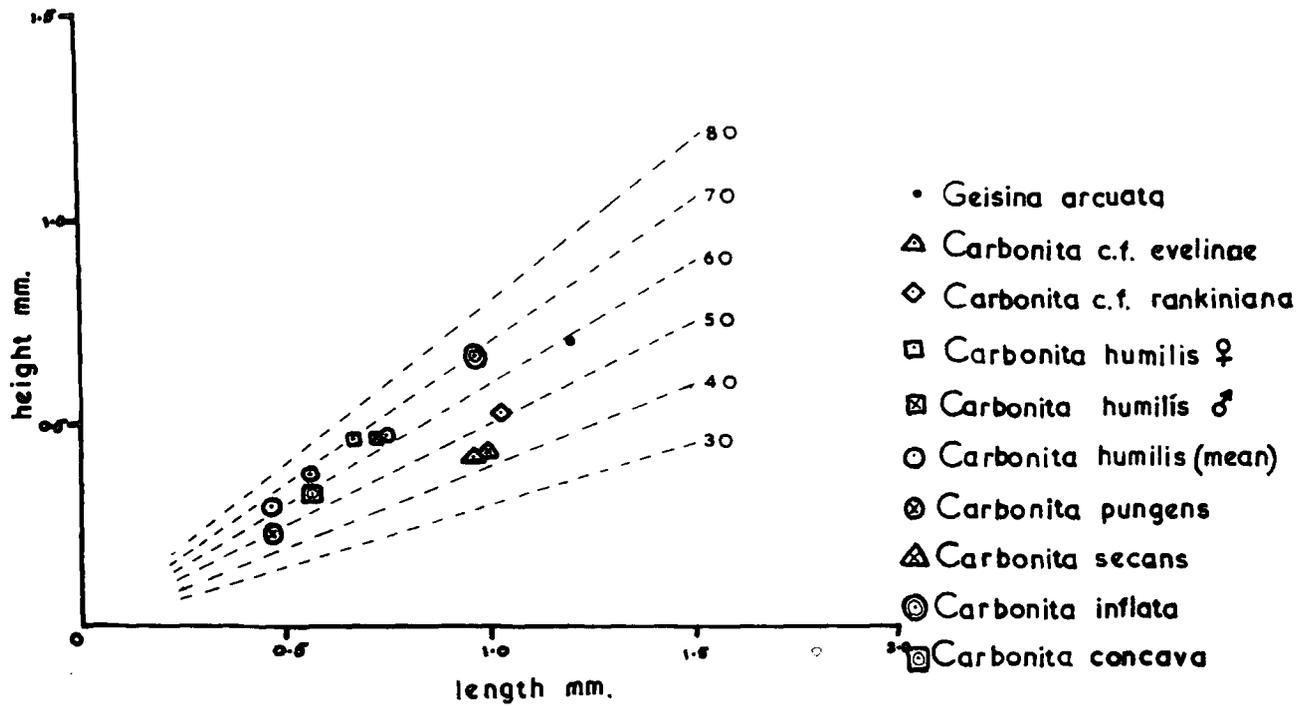
- 1-C. cf. sveiniae
- 2-C. cf. rontiniana
- 3-C. humilis
- 4-C. pungens
- 5-C. inflata
- 6-C. secans
- 7-C. concava
- 8-C. scalpellus

- common
- - - rare
- ..... dubious record

Figure 3.24. Graph of the mean height - length dimensions of the adult and juvenile instars of the various species of ostracods found in the sediments of the Hopkins' Band from several localities.

Figure 3.25. Graph of height- length relationships of species of Carbonita found in the Geisina Band at Hyiton , Co. Durham.  
The instar mean positions have been extrapolated from the adult using Przibram Growth factor.  
Dashed lines are percentage height of length.

# Hopkins' Band ostracod population



## SPECIES OF *CARBONITA* FROM HYLTON

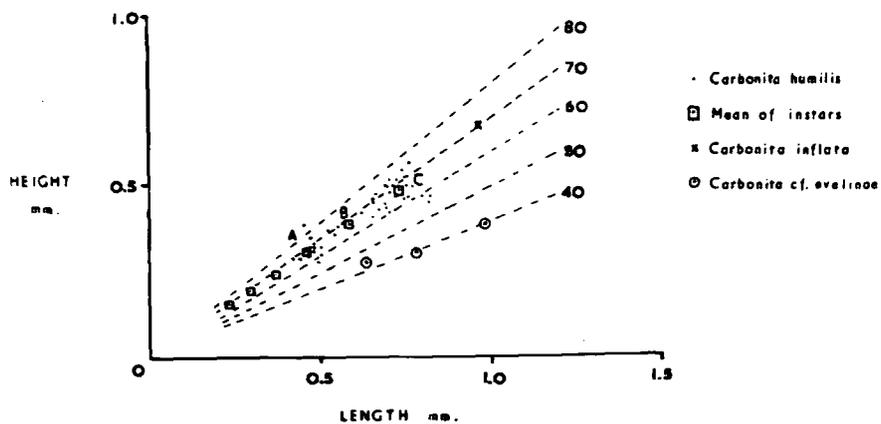


Figure 3.26. Graph of the height - length dimensions of Geisina subarcuata Jones , from the Claxheugh Shell Bed and ironstones from the Upper Similis-Pulchra Zone of North Staffordshire.

*H/L relationships in Geisina subarcuata*

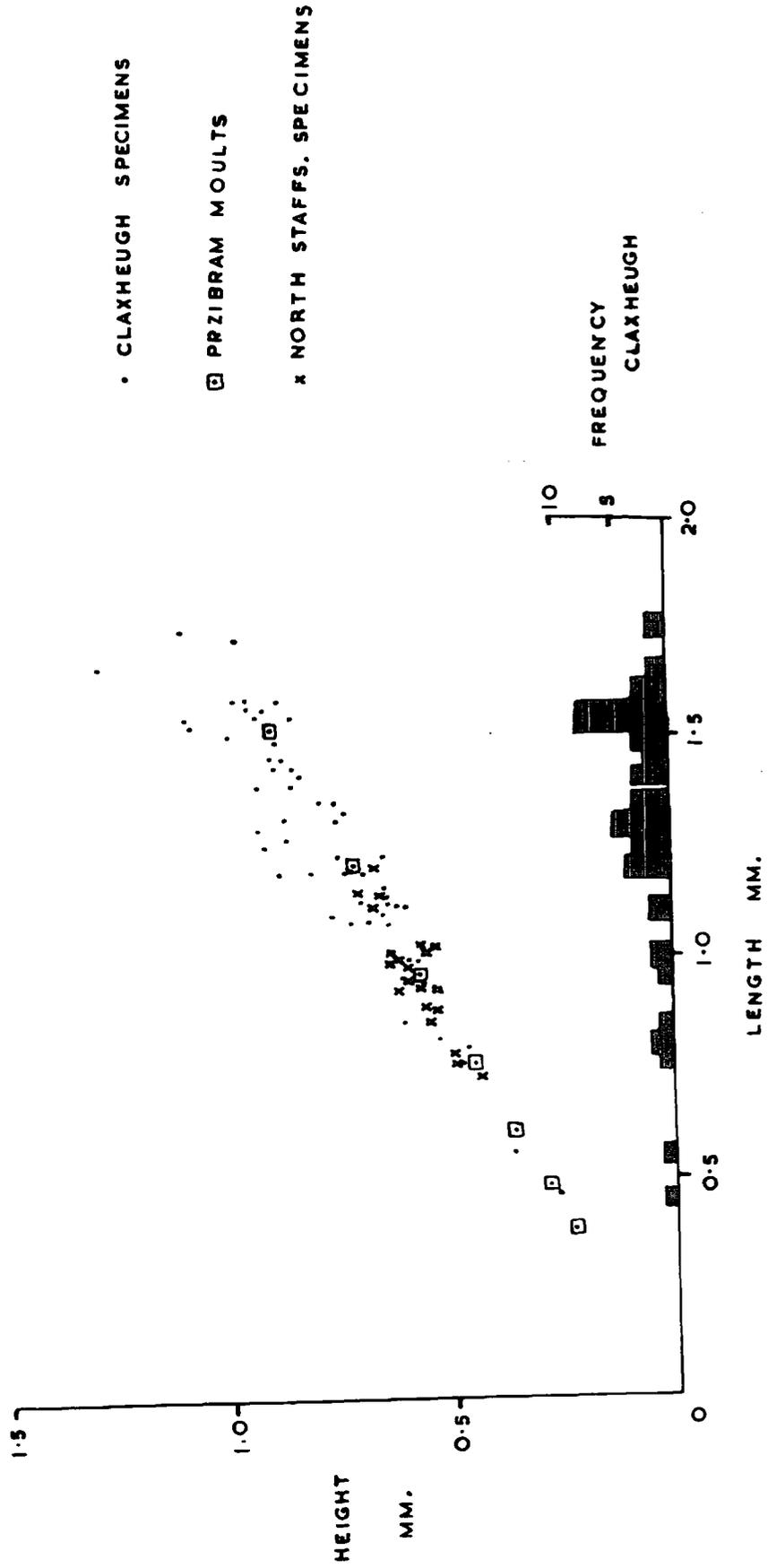


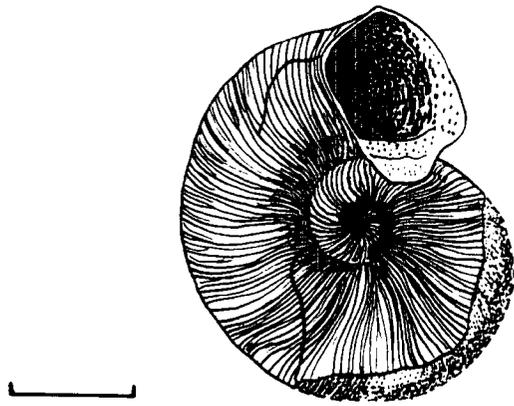
Figure 4.1. Growth forms of Microconchus ( Spirorbis)  
pusillus Martin, from the sediments of the  
Hopkins' Band.

Form a. is from the Geisina Band at Fenwick  
Colliery, East Holywell, Northumberland.

Form b. is from the sheley mudstone above the  
Geisina Band at Bearpark, BP. 105. series.

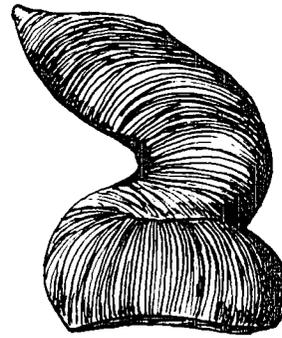
Figure 4.2. The internal mould of the tube of Microconchus  
( Spirorbis) pusillus from the Geisina Band  
at Whitworth Opencast, Co. Durham.

Microconechus (Spirorbis) pusillus



1.0mm.

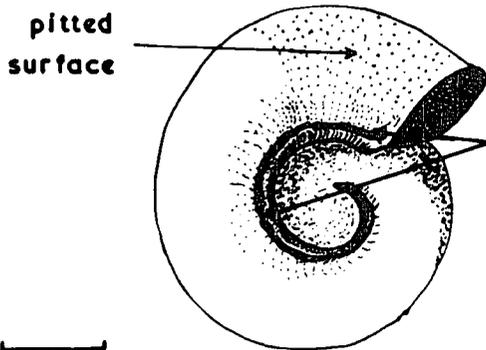
form a.



1.0mm.

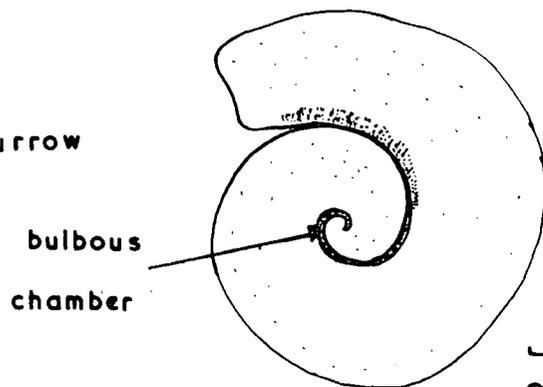
form b.

internal moulds



0.50mm.

ventral view



0.50mm.

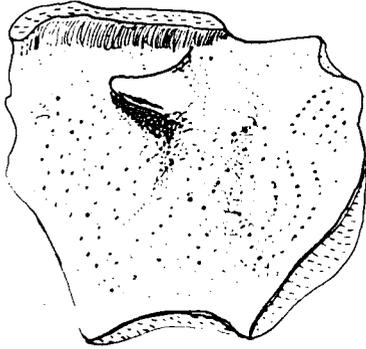
dorsal view

Figure 4.3. Internal features and wall structure of the tube of Microconchus ( Spirorbis) pusillus and Spirorbis borealis Daudin. Figs. c & d are not to scale.

- Fig. a. is a shell fragment showing the internal spine from the shaley mudstone at Bearpark.
- Fig. b. is a sectioned tube on slide 809 from grey shaley mudstone at Bearpark.
- Fig. c. is a reconstruction of the wall structure of the tube of S. borealis, collected from the sea shore at Hartly Bay, Northumberland.
- Fig. d. is a reconstruction of the tube wall of M. pusillus, from fragments and sections seen in the sediments of the Hopkins' Band.

a.

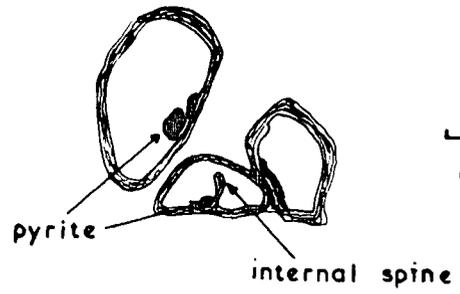
aperture →



0.50mm.

internal spine

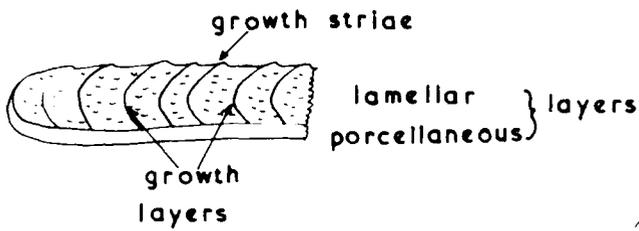
b.



0.50mm.

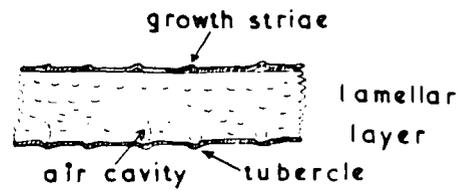
transverse section

c.



