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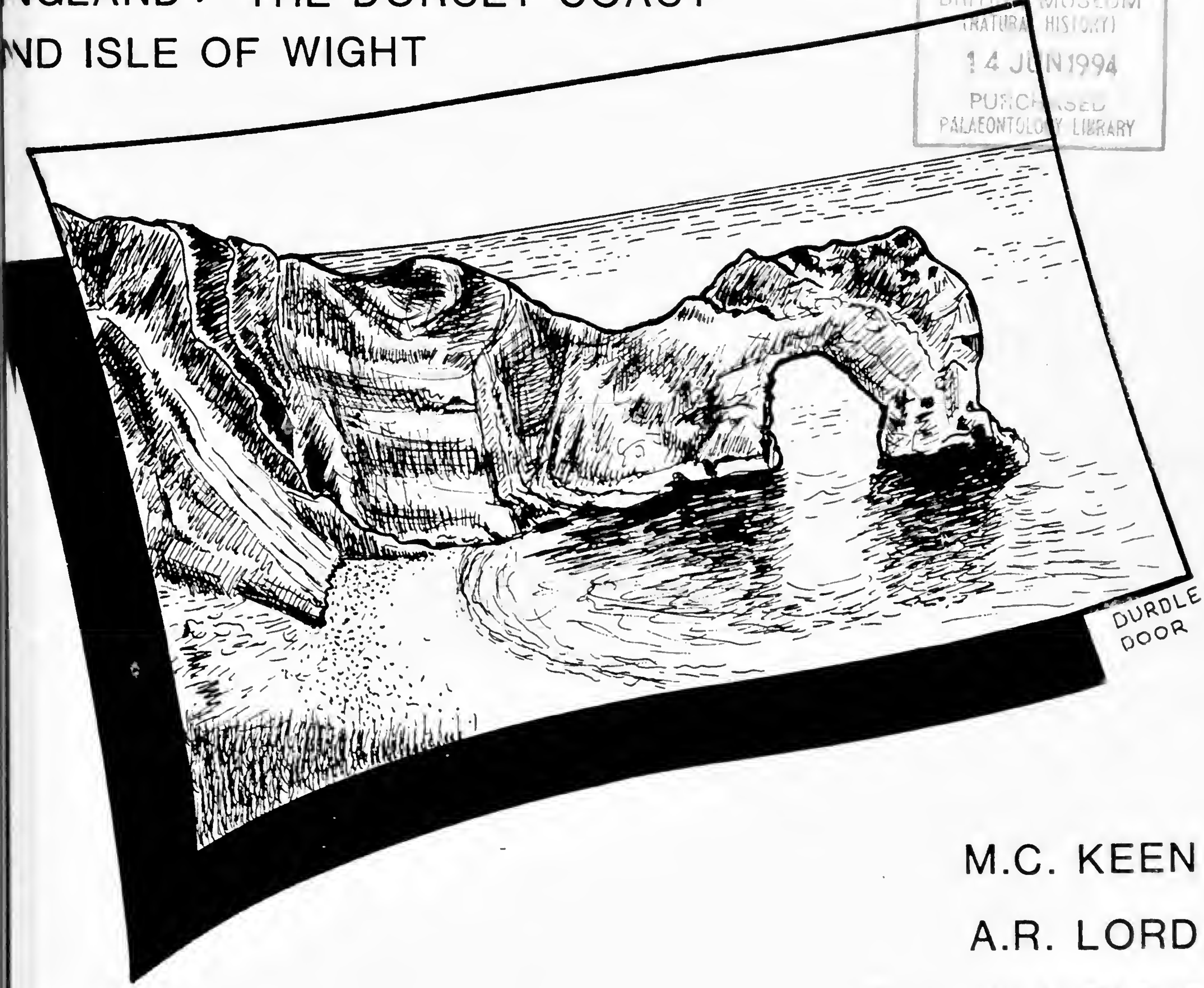
IELD GUIDE No. 6

ENTH INTERNATIONAL SYMPOSIUM ON OSTRACODA

BERYSTWYTH 1988

HE MESOZOIC AND TERTIARY OF SOUTHERN NGLAND: THE DORSET COAST ND ISLE OF WIGHT



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THE LOWER AND MIDDLE JURASSIC

A. R. LORD and I. D. BOOMER

The Jurassic of the Dorset Coast is a classic reference section of international importance. The lithostratigraphy and biozonation of this sequence has been summarised and discussed by Cope et al. (1980a, 1980b) with correlations to numerous other British sections. The Dorset coast is rivaled in Britain only by the fine sections exposed on the Yorkshire coast although, sadly, inland exposures between these two cliff sites are now becoming rare. The Dorset coast has been intensively studied for over 150 years and an extensive literature exists concerning the stratigraphy, palaeontology, sedimentology, structure, economic geology and geomorphology of the area. A useful guide with particular emphasis upon the petroleum geology of the area has been recently published by Stoneley and Selley (1986); see also Torrens (1969).

Source references for Ostracoda:
Bate (1978), Field (1966, 1968), Lord (1972, 1974, 1978), Park (1985), Sheppard (1981), and Sylvester-Bradley (1948).

Comment: The unpublished work of Park (1985) and new information is in preparation for publication.

THE LOWER JURASSIC - LYME REGIS TO BRIDPORT

The coastal cliffs expose an essentially complete Lower Jurassic sequence some 320m thick and dominantly composed of mudrocks (Figs.1-7). The Hettangian and Sinemurian are particularly bituminous and provide a source rock, whereas the Toarcian sands form the upper reservoir level of the Wytch Farm Oilfield in east Dorset. The units have a regional dip eastwards towards the Weymouth Anticline and many of the hills are capped by horizontal mid-Cretaceous shallow-water deposits that rest unconfomably upon the Lower Jurassic.

Notes:

1. The Lower Jurassic is not fully represented on the Dorset coast. Ammonite biostratigraphy has demonstrated that gaps exist in the Upper Sinemurian - the oxynotum zone and upper part of the obtusum zone are missing as is the upper part of the raricostatum zone. The time gaps occur within and at the top of the Black Ven Marls.

2. For the Lower Lias (Hettangian - Lower Pliensbachian) bed numbers from the pioneer work of W.D. Lang are used as a standard reference system (various publications 1923-1936). The cliffs are no longer those Lang measured and some of his units are difficult to recognise. Although the sections and their ammonite assemblages are well-known, no comparable modern work exists other than the revisions of Palmer (1972a, b).

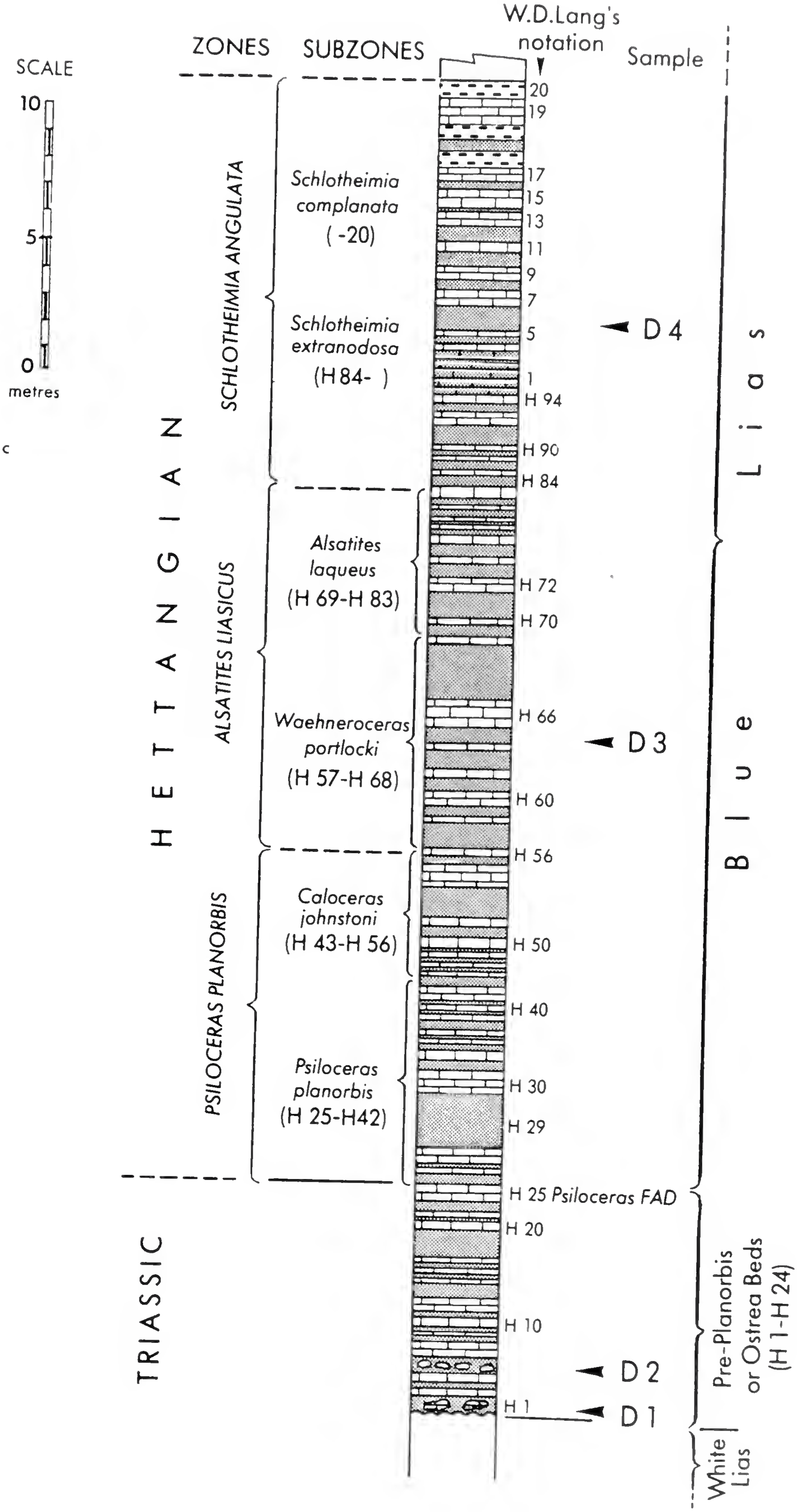
PINHAY BAY TO LYME REGIS (SY320908 - SY340920)

The only Triassic studied occurs in Pinhay Bay, to the east of the Pinhay Fault where the top of the Penarth Group (Rhaetian) can be seen. The White Lias consists of lithologically varied carbonates including intraformational conglomerates, slump beds and features such as mud cracks and algal laminae, indicating deposition in very shallow waters (Hallam, 1960). Sample D1 was taken from a shale parting below the topmost limestone of the White Lias.

Sample D1

No calcareous microfossils, but spores, pollen and acritarchs occur which indicate inshore marine conditions and a relatively warm climate (Riding 1987, p. 11).

The White Lias is succeeded by shales, paper shales and limestones of the


SCALE
10
5
0
metres
ZONES
SUBZONES
W.D.Lang's notation
Sample
SCHLOTHEIMIA ANGULATA
Schlotheimia complanata (-20)
Schlotheimia extranodosa (H84-)
ALSATITES LIASICUS
Alsatites laqueus (H 69-H 83)
Waehneroceras portlocki (H 57-H 68)
PSILOCERAS PLANORBIS
Caloceras johnstoni (H 43-H 56)
Psiloceras planorbis (H 25-H42)
HETTANGIAN
TRIASSIC
20
19
17
15
13
11
9
7
5
1
H 94
H 90
H 84
H 72
H 70
H 66
H 60
H 56
H 50
H 40
H 30
H 29
H 25 Psiloceras FAD
H 20
H 10
H 1
D 4
D 3
D 2
D 1
Blue Lias
Pre-Planorbis or Ostrea Beds (H 1-H 24)
White Lias

Blue Lias. Ammonites have not been found in the lowermost 2.5m (Lang beds H1-24) and the base of the Jurassic (base of Psiloceras planorbis Zone) is taken at Bed H25 where the oldest Psiloceras has been found (Cope et al 1980a). Sample D2 was taken in the Pre-Planorbis Beds, 1.5m above the base of the Blue Lias.

Sample D2

Monoceratina frentzeni Triebel and Bartenstein, Ogmoconchella aspinata (Drexler), Paracypris sp.1.

Comments
O.aspinata ranges from the topmost Triassic to Lower Sinemurian and often dominates the assemblages (as here). The assemblage is typical of the marine lowermost Lower Jurassic. The name Ogmoconchella ellipsoidea (Jones) has been applied by Lord (1978, etc.) to the form here called O.aspinata. The relationship of this species to Rhaetian taxa described by Anderson (1964), such as O.owthorpensis and O.martini, is still unclear but must be close.

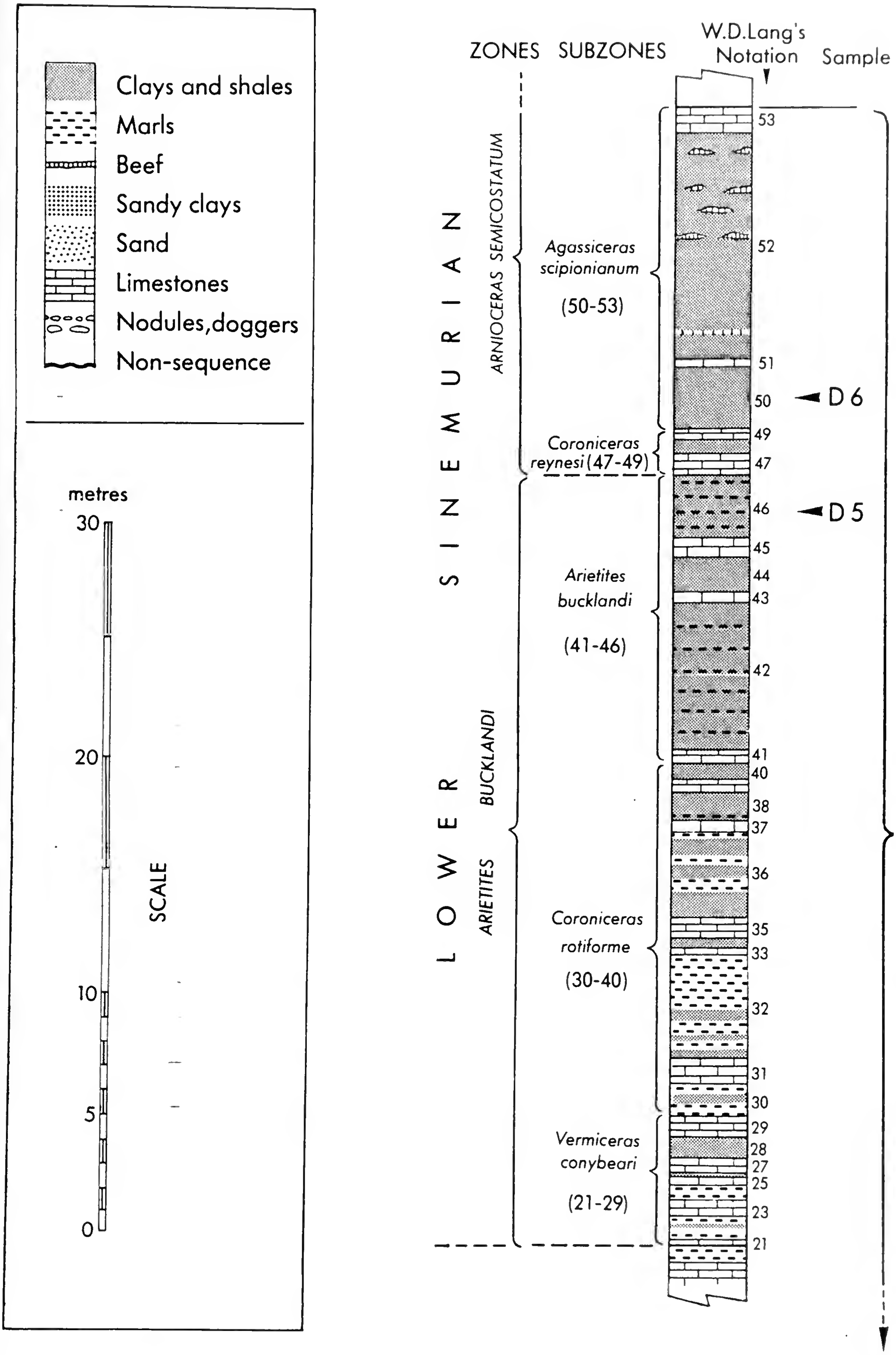
The Blue Lias forms the lower cliff from Pinhay Bay to Black Ven, east of Lyme Regis. The 29m thick sequence includes the entire Hettangian and basal Sinemurian. The characteristic lithology of alternating shales and limestones has been the subject of considerable attention in the past, having been studied in detail and each bed numbered by Lang (1924). The alternation appears to be both primary and secondary, reflecting both original sedimentary variation and later diagenetic segregation of calcite (Hallam, 1964). Large ammonites are common and numerous vertebrates, for which Lyme Regis is famous, have been collected in the past. Samples were collected through the sequence.

Sample D3 (Blue Lias Lang Bed H65; liasicus Zone, portlocki Subzone)
(SY32109085)

No foraminifera or ostracods and rare coccoliths. Near shore situation indicated by palynomorph assemblage of spores and pollen with subsidiary amount of marine microplankton.

Sample D4 (Blue Lias, Lang Bed 6; angulata Zone, extranodosa Subzone)
(SY32859100)

Monoceratina frentzeni Triebel and Bartenstein, Nanacythere aequalicostis Park MS., Nanacythere elegans (Drexler), Nanacythere sp., Ogmoconchella


Clays and shales
Marls
Beef
Sandy clays
Sand
Limestones
Nodules,doggers
Non-sequence
metres
30
20
10
5
0
SCALE
ZONES
SUBZONES
W.D.Lang's Notation
Sample
LOWER SINEMURIAN
ARNIOCERAS SEMICOSTATUM
ARIETITES BUCKLANDI
Agassiceras scipionianum (50-53)
Coroniceras reynesi (47-49)
Arietites bucklandi (41-46)
Coroniceras rotiforme (30-40)
Vermiceras conybeari (21-29)
53
52
51
50
49
47
46
45
44
43
42
41
40
38
37
36
35
33
32
31
30
29
28
27
25
23
21
D 6
D 5
Blue Lias

aspinata (Drexler), Ogmoconchella bispinosa (Gründel), Ogmoconchella hagenowi Drexler, Paracypris sp.1, Polycope cerasia Blake.

Comments
As in D2, O.aspinata is still present. N.aequalicostis was recorded by Park (MS) only within the angulata and bucklandi Zones of Dorset. The assemblage marks the first appearance of cytheracean ostracods.

Sample D5 (Blue Lias, Lang Bed 46, bucklandi Zone, bucklandi subzone) (SY33359150)

Bairdia gantoftensis Sivhed, B.molesta Apostolescu, Cardobairdia sp., Cytherelloidea circumscripta (Blake), ?Cytheropteron sp., Isobythocypris elongata (Blake), I. sp.1, Macrocypris sp.1, Monoceratina frentzeni Triebel and Bartenstein, M. sp., Ogmoconcha hagenowi Drexler, Ogmoconcha sp., Ogmoconchella aspinata (Drexler), O.bispinosa (Gründel), O.nasuta (Drexler), O.teleata (Drexler), Polycope cerasia Blake, Stenestroemia ?roedbyensis Michelsen.

Comments
Still within the range of O.spinata. S.roedbyensis was described from the Hettangian and Lower Sinemurian of Denmark by Michelsen (1970). In Dorset it has been recorded only in the bucklandi Zone. This assemblage is very similar to that of Drexler (1958) from Siebeldingen/Pfalz (Lias alpha, Hettangian), West Germany. Field (1966) analysed the occurrence of cytherellid forms in the Hettangian and Lower Sinemurian of this sequence.

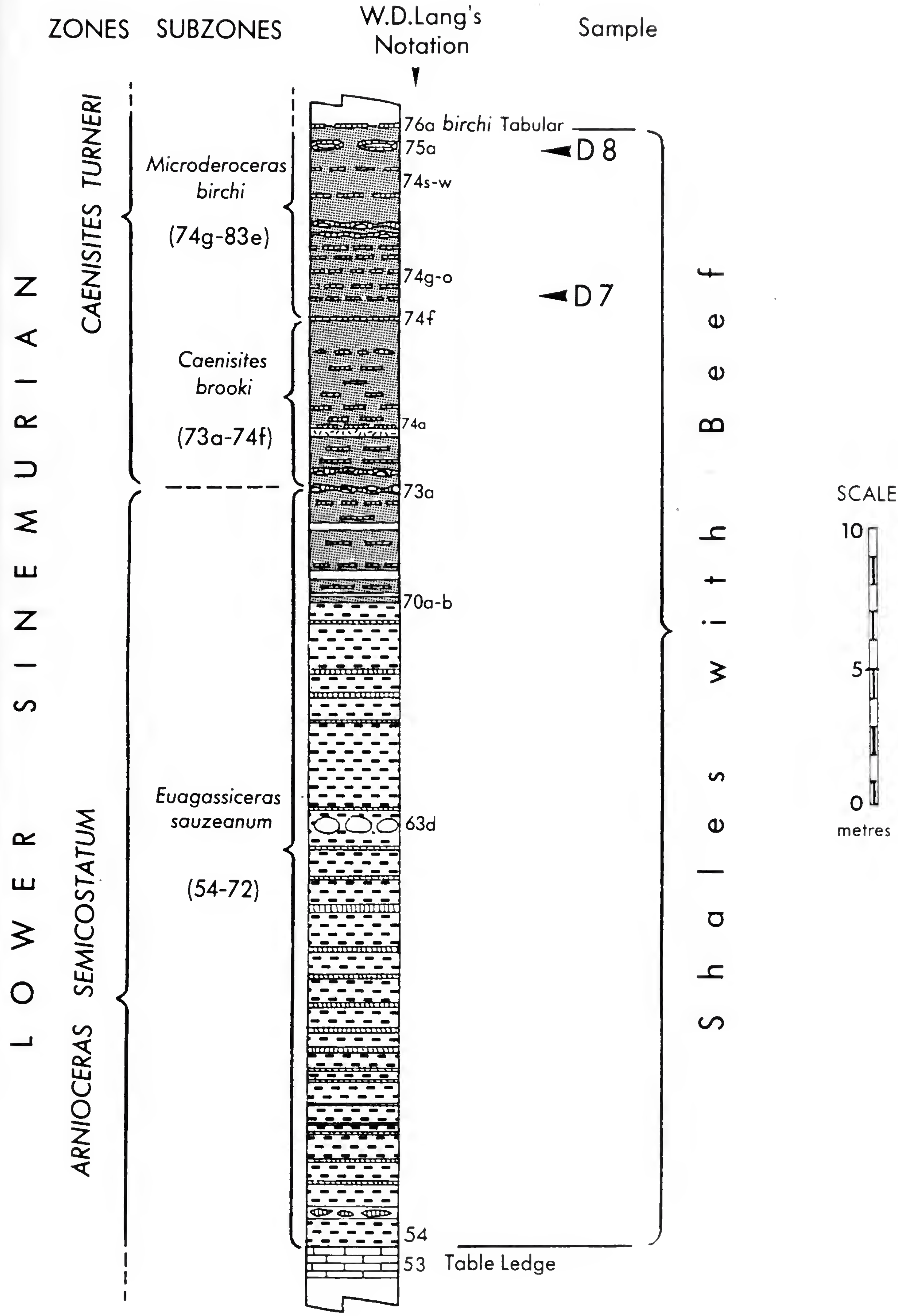
Sample D6 (Blue Lias, Lang Bed 50; semicostatum Zone, scipionanum Subzone) (SY33359150)

Ostracods not found but good foraminifera, calcareous nannofossils and palynomorph assemblages present.