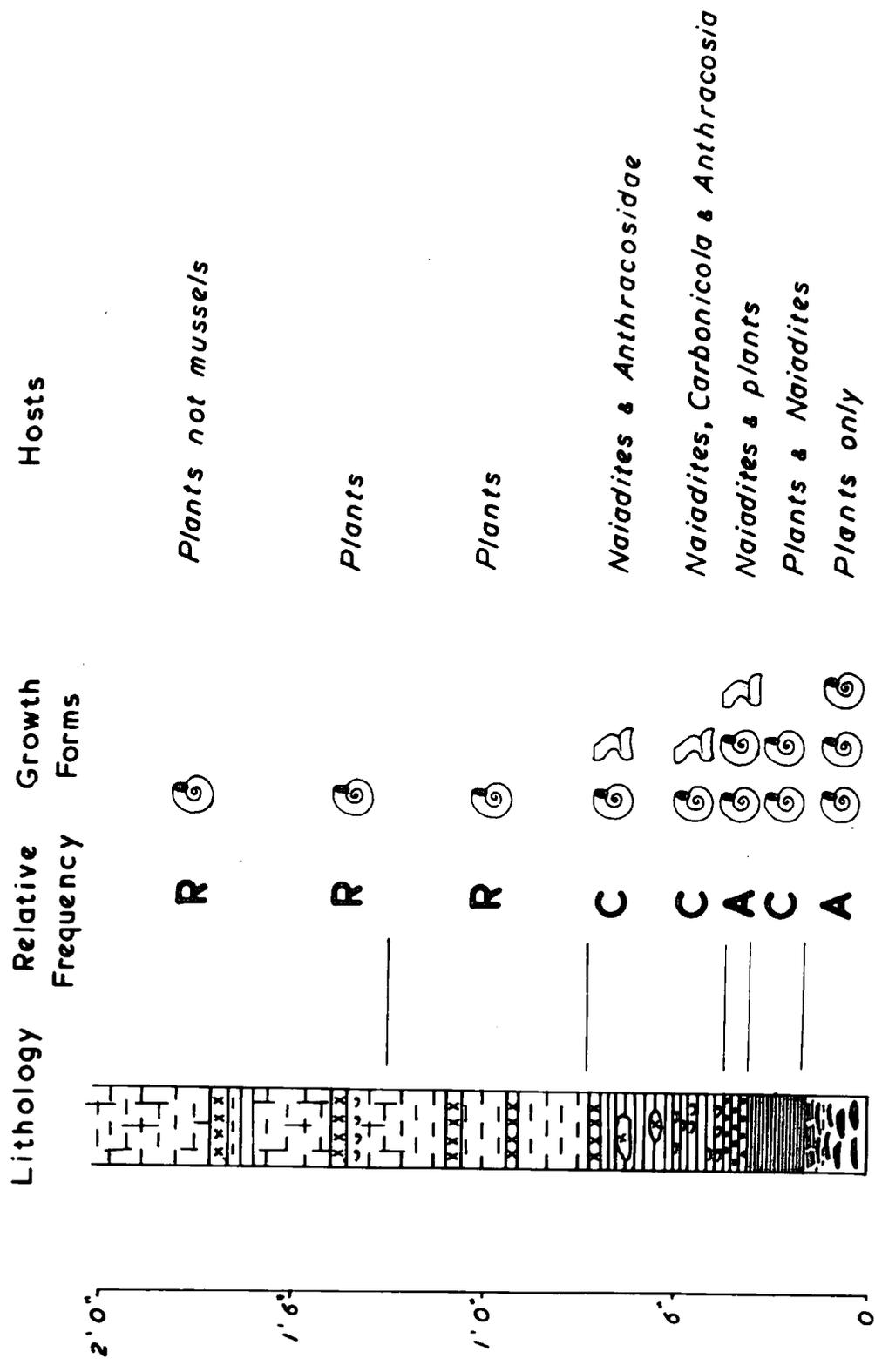
S. borealis Recent

d.



'S.' pusillus Hopkins' Band

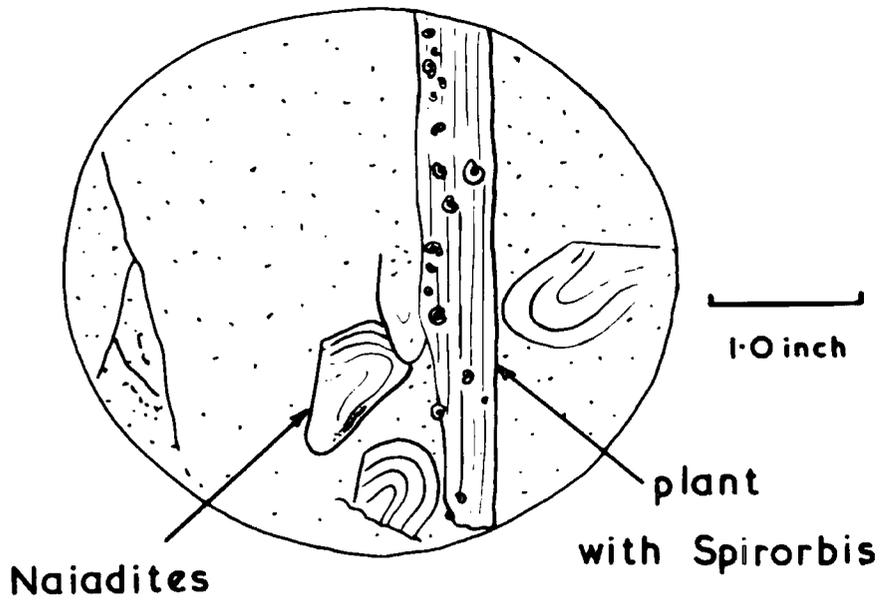
Figure 4.4. Diagram showing the correlation of lithology, relative frequency, growth form and hosts, of specimens of Microconchus (Spirorbis) pusillus in the sediments of the Hopkins' Band at Bearpark.



**R** - rare  
**C** - common  
**A** - abundant

Figure 4.5. Tubes of M. pusillus on a Cordaiæes leaf, rather than a Naiadites shell in the silty mudstone above the Hopkins' Band. The specimen is from a borehole at Fynemouth pierhead, Northumberland

Figure 4.6. Reconstruction of attachment and feeding positions of M. pusillus , to explain the advantages of uncoiling in the Hopkins' Band.



Borehole core of silty mudstone

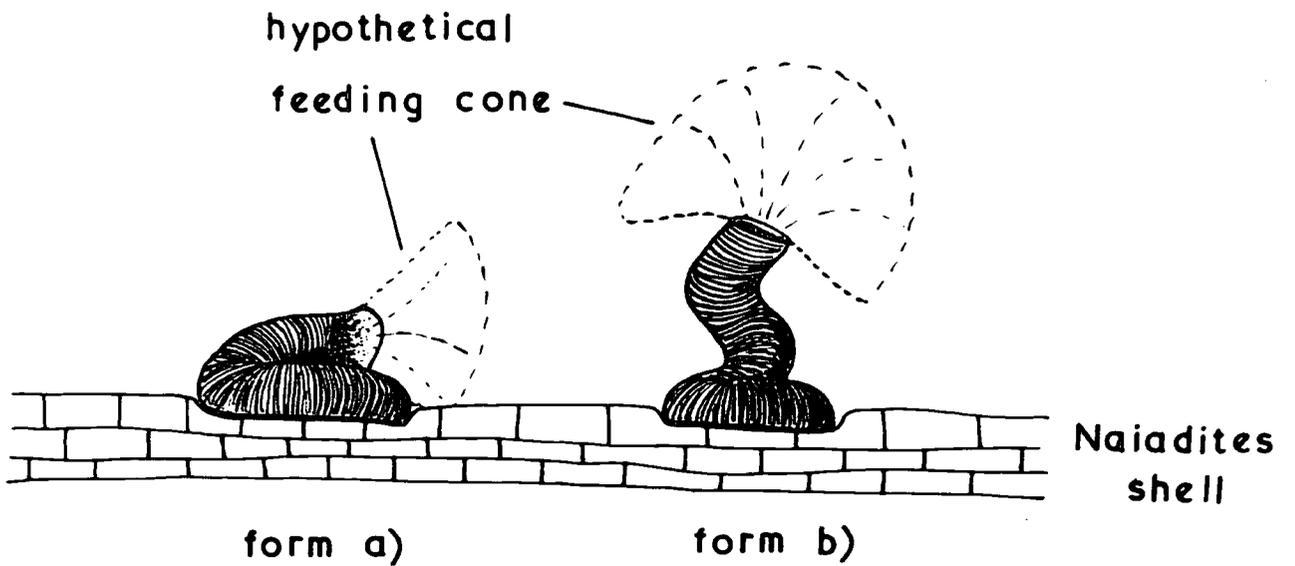
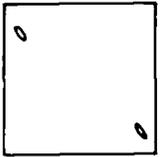
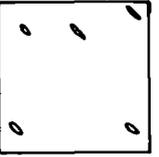
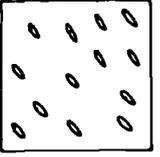
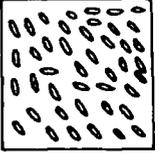


Figure 5.1. Key to the interpretation of the Faunal Phase diagrams, Figures 5.2. to 5.9.

# KEY TO FAUNAL PHASE DIAGRAMS

Relative Density	Description	Representation	Orientation of fossils	Fossils represented
	RARE	• • • •	<b>MUSSELS</b> <u>Anthracosia &amp; Carbonicola</u> ↳ Separate valves ↳ Joined valves ○ Life position	<i>Carbonita pungens</i> <i>Carbonita cf. evelinae</i> & <i>Carbonita cf. rankiniana</i> <i>Carbonita humilis</i>
	SCATTERED	—————	<u>Naiadites</u> ↳ Parallel to bedding ↳ Fragmented	<i>Geisina arcuata</i> <i>Microconchus (Spirorbis)</i>
	COMMON	—————	<b>OSTRACODS</b> <u>Geisina</u> ↳ Complete carapaces ↳ Single valves	<i>Naiadites</i> <i>Curvirimula</i>
	ABUNDANT	—————	<u>Carbonita</u> ↳ Complete carapaces	<i>Anthracosia</i> <i>Carbonicola</i> <i>Anthracosia</i> <i>Fish</i>



Lepidodendron bark



Calamites stem & Cordaites leaves

Figure 5.2. The Faunal Phases of the Hopkins' Band at the  
" type section" , Bearpark, locality 6.



Figure 5.3. The Faunal Phases of the Hopkins' Band at  
Whitworth Opencast, locality 7.



Figure 5.4. The Faunal Phases of the Hppkins' Band at  
Fenwick Colliery, East Holywell, Northumberland.  
locality 3.



Figure 5.5. The Faunal phases of the Hopkins' Band  
2½ miles north-east of Bates Pit, Blyth,  
Northumberland. ,locality 2.

BATES BLYTH locality 2

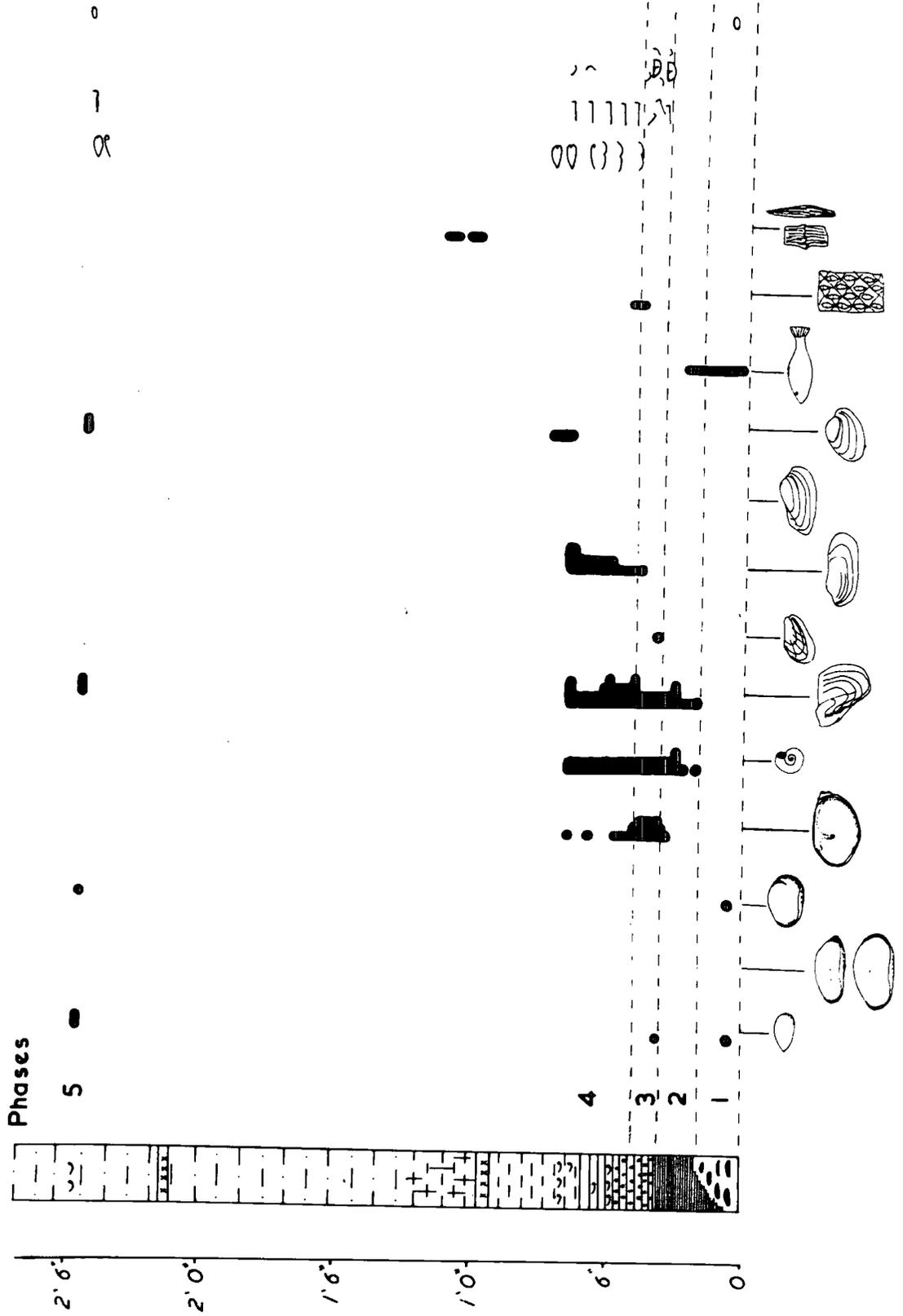


Figure 5.6. The Faunal Phases of the Hopkins' Band at  
Silksworth, locality 14.

# SILKSWORTH Locality 14

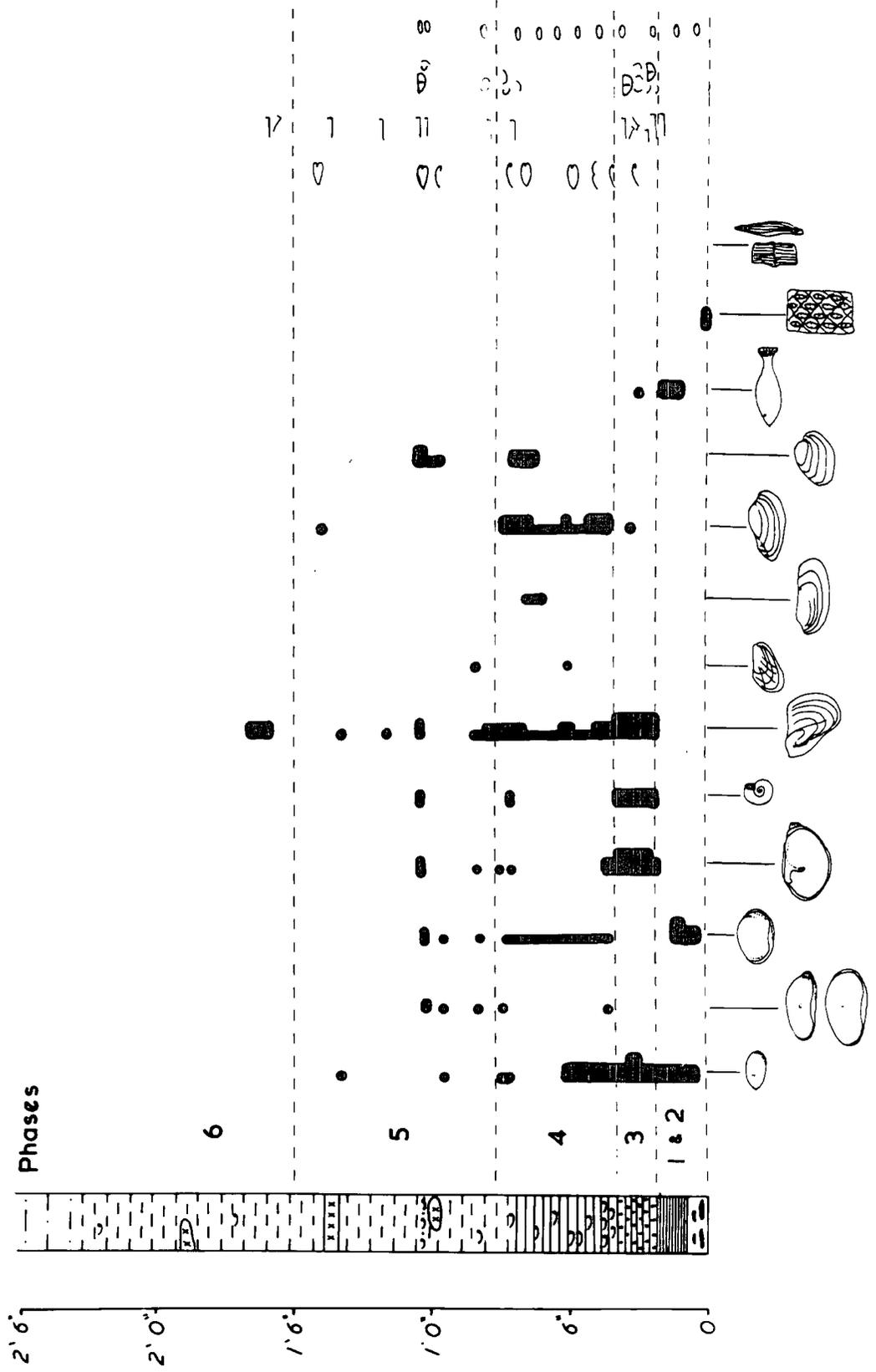


Figure 5.7. Faunal distribution in strata equivalent to  
the Hopkins' Band at Lanchester, locality 17.



Figure 5.8. Faunal distribution in the channel succession  
equivalent to the Hopkins' Band at Hedley  
Park, locality 9.

HEDLEY PARK Locality 9

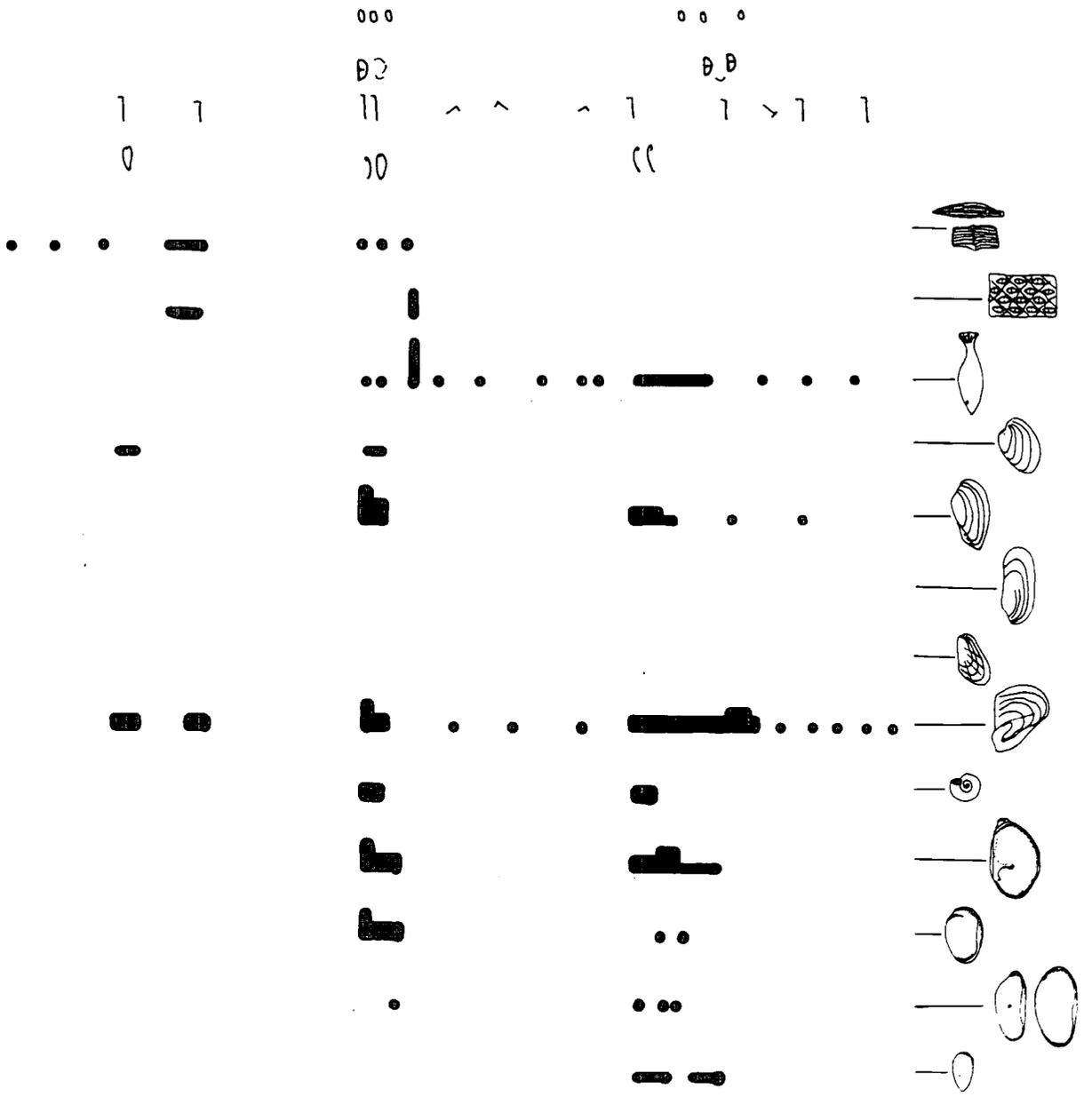
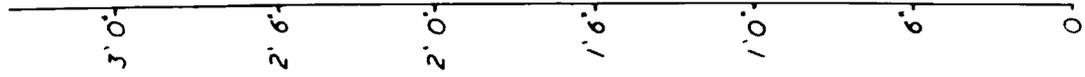


Figure 5.9. The Faunal Phases of the Three Quarter ostracod-mussel Band in borehole Fishburn 7.

( Symbolism and indexing of lithologies as  
for the Hopkins' Band diagrams. )

Lithology depth

# Three Quarter Seam borehole FISHBURN 7

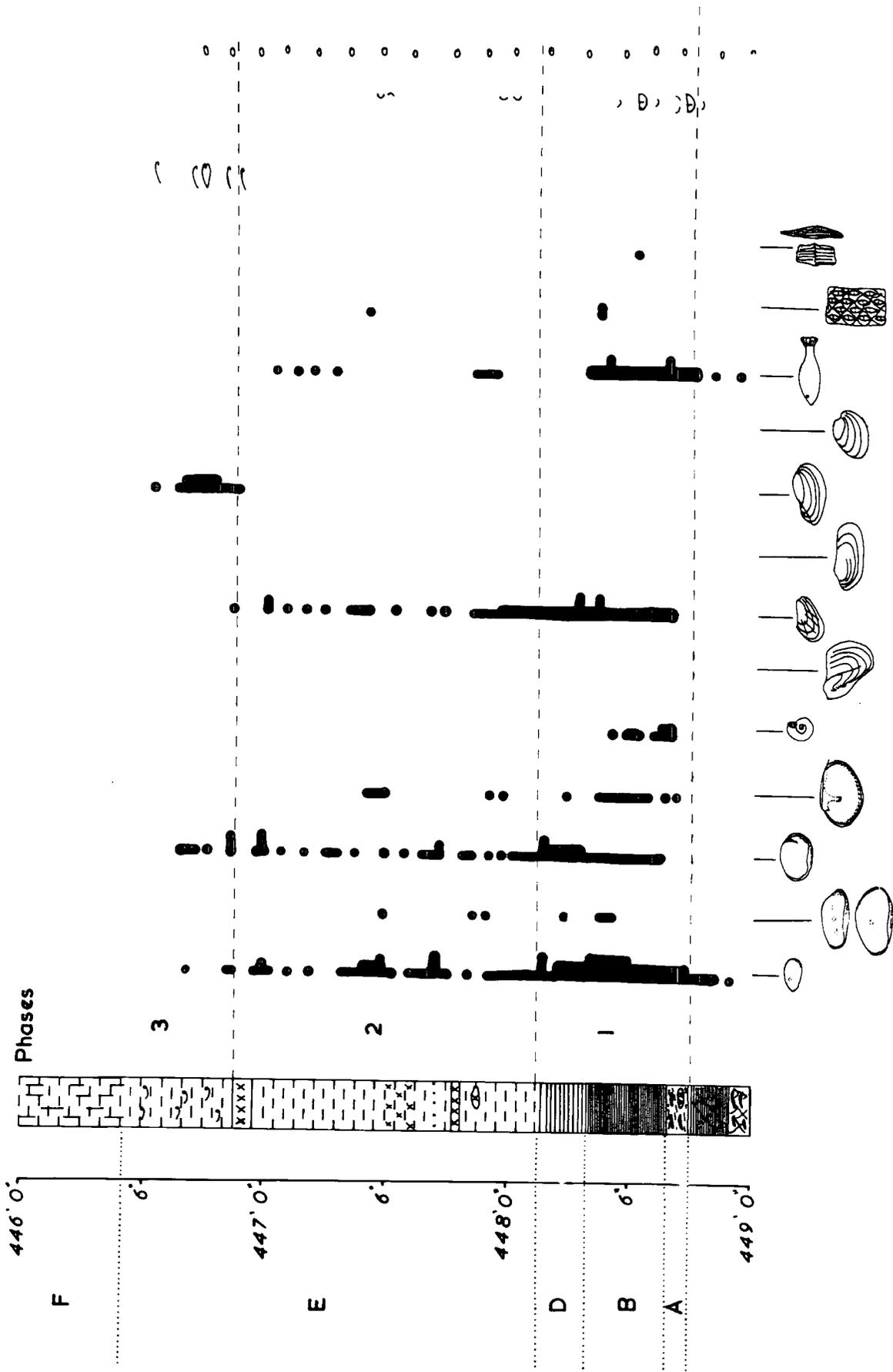


Figure 6.1. Comparison of X-ray mineralogical data and petrographic details of the sediments including the Hopkins' Band at Bearpark "type section", sampled in BP. 105 series.

The X-ray data is derived from the samples lettered A1 to V in the left hand column, while petrographic details are from slides 800 - 824 in the right hand column. Numbers on the X-ray lines refer to the  $2\theta$  angle of the peak represented.

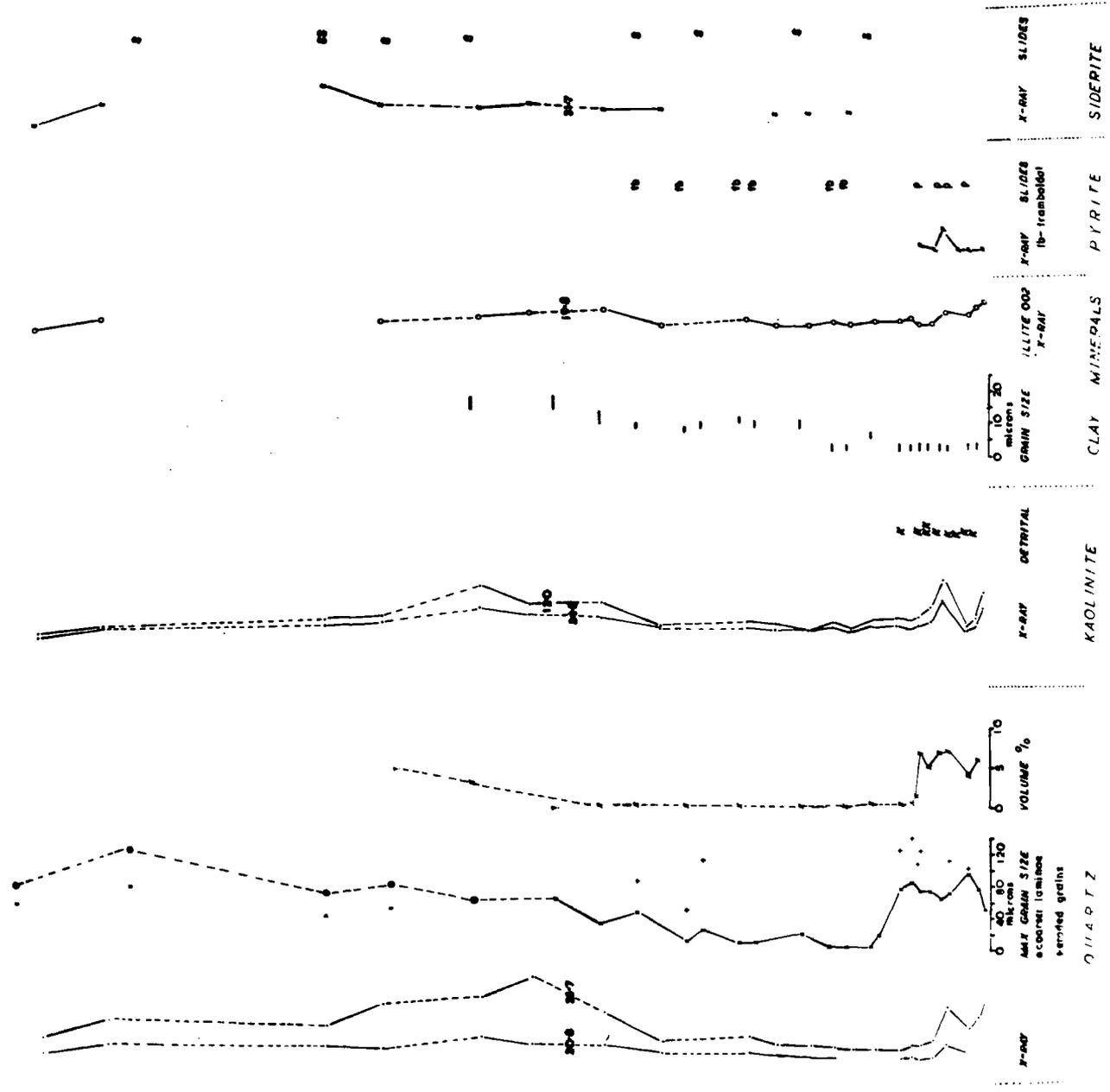
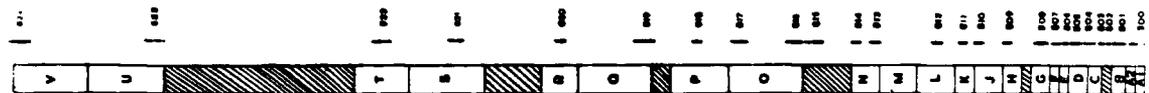


Figure 7.1. Typical X-ray diffraction patterns of the sediments, including the Hopkins' Band, sampled at Bearpark in BP. 105 series. Each sample represents a particular lithological type.

The lowest two diffractometer traces, A2 & C, have a greater background intensity as no discriminator was used on the diffractometer.

Exposure details : CuK radiation at a speed of  $\frac{1}{2}^{\circ}$   $2\theta$  per minute, chart speed 400 mm. per hour.