BLACK VEN, WEST OF CHARMOUTH (SY357932)

The top of the Blue Lias is seen east of Lyme Regis and in Black Ven, succeeded by Shales with Beef (21m), Black Ven Marls (43m) and Belemnite Marls (23m). The cliff is very susceptible to land slips and most of these formations are more conveniently examined east of Charmouth. The Shales with Beef were sampled under Black Ven and eastwards near the River Char. The term "Beef" refers to the layers of fibrous calcite formed during diagenesis and recently linked to overpressuring of the formation (Stoneley 1983). This and overlying units have up to 8% total organic carbon (Stoneley and Selley 1986) and are important source rocks. Deposition was under anoxic bottom conditions.

Cliff at east end of Black Ven


ZONES
SUBZONES
W.D.Lang's Notation
Sample
LOWER SINEMURIAN
CAENISITES TURNERI
ARNIOCERAS SEMICOSTATUM
Microderoceras birchi
(74g-83e)
Caenisites brooki
(73a-74f)
Euagassiceras sauzeanum
(54-72)
76a birchi Tabular
75a
74s-w
74g-o
74f
74a
73a
70a-b
63d
54
53 Table Ledge
D8
D7
Shales with Beef
SCALE
10
5
0
metres

C

Cliff at east end of Black Ven

Sample D7 (Shales with Beef, Lang Bed 74g; turneri Zone, basal birchi Subzone)

No Foraminifera or Ostracoda recovered - anoxic bottom conditions. Palynomorphs similar to D1 but still with relatively low level of marine components.

Cliff west of Heritage Coast Centre, below birchi Nodular Bed

Sample D8 (Shales with Beef, Lang Bed 74w; turneri Zone, mid birchi Subzone)

No Foraminifera, Ostracoda or Calcareous Nannofossils recovered. The absence of benthic organisms may be due to anoxic bottom conditions but the absence of calcareous plankton indicates decalcification.

STONEBARROW TO RIDGE WATERFALL, EAST OF CHARMOUTH (SY370929 - SY390924)

Successively dipping down to beach level, the Black Ven Marls (Upper Sinemurian), Belemnite Marls and Green Ammonite Beds (Lower Pliensbachian) can be conveniently examined along the shore.

Sample D9a (Black Ven Marls, Lang Bed 79; turneri Zone, high in the birchi Subzone).

Monoceratina fusiformis (Drexler), Paratrachycythere pseudotubulosa Park MS, Patellacythere gruendeli Herrig, ?Progonoidea reticulata (Klingler and Neuweiler), Gen et sp.1

Comments
P.gruendeli (bucklandi Zone - turneri Zone) and P.pseudotubulosa (turneri Zone - obtusum Zone) confirm the turneri Zone age of this sample. An impoverished foraminiferal assemblage dominated by Ammodiscus siliceus (Terquem), an agglutinated species, is indicative of probable dysaerobic bottom conditions (Copestake 1987, p. 18).

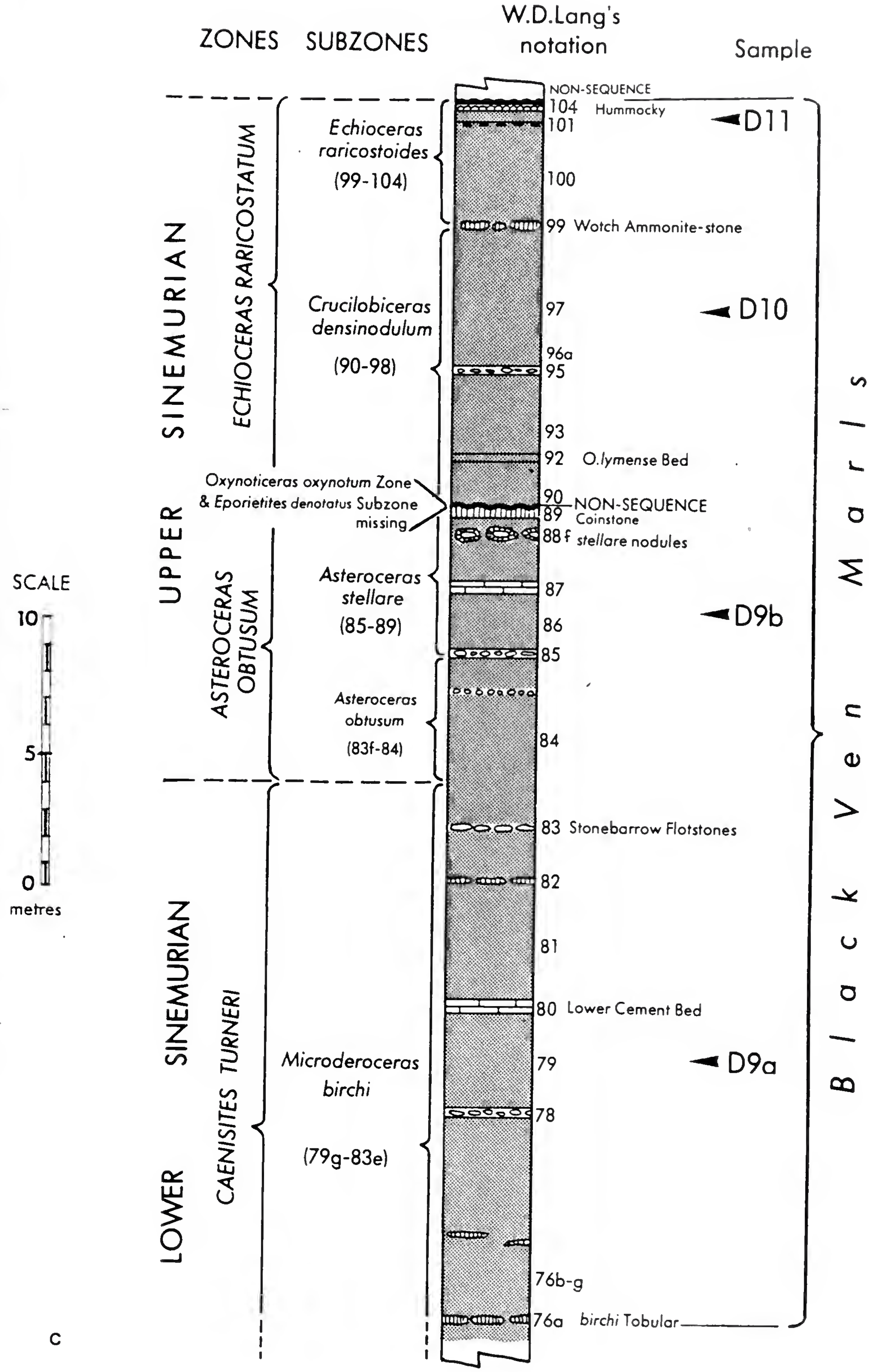
Sample D9b (Black Ven Marls, Lang Bed 86?; obtusum Zone, stellare subzone)

Ektyphocythere ?intermedia (Gramann).

Comments
Foraminifera and Ostracoda poor - marine, ?nearshore.

Sample D10 (Black Ven Marls, Lang Bed 97; raricostatum Zone, high in the densinodulum Subzone).

Macrocypris sp.1, Ogmoconchella cf. O.adenticulata (Pietrzenuk), O.bispinosa (Gründel), Paracypris sp.2, Polycope cerasia Blake, P.cincinnata Apostolescu, P.plumhoffi Bate and Coleman, P. sp. 4044 Michelsen, Spinocypris sp..


ZONES
SUBZONES
W.D.Lang's notation
Sample
SCALE
10
5
0
metres
UPPER SINEMURIAN
LOWER SINEMURIAN
ECHIOCERAS RARICOSTATUM
ASTEROCERAS OBTUSUM
CAENISITES TURNERI
Echioceras raricostoides (99-104)
Crucilobiceras densinodulum (90-98)
Oxynoticeras oxynotum Zone & Eporietites denotatus Subzone missing
Asteroceras stellare (85-89)
Asteroceras obtusum (83f-84)
Microderoceras birchi (79g-83e)
NON-SEQUENCE
104 Hummocky
101
100
99 Watch Ammonite-stone
97
96a
95
93
92 O.lymense Bed
90 NON-SEQUENCE
89 Coinstone
88 f stellare nodules
87
86
85
84
83 Stonebarrow Flatstones
82
81
80 Lower Cement Bed
79
78
76b-g
76a birchi Tabular
D11
D10
D9b
D9a
Black Ven Marls

c

Comments
Spinocypris sp. is only recorded in Dorset from the raricostatum Zone. The species O. cf. O.adenticulata is similar to "O.mouhersensis" of authors - Grundel 1970, Michelsen 1975 (part), Sivhed 1980 (part) and Park 1985. However, it has a distinct fingerprint ornament and lacks the well-defined vertical rib of the type description (Apostolescu 1959). Herrig (1969, p.1074) records O.adenticulata from the bucklandi Zone.

Sample D11 (Black Ven Marls, Lang Bed 102; raricostatum Zone, raricostoides Subzone).

Bardia? molesta Apostolescu, Cardobairdia sp., Gramannicythere cf. G.coniuncta Herrig, Gen. et sp.2, Isobythocypris elongata Blake, I. sp.2, Kinkelinella variabilis (Klingler and Neuweiler), Monoceratina amlingstadtensis Triebel and Bartenstein, Ogmoconchella cf. O.adenticulata (Pietrzenuk), O.bispinosa (Gründel), O.danica Michelsen, Paracypris sp.2, Patellacythere gruendeli Herrig, Polycope cerasia Blake, P.cincinnata Apostolescu, P.decorata Apostolescu, Spinocypris sp..

Comments
Age determination, as for D10. This is the oldest range recorded for M.amlingstadtensis, and the youngest range recorded for P.gruendeli (in Dorset).

The Belemnite Marls (Lower Pliensbachian) can be sampled east of Westhay Water (SY 38609250).

Sample D12 (Belemnite Marls, Lang Bed 110a - 2.5m below top; jamesoni Zone, polymorphus Subzone).

Acrocythere herrigi Park MS., Gramannicythere bachi bachi Herrig, Ogmoconchella sp.1, Ostracod no.19 Klingler (1962, pl.13, fig.22), Paradoxostoma pusillum Michelsen, Pleurifera vermiculata (Apostolescu).

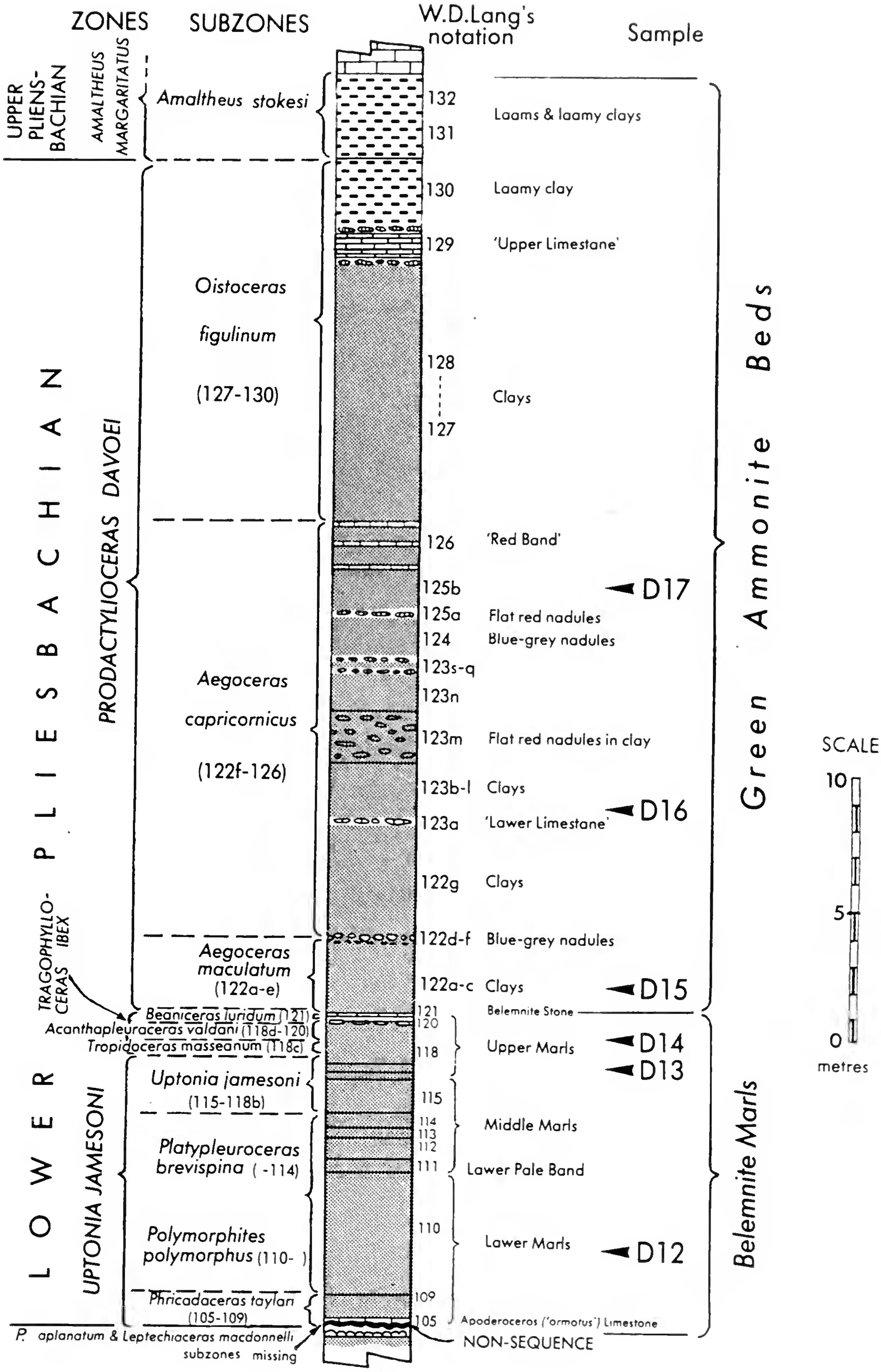
Comments
The presence of P.vermiculata indicates a jamesoni - lowest ibex Zone age (Park, 1985). Ostracod No.19 Klingler is identical to topotype material of Ostracode E Apostolescu (1959). Park (1985) recorded this species as Kinkelinella (Ektyphocythere) foveolata Michelsen. It is obviously ancestral to Gammacythere ubiquita Malz and Lord.

Sample D13 (Belemnite Marls, Lang Bed 118a - 3.6m below Belemnite Stone; jamesoni Zone, jamesoni Subzone).

Acrocythere herrigi Park MS., Gramannicythere bachi bachi Herrig, Monoceratina amlingstadtensis Triebel and Bartenstein, M.seebergensis Triebel and Bartenstein, Ogmoconchella bispinosa (Gründel), Ostracod no.19 Klingler, Paracypris sp.1, Paradoxostoma pusillum Michelsen, Polycope cerasia Blake, P.cincinnata Apostolescu, P.plumhoffi Bate and Coleman, P. sp..

Sample D14 (Belemnite Marls, Lang Bed 119 - 1.5m below Belemnite Stone; ibex Zone, valdani Subzone).

Acrocythere herrigi Park MS., Ektyphocythere foveolata Michelsen,


ZONES
SUBZONES
W.D.Lang's notation
Sample
UPPER PLIENS-BACHIAN
AMALTHEUS MARGARITATUS
Amaltheus stokesi
132
131
Loams & loamy clays
130
Loamy clay
129
'Upper Limestone'
Oistoceras figulinum (127-130)
128
127
Clays
LOWER PLIESBACHIAN
PRODACTYLIOCERAS DAVOEI
126
'Red Band'
125b
D17
125a
Flat red nodules
124
Blue-grey nodules
123s-q
123n
Aegoceras capricornicus (122f-126)
123m
Flat red nodules in clay
123b-l
Clays
123a
'Lower Limestone'
D16
122g
Clays
TRAGOPHYLLOCERAS IBEX
Aegoceras maculatum (122a-e)
122d-f
Blue-grey nodules
122a-c
Clays
D15
Green Ammonite Beds
Beaniceras luridum (121)
121
Belemnite Stone
Acanthopleuraceras valdani (118d-120)
120
Tropidoceras masseanum (118c)
118
Upper Marls
D14
D13
UPTONIA JAMESONI
Uptonia jamesoni (115-118b)
115
Platypleuroceras brevispina (-114)
114
113
112
Middle Marls
111
Lower Pale Band
Polymorphites polymorphus (110-)
110
Lower Marls
D12
Belemnite Marls
Phricadaceras taylori (105-109)
109
105
Apoderoceros ('armatus') Limestone
P. aplanatum & Leptechioceras macdonnelli subzones missing
NON-SEQUENCE
SCALE
10
5
0
metres

Gramannicythere bachi bachi Herrig, Liasina lanceolata (Apostolescu), Monoceratina amlingstadtensis Triebel and Bartenstein, M.frentzeni Triebel and Bartenstein, M.multistriata Triebel and Bartenstein, Ogmoconchella bispinosa (Gründel), Ogmoconchella sp., Pleurifera vermiculata Apostolescu, Polycope cincinnata Apostolescu, P.plumhoffi Bate and Coleman, P. sp..

Comments
The foraminiferal assemblage contains Marginulina prima spinata (Terquem) which is indicative of well-oxygenated shelf conditions in the Pliensbachian (Copestake 1987, p.24).

GOLDEN CAP, WEST OF SEATOWN (SY 406920)

The base of the Green Ammonite Beds (32m) can be seen at the foot of the cliff on both east and west sides of Golden Cap, although a minor syncline beneath the hill depresses the junction with the Belemnite Marls (marked by the Belemnite Stone) below beach level. Higher in the cliff Upper Pliensbachian Eype Clay and Down Cliff Sands crop out but are more readily examined in Down Cliff to the east. Golden Cap is the highest cliff on the Dorset coast and derives its name from the yellow Albian sands at its summit.

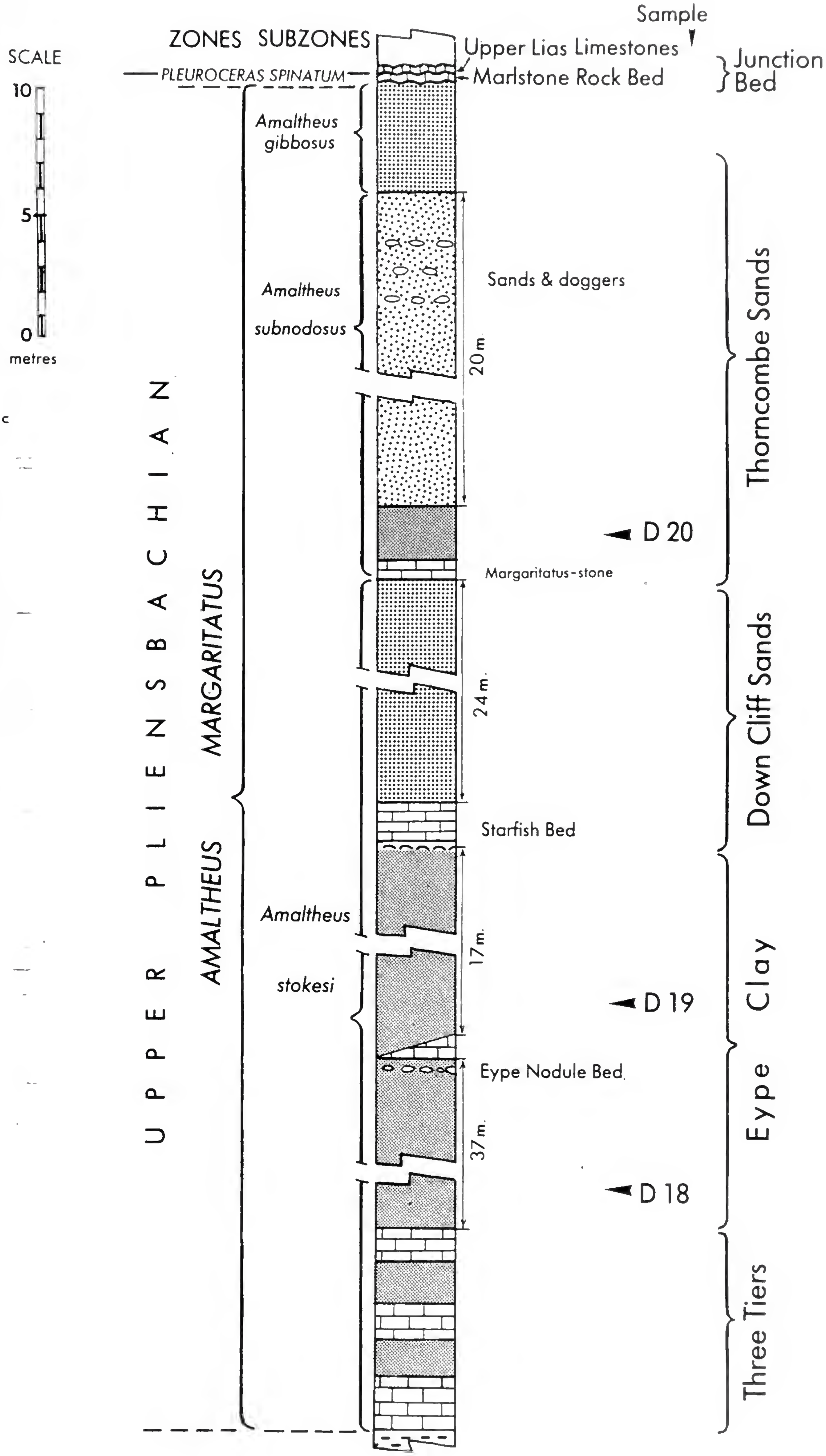
The Green Ammonite Beds, which take their name from green calcite occasionally found infilling ammonites, are dominantly argillaceous with minor limestones. Benthic assemblages may be poor due to bottom water anoxia. The lower Green Ammonite Beds were sampled east of Golden Cap and higher levels below the hill.