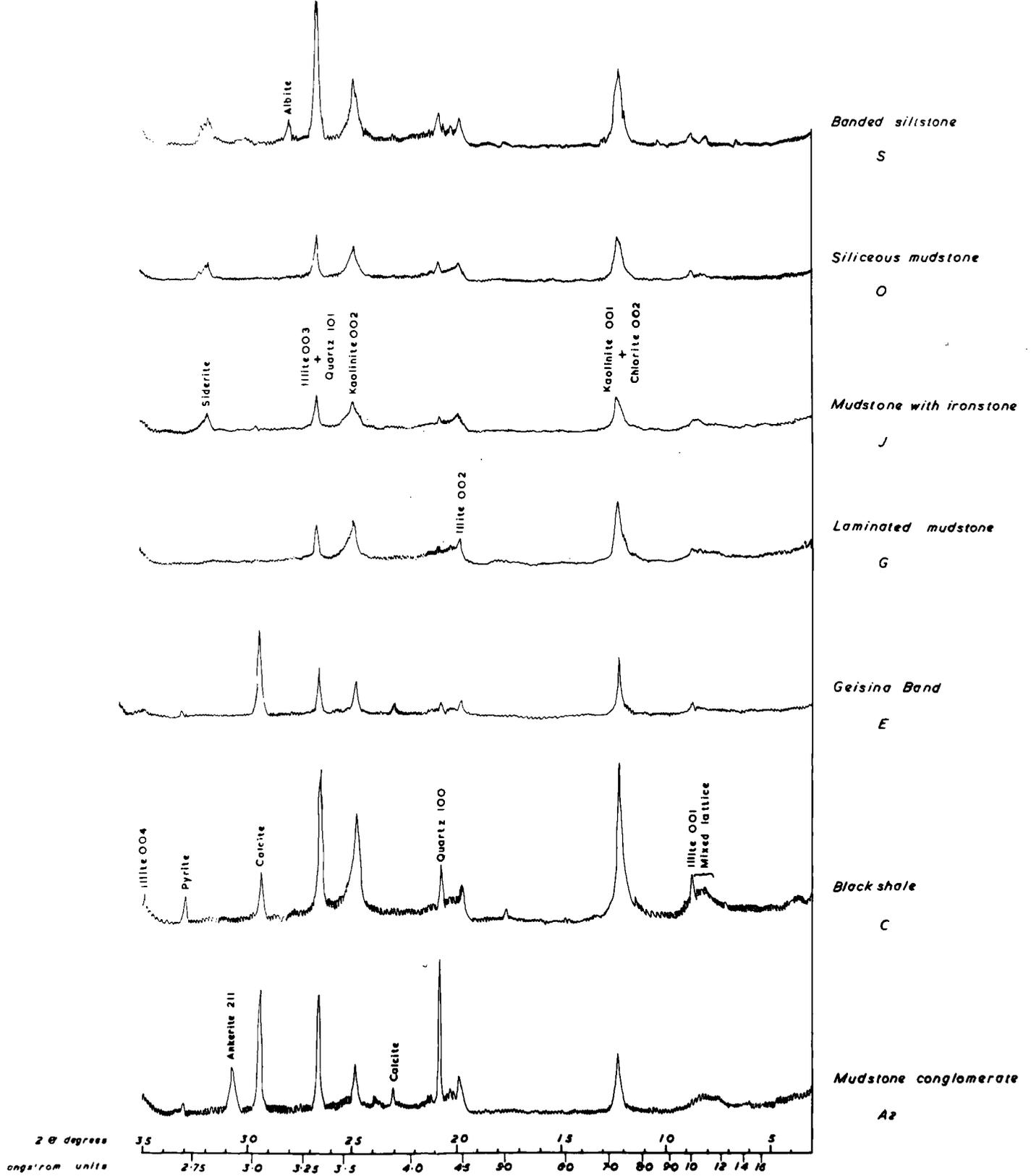


Figure 7.2. Comparison of X-ray diffraction and petrographic details of the fossiliferous sediments of the Hopkins' Band at Bearpark, "type section".

The X-ray data is provided by 17 vertical samples in the BP. 17 series, and petrographic details from the 17 thin sections shown.

Petrography

X-Ray diffraction

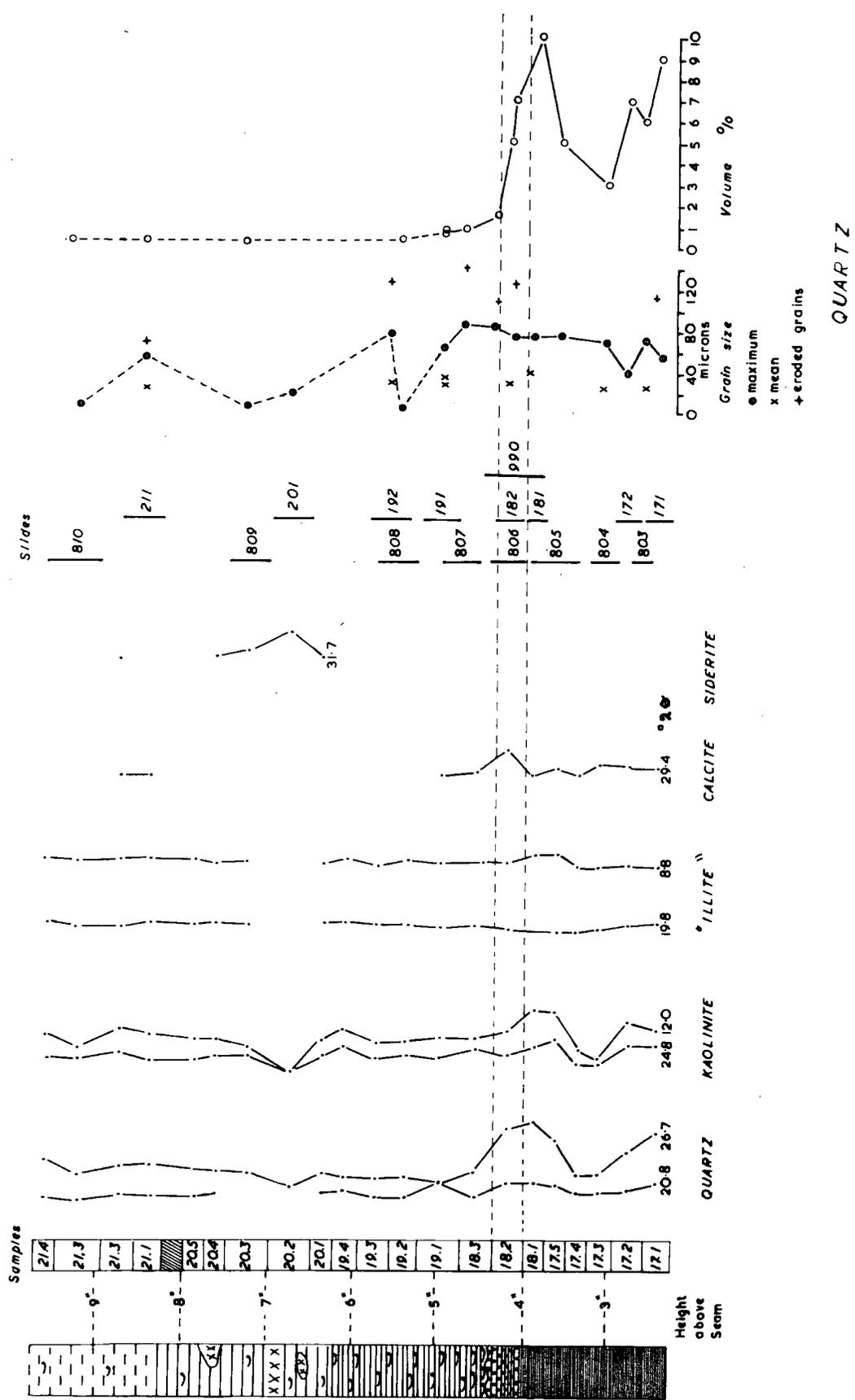


Figure 7.3. Variation in chemical composition of the sediments including the Hopkins' Band at Bearpark sampled in the BP. 105 series.

Samples lettered A1 to V and cross-hatched areas indicate unsampled strata. The lithological symbolism as on Figure 1.5.a. The absolute chemical compositions are recorded in

Appendix III.



V U T S R O P O N M L K J H G F E D C B A

5'0" 4'0" 3'0" 2'0" 1'0" 0

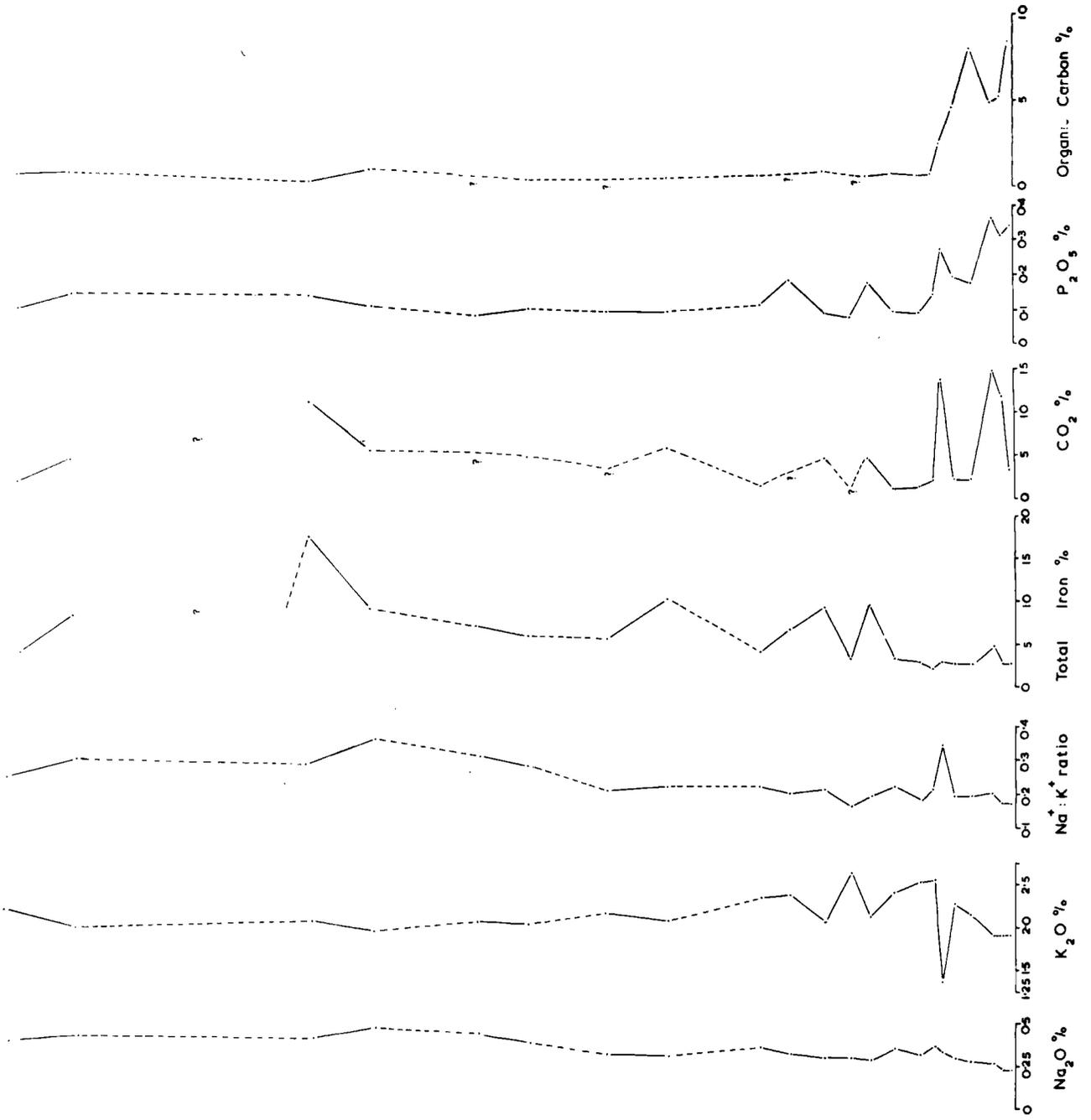


Figure 7.4. Eh - pH stability fields for  $\text{Fe}(\text{OH})_3$ ,  $\text{FeCO}_3$  and  $\text{FeS}$  at  $20^\circ\text{C}$  and 1 atmosphere pressure for  $[\Sigma \text{ dissolved sulphur ionic species}] = 10^{-3}$  mols/litre and  $[\Sigma \text{ dissolved carbonate ionic species}] = 10^{-3}$  mols / litre.

The probable chemical conditions in the Bearpark sediments are shown by the points, A, B, C, & D.

( After Nicholls and Loring 1962, fig.4, with additions . )

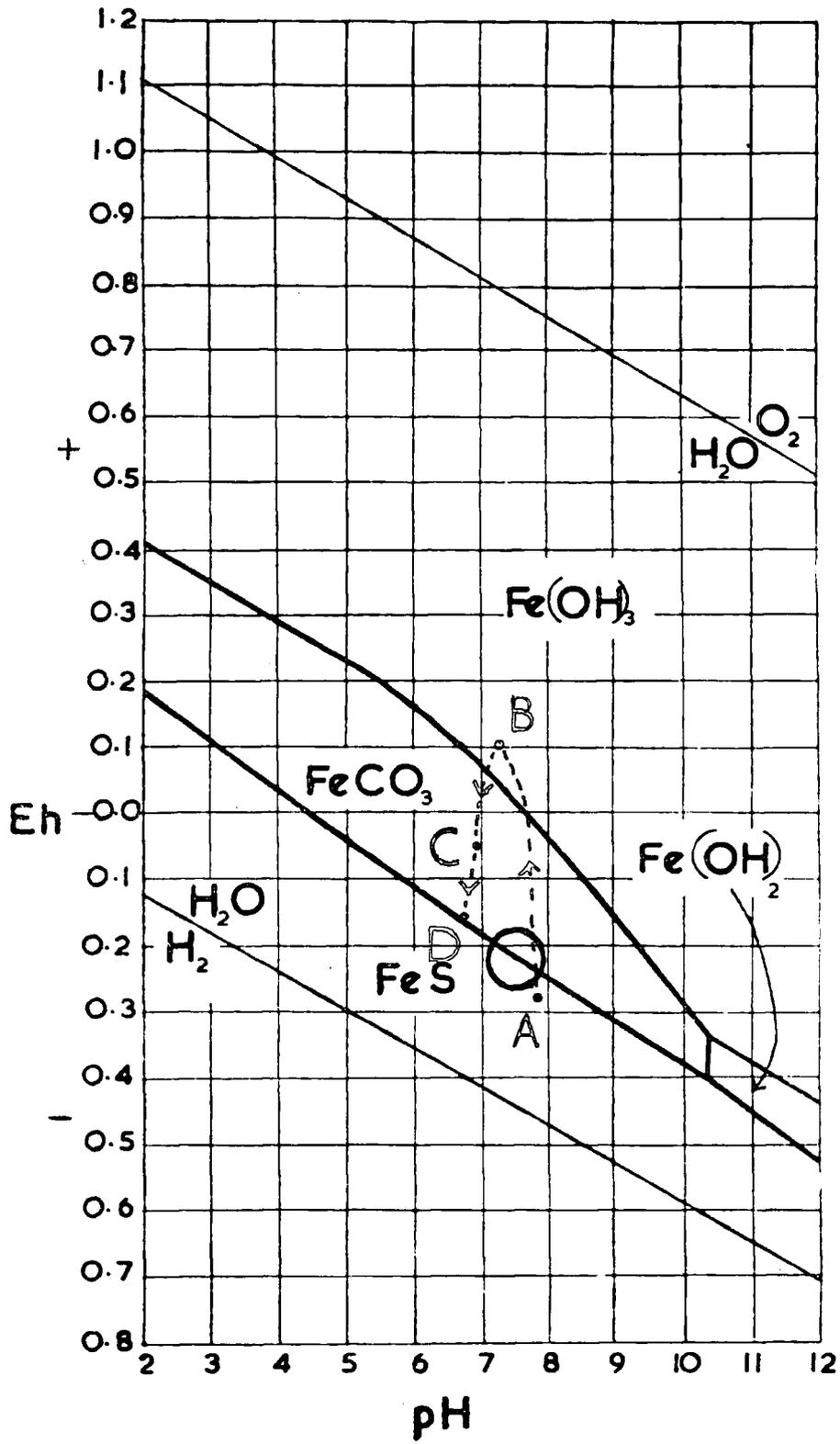


Figure 7.5. Sedimentary associations in relation to environmental limitations imposed by oxidation potential (Eh) and pH.  
( After Mason 1958, fig. 33. )

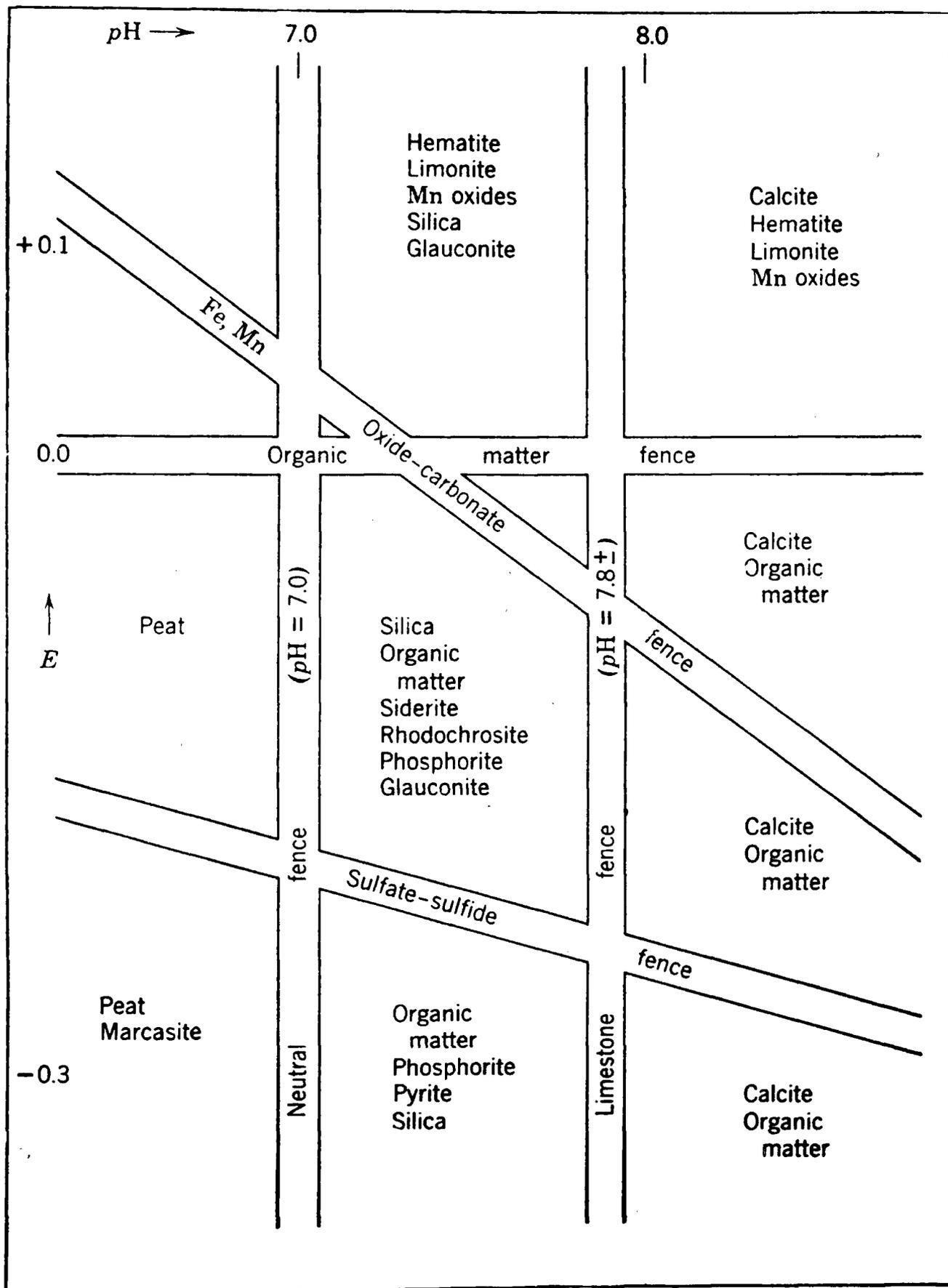


Figure 8.1. Diagram to illustrate the possible course of burial and preservation of mussel shells after death, related to sedimentation rate and compaction of the enclosing sediment.

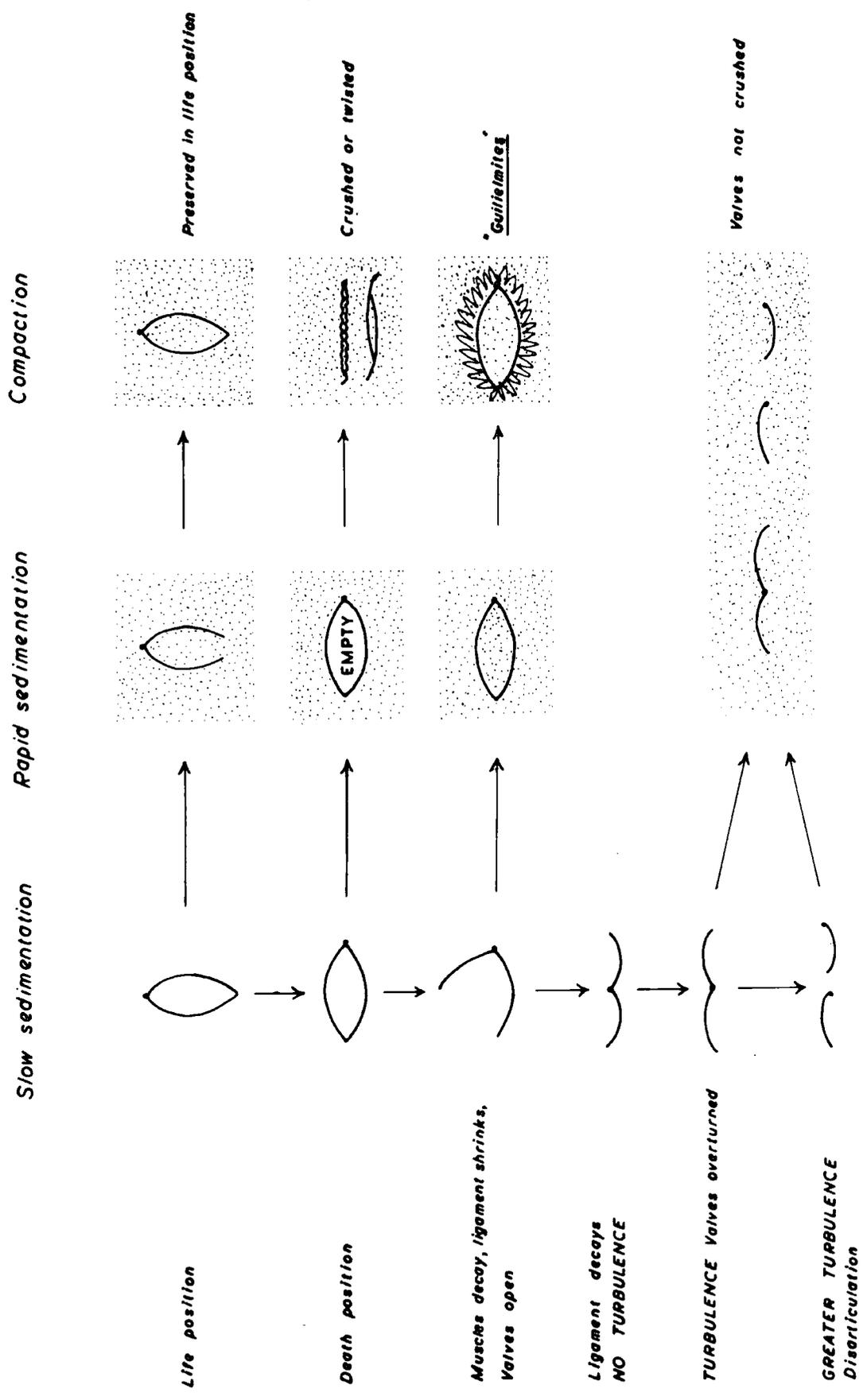


Figure 8.2. Correlation between Boron content and the occurrence of fossils interpreted in terms of palaeosalinity. " Salinity facies " diagram of Upper Carboniferous fossils , Ernst, Michelau and Tasch 1961, fig.5.

The range of Carbonita is added from boron values given by Ernst, Krejci-Graf and Werner (1958).

\* = Carbonita sp.

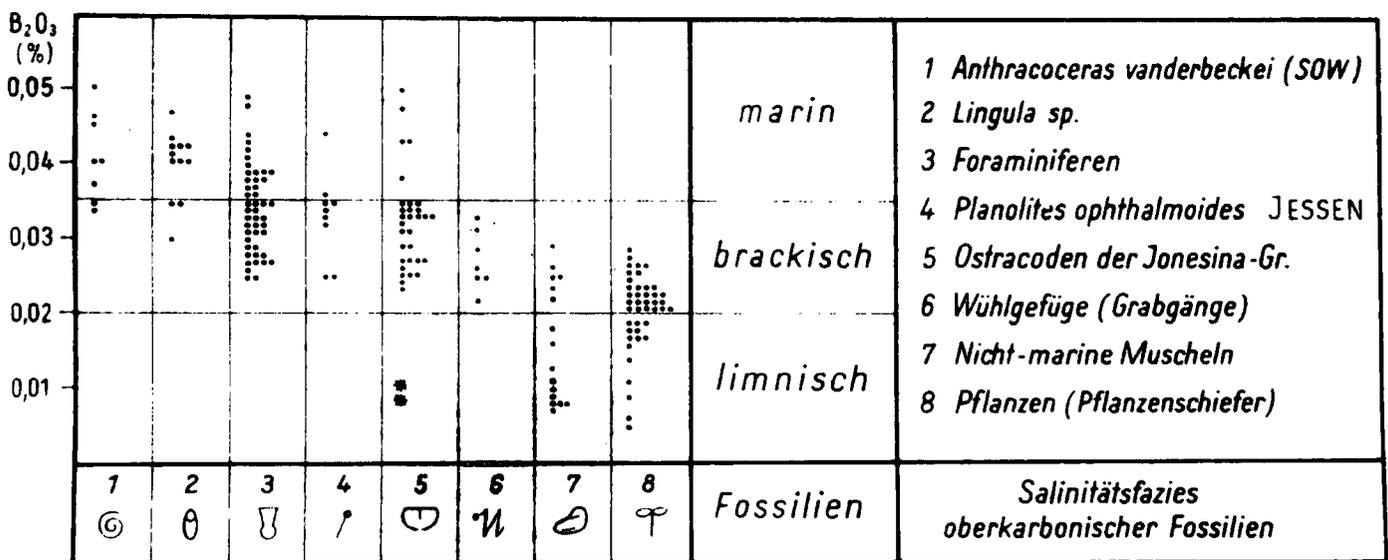


Figure 9.1. Diagram to illustrate the reconstruction of sedimentation, environmental conditions and distribution of the fauna, during the deposition of the sediments including the Hopkins' Band at Bearpark.

The suggested rate of sedimentation is purely relative and the size and number of arrows are only to give a relative idea of the degree of turbulence. The Eh values suggested are those at, or just below, the sediment - water interface. The symbolism of the fossils is that of Figure 5.1.



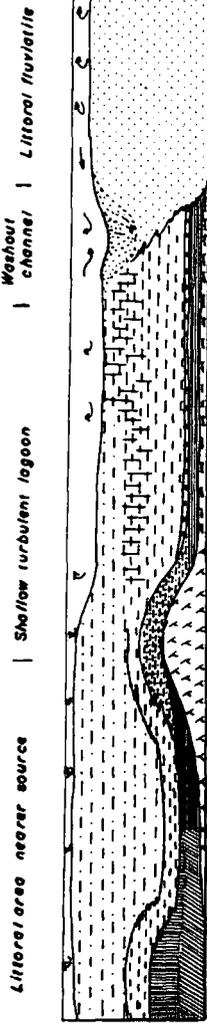
Figure 9.2. Reconstructions in space and time of the succession of sedimentary environments across the Durham Coalfield, that deposited the sediments including the Hopkins' Band.

Representation of lithologies as on Figure 1.5.a. Arrows indicate turbulence or current action . The base line of each reconstruction is the top of Harvey Seam and the top line the water level in the environment. The swamp in Reconstruction I consists of Lepidodendron, Cordaites and Calamites.

RECONSTRUCTION

Equivalent sedimentation  
at Bearpark

9 10 16 17 20 22



IV

Hopkins Band sediments

Littoral | Quiet lagoon | Littoral



III

Black shale deposition

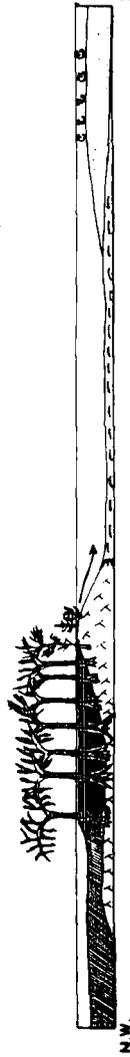
Canoe pool | Lagoon | Littoral | Deeper water | Shallow littoral



II

Initial inundation

Canoe pool | Swamp or marsh | Lagoon | Littoral



I

localities 9 10 16 17 20 22

— top of Harvey Seam

— water level

Horizontal scale 0 5 miles vertical not to scale

PLATES .

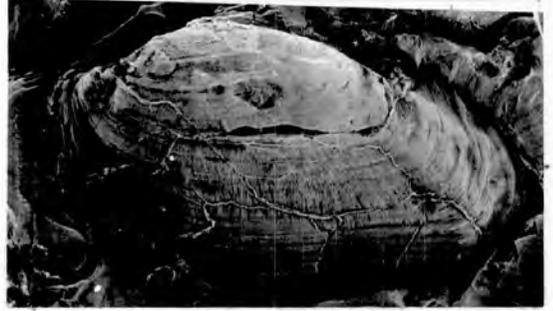
## PLATE I

## Mussels from the Hopkins' Band.

- Fig. 1. Carbonicola oslancis Wright. x2. specimen l, fig.2.1.  
Grey shale above Harvey Seam, Whitworth Opencast, Co. Durham.
- Fig. 2. Carbonicola cf. oslancis Wright. x2. ,specimen f ,fig.2.1.  
Grey shaley mudstone above Harvey Seam, Bearpark, Co. Durham.
- Fig. 3. Carbonicola aff. oslancis Wright. x2, specimen m, fig.2.1.  
above Harvey Seam, Hylton Colliery, Co. Durham.
- Fig. 4. Carbonicola cf. venusta Davies and Trueman. x2. specimen b,  
fig. 2.1., above Harvey Seam , Whitworth Opencast.
- Fig. 5. Carbonicola venusta Davies and Trueman. x4. specimen a, fig.  
2.1. , locality as Fig.3.
- Fig. 6. Carbonicola cf. embletoni Brown. x3., specimen i, fig. 2.1.  
above Beaumont Seam, Fenwick Pit, East Holywell, Northumberland.
- Fig. 7. Carbonicola cf. embletoni Brown. x2. specimen g , fig.2.1.  
locality as Fig. 2.
- Fig. 8. Carbonicola cf. oslancis Wright. x3. ( juvenile). specimen  
j ,fig. 2.1 , locality as Fig. 6.
- Fig. 9. Carbonicola aff. pectorata Wright. x2. specimen u , fig.2.1.  
above Harvey Seam , Eppleton Colliery, Co. Durham.



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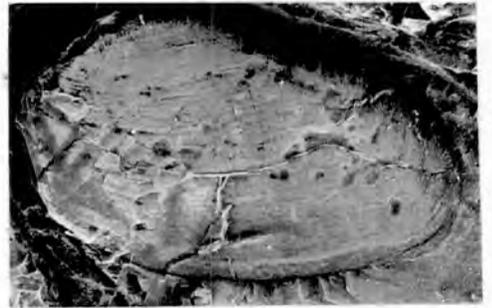
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## PLATE II

## Mussels from the Hopkins' Band.

- Fig. 1. Carbonicola cf. communis Davies and Trueman. x2. specimen p  
fig. 2.1. above Harvey Seam, Bearpark Colliery, Co. Durham.
- Fig. 2. Carbonicola cf. rhomboidalis Hind. x2 specimen r, fig.2.1.  
above Harvey Seam, Eppleton Colliery, Co. Durham.
- Fig. 3. Carbonicola cf. communis Davies and Trueman. specimen g, fig. 2.  
x2. above Harvey Seam, Wardley Colliery, Follonsby, Co. Durham.
- Fig. 4. Carbonicola cf. martini ? Trueman and Weir. x2. specimen s,  
fig. 2.1. above Beaumont Seam, Fenwick Pit, East Holywell,  
Northumberland.
- Fig. 5. Carbonicola cf. bipennis Brown. x2. specimen o, fig.2.1.  
locality as Fig. 3.
- Fig. 6. Carbonicola cf. bipennis Brown. x2. specimen n, fig. 2.1.  
locality as Fig. 1.
- Fig. 7. Anthracosia cf. regularis Trueman. x2. specimen R, fig.2.3.  
Mudstones above Harvey Seam, Whitworth Opencast, Co. Durham.
- Fig. 8. Anthracosia aff. regularis Trueman. x2. specimen M, fig.2.3.  
locality as Fig. 1.
- Fig. 9. Anthracosia aff. regularis Trueman. x2.5. specimen Q, fig.2.3.  
above Harvey Seam, Hylton Colliery, Co. Durham.