Sample D15 (Green Ammonite Beds, Lang Bed 122b; davoei Zone, maculatum Subzone). (SY 41309190).

Cardobardia sp., Gammacythere ubiquita Malz and Lord, Isobythocypris sp.2, Monoceratina sp.4135 Michelsen, Ogmoconchella cf. O.aequalis (Herrig), O.amalthei Form A Michelsen, Ogmoconchella sp., Polycope cerasia Blake, P.cincinnata Apostolescu, P.decorata Apostolescu, P.discus Fischer, P.plumhoffi Bate and Coleman.

Comments
G.ubiquita indicates an upper ibex Zone - davoei Zone age.

Sample D16 (Green Ammonite Beds, Lang Bed 123c; davoei Zone, capricornus Subzone). (SY 40409190).


Sample
ZONES SUBZONES
SCALE
10
5
0
metres
PLEUROCERAS SPINATUM
Upper Lias Limestones
Marlstone Rock Bed
Junction Bed
Amaltheus gibbosus
Amaltheus subnodosus
Sands & doggers
20 m
Thorncombe Sands
D 20
Margaritatus-stone
UPPER PLIENSBACHIAN
MARGARITATUS
AMALTHEUS
24 m.
Down Cliff Sands
Starfish Bed
Amaltheus stokesi
17 m.
Clay
D 19
Eype Nodule Bed
Eype
37 m.
D 18
Three Tiers

Sample D16 (Green Ammonite Beds, Lang Bed 123c; davoei Zone, capricornus Subzone). (SY 40409190).

Gammacythere ubiquita Malz and Lord.

Sample D17 (Green Ammonite Beds, Lang Bed 125b; davoei Zone, capricornus Subzone). (SY 40259200)

Monoceratina amlingstadtensis Triebel and Bartenstein, Ogmoconchella sp.1, Polycope cincinnata Apostolescu, P.plumhoffi Bate and Coleman, P. sp.

The junction of the Lower and Upper Pliensbachian falls in the uppermost part of the Green Ammonite Beds and does not coincide with the base of the overlying Eype Clay, taken at the top of three prominent limestones called the Three Tiers (= base Middle Lias of British usage). The basal Eype Clay was sampled on the east flank of Golden Cap.

Sample D18 (Eype Clay, 1.5m above Upper Tier; margaritatus Zone, stokesi Subzone). (SY 40659190)

Gramannella apostolescui Lord, Ogmoconcha transversa (Grundel), Ogmoconchella bispinosa (Gründel), ?Paracypris redcarensis Blake, Wicherella semiora semiora Lord.

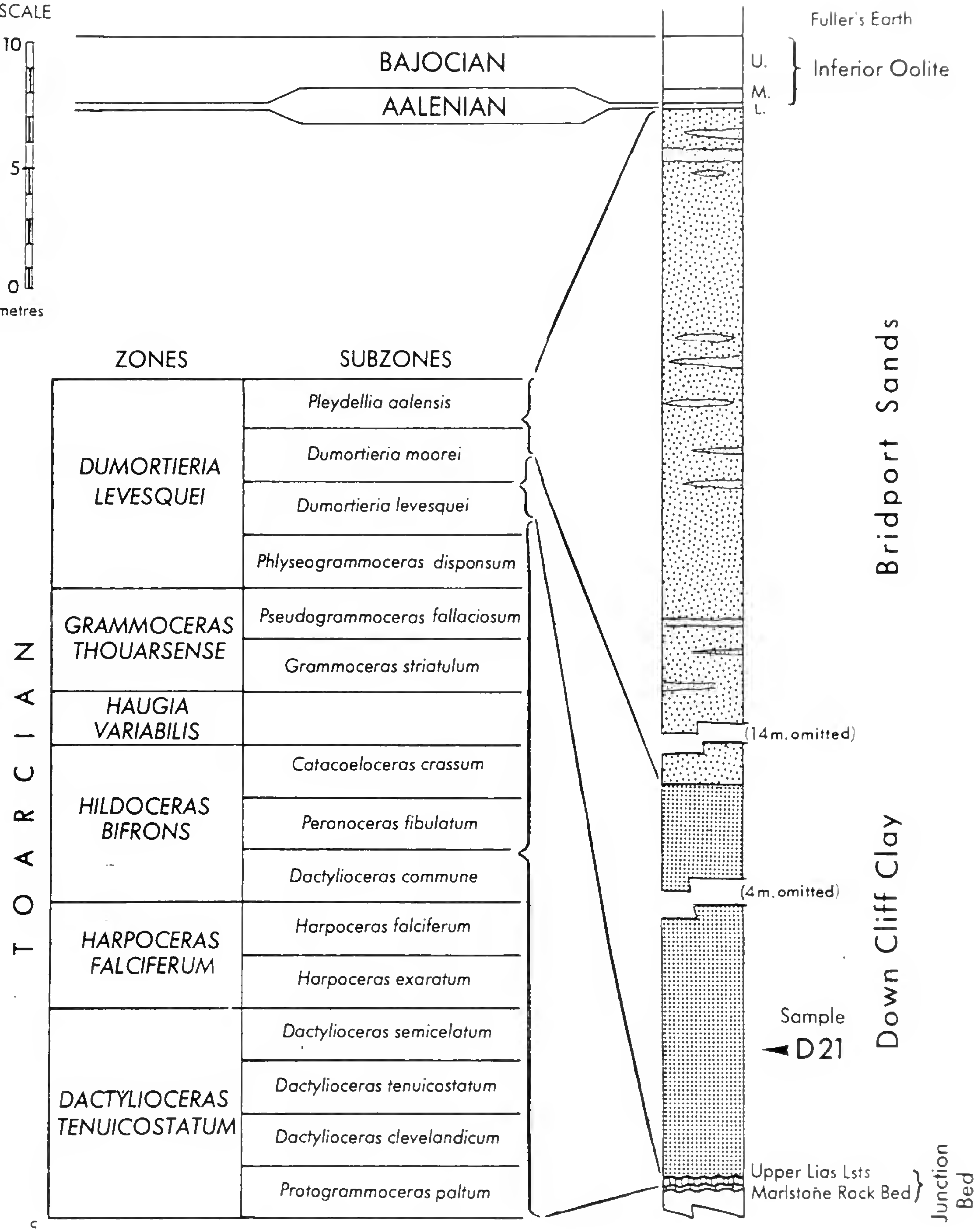
Comments
G.apostolescui and W.semiora semiora indicate a stokesi Subzone to lowest subnodus Subzone age in Dorset (Lord, 1972).

DOWN CLIFF AND THORNCOMBE BEACON, EAST OF SEATOWN (SY 420917-SY 437914)

The Eype Clay (60m) is a calcareous clay containing a prominent nodule band, the Eype Nodule Bed, at approximately 40m above the base. A fault brings the Eype Nodule Bed to beach level immediately east of Seatown where it forms a good marker horizon.

Sample D19 (Eype Clay, 1.7m above Eype Nodule Bed; margaritatus Zone, stokesi Subzone).

Cytherella sp., Gen. et sp.4, Gramannella apostolescui Lord, Liasina lanceolata (Apostolescu), Monoceratina michelseni Riegraf, Ogmoconcha transversa (Gründel), Ogmoconchella bispinosa (Gründel), Ogmoconchella cf. O.greundeli Malz, Polycope cerasia Blake, Wicherella semiora semiora Lord.



SCALE
10
5
0
metres
BAJOCIAN
AALENIAN
Fuller's Earth
U.
M.
L.
Inferior Oolite
ZONES
SUBZONES
DUMORTIERIA LEVESQUEI
Pleydellia aalensis
Dumortieria moorei
Dumortieria levesquei
Phlyseogrammoceras disponsum
GRAMMOCERAS THOUARSENSE
Pseudogrammoceras fallaciosum
Grammoceras striatulum
HAUGIA VARIABILIS
HILDOCERAS BIFRONS
Catacoeloceras crassum
Peronoceras fibulatum
Dactylioceras commune
HARPOCERAS FALCIFERUM
Harpoceras falciferum
Harpoceras exaratum
DACTYLIOCERAS TENUICOSTATUM
Dactylioceras semicelatum
Dactylioceras tenuicostatum
Dactylioceras clevelandicum
Protogrammoceras paltum
TOARCIAN
Bridport Sands
(14m. omitted)
(4m. omitted)
Down Cliff Clay
Sample
D21
Upper Lias Lsts
Marlstone Rock Bed
Junction Bed

Comments
Type locality for Gramannella and Wicherella.

The top of the Eype Clay is marked by the Starfish Bed, which is succeeded by the Down Cliff Sands (27m), all of which belong to the stokesi Subzone. The Margaritatus Stone and Clay (3m) and Thorncombe Sands (23m) belong to the subnodus Subzone. The Margaritatus Clay was sampled on the west side of Thorncombe Beacon.

Sample D20 (Margaritatus Clay; margaritatus Zone, subnodus Subzone).

Acrocythere herrigi Park MS., Bairdia ?molesta Apostolescu, Ektyphocythere quadrata Boomer and Lord, Gramannella apostolescui Lord, Monoceratina amlingstadtensis Triebel and Bartenstein, Nanacythere simplex Herrig, Ogmoconcha contractula Triebel, Ogmoconchella aequalis (Herrig), O.bispinosa (Gründel), O.greundeli (Malz), O. cf. O.greundeli Malz, Paracypris sp.1, Polycope cerasia Blake, ?Pseudohealdia truncata Malz, Trachycythere tubulosa seratina Triebel and Klingler.

Comments
Palynomorph assemblage indicates nearshore situation adjacent to a region of high freshwater input (Riding 1987, p.30).

The uppermost part of the Pliensbachian (spinatum Zone) is represented by a condensed limestone sequence, the Marlstone Rock Bed. The Marlstone Rock Bed (0-0.6m) is itself the lower part of a more substantial condensed limestone unit called the Junction Bed (0.5-2.6m, not including the Marlstone) which represents most of Toarcian time (tenuicostatum to basal levesquei Zones). Thin argillaceous bands have been recorded from the Junction Bed but it is dominantly a carbonate with numerous remanie ammonites and erosion surfaces. The Down Cliff Clay (21m) rests on the Junction Bed and is a silty clay representing parts of the levesquei and moorei Subzones, levesquei Zone. This unit can be sampled by the intrepid on Thorncombe Beacon.

Sample D21 (Down Cliff Clay, 5m above base; levesquei Zone, levesquei Subzone).

Acrocythere herrigi Park MS., Acrocythere sp., Bairdiacypris sp., Bardia ohmerti Knitter, Cytherella toarcensis Bizon, Cytherelloidea cadomensis Bizon, Cytheropteron alafastigatum Fischer, Gen et sp.4, 5, and 6, Kinkelinella semoisensis (Apostolescu), Kinkelinella sp., Cardobairdia sp., Lophodentina cultrata Apostolescu et al., Macrocypris sp.2 and 3, Monoceratina scrobiculata Triebel and Bartenstein, Otocythere callosa Triebel and Klingler, Paracypris sp.3, Praeschuleridea sp..

Comments
Typical Toarcian assemblage with elements in common with the Paris Basin. Metacopine ostracods now extinct. Palynomorphs indicate an open marine environment.

The uppermost unit of the Lower Jurassic, the Bridport Sands (20-30m) is of levesquei Zone age although the uppermost 2m have been placed in the basal Aalenian opalinum Zone. The Bridport Sands are lithologically distinctive with alternations of hard (calcareous) and soft (less calcareous or decalcified) sands. Individual bands are recognisable for up to 4km in the Bridport area but not in the Wytch Farm Oilfield in east Dorset where the Bridport Sands form a reservoir level (J.Storey, pers comm.). No samples were taken, although impoverished calcareous nannofossil assemblages have been recovered from the soft sands.

THE MIDDLE JURASSIC - BRIDPORT TO WEYMOUTH

The Middle Jurassic is the least well exposed part of the Dorset coast section. The lithologies concerned and the geomorphology of the area combine so that the imposing sea cliffs exposing the Lower Jurassic fade away near Burton Bradstock. The coast is shielded from the sea by the impressive depositional feature of the Chesil Beach. In addition, the Aalenian and Bajocian are represented by a thin, condensed limestone sequence, approximately 5m thick at Burton Bradstock where it can be seen capping the cliffs of Bridport Sands. The insignificance of the Aalenian in this classic section does much to explain the reluctance of British workers in the past to adopt the stage. The divisions within this condensed sequence are impersistent even over short distances but are highly fossiliferous and clearly deposited in very shallow waters. Most of the classic inland sections have now vanished. The Upper Bathonian is accessible at two sites but the Lower and Middle Bathonian clays are not exposed. The Callovian part of the Oxford Clay (Lower and Middle Oxford Clay) was exposed in brick pits near Weymouth but Putton Lane has been infilled and Crook Hill is at present not open to visitors. Thus, no samples were collected from Aalenian, Bajocian or Callovian deposits.

WATTON CLIFF, BRIDPORT (SY 45609065)

A fault block exposes Bathonian sediments, preserved within the area of the Lower Jurassic. An imposing cliff is formed of Upper Fuller's Earth and the Boueti Bed.

Sample D22 (Upper Fuller's Earth, "basal marl" of Wilson et al. (1958, p.103), 5m above sea wall; aspidoides Zone).

Cytherella fullonica Jones and Sherborn, Cytherelloidea catenulata (Jones and Sherborn), Fossaterquemula blakeana (Jones), Lophocythere ostreata (Jones and Sherborn), L.propinqua Malz, Micropneumatocythere brendae Sheppard, Monoceratina herburyensis Sylvester-Bradley, M.striata Triebel and Bartenstein, M.vulsa (Jones and Sherborn), Oligocythereis fullonica (Jones and Sherborn), Paracypris cf. P.terraefullonica (Jones and Sherborn), Praeschuleridea quadrata Bate, Progonocythere stilla Sylvester-Bradley, Terquemula bradiana (Jones).

Comments
Typical marine Upper Bathonian assemblage for Dorset, as in nearby Winterborne Kingston and Seabarn Farm boreholes (Sheppard 1981). Diverse and well-preserved palynomorph assemblage with good dinoflagellate cyst element indicative of fully marine conditions.

Sample D23 (Upper Fuller's Earth Clay, top of "blue-grey marl" (Wilson et al.); aspidoides Zone).

As D22

Sample D24 (Upper Fuller's Earth Clay, "blue shaley marl" (Wilson et al.); aspidoides Zone.

As D22

THE FLEET - LANGTON HIVE POINT AND HERBURY

Small outcrops occur on the landward side of The Fleet, near Langton Herring. At Langton Hive Point (SY 60608140) a small cliff exposes 3.6m of oyster beds overlying clay of the Upper Fuller's Earth Clay. Sample taken in clay at base of cliff.

Sample D25 (Upper Fuller's Earth clay; aspidoides Zone?).

Sparse assemblage of Micropneumatocythere.

To the south-east, Herbury peninsula projects into The Fleet and a low cliff exposes the Boueti Bed with Upper Fuller's Earth clays below and Lower Forest Marble, of which the Boueti Bed is the basal member, above. This is the classic ostracod site of Sylvester-Bradley (1948).

Sample D26 (Upper Fuller's Earth clay, 1.8m below Boueti Bed; aspidoides Zone).

Cytherelloidea catenulata (Jones and Sherborn), Fossaterquemula blakeana (Jones), Lophcythere ostreata (Jones and Sherborn), L.propinqua Malz, Marslatourella bullata Bate, Micropneumatocythere brendae Sheppard, Monoceratina herburyensis Sylvester-Bradley, M.strata Triebel and Bartenstein, M.visceralis (Jones and Sherborn), M.vulsa (Jones and Sherborn), Oligocythereis fullonica (Jones and Sherborn), Paracypris assymetrica Sheppard MS., Parariscus bathonicus Oertli, Polycope sp., Progonocythere stilla Sylvester-Bradley, Terquemula bradiana Jones.

Comments
Closely comparable to Upper Fuller's Earth Clay assemblages seen at Watton Cliff, Bridport.

Sample D27 (Lower Forest Marble, 0.4m above Boueti Bed; aspidoides Zone).

Bairdia hilda Jones, Cytherella fullonica Jones and Sherborn, Cytherelloidea catenulata (Jones and Sherborn), C.jugosa (Jones), C.longicosta Sheppard MS., Fastigatocythere juglandica (Jones), Fossaterquemula blakeana (Jones), Glyptocythere guembeliana (Jones), Looneyella subtilis Oertli, Lophocythere ostreata (Jones and Sherborn), L.propinqua Malz, Marslatourella bullata Bate, Micropneumatocythere brendae Sheppard, Monoceratina herburyensis Sylvester-Bradley, M.striata Triebel and Bartenstein, M.visceralis (Jones and Sherborn), M.vulsa (Jones and Sherborn), Oligocythereis fullonica (Jones and Sherborn), Paracypris assymetrica Sheppard MS., Parariscus bathonicus Oertli, Polycope sp., Progonocythere stilla Sylvester-Bradley, Terquemula bradiana (Jones), Schuleridea (Eoschulerida) trigonalis (Jones).

Comments
Some new elements in an assemblage which is generally similar to that of Upper Fuller's Earth Clay but more diverse. Herbury is a classic ostracod locality from the work of Sylvester-Bradley (1948) in which ostracods were described from the Boueti Bed itself. Type locality for important genera Lophocythere and Progonocythere.

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FIELD EXCURSION TO THE UPPER JURASSIC OF THE DORSET COAST

Robin Whatley

INTRODUCTION.

Upper Jurassic strata, from Callovian to Tithonian in age, are exposed in classic sections in the northern limb of the Weymouth Anticline, in a series of coastal exposures and quarries. The northern limb of this anticline is very steeply dipping and in places overturned. A complex of faults and secondary folds causes the beds to be frequently repeated. Kimmeridgian, Portlandian and Purbeckian rocks are also preserved on the Isle of Portland, the sole relict of the gently southward dipping southern limb of the Weymouth Anticline. Cretaceous strata are also exposed in the northern limb but, apart from a consideration of that part of the Purbeckian facies which belongs to the Neocomian, these strata will not be considered in detail on this excursion since they will be seen again in the Isle of Wight.

Sections both east and west of Weymouth have attracted the interest of geologists and palaeontologists since early in the nineteenth century. The Dorset Coast was one of the classic areas in which pioneer studies on the application of ammonoids to biostratigraphy was carried out. The standard ammonite zonation has evolved through a considerable history into the sophisticated classification of today. The subject is elegantly treated in Cope et al. (1980a,b).

THE GEOLOGICAL HISTORY OF THE DORSET COAST IN THE UPPER JURASSIC.

The Callovian to Kimmeridgian interval was, in this area, one of exclusively marine deposition. It was, however, a time of some instability which saw alternations of deeper and shallower water environments of deposition. This was mainly a large scale phenomenon but at times a smaller scale cyclicity was imposed on the larger scale rhythms.

The lowest part of the Callovian, the Upper Cornbrash, is represented by the deposition of rather nearshore limestones while the succeeding Kellaways Clay is a deeper water, more open marine deposit. The overlying Kellaways Rock, an essentially arenaceous unit, is a shallow water high energy deposit while, in contrast, both the Callovian and Oxfordian parts of the overlying Oxford Clay were deposited in offshore, fairly deep and low energy environments.

Although when seen in the field it would seem to indicate the contrary, the overlying Corallian facies of the Upper Oxfordian contains a dominance of argillaceous units. These, however, are much less well exposed than the more salient calcareous and arenaceous members. Overall, the Corallian represents a return to shallow, more marginal marine conditions. It is also the product of a much less stable depositional regime than that obtaining during Oxford Clay times. Arkell (1936, 1947) demonstrated that the Corallian of the Dorset Coast consists of cyclically repetitive deposits of clay, sandstone and limestone (in that order), with minor cycles superimposed on the larger ones. This can be seen by referring to Fig. 2, and in the classic coastal sections east of Weymouth. Despite the rythmic nature of its deposition, no non-marine levels have been recognised in the Dorset Corallian. However, Whatley (1965, MS.) has shown that certain parts of the succession were deposited in rather restricted, probably reduced salinity environments (e.g. the upper part of the Nothe Clay).

The deepest water environments of the Upper Jurassic in this area were in the Kimmeridgian which was deposited in offshore muddy environments.

The last stage of the Jurassic, the Tithonian is very much a regressive phase in this region. Its two divisions, the Portlandian and the overlying Purbeckian (Lulworth Beds) comprise shallow marine sandstones and limestones and a variety of non-marine deposits respectively. Convential wisdom has it that the brief brackish/marine incursion which deposited the Cinder Bed in the midst of non-marine Purbeckian sediments, marks the base of the Cretaceous in southern England.

THE OSTRACODA.

The principal studies on the Ostracoda of the Dorset Upper Jurassic have been made since the 2nd World War. The Callovian and Oxfordian faunas were studied by Whatley (1964, 1965, MS., 1970) and Fuller (1983, MS.). Kilenyi (1969, 1978) studied the Kimmeridgian, and the Tithonian and Neocomian have been extensively studied by Anderson (1939, 1966, 1971, 1973, 1985), Clements (1969, 1973 and in Cope et al. 1980) and Sylvester-Bradley (1949).

Globally, the Upper Jurassic witnessed major changes in the structure and composition of the ostracod faunas and most of these changes are enshrined in the rocks of the Dorset Coast. The faunas also declined in diversity from a Bathonian high and only in the early Neocomian did diversity exceed that of the Bathonian. In this respect the ostracod faunas of the south coast of England exactly mirror the global changes taking place at this time (Whatley and Stephens, 1976, Whatley 1986, In Press 1,2,3.).

While Bathonian faunas were dominated by entomodont-hinged progonocytherids and while this group largely maintained their importance during the Callovian, they began to decline in the Lower Oxfordian and soon after the beginning of the Upper Oxfordian, they became reduced to two genera (Neurocythere and Progonocythere), the latter becomes extinct during the early part of the Corallian, and before the end of this unit they are reduced to a single species. This species, Neurocythere multicostata (Oertli), lingers on into the Kimmeridgian but its demise sees the last of the true entomodont hinge, a most successful evolutionary experiment as attested by the large number of Jurassic ostracods which it articulated. These were the first cytheraceans which, because of their thick-shelled and ornate carapaces articulated by a complex hinge, were able to expand their ecological range into shallow water high energy environments.

Even before the entomodont hinge had become extinct, a new hinge type had evolved. (There does not seem to be a causal relationship between these two phenomena). This new hinge type, the amphidont, borne by so many subsequent ornate cytherids, first appeared in the Corallian. It did so in its most primitive form (the paramphidont hinge) in Macrodentina Malz and Amphicythere Oertli. However, it was not until the Lower Cretaceous that the amphidont hinge became the dominant type of articulation of ornate cytherids.

Upper Jurassic ostracod faunas differ from those of the Middle Jurassic essentially in the decline of the true Progonocytheridae (those with entomodont hingement), the Pleurocytherinae and certain conspicuous genera such as Praeschuleridea and in the rise to prominence of such genera as Macrodentina and Galliaecytheridea Oertli, from the Corallian onwards. Other important additions to the fauna are Paranotacythere and Pseudocythere, for example, while the cytherurids, marine cyprids and platycopids remain largely unchanged in their relative importance.

While in many respects Callovian faunas have more in common with those of the Middle Jurassic than with Upper Oxfordian and subsequent faunas, Upper Jurassic marine faunas, apart from such genera as Paranotacythere, bear very little resemblance to those of the Lower Cretaceous.

Participants are advised to carefully examine the fine fractions of their samples. These can yield numerous small well-preserved cytherurid and bythocytherid (particularly Pseudocythere) species which have been overlooked by many workers. This is particularly true for the Callovian-Oxfordian.

TAXONOMIC NOTE.

The present author considers Terquemula Blaszyk and Malz to be quite distinct from Neurocythere Whatley 1970, he also subsumes Nophrecythere Grundel within Neurocythere. (See Ware and Whatley 1981, pp. 205, 206).

CALLOVIAN.

Although very poor exposures of the uppermost part of the Callovian and the lowermost Oxfordian can still be seen at Tidmoor Point, on the Fleet shore some 1 1/2 miles south of Chickerell Church, west of Weymouth, the principal exposures in the area which were sampled by Whatley in the early 1960's are no longer available. The brick pit at Putton Lane has now been infilled and that at Crook Hill is not open to visitors at present. At the latter locality excellent exposures of the Oxford Clay facies of the Callovian (jason-lamberti zones) is

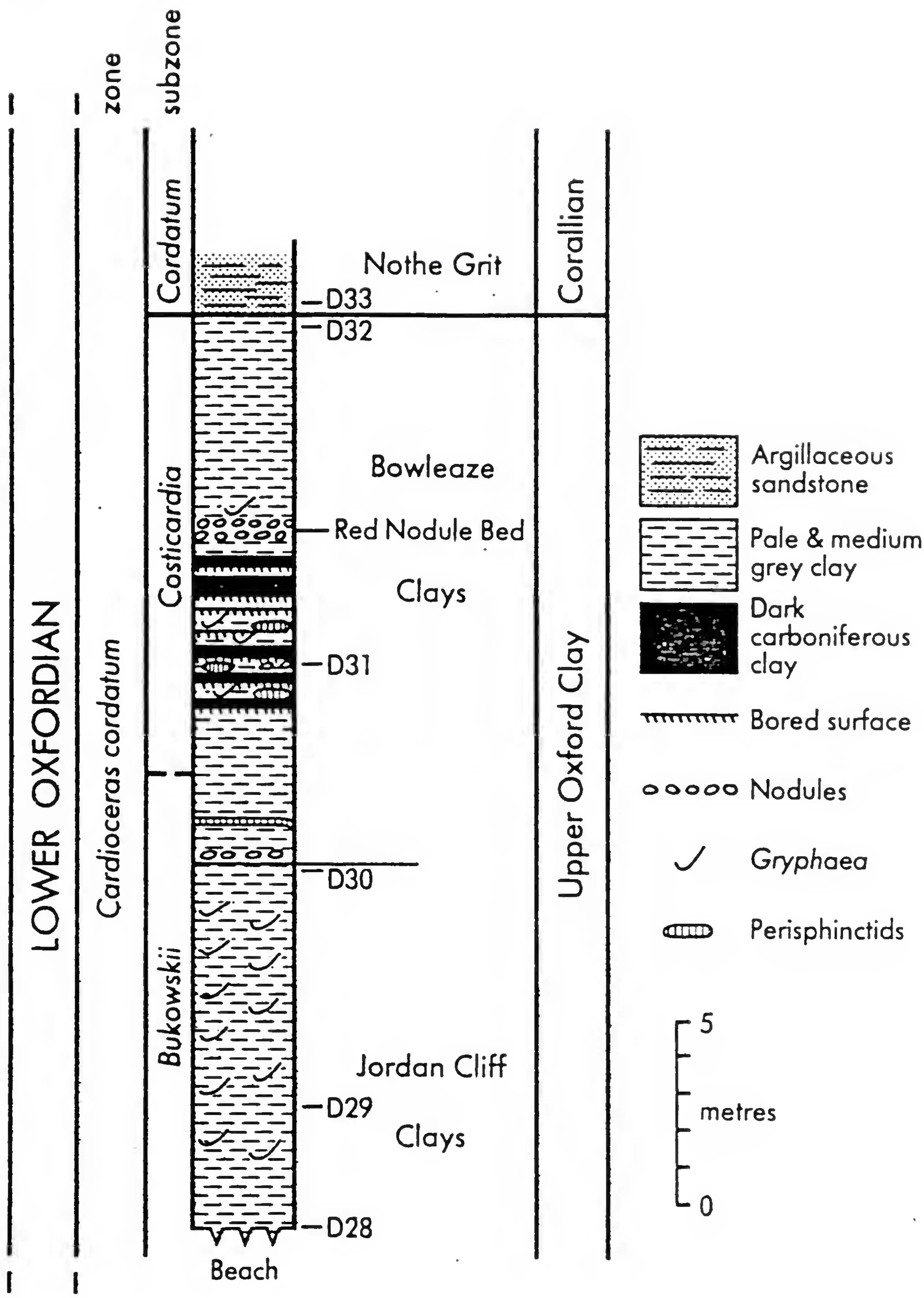

Fig. 1. Upper Oxford Clay (Lower Oxfordian) of Furzy Cliff. (After Wright 1986).

exposed.

Whatley (1965, MS.) recorded 33 species from the Callovian of the area immediately west of Weymouth from all the ammonite zones except the jason. These species are listed in order of their first appearence in the succession and the ammonite zonal range (within the Callovian) is given for each species:

Caytonidea terraefullonicae (Jones & Sherborn)	macrocephalus	
Praeschuleridea batei Whatley	macrocephalus	- lamberti
Monoceratina vulsa (Jones & Sherborn)	"	- "
Glabellacythere dolabra Wienholz	"	- "
Eucytherura (V.) costaeirregularis Whatley	"	- "
Procytheropteron sp. B.	"	- athleta
Parariscus sp.	"	
Neurocythere bradiana (Jones)	"	
Neurocythere cruciata plena (Triebel)	"	
Palaeocytheridea parabakirovi Malz	"	
Paracypris sp. cf. P. bajociana Bate	koenigi	
Fastigatocythere juglandica s.l. (Jones)	"	
Lophocythere scabra scabra Triebel	"	
Glabellacythere reticulata Whatley	"	- lamberti
Fuhrbergiella (P.) horrida horrida Brand & Malz	"	
Lophocythere interrupta interrupta Triebel	coronatum	- lamberti
Polycope sububiquita Whatley	athleta	- lamberti
Gen. indet gublerae (Bizon)	"	
Monoceratina scrobiculata Triebel & Bartenstein	"	- "
Angliacytheridea sp. 'm'.	"	
A. sp. 'f'.	"	
Procytheropteron sp. A.	"	
Lophocythere scabra bucki Lutze	"	- "
Neurocythere caesa caesa (Triebel)	"	- "
N. cruciata intermedia (Lutze)	"	- "
N. flexicosta lutzei Whatley	"	- "
N. flexicosta subsp. 'a'	"	- "
Polycope cerasia Tate & Blake		"
Paracypris sp. A.		"
?Monoceratina sp.		"
Eucytherura (V.) horrida Whatley		"
Neurocythere dorni Lutze		"

OXFORDIAN.

Rocks of the Oxfordian stage are well exposed in the northern limb of the Weymouth Anticline, particularly east of the town. They comprise a little over 100m in thickness in this area and consist of the Upper Oxford Clay (40m) below and the Corallian (65m) above.

The Upper Oxford Clay is well exposed at Furzy Cliff in Bowleaze Cove, immediately to the east of Weymouth (SY 701819). Here it comprises the Jordan Cliff Clays below and the Red Nodule Beds above (Fig. 1). Both divisions are essentially argillaceous and were deposited in an open marine environment of no great depth.

Whatley (1965, MS.) recovered 25 species from the 18 samples he studied through the succession. In most samples, the fauna is of rather low incidence. Whatley's species list, in order of first appearence in the succession is given below:

Monoceratina vulsa (Jones & Sherborn)
Eucytherura (V.) costaeirregularis Whatley
Glabellacythere dolabra Wienholz
Polycope sububiquita Whatley
Monoceratina scrobiculata Triebel & Bartenstein
Lophocythere scabra bucki Lutze
Neurocythere cruciata intermedia (Lutze)
Neurocythere cruciata oxfordiana (Lutze)

Paracypris sp.
Procytherura tenuicostata Whatley
Procytheropteron sp.
Pseudoperissocytheridea parahieroglyphica Whatley
Parcypris acris Oertli
Pseudocythere sp.
Neurocythere caesa s.l. (Triebel)
Cytherella index Oertli
Macrocypris aequabilis Oertli
Schuleridea triebeli oblonga Donze
Nodopthalmocythere martini (Bizon)
Mandelstamia angulata Kilenyi
Progonocythere multipunctata Whatley
Schulerideinid indet. gen. sp. 1.
Pseudohutsonia sp.
Vernoniella caletorum Oertli
Galliaecytheridea postrotunda s.l. "pr" Oertli

From the 5 samples (D 28-D 32) shown in Fig. 1, Fuller (In Lord and Brown, 1987) encountered the following species:

D 28 Eucytherura (V.) costaeirregularis, ?Pseudocythere sp., Pseudoperissocytheridea parahieroglyphica.

D 29 Pseudocythere sp., ?Pseudocythere sp., P. parahieroglyphica.

D 30 Neurocythere multicostata (Oertli)

D 32 Eucytherura (V.) costaeirregularis, Procytherura sp., Pseudocythere sp., ?Pseudocythere sp.

CORALLIAN.

While the Upper Oxford Clay was deposited under an open sea regime, the Corallian is the product of less stable more marginal marine and usually shallower water conditions. Energy levels fluctuated from very low during the deposition of the Nothe Clay to much higher during times when the oolites and particularly the pisolite were forming.

Whatley (1965, MS.) recorded 67 species from the 57 samples he studied throughout the succession east of Weymouth. Fig. 2 is a composite succession for the area and the ostracods recorded from each of the major divisions by Whatley and by Fuller (In Lord and Brown, 1987) are given below. Whatley's records are given in order of first appearence in the division:

NOTHE GRIT.

Whatley (1965, MS.) from 3 samples of the more argillaceous levels in this unit of muddy, impure sandstones and indurated argiiaceous clays with numerous concretions:

Procytheropteron sp.
Schulerideinid indet. gen. sp. 1.
Neurocythere cruciata oxfordiana (Lutze)

Fuller records from samples D 33,34 (Fig. 2):

D 33 Macrodentina (M.) tenuistriata Malz
D 34 Barren

NOTHE CLAY.

Most of this unit is argillaceous with some impure limestones and shell beds. Gryphaea dilatata is common. Whatley, from 13 samples in which he records a major diversity drop towards the top of the unit, recorded the following 35 species:

Procytheropteron sp.
Neurocythere cruciata oxfordiana
Macrocypris sp.
Paracypris sp.
Apatocythere sp.
Acrocythere sp.

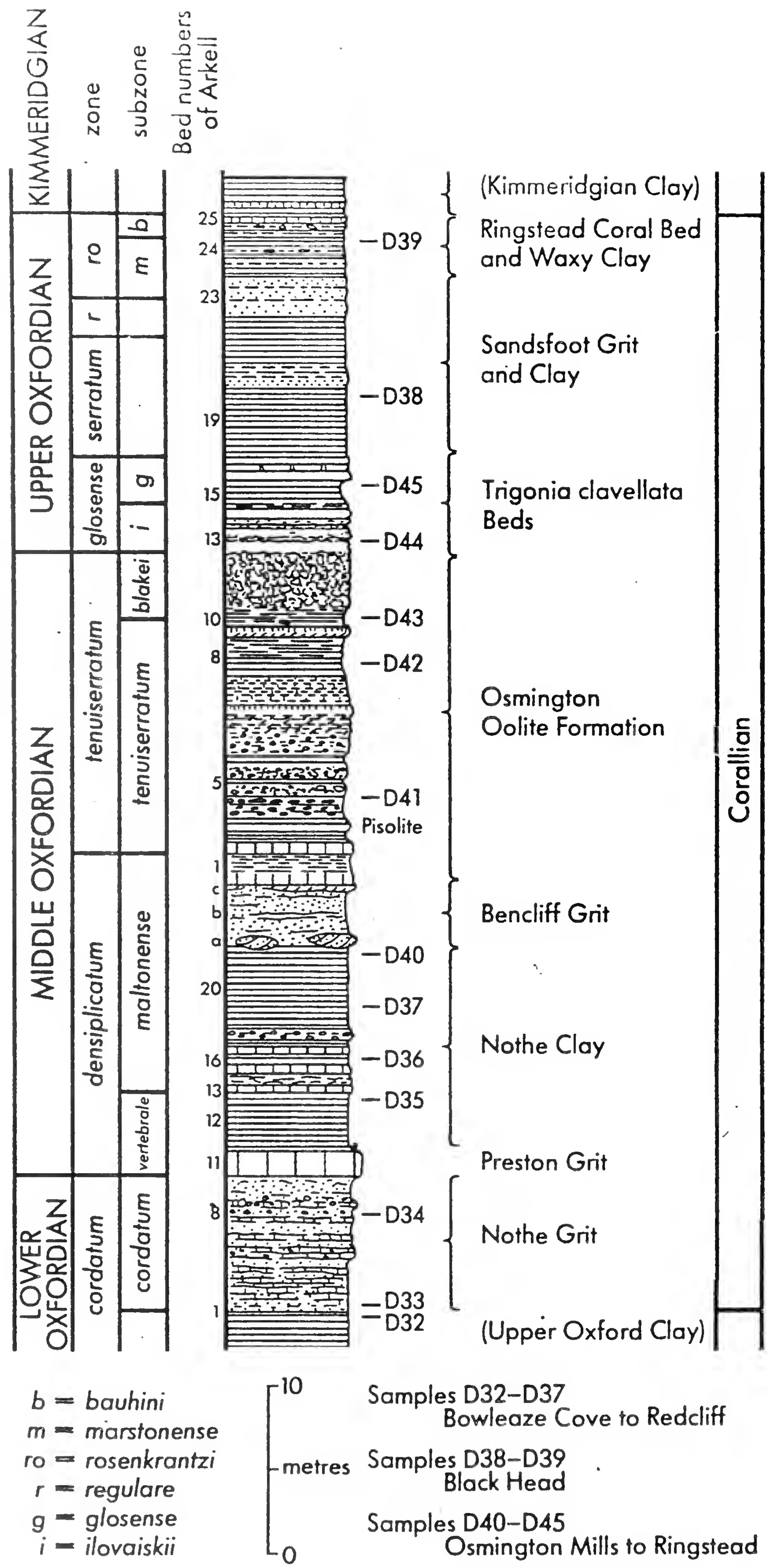

Fig. 2. Corallian (Oxfordian) lithostratigraphy between Furzy Cliff and Ringstead Bay. (Redrawn from Arkell 1947).

Protocythere sp.
Eucytherura (V.) sp.
Schuleridea triebeli oblonga
Monoceratina scrobiculata
Procytherura tenuicostata
Eucytherura (V.) sp. "m".
Neurocythere sp.
Paranotacythere extendata Bassiouni
Progonocythere multipunctata
P. parastilla Whatley
Neurocythere multipunctata
Pseudoperissocytheridea parahieroglyphica
Protocythere sigmoidea s.l. Steghaus

(All the above species were from the basal sample)

Neurocythere sp. "c"
Sculerideinid indet. gen. sp. 2.
Nodopthalmocythere martini
Mandelstamia angulata
Cytherella index
Progonocythere sp.
Neurocythere oertlii (Bizon)
Monoceratina vulsa
Cytheropteron aquitanum
Eucytherura (V.) costaeirregularis
Cytheropteron sp.
Liasina argoviense (Oertli)
Macrodentina (M.) tenuistriata Malz
Galliaecytheridea postrotunda s.l. "pr" Oertli
Acrocythere sp. "k".

Fuller, from samples D 35-D 40 (Fig. 2) recorded the following:
D 35 ?Pseudocythere sp.
D 36 Neurocythere cruciata oxfordiana, Pseudocythere sp., Progonocythere multipunctata, Schuleridea triebeli, Neurocythere multicostata.
D 37 Macrodentina (M.) tenuistriata
D 38 " "

BENCLIFF GRIT.

From this approximately 2m thick unit of false bedded sands with an oil seep bounded above and below by large doggers and containing lenses of sandy clay, 2 samples yielded to Whatley the following 4 species which occurred in low numbers and which were poorly preserved:

Procytheropteron sp.
Schuleridea triebeli oblonga
Macrodentina (M.) tenuistriata
Galliaecytheridea postrotunda s.l. "pr".

OSMINGTON OOLITE FORMATION.

In this area this unit is approximately 28m thick. It is a very variable unit containing arillaceous, calcareous, shelly, nodular beds and even a pisolite. Whatley (1965, MS.) recovered 19 species from 14 samples. In many of the samples both incidence and diversity were rather low. The species are listed in ascending order of first appearence in the unit:

Procytheropteron sp.
Neurocythere cruciata oxfordiana
Schuleridea triebeli oblonga
Procytherura tenuistriata
Neurocythere multicostata
Mandelstamia angulata
Cytherella index

Liasina argoviensis
Macrodentina (M.) tenuistriata
Galliaecytheridea postrotunda s.l. "pr".
Macrodentina (M.) sp. A.
?Camptocythere sp.
Cytherella weberi Steghaus
Galliaecytheridea postrotunda s.l. "pe".
Vernoniella sequana Oertli
Macrodentina (M.) whatleyi Kilenyi
Galliaecytheridea sp. "n".
Pseudohutsonia sp. "c".
"Bairdia" sp.

Fuller (In Lord and Brown, 1987) recorded the following spp. from the 3 samples shown in this unit in Fig. 2:

D 41 ?Eocytheropteron sp. aff. ?E. purum Schmidt, Hekistocythere sp., Macrodentina (M.) tenuistriata, Protocythere sp., Pseudocytherura spp., Neurocythere multicostata.

D 42 Galliaecytheridea sp., G. postrotunda, Procytheropteron sp., Procytherura teunuistriata.

He also records from other samples from the same bed: Macrodentina (M.) tenuistriata, M. (M.) whatleyi, Pseudohutsonia tuberosa Wienholz, Pseudocythere spp.

D 43 Galliaecytheridea sp., Macrodentina (M.) tenuistriata, M. (M.) whatleyi, P. tuberosa, Schuleridea sp., Procytherura spp., Pseudocythere spp.

TRIGONIA CLAVELLATA BEDS.

This 10m unit comprises marls, limestones and sandstones, rubbly and oolitic beds and shelly levels. Whatley studied 7 samples which yielded the following 11 species in order of first apperence upwards through the succession:

Procytheropteron sp.
Neurocythere cruciata oxfordiana
Schuleridea tribeli oblonga
Procytherura tenuicostata
Galliaecytheridea postrotunda s.l. "pe".
Vernoniella sequana
Cytherella woltersdorfi Oertli
Vernoniella caletorum
Galliaecytheridea postrotunda s.s.
Protocythere sigmoidea s.s. Steghaus
Galliaecytheridea wolburgi (Steghaus)

Fuller from the two samples shown in Fig. 2, records the following:

D 44 Galliaecytheridea spp., Macrodentina (M.) whatleyi, Mandelstamia rectilinea Malz, Pseudohutsonia tuberosa, Schuleridea triebeli, Vernoniella sequana. He also notes that the following species have been found at this level: Amphicythere pennyi Kilenyi, Cytherelloidea paraweberi Oertli, Galliaecytheridea confundens Kilenyi, G. dissimilis Oertli, Macrodentina (M.) cicatricosa Malz, Neurocythere multicostata.

D45 Galliaecytheridea postrotunda, Protocythere sp., Sculeridea triebeli, Neurocythere multicostata, Vernoniella caletorum, V. sequana. He also notes that the following species can be found at this level:

Galliaecytheridea mandelstami (Lubimova), Macrodentina (Polydentina) proclivis Malz, Neurocythere cruciata oxfordiana, Procytheropteron sp.

SANDSFOOT GRIT AND CLAY.

Whatley studied 8 samples from this 9m unit of blue and brown clays and impersistent sandstone bands. His single sample from the arenaceous Sandsfoot Grit was barren of ostracods. He recorded 13 spp. from the Sandsfoot Clay which are listed below in the order of their first appearence up succession:

Neurocythere cruciata oxfordiana

Vernoniella sequana
Schuleridea triebeli oblonga
Paranotocythere extendata
Mandelstamia angulata
"Bairdia" sp.
Galliaecytheridea wolburgi
?Platylophocythere sp.
Mandelstamia triebeli Kilenyi
Cytheropteron decoratum
Bythocypris sp.
?Liasina sp.
Macrodentina (M.) cicatricosa

From the single sample (D 38) from this unit (Fig. 2), Fuller records the following:

?Galliaecytheridea sp. (probably G. postrotunda), Schuleridea triebeli.

RINGSTEAD WAXY CLAY.

This unit contains per unit volume, more ostracod specimens than than any other Jurassic deposit known to the author. Virtually complete ontogenetic stages are preserved, indicating deposition in very low energy environments. Despite the presence of numerous oysters, the fauna suggests open marine conditions with no diminution of salinty. Whatley studied 5 samples and recorded the following 24 spp. which are listed in the usual order:

Procytherura sp.
Sculeridea triebeli oblonga
Procytherura tenuistriata
Paranotacythere extendata
Mandelstamia angulata
?Camptocythere sp.
Vernoniella sequana
Pseudohutsonia sp.
Galliaecythidea postrotunda
G. wolburgi
Mandelstamia triebeli
Cytheropteron decoratum
Bythocypris sp.
Macrodentina (M.) cicatricosa
Galliaecytheridea gracilis Glashoff
G. sp. "e".
Dicrorygma sp.
Procytheropteron sp. "c.i."
Protocythere rodewaldensis (Klingler)
Amphicythere confundens Oertli
Galliaecytheridea dissimilis Oertli
Cytheropteron bispinosum Schmidt
Procytheropteron sp. "c.c.".
Macrodentina (P.) ornata (Steghaus)

From sample D 39 (Fig. 2), Fuller records the following 2 species:

Galliaecytheridea postrotunda, Schuleridea triebeli.