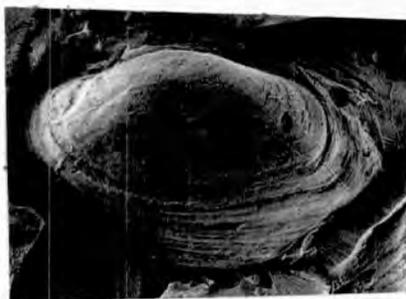
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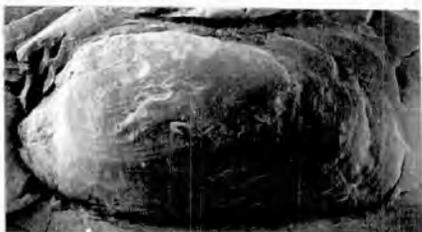
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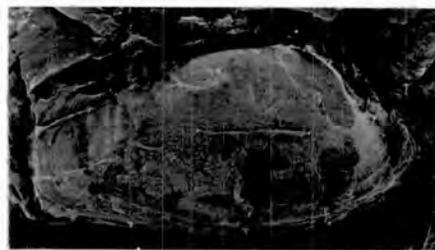
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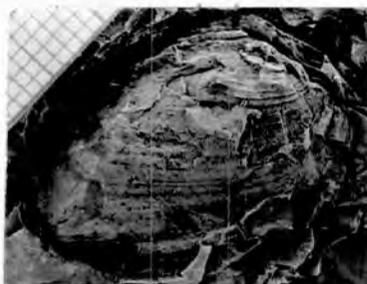
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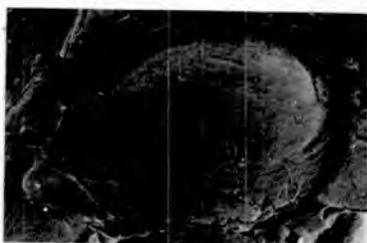
## PLATE III

## Mussels from the Hopkins' Band.

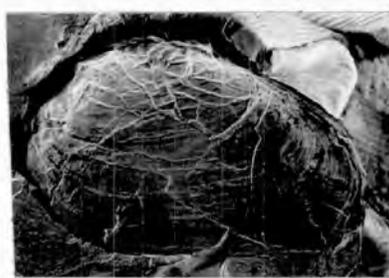
- Fig. 1. Anthracosia regularis Trueman. x2. specimen N, fig.2.3.  
above Beaumont Seam, Fenwick Pit, East Holywell, Northumberland.
- Fig. 2. Anthracosia regularis Trueman. (+ Spirorbis) x2. specimen  
P, fig.2.3. Above Harvey Seam, Bearpark, Co. Durham.
- Fig. 3. Anthracosia regularis Trueman. x2. specimen G, fig.2.3.  
above Harvey Seam, Hylton Colliery, Co. Durham.
- Fig. 4. Anthracosia cf. retrotracta Wright. x2.5 . specimen C, fig.2.3.  
above Harvey Seam, Whitworth Opencast, Co. Durham.
- Fig. 5. Anthracosia cf. ovum Trueman and Weir. x2.5. , specimen K,  
fig. 2.3. locality as Fig 4.
- Fig. 6. Anthracosia cf. retrotracta Wright. x2. specimen D, fig.2.3.  
locality as Fgg. 4 & 5.
- Fig. 7. Anthracosia cf. aquilina-retrotracta x2. specimen A, fig.2.3.  
locality as Fig. 4.
- Fig. 8. Anthracosia ovum-aquilina x2. specimen J, fig. 2.3.  
locality as Fig. 4.
- Fig. 9. Anthracosia cf. aquilina J. de C. Sowerby. x2. specimen I,  
fig.2.3. locality as Fig. 4 etc.
- Fig.10. Anthracosia aff. ovum Trueman and Weir. x2. specimen L, fig.2.3.  
above Beaumont Seam, Fenwick Pit, East Holywell, Northumberland.
- Fig. 11. Anthracosia aquilina -retrotracta x2. specimen H, fig.2.3.  
locality as Fig .4. etc.



1



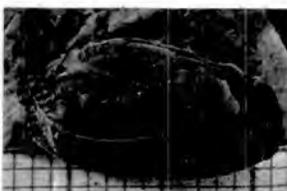
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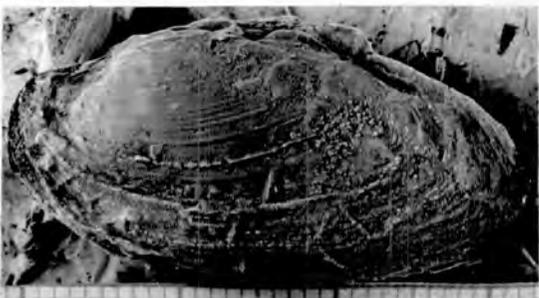
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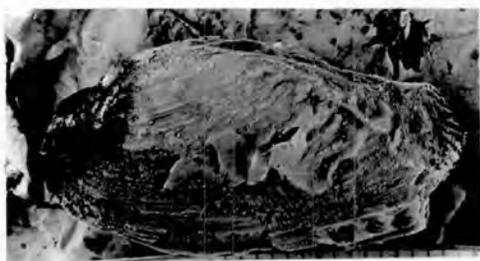
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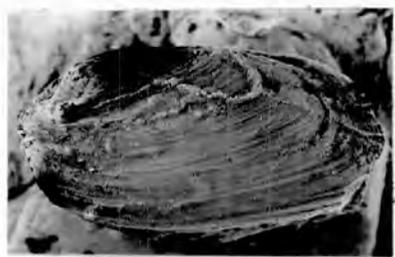
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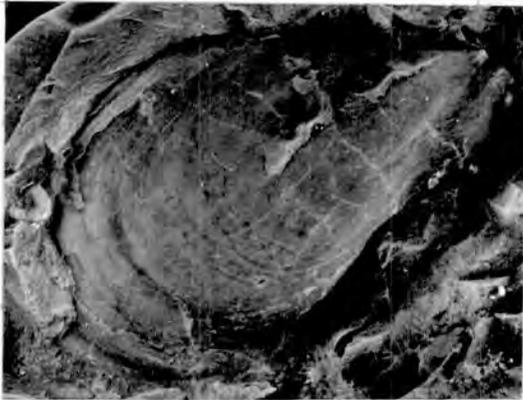


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## PLATE IV

## Mussels of the Hopkins' Band .

- Fig. 1. Naiadites productus Brown. x2 . specimen v, fig.2.4. from the mudstones above the Harvey Seam, Silksworth, Co. Durham.
- Fig. 2. Naiadites aff. productus Brown. x2. specimen vi , fig.2.4. Mudstones above the Harvey Seam, Bearpark , Co. Durham.
- Fig. 3. Naiadites productus towards subtruncatus x1, specimen vii fig.2.4. Siliceous mudstone above the Harvey Seam , Whitworth, Opencast , Co. Durham.
- Fig. 4. Naiadites productus towards triangularis x1.5 . specimen iv fig.2.4. Grey shale above Harvey Seam, Whitworth Opencast.
- Fig. 5. Naiadites carinatus J. de C. Sowerby . x3 . specimen xi, fig.2.4. above Harvey Seam, Silksworth, Co. Durham.
- Fig. 6. Naiadites cf. quadratus J. de C. Sowerby. x2. specimen ix , locality as Fig. 2.
- Fig. 7. Naiadites subtruncatus Brown. x 2.5 . specimen viii, fig.2.4. horizon and locality as Fig. 2.



1



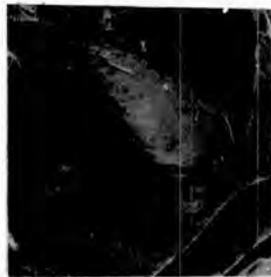
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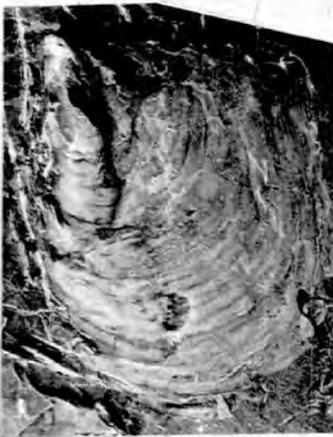
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## PLATE V

## Mussels from the Hopkins' Band.

- Fig. 1. Naiadites cf. flexuosus Dix and Trueman. x2. specimen xii, fig.2.4. above Beaumont Seam. Fenwick Colliery, East Holywell Northumberland.
- Fig. 2. Naiadites between quadratus and carinatus x2. (+Spirorbis) specimen x, fig.2.4. above Harvey Seam, Whitworth Opencast, Co. Durham.
- Fig. 3. Anthraconaia modiolaris J. de C. Sowerby. x1. specimen Y, fig.2.5. above Beaumont Seam, 2½ miles north-east of Bates Pit, Blyth, Northumberland.
- Fig. 4. Anthraconaia modiolaris (juvenile) x3. specimen W, fig.2.5. horizon and locality as Fig. 3.
- Fig. 5. Anthraconaia cf. fugax Eagar. x2. specimen V, fig. 2.5. above Hargey Seam, Hylton, Colliery, Co. Durham.
- Fig. 6. Anthraconaia modiolaris (juvenile). x2. specimen X, fig.2.5. horizon and locality as Fig. 3,
- Fig. 7. "Mussel Band" above the Geisina Band at Fenwick Colliery, East Holywell x1. The mussels if this Band have been counted and their orientations analysed in Chapter VIII.
- Fig. 8. "Carbonicola carissima" Wright. x2. Stunted or juvenile forms of Anthracosia sp. from the siliceous mudstone above the Harvey Seam at Whitworth Opencast.



1



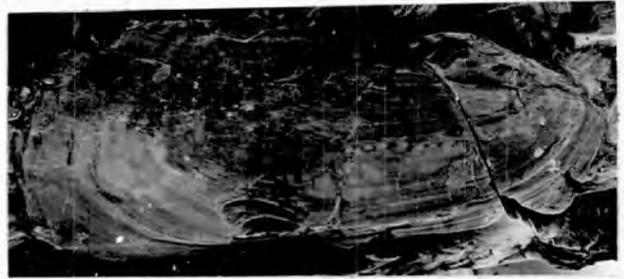
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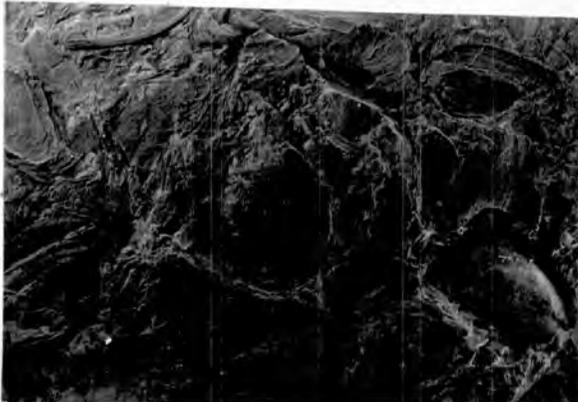
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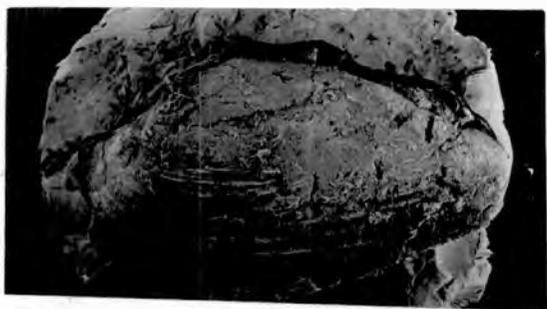


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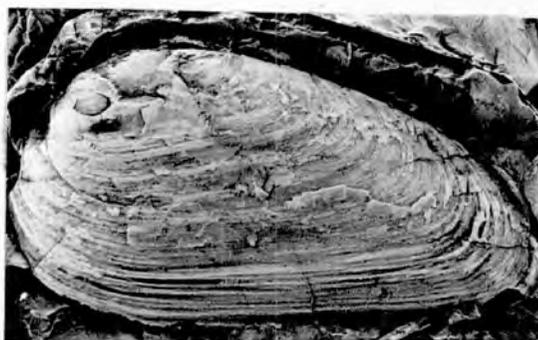
## PLATE VI

## Mussels from the Three Quarter Seam horizon.

- Fig. 1. Carbonicola between communis and pseudorobusta  $\times \frac{1}{2}$ .  
Shales above the Three Quarter Seam, Medomsley Colliery,  
Consett, Co. Durham.
- Fig. 2. Carbonicola cf. cristi-galli Wright.  $\times 2$ . horizon and locality  
as for Fig. 1.
- Fig. 3. Curvirimula cf. belgica Hind.  $\times 4$  . Form named "Anthraconauta"  
subovata var. candela Dewar. In Three Quarter horizon  
ostracod-mussel band in borehole Fishburn 6.
- Fig. 4. Carbonicola declevis Trueman and Weir.  $\times 2$ . horizon and  
locality as for Fig. 3.



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2



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4

## PLATE VII

Geisina arcuata Bean.

Figures 1 - 4 are of an adult female from the Geisina Band at Eppleton Colliery, Co. Durham. Figures 5 & 6 are shell fragments from the same locality and horizon.

The arrow on each figure points anteriorly with respect to the orientation of the ostracod.

Fig. 1. Lateral view of the Left valve. Note : The impressed sulcus, the overlap of the right valve over the Left around the entire margin ; and the right angled posterior dorsal corner. x50 approx.

Fig. 2. Lateral view of the Right valve. Note: raised dorsum: rectangular bulb at posterior dorsal corner; pointed bulb at median anterior margin and pitted surface. x 50 approx.

Fig. 3. Ventral view. Note: thickened ventral rim of the Right valve ; and prominent posterior dorsal bulb. x 50 approx.

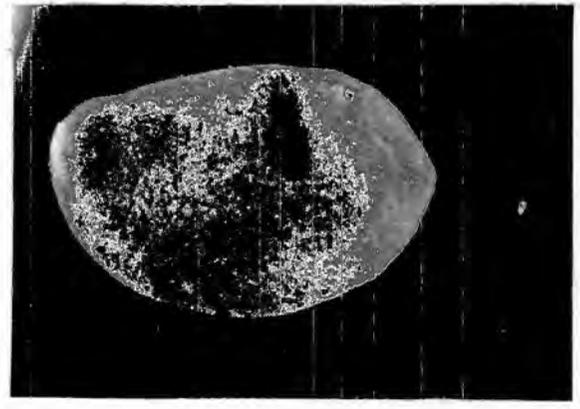
Fig. 4. Dorsal view. Note: straight hinge line and the advance of the right valve over the Left at both cardinal angles. x 60 approx.

Fig. 5. Interior of part of the Left valve. Note: thin hinge structure with upward reflexed anterior dorsal corner; thickened anterior rim to the valve; internal swelling due to sulcus. x 60 approx.

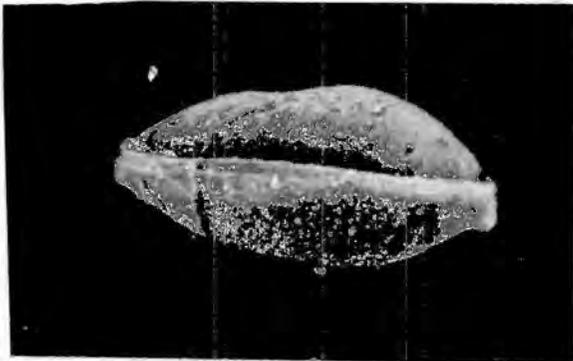
Fig. 6. Interior of the anterior dorsal part of the Right valve. Note: Shallow grooved hinge narrowing posteriorly. x 60 approx.