He also notes that 30 spp. have been recorded from this unit and lists the following as the most important:

Amphicythere pennyi Kilenyi, A. sphaerulata Kilenyi, Cytherella fullonica Jones and Sherborn, Cytherelloidea paraweberi, Dicrorygma (O.) spp., Galliaecytheridea spp., Hekistocythere spp., Mandelstamia rectilinea Malz, Paranotacythere neali Bassiouni, Paranotacythere extendata.

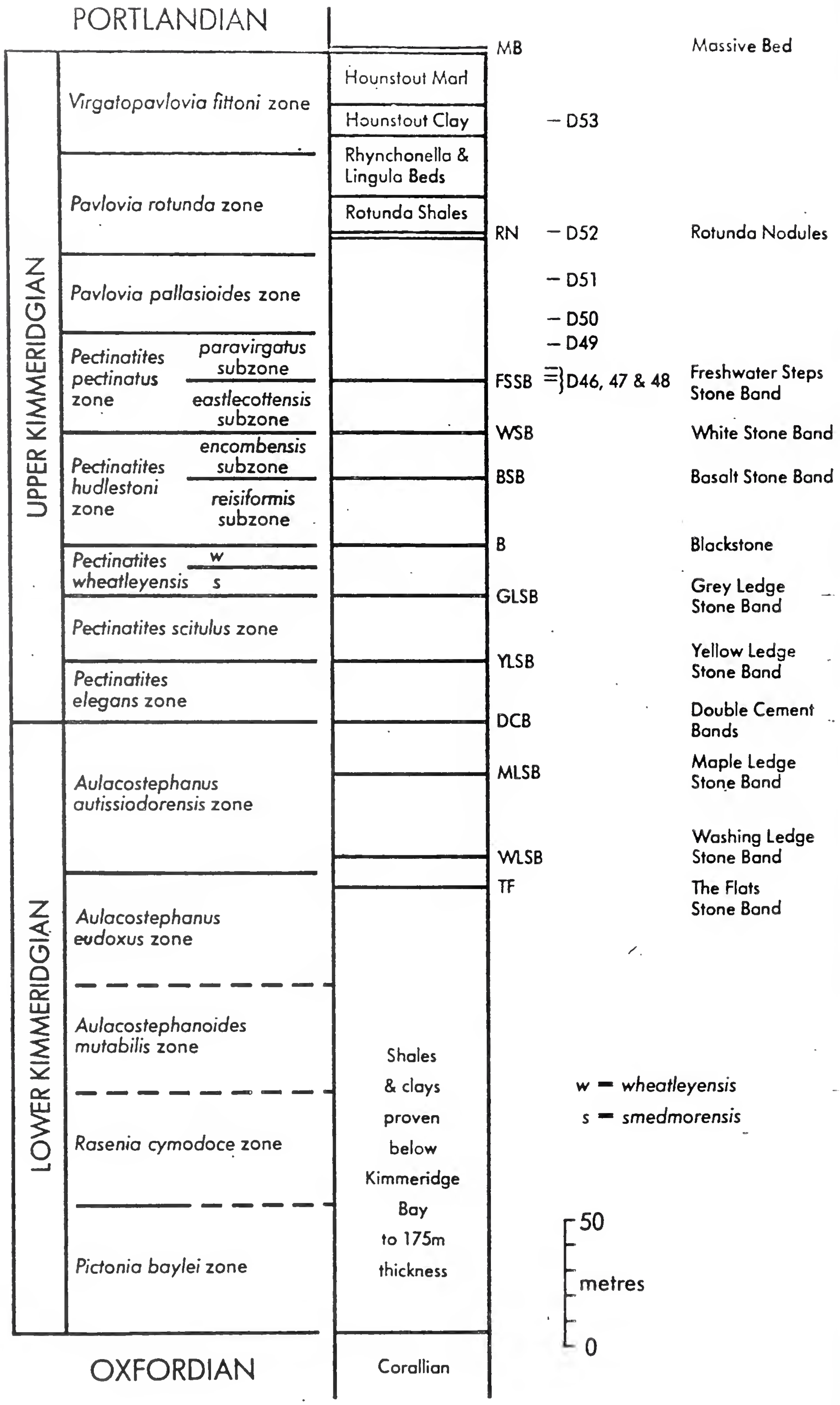

Fig. 3. Lithostratigraphy of the Kimmeridgian in the Kimmeridge area. (After Cope et al. 1980b).

KIMMERIDGIAN.

After the shallow somewhat marginal marine conditions under which the Corallian was deposited, the Kimmeridgian, represented by the Kimmeridge Clay, saw a return to more open sea and deeper water conditions. Although not all of the succession is exposed in the cliffs to the east of Weymouth, from a combination of outcrop and subsurface evidence, it is known that the Kimmeridge Clay attains a thickness of some 500m in this area; thicker than elsewhere in the U.K.

The principal references to the Ostracoda of the Dorset Kimmeridgian are by Kilenyi (1969, 1978) and Christensen & Kilenyi (1970). Fuller (In Lord and Brown, 1978) provides a list of species from samples taken from the late Upper Kimmeridgian.

Kilenyi (1969) recorded 59 spp. from this stage in Dorset; many of the species range up from the underlying Corallian. Fig. 3 gives the type section of the Kimmeridgian in the area of Kimmeridge Bay. Other important exposures of the Lower Kimmeridgian, are preserved by faulting further west.

Kilenyi's species list and their occurrence (in Dorset) by ammonite zone (after Arkell, 1947) is reproduced here:

Cytherella recta Sharapova	Corallian - cymodoce
Cytherelloidea weberi Steghaus	" - mutabilis
C. paraweberi Oertli	mutabilis - Portlandian
Paracypris sp. C. Oertli	baylei
Paracypris sp. 1.	rotunda
?Paracypris problematica Kilenyi	rotunda
Schuleridea triebeli (Steghaus)	Corallian - mutabilis
S. sp. 1.	wheatleyensis
S. sp. 2.	pectinatus
Nodopthalmocythere tripartita Malz	mutabilis
Galliaecytheridea dissimilis Oertli	Corallian - pseudomutabilis
G. wolburgi (Steghaus)	" - mutabilis
G. punctata Kilenyi	" - cymodoce
G. elongata Kilenyi	mutabilis
G. malzi Kilenyi	Corallian - baylei
G. trapezoidalis Kilenyi	mutabilis
G.confundens Kilenyi	Corallian - pseudomutabilis
G. cf. mandelstami (Ljubimova)	mutabilis
G. spinosa Kilenyi	rotunda
G. polita Kilenyi	pallasoides
G. postrotunda Oertli	Corallian - Portlandian
G. fragilis Kilenyi	" - cymodoce
G. sp. 1.	mutabilis
G. sp. 2.	cymodoce
G. sp. 3.	pectinatus - rotunda
Pyrocytheridea sp.	rotunda
Mandelstamia rectilinea Malz	Corallian - pseudomutabilis
M. angulata Kilenyi	" - cymodoce
M. triebeli Kilenyi	mutabilis - pseudomutabilis
M. maculata Kilenyi	grandis
M. sp. 1.	pectinatus
Dicrorygma kimmeridgensis (Kilenyi)	mutabilis
Indet. gen. A sp. 1.	cymodoce
Protocythere sigmoidea Steghaus	rotunda
P. rodewaldensis (Klingler)	baylei
P. neali Kilenyi	rotunda
Cytheropteron aquitanum Donze	wheatleyensis
C. sp.	"
Eocytheropteron decoratum (Schmidt)	Corallian - baylei
Procytheropteron sp. 1.	" - "
Paranotacythere extendata Bassiouni	" - mutabilis
P. pustulata (Kilenyi)	pectinatus - rotunda

P. sp.	rotunda
Monoceratina sp. 1.	"
M. sp. 2.	"
Amphicythere confundens Oertli	Corallian - cymodoce
A. pennyi Kilenyi	pseudomutabilis
A. sphaerulata Kilenyi	cymodoce
Macrodentina (M.) maculata Malz	mutabilis
M. (M.) sp. 1	"
M. (P.) proclivis proclivis Malz	Corallian - pseudomutabilis
M. (P.) proclivis striata Kilenyi	pseudomutabilis
M. (P.) parvapentata Kilenyi	mutabilis
Exopthalmocythere furhbergensis (Steg)	"
Indet. gen. B. sp. 1.	rotunda

Many of these species are illustrated with SEM by Kilenyi (1978). In his 1969 paper, he demonstrated that the fauna is more abundant and diverse in the lower part of the succession.

Fuller (In Lord and Brown, 1987) recorded the following species from the samples shown in Fig. 3:

D 46, 47, 48 Barren.

D 49 Dicrorygma (O.) kimmeridgensis, Galliaecytheridea ? trapezoidalis, Macrodentina (P.) proclivis striata, Monoceratina sp. 1, ?Pseudocythere sp.

D 50 Eocytheropteron decoratum (Schmidt), Paranotacythere sp., Pseudocythere sp.

D 51 Same fauna.

D 52 Galliaecytheridea postrotunda, G. spinosa, G. trapezoidalis, Pseodocythere sp.

D 53 Barren.

PORTLANDIAN.

The arenaceous and calcareous facies of the Portlandian (sensu Arkell, 1947) of Dorset is largely inimical to the preservation or collection of Ostracoda. However, Barker (1966a) from a number of localities in the area recorded a total of 14 marine species. Eleven species were from the Portland Sand below and 7 from the Portland Stone above; six species were common to both units as shown in the following table:

	Portland Stone	Portland Sand
Paracypris sp.	0	
Procytheropteron bicosta Barker	0	
Macrodentina (M.) rugulata (Jones)	0	
M. (M.) transiens (Jones)	0	
M.(M.) retirugata (Jones)	0	
Eocytheridea eusarca (Anderson)	0	0
Protocythere serpentina (Anderson)	0	0
Paranotacythere rimosa (Martin)	0	0
P. levis Barker	0	0
P. elongata Barker		0
Macrodentina (M.) rudis Malz		0
Galliaecytheridea wolburgi (Steghaus)		0
G. postrotunda Oertli		0
Cytherelloidea paraweberi		0

Portlandian faunas are much better preserved in the Aylesbury area, NE of London, where they have been the object of considerable investigation as outlined by Barker (1966b). The classic outcrops in Dorset are in the Isle of Portland (Fig. 4.) and in the northern limb of the Weymouth anticline.

Fuller (In Lord and Brown, 1987) examined the 3 samples (D 54-56) shown in Fig. 5, but all were barren of Ostracoda.

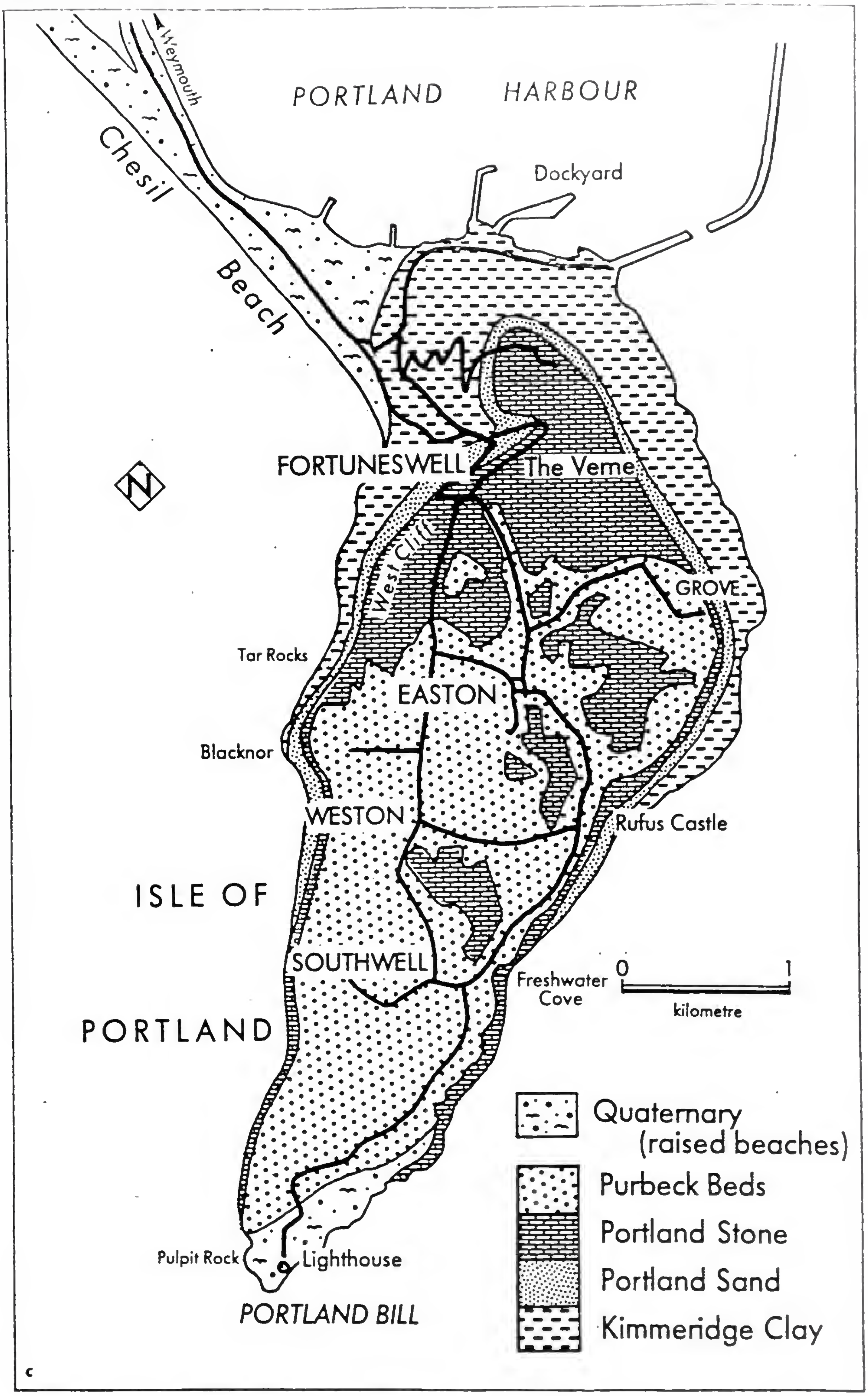

Fig. 4. Geological map of the Isle of Portland. (After Geological Survey).

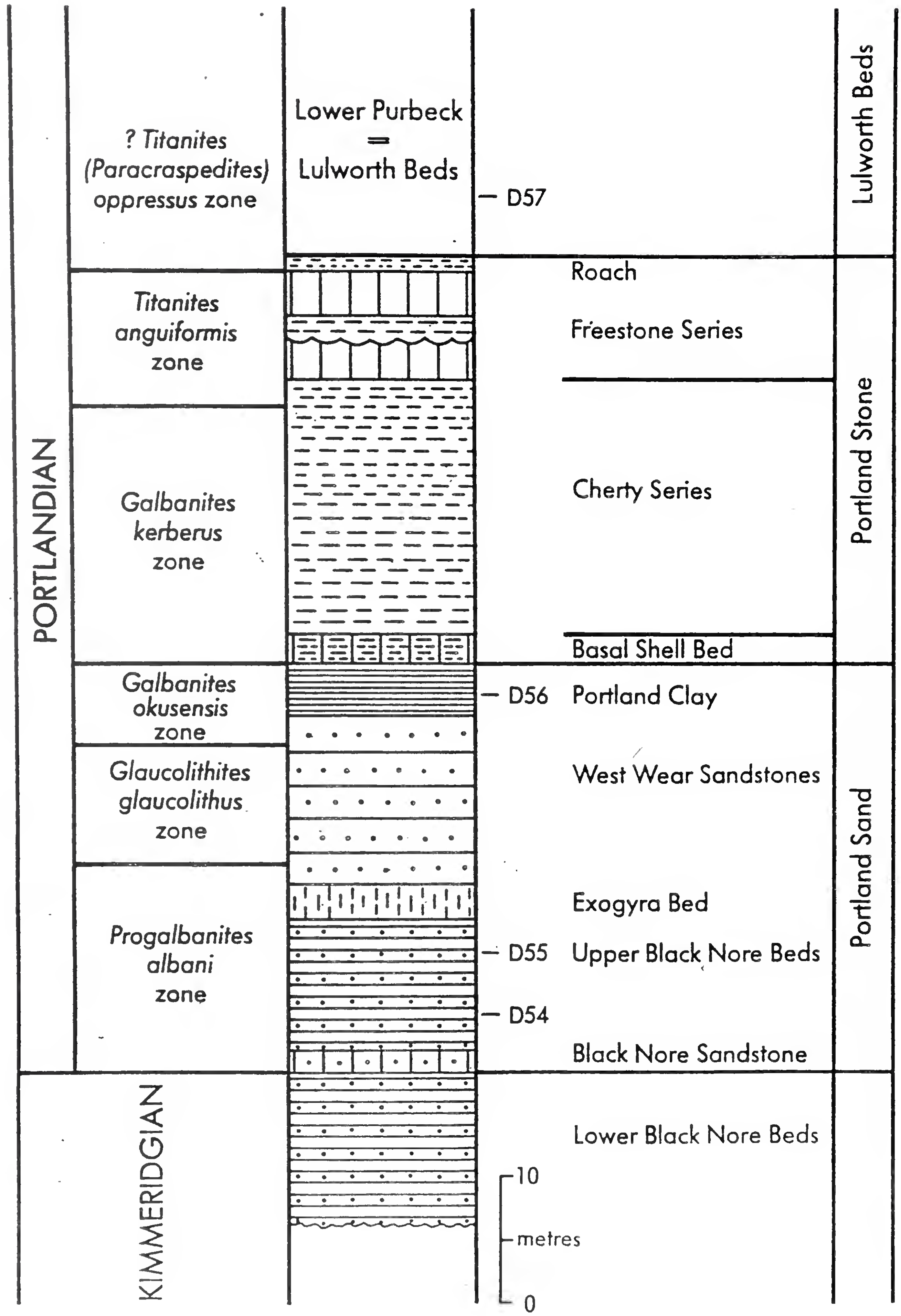

Fig. 5. Lithostratigraphy of the Portlandian of Portland. (After Arkell 1947).

"PURBECKIAN".

The "Purbeckian" rocks of Dorset have attracted the attention of ostracod workers since the time of Fitton (1836) and their earliest biostratigraphical application was by Lyell (1855) who used the faunas described by Fitton and Forbes (1855) in this role. Jones (1878, 1888), Sylvester-Bradley (1949), Barker (1966a, 1975), Clements (1973 MS., 1978 and In Cope et al. 1969) and Anderson in a series of papers between 1932 and 1985 (postmortem), have all contributed to our knowledge of the ostracods of this region. In the latter paper particularly, Anderson demonstrates the importance of Ostracoda to the interpretation of Purbeck/Wealden stratigraphy, events and environments.

Rocks of the Purbeck Group are exposed on the Isle of Portland, in a number of periclinal and downfaulted exposures immediately east of Weymouth, and in the Lulworth area. However, although the lowest beds of the Lower Purbeck are not exposed (they are well exposed at Lulworth Cove), the best section can be seen in Durlston Bay near Swanage where approximately 120m are exposed.

Fig. 6 is based on Clement's section in (fig. A35) Cope et al. 1969. This section shows that the Purbeck Group are of marginal marine and non-marine origin; non-marine deposits being both aqueous and terrestrial. The range of deposits is remarkable and includes evaporites, sabkha-type deposits, soils with roots and boles of large trees, algal and bioclastic (including some which are almost entirely ostracod) limestones, clays and marls. Although ostracods, and both bivalves and gastropods dominate the fauna, the Purbeck is also renowned for its insect and vertebrate faunas.

Anderson (1985) has shown that Purbeck/Wealden ostracod faunas comprise often alternating, more and less salinity tolerant assemblages. This can be seen in the Dorset succession where the Cinder Bed, which represents a marine incursion at the end of the Jurassic, is dominated by the marine genus Galliaecythereidea while other parts of the succession are dominated by the non marine Cypridea (Anderson, 1985).

Sample D 57 (Fig. 6) from the Purbeck of the Isle of Purbeck and samples D 58-66 (Fig. 6) were examined by Clements and his 1987 (In Lord and Brown) analyses are reproduced here:

D 57 Poorly preserved but abundant ostracods. Mostly crushed and/or worn algal coated valves and carapaces. None of the specimens show in themselves sufficient detail (no internal detail seen) to be identified. However, assuming a Lower Purbeck age for the sample, the best preserved specimens are all probably Mantelliana purbeckensis (Forbes) (from shape and size alone). The others are probably mostly the same species, although some (one or two) may be Fabanella sp.

Comments.

M. purbeckensis is a long-ranging species (as is the genus Fabanella), but the assemblage is typical of the Lower Purbeck (sensu anglica) and is thought to have characterised near-marine salinities in enclosed lagoons ("stage 3": of the "closed series" of Clements 1973 MS.).

D 58 Barren.

D 59 Scabriculocypris trapezoides Anderson.

Comments.

S. trapezoides ranges through the Lower Purbeck and into the lower Middle Purbeck and typically occurs in moderate salinity lagoonal associations (typically "stage 2" of the "closed series" of Clements 1973 MS.).

D 60 Very poorly preserved, most of the specimens are individually, specifically and even generically indeterminate.

Mantelliana cf. purbeckensis, Scabriculocypris trapezoides, Cypridea sp. indet., one or two other ostracod spp. indet. and one foram contaminant.

Comments.

A typical Lower Purbeck (sensu anglica) assemblage (although all the forms

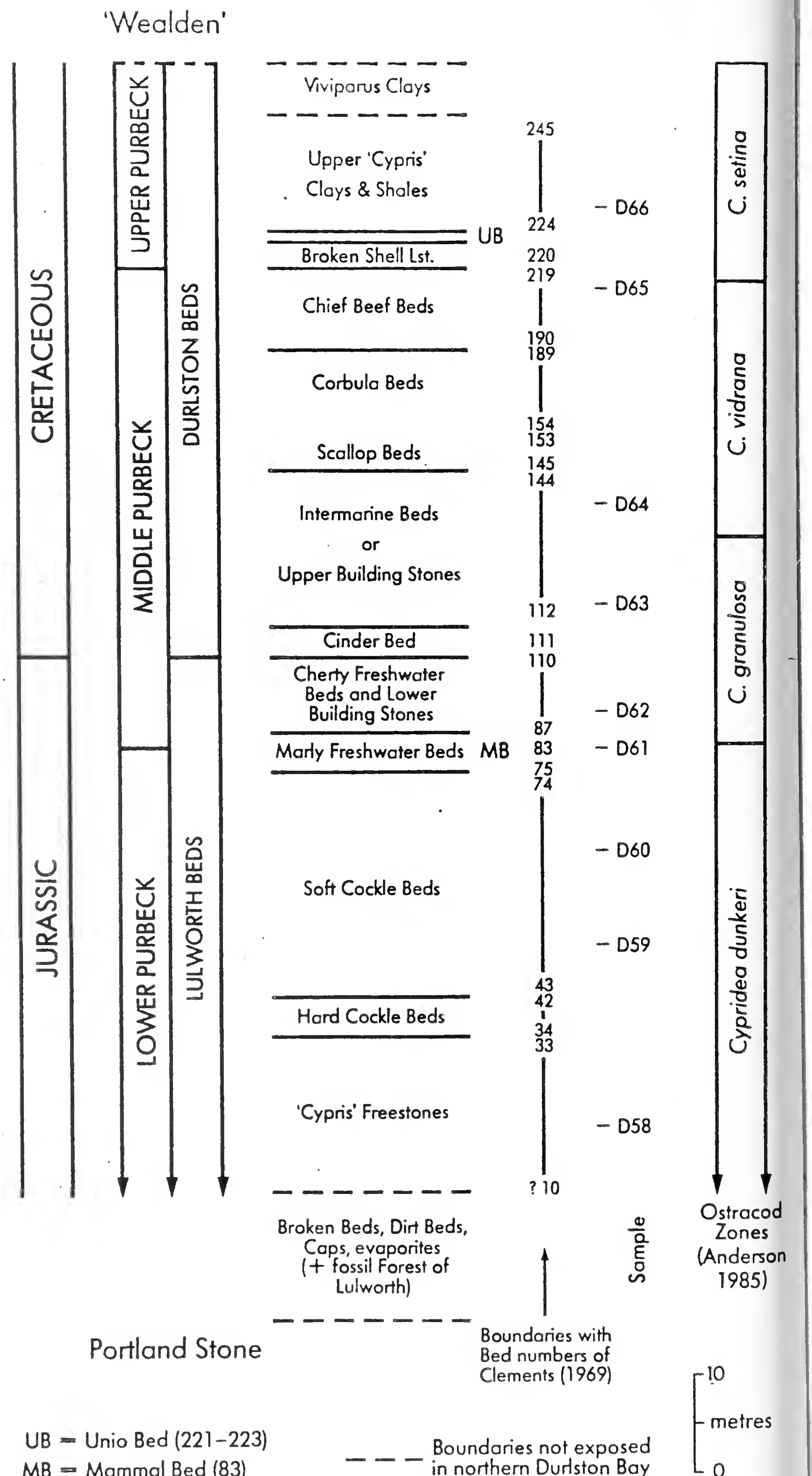

Fig. 6. Outline lithostratigraphy of the Purbeck Group and the Jurassic-Cretaceous boundary sequence in Durlston Bay. (After Clements 1969).

are longer ranging), representing a moderate salinity lagoonal association ("stage 2" of the "closed series", Clements 1973 MS.).

D 61 Scabriculocypris trapezoides.

D 62 Cypridea dunkeri Jones, C. posticalis Jones, C. sp. juv. (?) indet. Darwinula leguminella (Forbes), D. oblonga (Roemer), Mantelliana (?) sp. indet. (contaminant?).

Comments.

G. posticalis is a highly characteristic species with restricted vertical range and a wide geographical distribution. It is associated with the transition from C. granulosa s.s. to C. granulosa fasciculata zones and the beds immediately below where the Jurassic/Cretaceous boundary is currently conventionally drawn in southern England and north-west Germany. C. dunkeri is a Lower Purbeck and lower Middle Purbeck (sensu anglica) species. The assemblage indicates a low salinity/freshwater environment. The presence of Mantelliana suggests the association may belong to Clement's (1973 MS.) "closed series" rather than to his "open series".

D 63 Bisulcocypris striata Martin, Cypridea cf. brevirostrata Martin, C. granulosa fasciculata (Forbes), Darwinula leguminella

Comments.

C. granulosa fasciculata and C. cf. brevirostrata indicate an upper Middle Purbeck (sensu anglica) age, near the top of the C. granulosa fasciculata Zone. In England B. striata is most typical of the Upper and Middle Purbeck Beds. The assemblage suggests low salinity/freshwater, open lagoon/estuarine conditions ("Stage 1" of the "open series" of Clements 1973 MS.).

D 64 Cypridea cf. vidrana Wolburg, Macrodentina (Dictyocythere) mediostricta (Sylvester-Bradley), Paranotacythere nodosaria (Anderson), ostracods indet.

Comments. C. vidrana is typical of, and typically confined to, the eponymous uppermost zone of the Middle Purbeck (sensu anglica). M. (D.) mediostricta and P. nodosaria are strongly euryhaline elements and the assemblage indicates moderate (?mesohaline) salinities in an open lagoon/estuarine setting upper part of "stage 2" of the "open series" of Clements 1973 MS.).

D 65 Bisulcocypris sp. juv. cf. striata, Cypridea cf. penshurstensis Anderson,Darwinula cf.oblonga, D. cf. D. leguminella, ?Rhinocypris jurassica? (Martin).

Comments.

A low salinity/freshwater assemblage (probably "stage 1" of Clements's 1973 MS. "open series"). All are long-ranging forms. C. cf. penshurstensis is consistent with a C. vidruna Zone age but ranges through the whole of the upper Middle and Upper Purbeck Beds.

D 66 Cypridea propunctata (Sylvester-Bradley) (includes some early instars of this (?) sp.), C. setina (Anderson), Rhinocypris jurassica (Martin).

Comments.

Both C. setin and C. propunctata are typical and characteristic of the C. setina Zone (= Upper Purbeck sensu anglica as usually defined). Both species range somewhat beyond the limits of the zone. A low salinity/freshwater assemblage ("stage 1" of Clements's 1973 MS. "open series"). In the Upper Purbeck this is probably the closest approach in the whole formation to true freshwater assemblages.

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QUATERNARY.

A well preserved and well exposed raised beach, the famous Portland Raised Beach occurs at Portland Bill, the southern tip of the Isle of Portland. Robinson (In Lord and Brown, 1987) describes the deposit, its fauna and its history in some detail. Although he states that ostracods have not been found in it, the present author has recovered a few abraded specimens of *Aurila convexa* (Baird) and one of *Pontocythere elongata* (Brady).

RECENT OSTRACODA.

Whittaker studied the Recent Ostracoda of The Fleet and the littoral of Weymouth Bay for his doctoral research (MS. 1972). A synopsis of his study of The Fleet (extracted from Whittaker, 1986) was included in Lord and Brown (1987) and is reproduced here and the distribution of the most important species is shown in Fig. 7.

Living Ostracoda of the Fleet

J.E. Whittaker

A survey of living ostracods was carried out on a seasonal basis between 1967 and 1969 (Whittaker 1972, 1981a), before The Fleet was invaded by Sargassum. Three assemblages of ostracods were recognised, correspoding almost exactly to the divisions of The Fleet suggested on the basis of the salinity regime (Whittaker 1980, 1981b). Unlike a normal estuary, The Fleet is long and narrow, with a relatively small input from rivers, a large volume of "estuarine water" at low tide, and a tidal flow greatly retarded by the small size of the marine inlet. Thus a salinity gradient is well developed from Smallmouth to Abbotsbury, though the degree of dilution and hence steepness of the gradient varies seasonally. In terms of salinity, therefore, The Fleet can be divided into three parts:

1. A marine to near-marine part, extending from Smallmouth to Butterstreet Cove (The effective limit of the tidal flow, only extending further northwest during high tides in summer months and long periods of fine weather.
2. A high salinity brackish part, covering most of West Fleet, with salinity values between 15 and 30^{o}/oo in winter and spring, generally a little higher in the summer.
3. A low salinity brackish part found in Abbotsbury Embayment, with values frequently below 10^{o}/oo rising to 20^{o}/oo or more during periods of low stream discharge.

The chief factor influencing the salinity of The Fleet, as with the water levels, is the tidal effect; this is despite the low tidal range (Robinson 1981) and the restricted marine inlet. This is then modified in the West Fleet by a small amount of percolation through the Chesil Bank and freshwater runoff.

Salinity is not the sole factor governing ostracod distribution, but it does appear to control the distribution of the algae and sea-grasses on which a great many invertebrates, including the ostracods, depend. The shallow waters of The Fleet behave like a gigantic rock pool with, in spring and summer pH values (9), mean dissolved oxygen content (ca 150%) and mean water temperatutre (18^{o}C) all very high compared to the open sea. It is also sheltered under most conditions by the Chesil Beach. The only detrimental ecological parameter for sediment dwelling ostracods is the unsuitability of much of the substrate which, for most of The Fleet above The Narrows is composed of soft, toxic, organic silt. Only on the landward shore and in the vicinity of the Abbotsbury Swannery and Smallmouth are there tracts of suitable, well-oxygenated substrate which can support a benthic ostracod population. Many of these ostracods appear to be tolerant of a wide range of salinities and are governed more by the substrate type (e.g. Leptocythere lacertosa (Hirschmann)), but others (e.g. L. porcellanea (Brady)) are still restricted to lower salinities.

Assemblage 1 - The East Fleet "Restricted Marine" Fauna.

This assemblage is characterised by large numbers of marine phytal species which die out slowly westwards with distance from the sea, lowering salinity and disappearence of most marine seaweeds. No difference in fauna was found between the deeper water channels of Littlesea and The Narrows, characterised by luxuriant algae, and the shallow areas of Littlesea, charcterised by Zostera and Ruppia, although ostracod populations in the former tend to be more plentiful. This assemblage is termed "restricted marine" because there is a lower species diversity in comparision to Weymouth Bay. Nevertheless, the number of individuals in this sheltered environment is very large indeed. In total 20 phytal species were found living on the fronds of the algae and sea grasses and associated epiphytes. Some of the more important ones include Paradoxostoma spp. (e.g. P. fleetensis Horne and Whittaker, Xestoleberis rubens Whittaker and Hirschmannia viridis (Muller). The commonest species of this assemblage is X. rubens, first described by Whittaker in 1978, and a remarkable local phenomenon; it has yet to be found elsewhere in Britain, although it has recently been found in W. and N.W. France. It is totally replaced in Weymouth Bay by another xestoleberid, X. aurantia (Baird). The characteristic ostracod of the lower salinity Assemblage 2, X. nitida (Lilljeborg), is found only on the Zostera/Ruppia beds in Littlesea, coexisting with X. rubens but gradually replacing it northwestwards. In addition 12 benthic species live either in the non-toxic sediment along the landward shore, in the sediment trapped by algal holdfasts, or in the extensive rootmass of Zostera.

Assemblage 2 - The West Fleet Fauna.

This assemblage, found in the area from between Butterstreet Cove to Shipmoor Point, is characterised by a smaller number of species, both phytal and benthic, and by few individuals except in summer months. It is the realm of Zostera and Ruppia with their associate mat of "flannel weed" (trailing masses of filamentous, mainly green algae (Burrows, 1981)). When these sea-grasses die back in the late autumn, very little microfauna can survive except in a few area of stable, oxygenated sediment and green algae, mainly on the landward side. In winter the main population of Xestoleberis nitida appears to migrate into Littlesea. Only 2 indigenous phytal species live in West Fleet; however, in summer months when salinities are higher, a further 4 phytal species migrate into West Fleet, though never in large numbers. A further 5 benthic species make up Assemblage 2.

Assemblage 3 - The Abbotsbury Brackish Fauna.

The Abbotsbury Embayment and adjacent Fleet has the lowest salinities of the lagoon, large expanses of well-oxygenated mud, Phragmates reedbeds and perennial freshwater dilution. It is the most typically estuarine of the Fleet environments. It is therefore not surprising that the ostracod fauna is marked by the appearence, for the first time in large numbers, of the truly brackish estuarine species Cyprideis torosa (Jones) and Leptocythere porcellanea: in all 7 species are found alive.

In such an environment, the puzzling absence of Loxoconcha elliptica Brady, virtually ubiquitous throughout European estuaries (Whittaker, 1981c) is hard to explain. This is particularly so since thousands of its calcareous shells and disarticulated valves have been found in the sediment of the Abbotsbury Embayment and the shore stations of West Fleet. Live specimens have not been found despite a close search for its possible habitat. A clue to its disappearence may lie in a similar more widespread presence of dead shells of C. torosa in comparison to its live distribution. Perhaps at some time in the past The Fleet (at least in West Fleet), presented a much more brackish environment than today. Whether this can be placed as recently as before the building of Portland Harbour and the first Smallmouth bridge (pre-1840/1850) when the tidal inlet there may have been more susceptible to silting, is debatable. Under such conditions, The Fleet could have been cut off for long periods from the sea, becoming brackish and even hypersaline.

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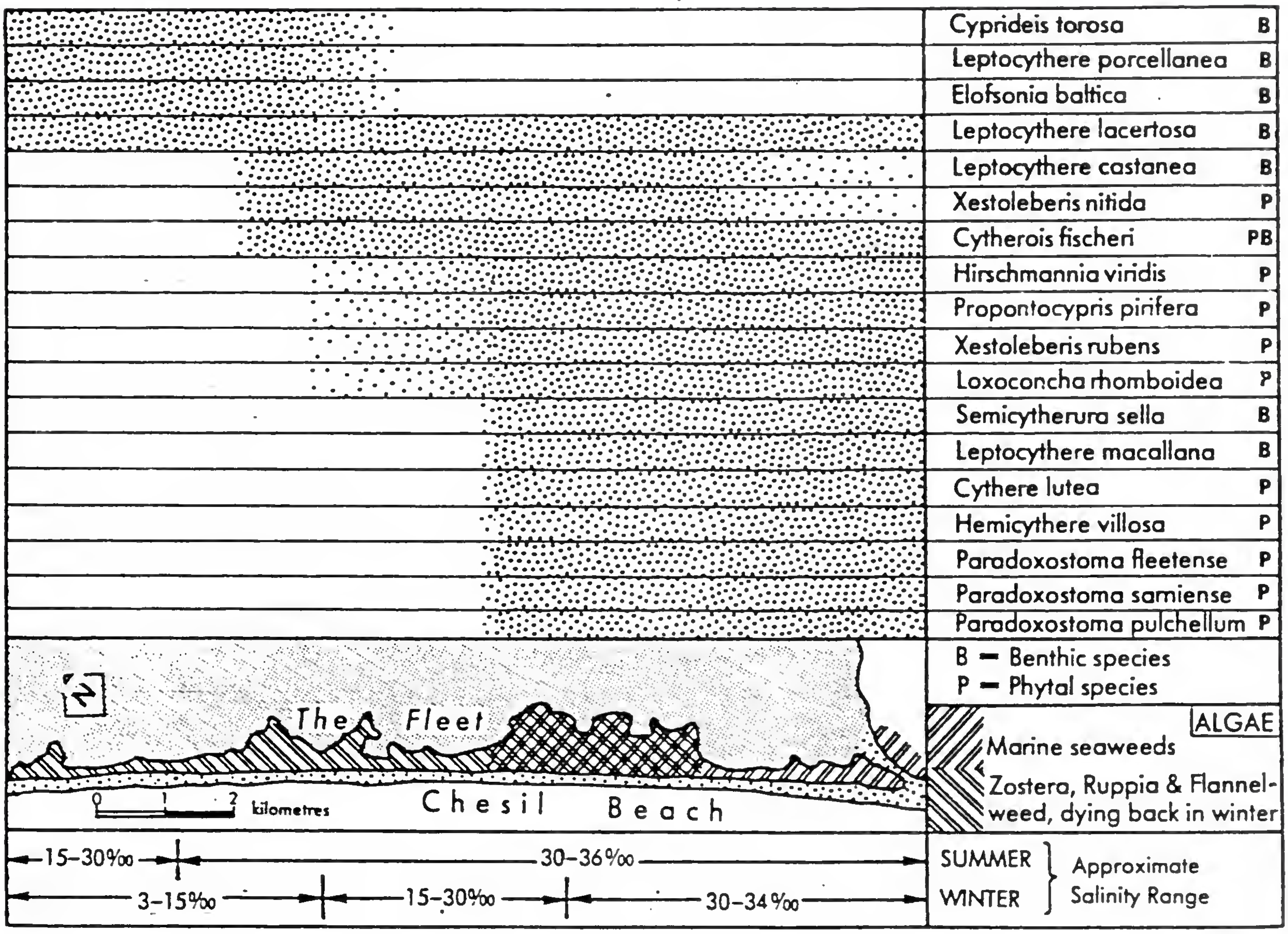

Fig. 7. Distribution of Recent ostracods in The Fleet. (Redrawn after Whittaker 1986).

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THE LITTORAL FAUNA OF WEYMOUTH BAY.

Whittaker collected from a number of littoral rock pool localities between Weymouth and Lulworth Cove. His samples were from algae, such as *Fucus* spp., *Corallina* sp., *Enteromorpha intestinalis* and *Cladophora rupestris* and he recorded the following species live (1972 MS.):

Cythere lutea (O.F. Muller)
Semicytherura nigrescens (Baird)
S. tela Whittaker
Aurila convexa (Baird)
Callistocythere badia (Norman)
Palmoconcha laevata (Norman)
Paradoxostoma variabile (Baird)
P. pulchellum Sars
Cytherois fischeri (Sars)
Xestoleberis aurantia (Baird)
Hemicytherura cellulosa (Norman)
S. striata (Sars)
Hemicythere villosa (Sars)
Heterocythereis albomaculata (Baird)
Loxoconcha rhomboidea (Fischer)
Hirschmannia viridis (O.F. Muller)
P. robinhoodi Horne & Whittaker
P. sarniense Brady
C. pusilla Sars

Also, from sand and spongy filamentous algae scraped from rocks in the littoral, he recorded the following 3 species:

Semicytherura sella (Sars)
L. porcellanea (Brady & Robertson)
Leptocythere macallana (Brady & Robertson)

Whittaker also encountered the following species dead in the littoral rock pools he studied:

Neocytherideis subulata (Brady)
Cytheropteron depressum Br. & Norm.
Urocythereis distinguenda (Nev.)
Callistocythere crispata (Brady)
Paracytherois flexuosa (Brady)
Pontocythere elongata (Brady)
Semicytherura cornuta (Brady)
Leptocythere pellucida (Baird)
Elofsonia pusilla Sars
Paracytheridea cuneiformis (Brady)

FIELD EXCURSION TO THE CRETACEOUS AND TERTIARY OF THE ISLE OF WIGHT AND THE NEW FOREST AREA, HAMPSHIRE.

MICHAEL C. KEEN
(University of Glasgow)

The short lived marine transgression indicated by the Middle Purbeck Cinder Bed, marks the beginning of the Cretaceous Period in southern England. The Cinder Bed lies within the **DURLSTON BEDS** which are mostly non-marine; they are succeeded by the **WEALDEN BEDS** which accumulated over some 30 million years during the Ryazanian to Barremian. The Wealden sediments were deposited in large flood plains; during times of uplift and large sediment input, braided river systems formed;when the relief of the neighbouring hinterland was reduced and sedimentation low, shallow lagoons formed. The presence of *Iguanodon* remains and footprints, and desiccation cracks, indicate that water depth was never very great. On the Isle of Wight the Wealden is divided into two, the **WESSEX FORMATION** (previously named the **WEALDEN MARLS**), and the overlying **VECTIS FORMATION** (previously named the **WEALDEN SHALES**). The former consist of a series of upwards-fining cycles of sandstones, siltstones, and clays; the latter are shales, often crowded with ostracods, and showing marine influence towards the top where oysters and other molluscs are found.

The **LOWER GREENSAND** shows a change to fully marine conditions, and marks the beginning of the great Cretaceous marine transgression, which led to most of the British Isles being submerged by late Cretaceous times. The four formations recognised on the Isle of Wight are the **ATHERFIELD CLAY**, **FERUGINOUS SANDS**, **SANDROCK SERIES**, and the **CARSTONE**. These are all marine deposits, and, as the names suggest, are comprised of clays below and sandstones above; the latter are rarely green in colour, usually weathering to a brownish red, with white and yellow sands in the Sandrock Series. They are of Aptian age. The succeeding **GAULT CLAY** and **UPPER GREENSAND** are, respectively, successive formations of predominantly clay or predominantly glauconitic sandstone. The sandy facies becomes predominant westwards, with the Gault Clay disappearing near Lyme Regis in Dorset. They overstep the Jurassic formations and eventually rest on Triassic sediments in Devon. They are of Albian age and contain marine fossils. On the Isle of Wight they are separated by the **PASSAGE BEDS**.

The Upper Cretaceous consists entirely of the **CHALK**, an open shelf-sea deposit comprised mainly of coccoliths. It is divided into Lower, Middle, and Upper divisions; the Lower Chalk has a higher argillaceous content than the others, and contains the **PLENUS MARLS** at the top, deposits formed during the late Cenomanian oceanic anoxic event. The Chalk is not a uniform deposit; it is extensively bioturbated, and also has limestone/marl cycles which have recently been related to Milankovich Cycles. Aragonitic shelled fossils such as ammonites are absent in most of the Middle and Upper Chalk, so a variety of bivalves, brachiopods, echinoids, crinoids, and belemnites have been used for macrofossil biozonation, with ammonite zones restricted to the Lower Chalk.

Comprehensive recent studies can be seen in Hart et al (1981) for the Foraminifera and Crux (in Lord 1982)for the calcareous nannoplankton. Ostracod studies commenced with Jones in 1849, followed by Jones and Hinde (1890); more recent accounts are Neale (1978) for the whole of the Cretaceous, and Weaver (1982) for the Cenomanian; Anderson's lengthy studies of Purbeck and Wealden ostracods are reviewed in Anderson (1985). Kaye published a series of papers on Lower Cretaceous ostracods from Britain, including one on the Isle of Wight (1965).