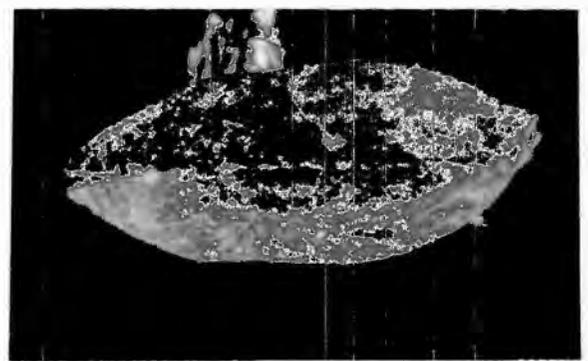
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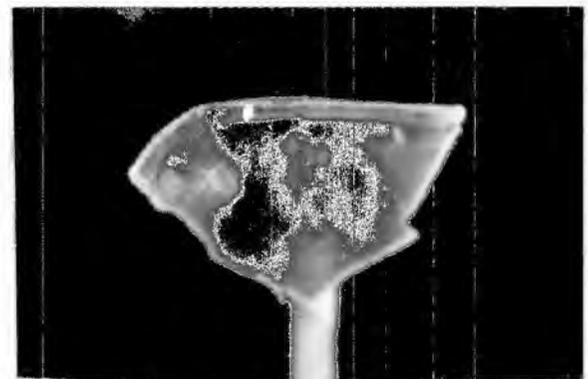
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## PLATE VIII

Fig. 1. The strata of the Hopkins' Band above the Harvey Seam at Whitworth' Opencast, Co. Durham.

Figure 2. The shale section of the Claxheugh Shell Bed, north bank of River Wear, North Hylton, Co. Durham.  
The ostracod fauna comes from the thick ironstone band by the hammer head.

PLATE VIII

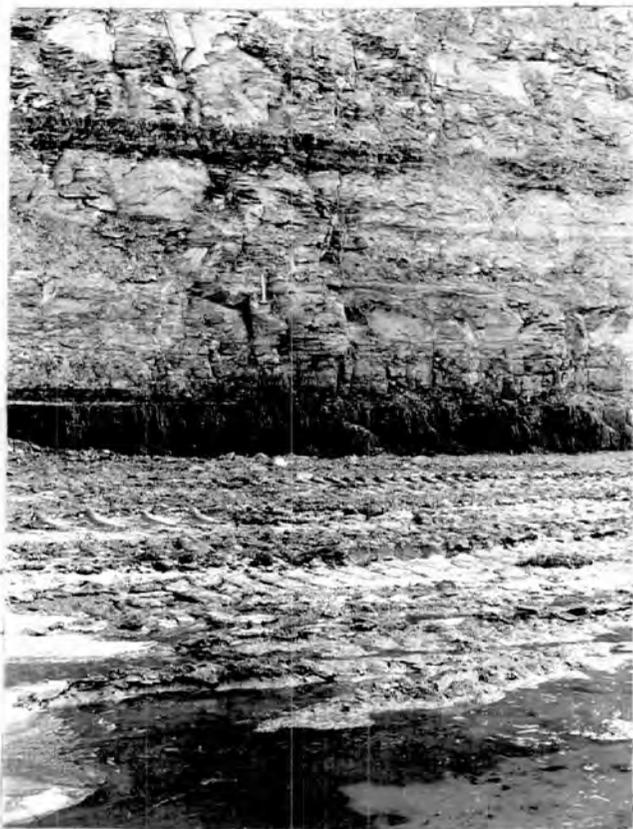


Figure 1.



Figure 2.

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PLATE IX

Figure 1. Strata including the Hopkins' Band above the Harvey Seam at Whitworth Opencast. Harvey Seam at the base overlain by the leached basal layers of the mudstone conglomerate then black shale and grey shale and mudstone above.

Figure 2. Mudstone conglomerate, black shale and grey mudstone above the Harvey Seam at Whitworth Opencast. The blocky weathering mudstone conglomerate at the base, has an irregular base and distinct carbon parting at the top. The thin Geisina Band is present at the top of the black shale.

PLATE IX

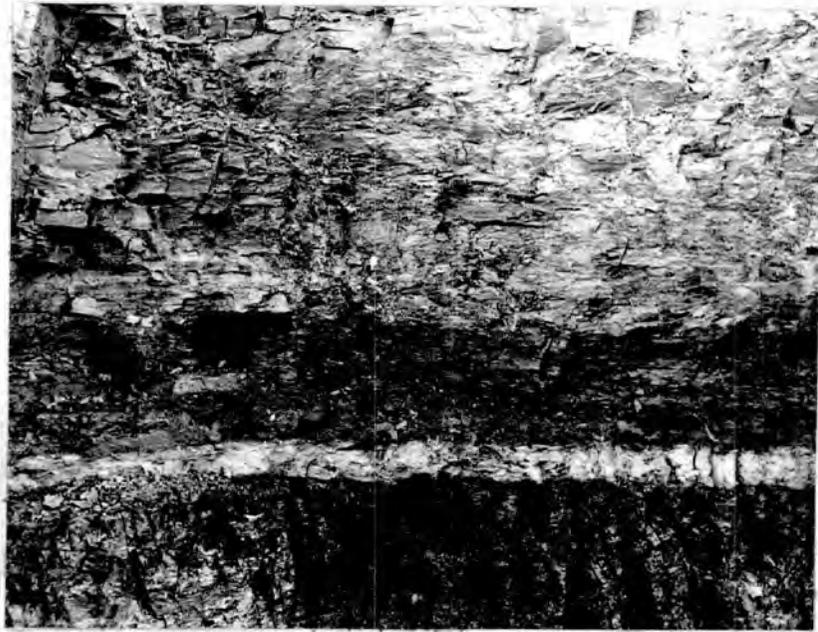


Figure 1.



Figure 2.

## PLATE X

Figure 1. Grey mudstone 2 feet above the Harvey Seam at  
Whitworth Opencast.

Figure 2. Sediments 1 to 3 feet above the Harvey Seam at  
Whitworth Opencast. Grey mudstone below and grey  
quartz banded siltstone above, by the ruler.

PLATE X

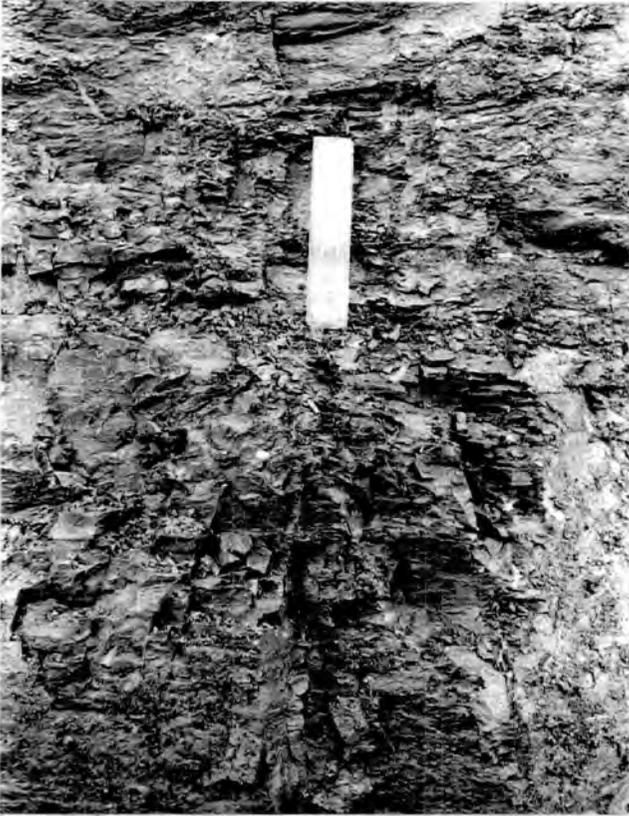


Figure 1.



Figure 2.

## PLATE XI

Figure 1. Photomicrograph of mudstone conglomerate,  $2\frac{1}{2}$  miles north-east of Bates Pit, Blyth, slide 730. x 40 approx. polarised light.

Pale coloured carbonate fragments in a matrix of carbon, clay minerals and quartz.

Figure 2. Photomicrograph of the top of the mudstone conglomerate base of the black shale at Bearpark, slide 801. x 40 approx ordinary light.

Dense black patches of carbonaceous matter, paler patches of quartz, and clay minerals with some carbon. Bedding N.W. to S.E. direction. Ostracods probably Carbonita humilis seen in transverse section.

PLATE XI

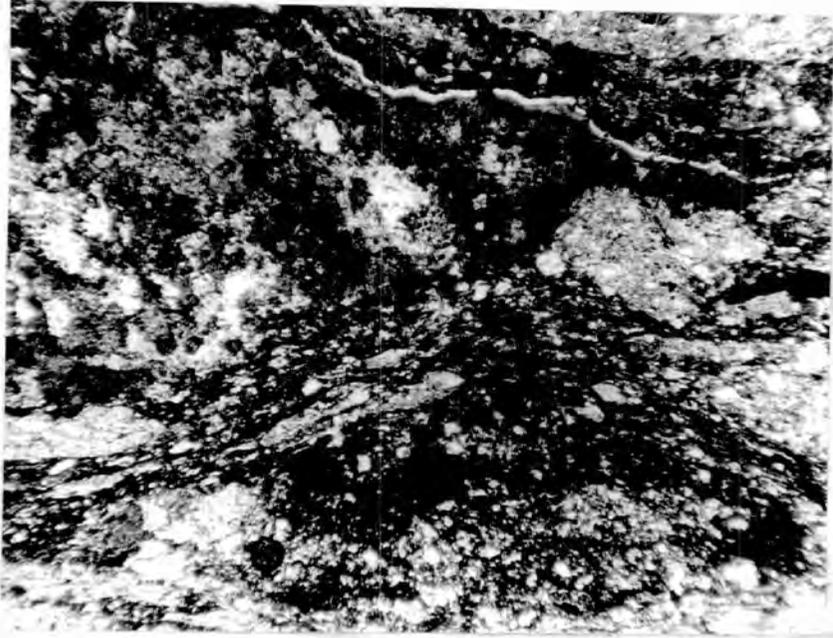


Figure 1.

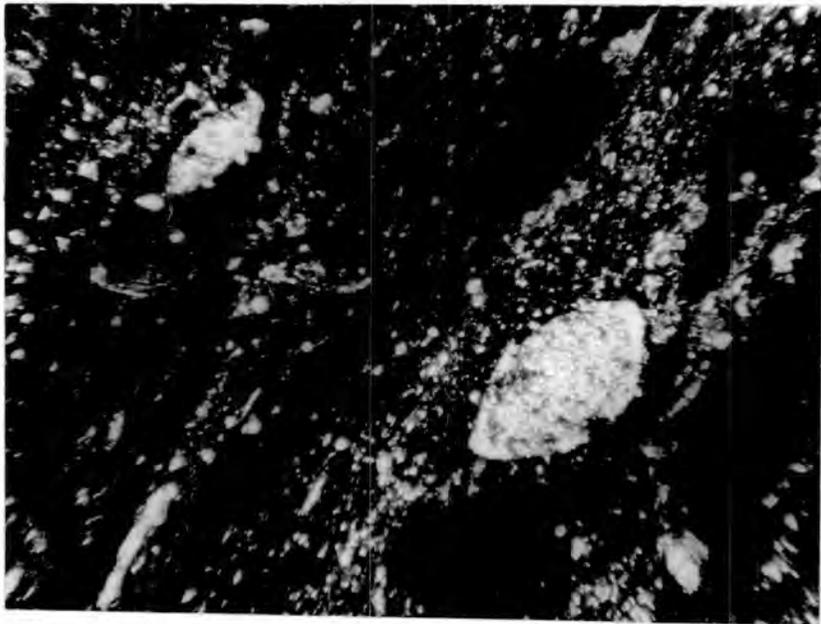


Figure 2.

## PLATE XII

Figure 1. Photomicrograph of the black silty shale below the Geisina Band, nr. Bates Pit ,Blyth. slide 733. x 40 approx . Ordinary light. Carbonaceous shale , very rich in detrital quartz and with Naiadites shells parallel to the bedding.

Figure 2. Photograph of a thin section of the Geisina Band at Eppleton. slide 725. x 5.5 . ordinary light. Black shale below with scattered patches of Naiadites -ostracod coquina, pale grey shale above with fine " cryptophyllite" texture. Complete ostracod carapaces and J 2 shaped cross section of a Spirorbis tube in the grey shale.

PLATE XII

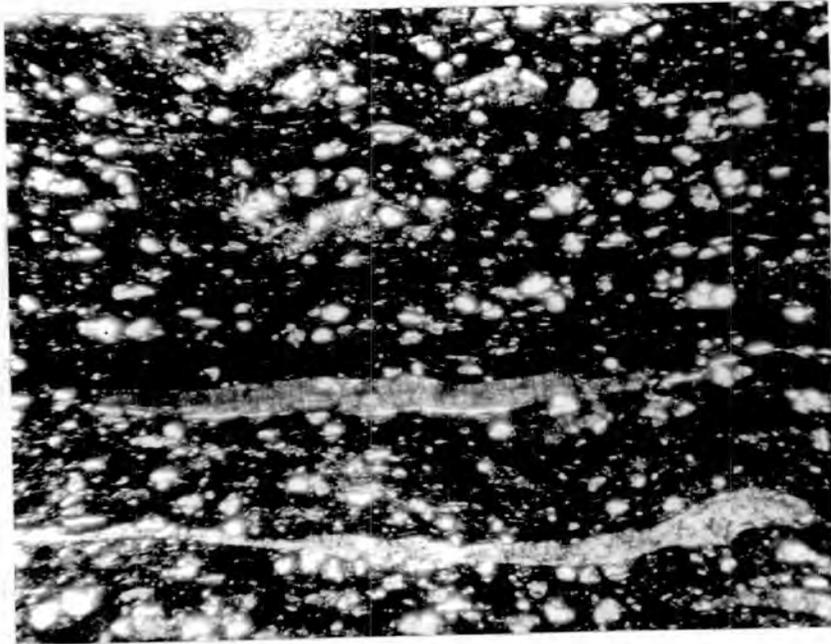


Figure 1.

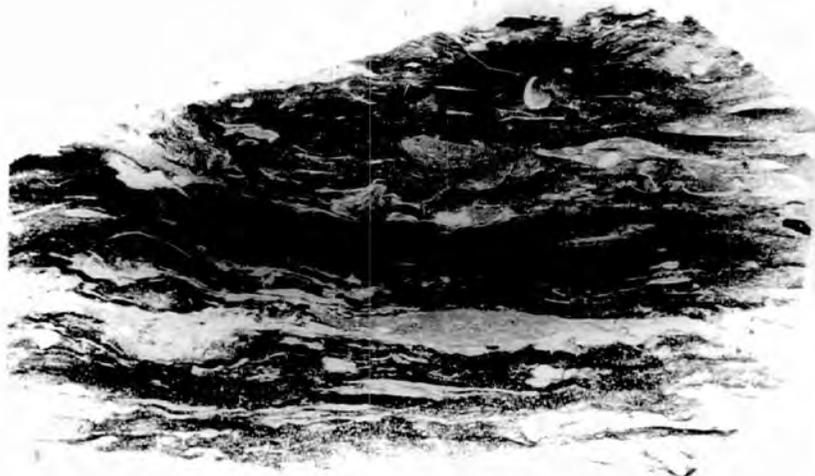


Figure 2.

## PLATE XIII

Figure 1. Photomicrograph of the Geisina Band at Whitworth Opencast. slide 705. x 40 approx. Polarised light.

Interlaminated shale and shell coquina.

Longitudinal section of a complete carapace of Geisina arcuata . Note : the thickening of the ostracod shell internally to the sulcus and at the posterior end of the right valve. ( Bulb described in taxonomic section Chapter III )

Figure 2. Photomicrograph of the Geisina Band at Follonsby slide 726. x 40 approx. polarised light.

Dense Naiadites - Geisina - Spirorbis coquina with a carbon rich matrix.

- A - G. arcuata transverse section . ventral thickening of the overlapping edge of the R. valve.
- B - G. arcuata longitudinal section of the carapace, crushed
- C - C. humilis , transverse section crushed.
- D - Spirorbis , transverse section
- E - Naiadites shell transverse section, showing prismatic structure.



Figure 1.



Figure 2.

## PLATE XIV

Figure 1. Photomicrograph of the grey shaley mudstone 5 to 6 inches above the Harvey Seam at Bearpark. slide 192. x 40 approx. polarised light.

Virtually pure clay mineral rock, " cryptophyllite" texture and bedding running N.W. to S.E. , disturbed around fossil fragments. Separated ostracod valve on extreme left, large eroded quartz grain 190 by 125 microns seen in top right hand corner.

Figure 2. Photomicrograph of grey shaley mudstone  $8\frac{1}{4}$  to  $8\frac{3}{4}$  inches above the Harvey Seam at Bearpark. slide 211. x 40 approx. ordinary light.

Horizontal bedding " cryptophyllite " texture  
Left half of the photograph is enriched in finely divided carbon. Crushed carapace of G. arcuata in bottom right hand corner.

PLATE XIV

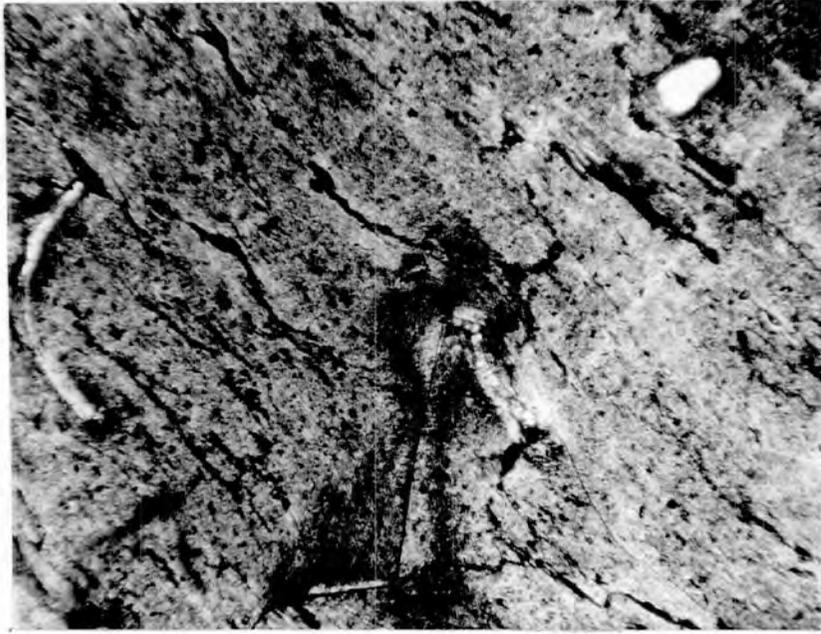


Figure 1.

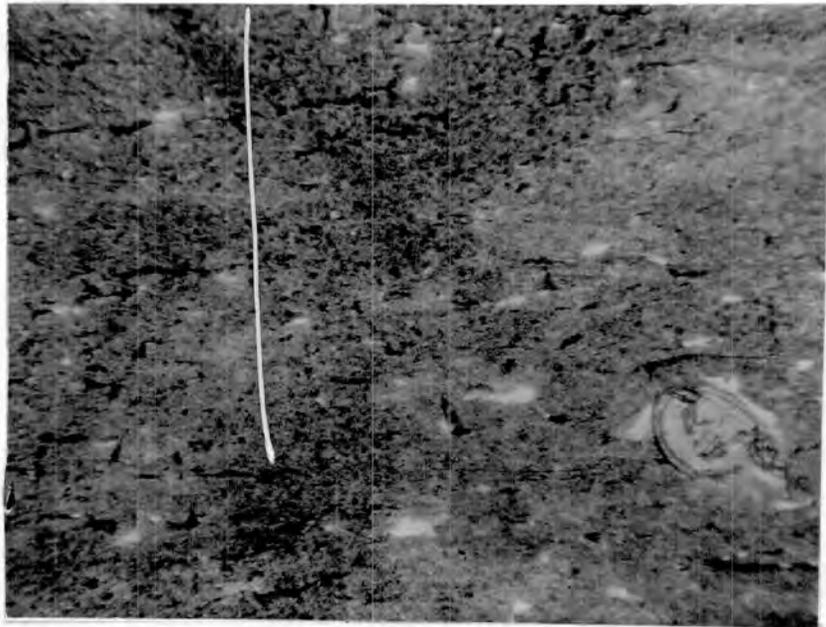


Figure 2.

Figure 1. Photomicrograph of the pale grey mudstone 11 to 12 inches above the Harvey Seam at Bearpark. slide 812, x 100 approx. polarised light.

Coarse texture of distinctly micaceous clay minerals, about 10 microns in length, sub-parallel arrangement bedding top left to bottom right. Ironstone nodule in the top right hand corner.

Figure 2. Photomicrograph of the siliceous or slightly silty mudstone 2 ft. 3 inches above the Seam at Bearpark. slide 819. x 100 . polarised light.

Clay minerals 15 - 20 microns grain size, fine quartz, random orientation of the clay minerals. Fine granules of sphaerosiderite in the groundmass causes dark colour.

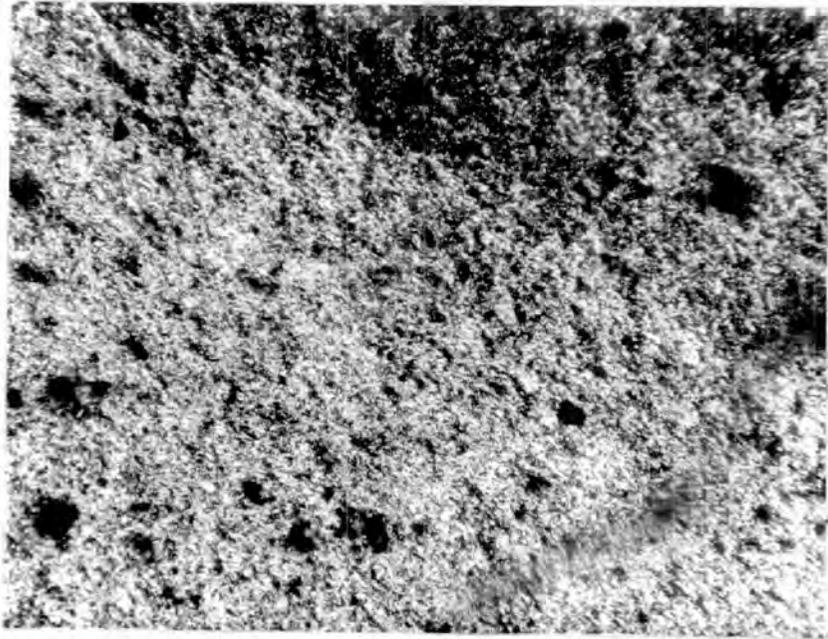


Figure 1.

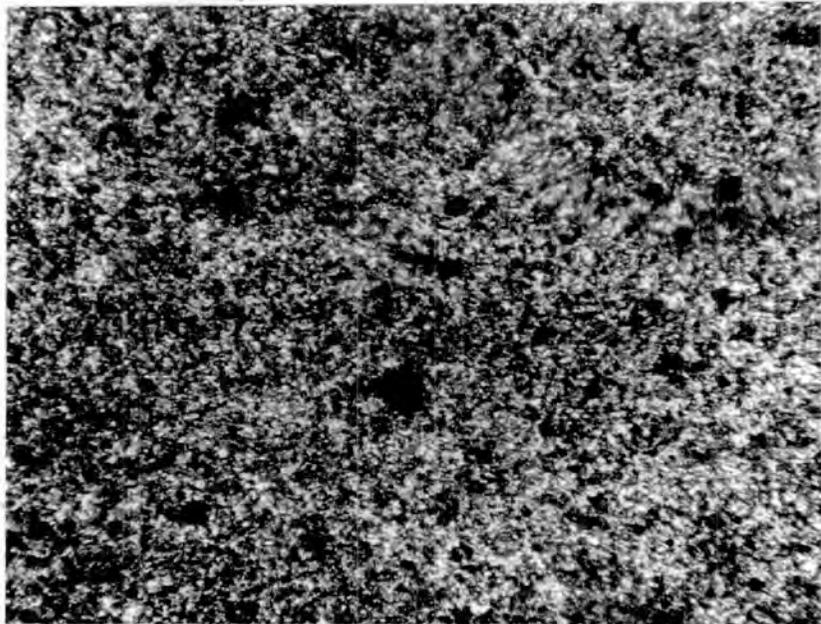


Figure 2.

## PLATE XVI

Figure 1. Photograph of a thinsection of the laminated muddy siltstone, 3ft. above the Seam at Bearpark. slide 821. x 4 approx. ordinary light.

Dark laminae of carbon and clay minerals, pale laminae of quartz and muscovite. Disturbance of the laminated texture in the upper part due to a burrowing organism .

Figure 2. Photograph of a thin section of siltstone and mudstone about 5 ft. above the Seam at Bearpark. slide 824. x 4. ordinary light.

Mudstone with coarse quartz-muscovite laminae below ,siltstone above. A worm burrow curving to the left descends from the siltstone through the underlying mudstone.

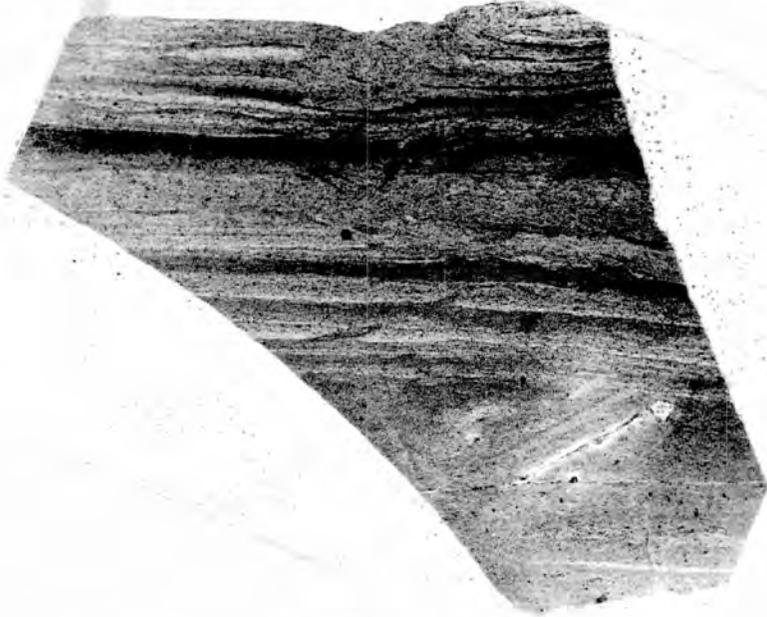


Figure 1.

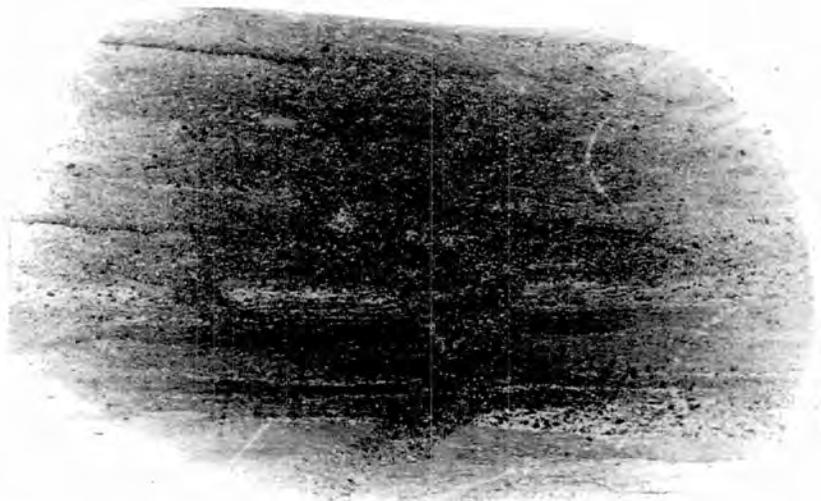


Figure 2.

Figure 1. Photograph of a thin section of a cross-bedded quartz - mica sandstone, 3ft. 4in. above the Harvey Seam at Whitworth Opencast. slide 710. x 4. ordinary light.

Very rich in carbonaceous matter that outlines the cross - bedding.

Figure 2. Photomicrograph of the sandstone in Fig. 1. x 40 . ordinary light.

Equigranular texture of angular quartz and muscovite with patches of dense carbonaceous matter.

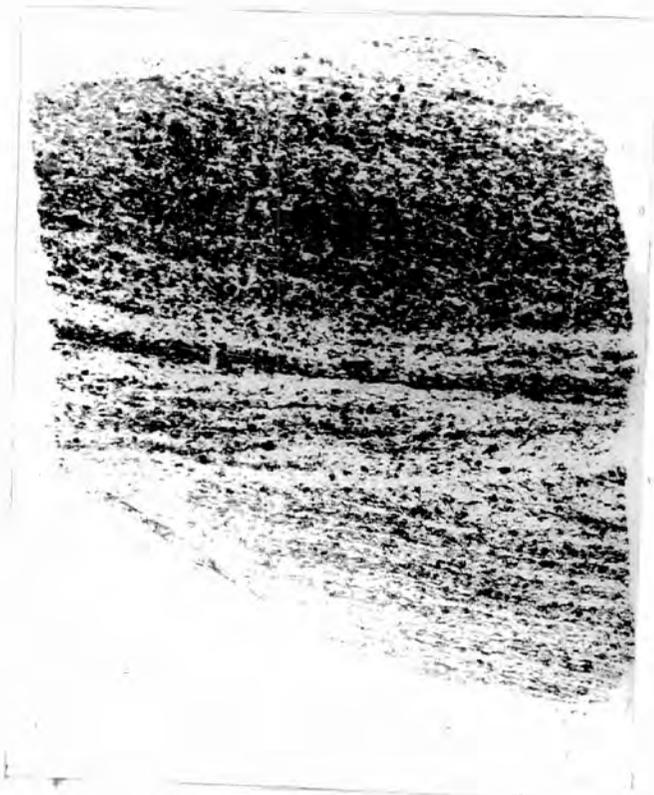


Figure 1.

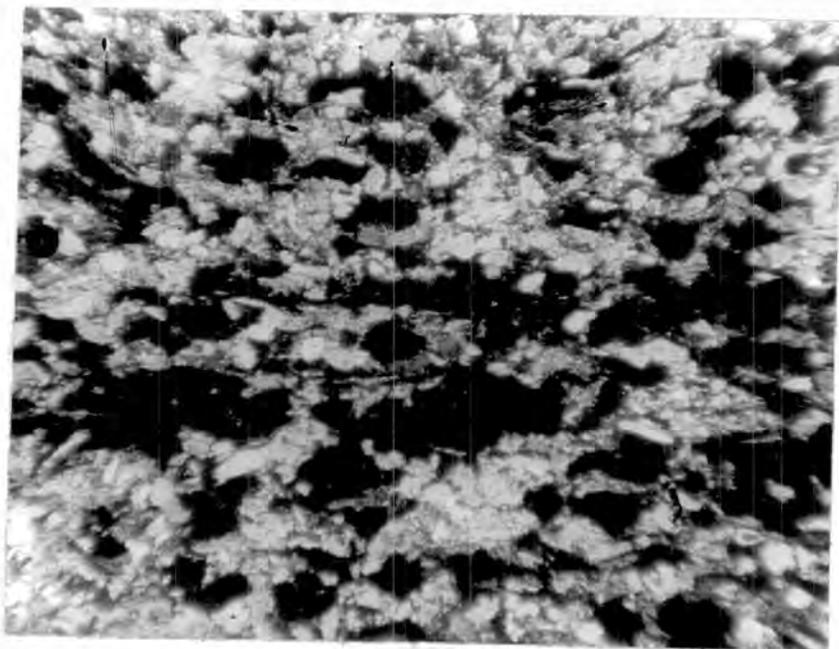


Figure 2.