A major regression occurred at the end of the Cretaceous, with a gentle doming of the whole area of the British Isles. This was associated with a mantle plume giving pronounced igneous activity off western Scotland, probably associated with an aborted rifting episode. In southern England the Chalk was gently folded and eroded so that the Tertiary deposits rest on different horizons at different places. The land surface was of low elevation and relief, with occasional widespread transgressions of the sea, which can be related to global eustatic change (Plint, 1988). The geological record shows a picture of shallow seas, estuaries, deltas, lagoons, rivers, and lakes; facies changes can be very rapid over short

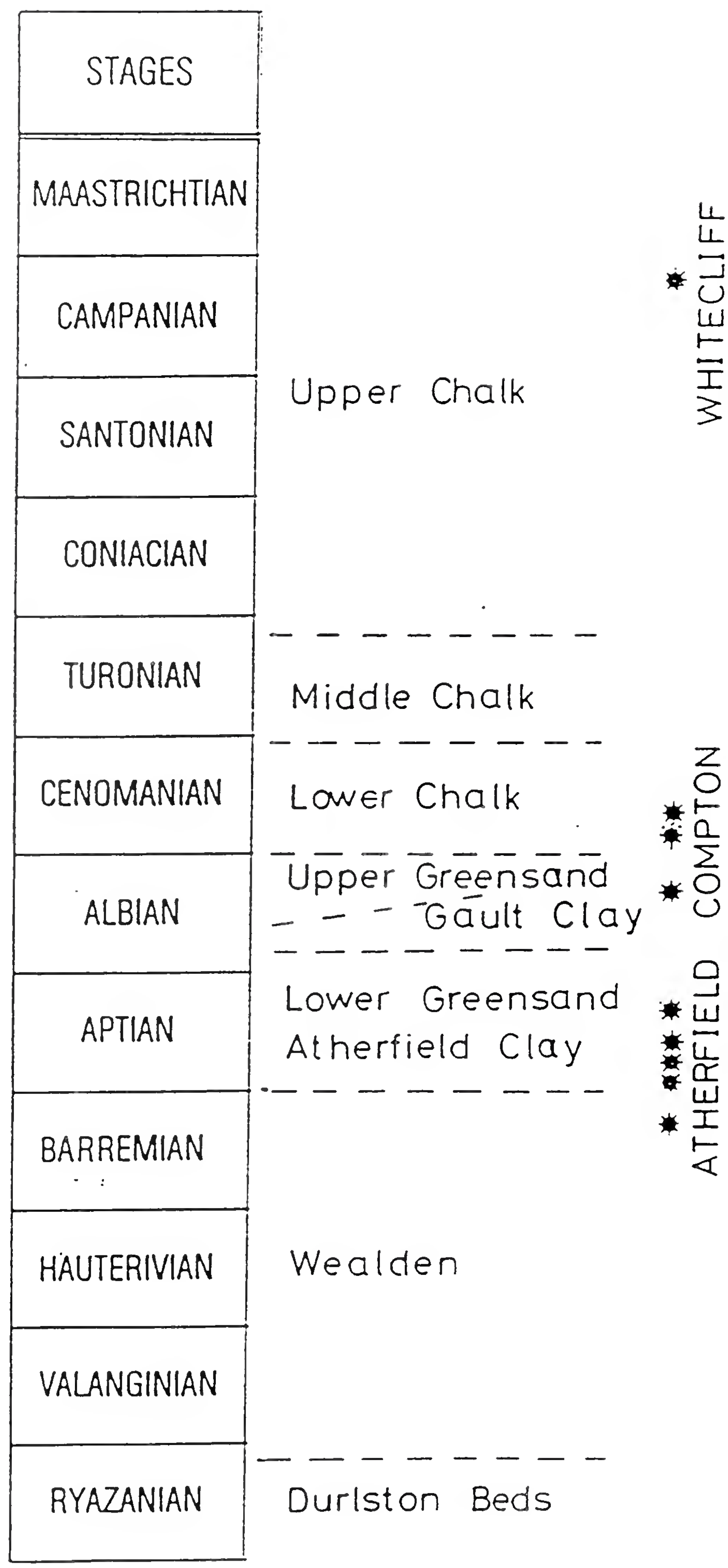


FIG.1. The Cretaceous succession seen on the Isle of Wight, with localities and horizons to be sampled.

FIG.2. The distribution of Palaeogene sediments at outcrop. (Hants =Hampshire Basin). (From Keen, 1978).

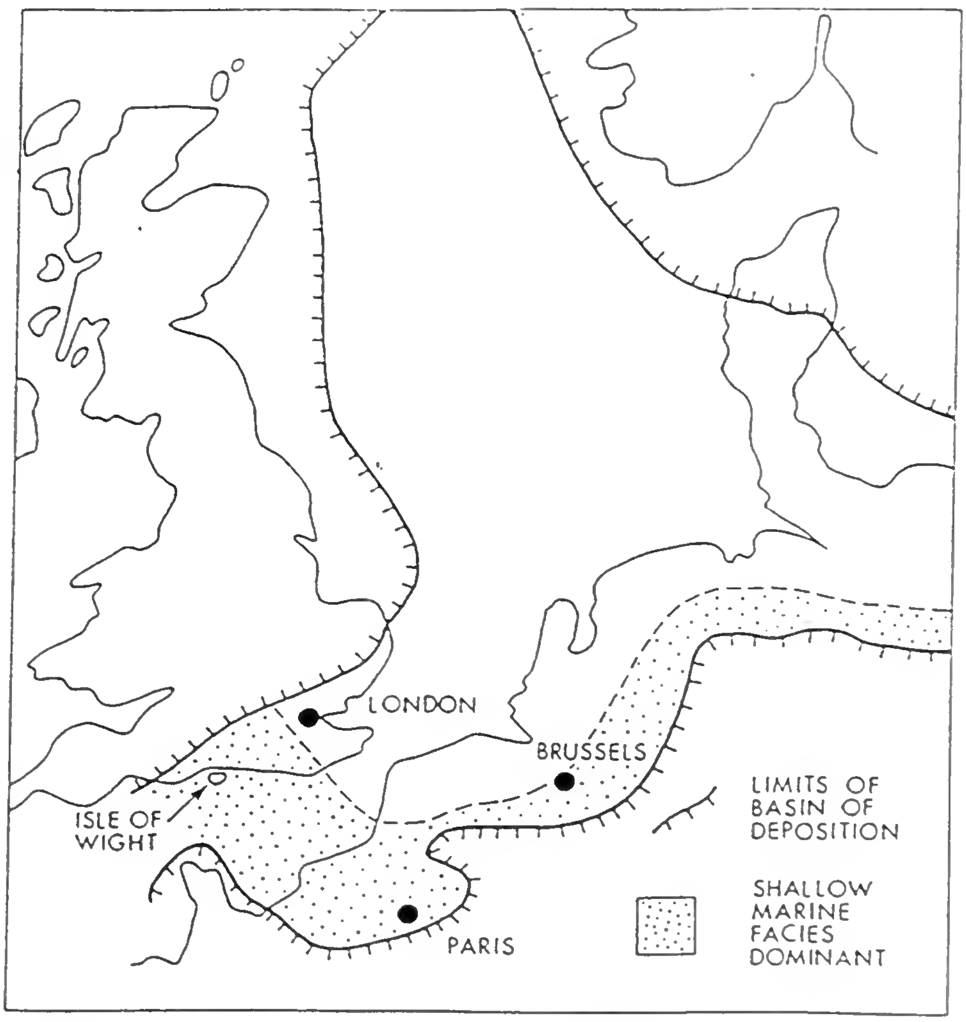


FIG.3. The Ypresian Basin of deposition.

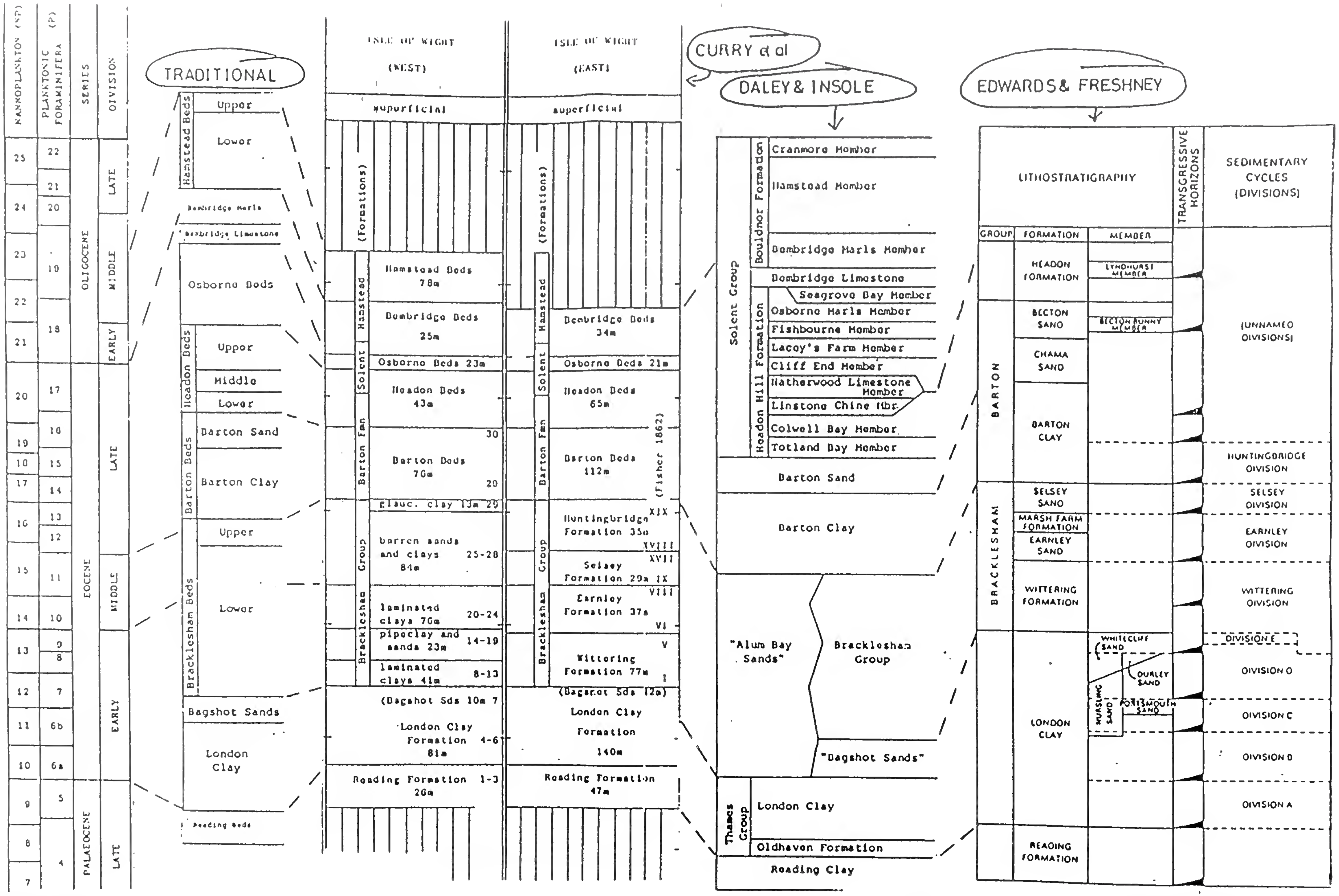


FIG.4. Lithostratigraphy of the Palaeogene rocks of southern England.

distances, both laterally as well as vertically.

The Tertiary rocks of southern England occur in two distinct areas referred to as the London and **Hampshire Basins** (Fig.2).These were separate depositional basins during the Palaeogene, although frequently connected geographically (Fig.3). The London Basin was an integral part of the larger North Sea Basin, and as such has much in common with other onshore areas surrounding the latter, such as Denmark, Germany and Belgium. The Tertiary deposits of the London Basin range in age from Palaeocene (Thanetian) to Middle Eocene (Lutetian). The Hampshire Basin was also at times part of the southern North Sea Basin, and the faunas often show similarities to those of Germany, but more especially those of Belgium. However there is also a strong westerly and southerly influence,indicating contact with areas outside the North Sea Basin. The faunas frequently show similarities to those of the Paris Basin,while the occasional occurence of *Nummulites* horizons enables correlation with the Tethyan Province. The succession in the Hampshire Basin is more complete than that of the London Basin, ranging from late Palaeocene to mid Oligocene.

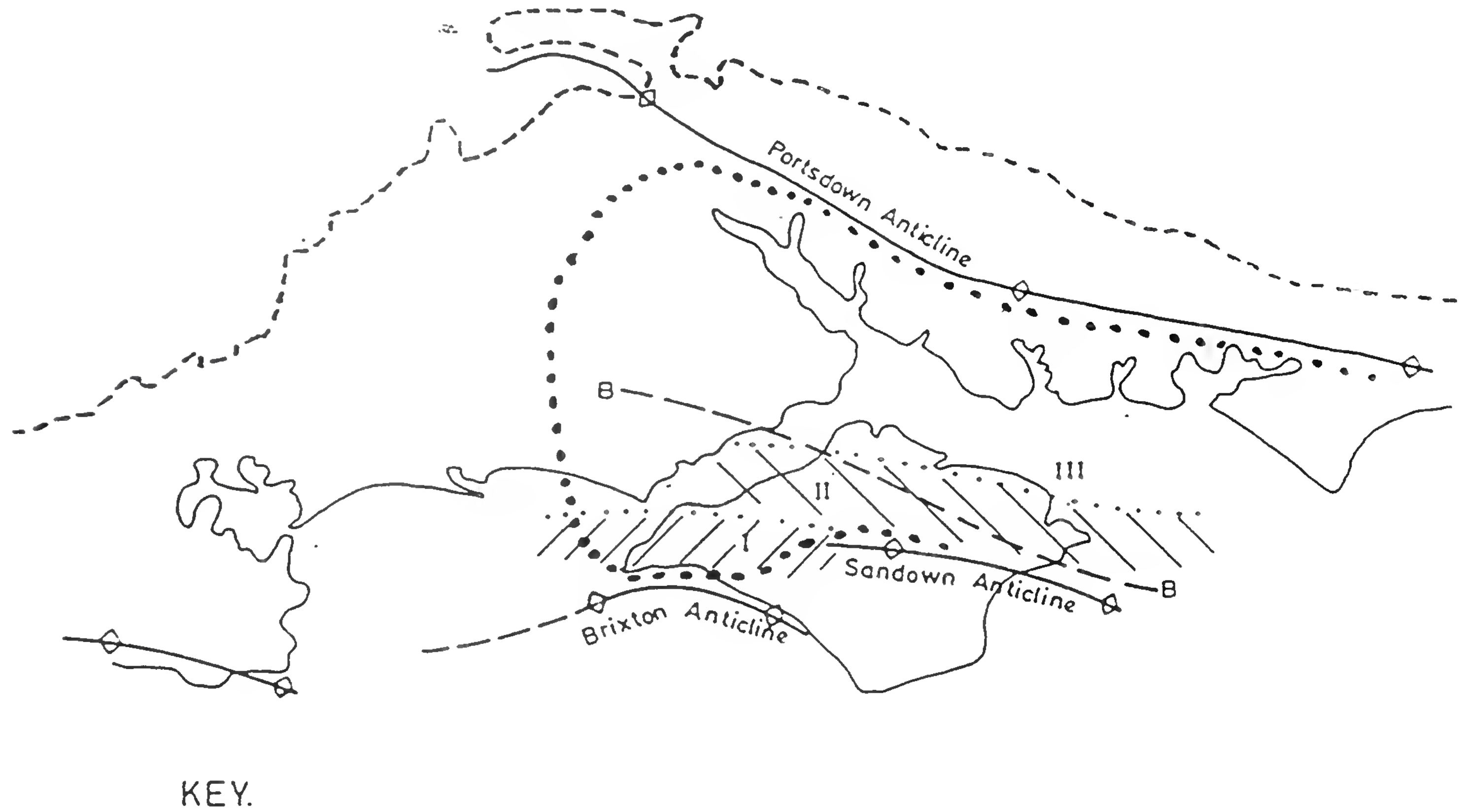
The stratigraphic nomenclature of the English Palaeogene has suffered from considerable revision in recent years. A complete review can be seen in Curry *et al* (1978); since then changes have been proposed for the Lower Eocene (King 1981), the Eocene (Edwards and Freshney, 1987a,b), and for the Upper Eocene and Oligocene (Insole and Daley 1985). Many papers have been published on the correlation of these strata with those of neighbouring Europe and elsewhere; these are summarised in Curry *et al* (1978). Calcareous nannofossil studies (Aubry 1983,1986) have enabled the international zonation to be applied to the succession, while magnetostratigraphical studies (Townsend and Hailwood 1985, Aubry *et al* 1986) offer hope for detailed correlation with international classification. The current nomenclature is summarised in Fig.4.

The **READING BEDS** consist of mottled red, green, and brown clays and silts, but contain no calcareous fossils; they probably accumulated in fluvial swamps. The succeeding rocks form a complex sequence of sands and clays showing marked lateral and vertical changes, reflecting transgressive and regressive events. They have been divided into Thames, Bracklesham, and Barton Groups, and generally show a stronger marine influence in the east with continental influence increasing westwards to a shoreline frequently lying in the vicinity of Alum Bay. There is a strong structural control on sedimentation and palaeogeography (Fig.5). The **THAMES GROUP** consists of a thin basal **OLDHAVEN FORMATION** and a much thicker **LONDON CLAY FORMATION.** King (1981) has recognised five coarsening upwards cycles, referred to as Divisions A-E, which indicate transgressive-regressive events. The London Clay contains a rich, though not abundant, marine fauna. Conditions of deposition ranged from below wave base to the littoral zone, each cycle prograding eastwards towards Whitecliff Bay. The base of Division B has a planktonic datum (Wright 1972) which can be recognised throughout the London and Hampshire Basins. It is characterised by abundant planktonic forams, and is believed to be related to improved circulation associated with a marine transgression and better communication with marine waters lying to the west. The immigration of many new species is associated with this event.

The **BRACKLESHAM GROUP** includes beds formerly referred to as the Bagshot and Bracklesham Beds. They have been divided into a series of formations which are distinctive enough for mapping over limited areas, and the presence of marker horizons allows correlation throughout the Hampshire Basin. The **WITTERING FORMATION** consists of laminated clays and fine sands, their proportions showing considerable variation. The presence of *Nummulites planulatus* indicates a Cuisian age for the middle part of the formation where marine conditions prevailed. Another marker horizon recognisable throughout the Hampshire Basin is the Whitecliff Bay Bed, a distinctive blackish-brown carbonaceous clay or lignite which rests on a seat earth penetrated by rootlets. The Wittering Formation was mainly deposited on intertidal mud and sand flats, although shallow offshore conditions or supratidal conditions sometimes prevailed. The **EARNLEY FORMATION** of Curry et al (1978) has been divided into a lower **EARNLEY SAND** and an upper **MARSH FARM FORMATION** (see Edwards and Freshney 1987b). The Earnley Sand is a transgressive glauconitic, bioturbated, fine-grained sand or silt, often very fossiliferous; it contains a distinctive and widespread faunal marker, the Nummulites laevigatus Bed, which dates the formation as Lutetian. It was deposited in a shallow (10-30m.) shelf sea fringed by tidal flats, marshes, and lagoons. The Marsh Farm Formation consists of laminated carbonaceous clays and fine-grained sands deposited in intertidal environments; marine intercolations are present in

Whitecliff Bay. The SELSEY FORMATION is a glauconitic fine-grained sand, frequently bioturbated and often with abundant fossils. It is a transgressive deposit similar to the Earnley Sands. *Nummulites variolarius* is frequently present. The HUNTING BRIDGE BEDS have been placed at the top of the Bracklesham Group (Curry *et al* 1978) or the base of the Barton Group (Edwards and Freshney 1987a,b). The latter viewpoint is more justified because of lithology, although the fauna is more similar to that of the Bracklesham Group. The BARTON GROUP is divided into two formations, the BARTON CLAY and the BECTON SANDS. The former is a highly fossiliferous marine clay mainly deposited below wave base; the latter is a barrier complex with a transition from middle to upper shoreface through time. It is a regressive facies, and as such it is very diachronous, its base being youngest in the east (Whitecliff Bay) where it is also the thickest.

The remainder of the Palaeogene was formerly referred to as the Fluvio-marine series, a descriptive name for a sequence of clays, sands, and limestones deposited in an essentially non-marine environment. Various modern classifications have been proposed, and Daley and Insole have named the whole succession the SOLENT GROUP, divisible into three mappable formations, the HEADON HILL FORMATION, BEMBRIDGE LIMESTONE, and BOULDNOR FORMATION, with 13 members. The succession is very complex, with rapid facies changes indicative of a variety of coastal environments from flood plain lakes, rivers and swamps, through coastal lagoons and barrier islands to a shallow sea (Keen 1977b, Plint 1984). Throughout the succession deposition was related to structure (Fig.5). Fuller details of the stratigraphy is given in the individual excursions. The stratigraphical nomenclature used is a mixture taken from various authors (see Fig.4).



KEY.

BB. Southern limit of known Brockenhurst Beds.

Bembridge Limestone { I Thick limestones; II Limestones and clay intercolations; III Clay predominant

Approximate average position of shoreline during deposition of Bracklesham Group.

FIG.5. Structure and sedimentation during the Palaeogene.

The Becton Sands regression allowed the development of a coastal plain (LOWER HEADON BEDS) behind a barrier complex represented by the sands; these formed earlier in the west at Milford (Hordle Cliff) and Headon Hill. The MIDDLE HEADON BEDS were deposited during a minor marine transgression from the east, with several distinct facies: shallow marine (the Brockenhurst Bed), barrier complex (Barren Sands), open lagoon (Venus and Oyster Beds), and closed lagoons. (fig.19). The sequence is only fully developed at Whitecliff Bay, the western Isle of Wight was always behind the barrier island, so has only lagoonal sediments. Another very minor transgression from the east is indicated by the Bembridge Oyster Bed. The BEMBRIDGE MARLS. and HAMSTEAD BEDS were deposited in non-marine conditions, with a final transgression seen in the UPPER HAMSTEAD BEDS , an indication of the major Oligocene transgression affecting many parts of Europe. The Eocene Oligocene boundary lies somewhere between the Bembridge Limestone and the Upper Hamstead Beds; preliminary palaeomagnetic studies suggest it is in the lower part of the Bembridge Marls where Anomaly 13 may be present.

Microfossils from the Hampshire Basin succession have been widely studied in recent years; **Foraminifera:** Murray and Wright 1974, King 1981, Murray *et al* 1981; **Calcareous nannoplankton:** Hamilton and Hojjatzadeh 1982, Aubry 1983, 1986; **Microplankton:** Davey *et al* 1966, Eaton 1976, Costa and Downie 1976, Costa *et al* 1976, Bujak *et al* 1980, Liengjarern *et al* 1980. Amongst these, the dinoflagellates have proven to be the most useful group for correlation between England, Belgium, France, and Germany.

The **Tertiary ostracods** of England were amongst the first of the class to be described in detail in two important monographs by Jones (1857) and Jones and Sherborn (1889). There then followed a long gap until work recommenced in the 1950's, with Bowen (1953), Eagar (1965), and Gokcen (1971).The most extensive modern monograph is that of Haskins, dealing with the Isle of Wight and Barton, published between 1968 and 1971. Keen has published a series of papers on various aspects of the ostracod faunas (1968, 1971, 1972a,b, 1975, 1977, and1978.). The ostracods have proven valuable both for stratigraphical correlation and for environmental interpretation. A series of ostracod zones have been established (Keen 1977a, 1978) which can be used in Germany, Belgium , and the Paris Basin (Fig.6). These have been based on species with known phylogenies, so the problem of ecozones is minimised. They are subject to revision, and recent work (Keen and King in prep.) has recognised a more detailed zonation for the Lower Eocene. The recognition of an **Echinocythereis sp.A Zone** allows accurate correlation over a wide area (Fig.7,8). Biozones are difficult to apply to successions deposited in widely fluctuating conditions; an example is illustrated in Fig.9, taken from Keen (1983). In this example the strata range from the Barton Clay to the Bembridge Oyster Marl, and because of diachronously developed facies, the ranges of the ostracod species are also diachronous, so the difference between biozones and chronozones becomes apparent. However it does allow integration between marine ostracod zones and brackish-water zones, because the boundary between the Neocyprideis colwellensis and N.williamsoniana Zones can be accurately placed.

The other contribution of the ostracods is in the field of palaeoenvironmental reconstruction. Six major ostracod assemblages can be recognised (Fig.10), although it is possible to further subdivide the brackish-water and marine assemblages. Figs. 15-18 show the application of ostracod studies in this field, and are further discussed in individual field excursions. The marine sediments of the Hampshire Basin Palaeogene are primarily argillaceous, with mobile muddy bottom waters being the norm during deposition. However, occasionally faunas occur which suggest clear shallow bottom waters, possibly with Posidonia sea meadows; such an horizon is Fisher Bed XVII of the Selsey Formation, to be sampled at Whitecliff Bay.

Many of the localities to be visited during the excursions are the type localities for Tertiary ostracod species; these are either described as such in the text or marked with an asterisk*.

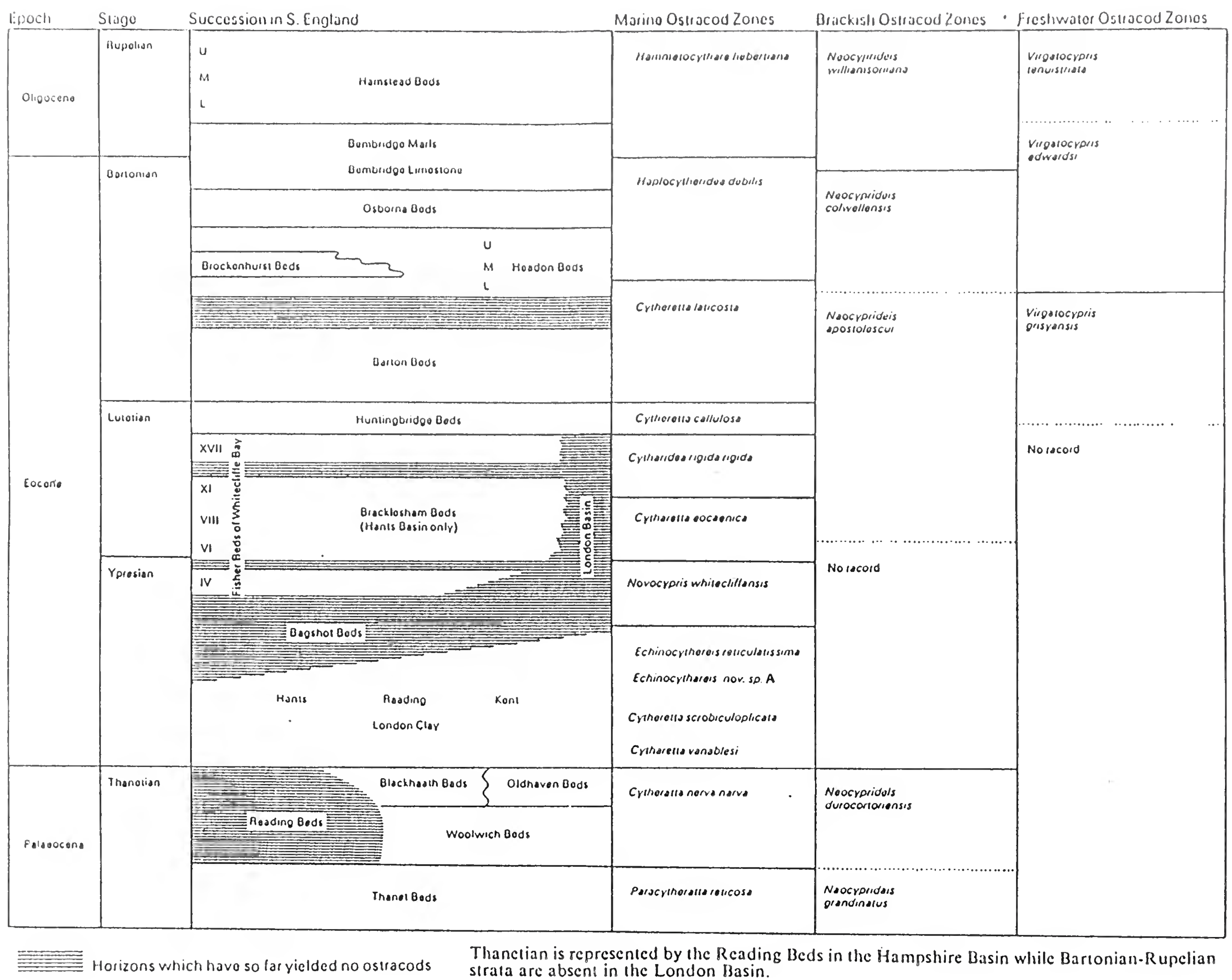


FIG.6 Ostracod biozones for the Palaeogene of southern England.(From Keen, 1978).

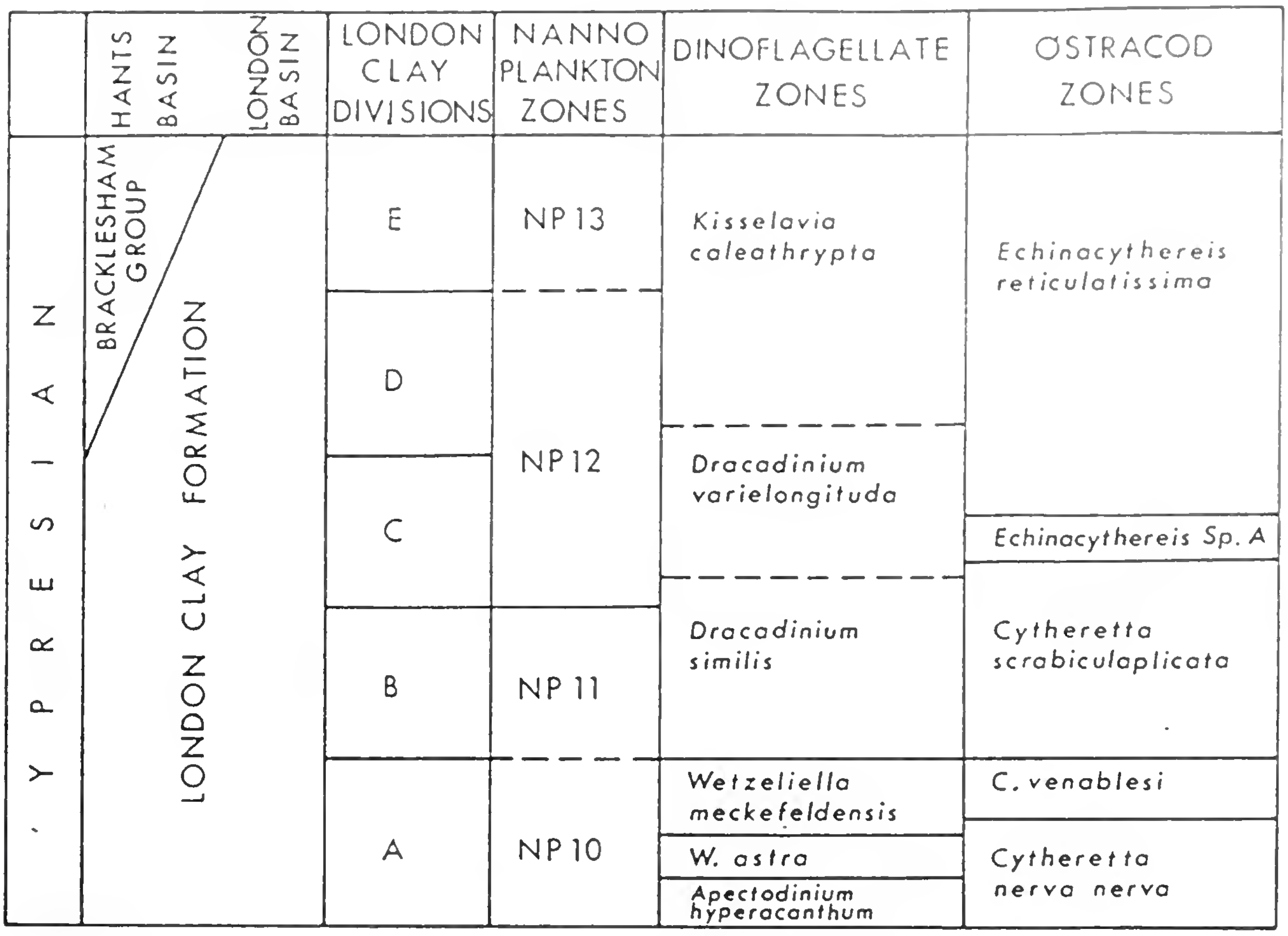


FIG.7. Lithostratigraphy and biozonation of the Lower Eocene of southern England.

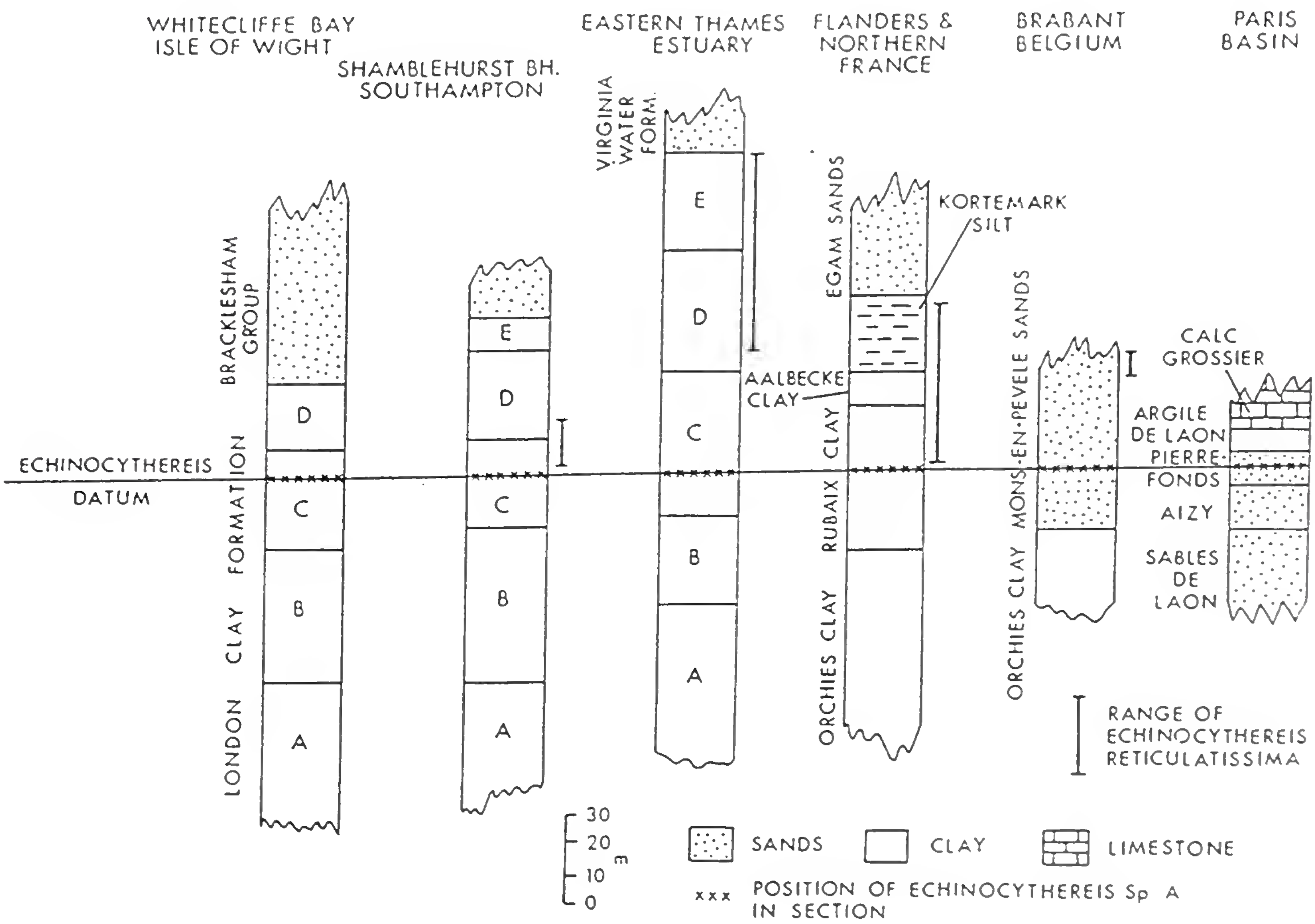
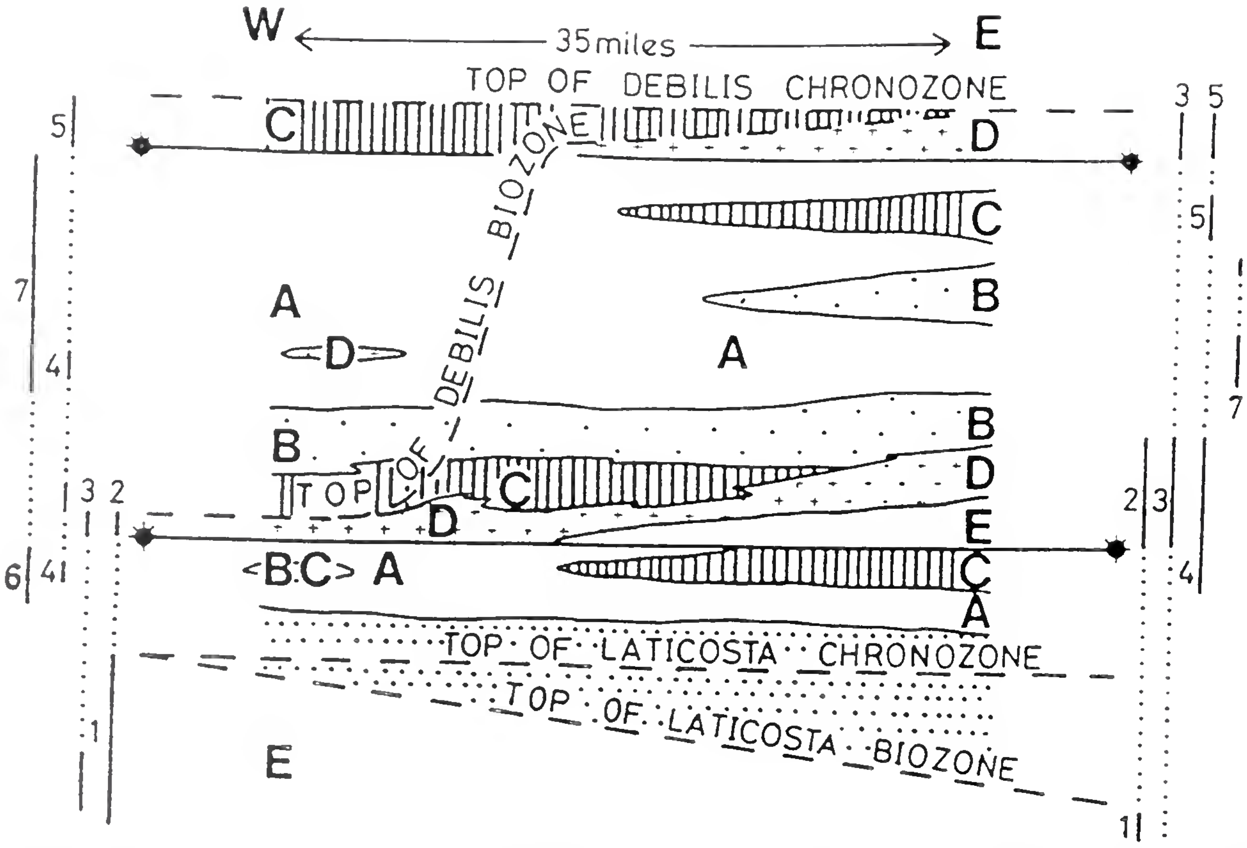


FIG.8. Correlation of Ypresian rocks and the Echinocythereis Datum.



Letters refer to biofacies as follows: A, freshwater; B, oligohaline and lower mesohaline; C, upper mesohaline; D, polyhaline; E, shallow marine. Distributions of taxa are as follows: 1, Cytheretta laticosta; 2, C. porosacosta; 3, Haplocytheridea debilis; 4, Neocyprideis colwellensis; 5, N. williamsoniana; 6, Moenocypris sherborni Keen; 7, M. reidi Keen. Closely spaced dots = sands devoid of calcareous fossils. Lines with asterisks = marine transgressions = time planes.

FIG.9. Late Eocene biozones and their equivalent chronozones on the Isle of Wight. (From Keen, 1983).

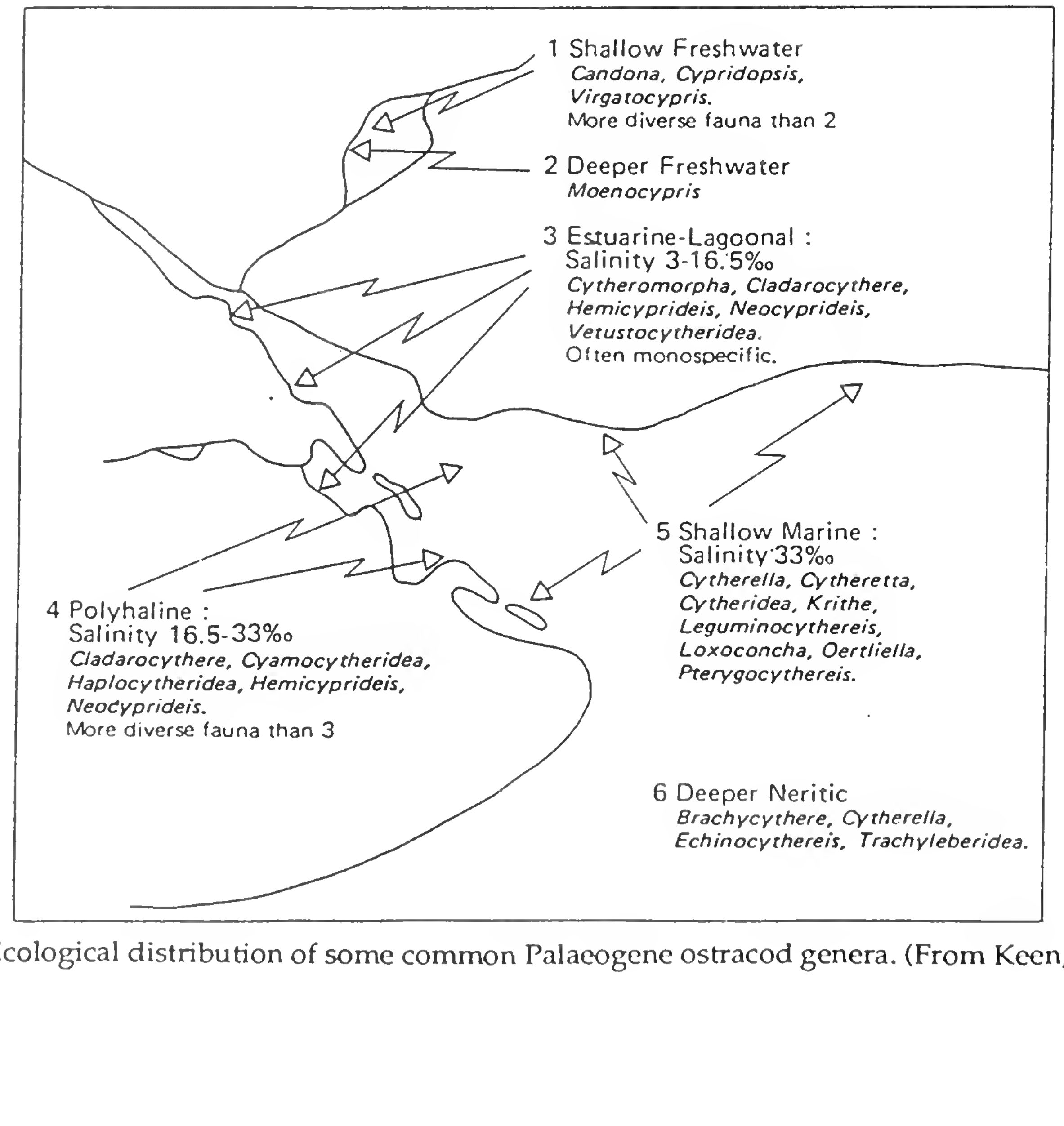


FIG.10. Ecological distribution of some common Palaeogene ostracod genera. (From Keen, 1978).

THE EXCURSIONS

NEW FOREST LOCALITIES

The Tertiary deposits of the New Forest are not very well exposed, and apart from temporary exposures, they are mainly exposed in the banks of small streams which cut through the soft Tertiary sediments. Two localities will be visited to collect material from the BRACKLESHAM GROUP.

1. SHEPHERDS GUTTER (Grid ref. 262153). This is in the **SELSEY FORMATION**, and is probably equivalent to Fisher Bed XV or XVI of Whitecliff Bay. A rich ostracod fauna belonging tothe **Cytherideа rigida rigida Zone** can be found; see Fig.27 for species. This is the locality referred to as Bramshaw in the publications of Keen.

2. STUDLEY WOOD (Grid ref. 22721592). This is now the only satisfactory eposure of the **HUNTINGBRIDGE BEDS**, which are regarded as the top of the Bracklesham Group or base of the Barton Group. The ostracod fauna is very rich and belongs to the **Cytheretta cellulosa Zone**; the species from this horizon are shown on Fig.27. The ostracods are very similar to those of the Auversian of the Paris Basin.

3.BARTON. The section at Barton has deteriorated in recent years (from a geological perspective!) due to extensive coastal protection works. However it is still possible to collect samples yielding rich ostracod faunas of the **Cytheretta laticosta Zone**. The ostracod faunas are fairly uniform throughout the **BARTON CLAY**; it is hoped to collect samples from the Middle Barton Clay. Detailed faunal lists for the Barton Beds are given for the excursion to Alum Bay in the Isle of Wight. Barton is the type locality for the following species: *Cytheretta laticosta* (Reuss 1850), *Krithe bartonensis* (Jones 1857), *Paracypris contracta* (Jones 1857), *Pterygocythereis fimbriata bartonenesis* Keij 1957, *Cytherella chewtonensis* Haskins 1968, *Cytheretta costellata antecalva* Keen 1972, *Flexus solentensis solentensis* Keen 1972 and *F.solentensis congestus* Keen 1972.

4. HORDLE CLIFF, MILFORD. This locality will only be visited if time allows. The **LOWER HEADON BEDS** are seen in the cliffs and will be sampled for freshwater ostracods. This is the type locality for *Moenocypris sherborni* Keen 1972, which is found in the **Unio Beds**.

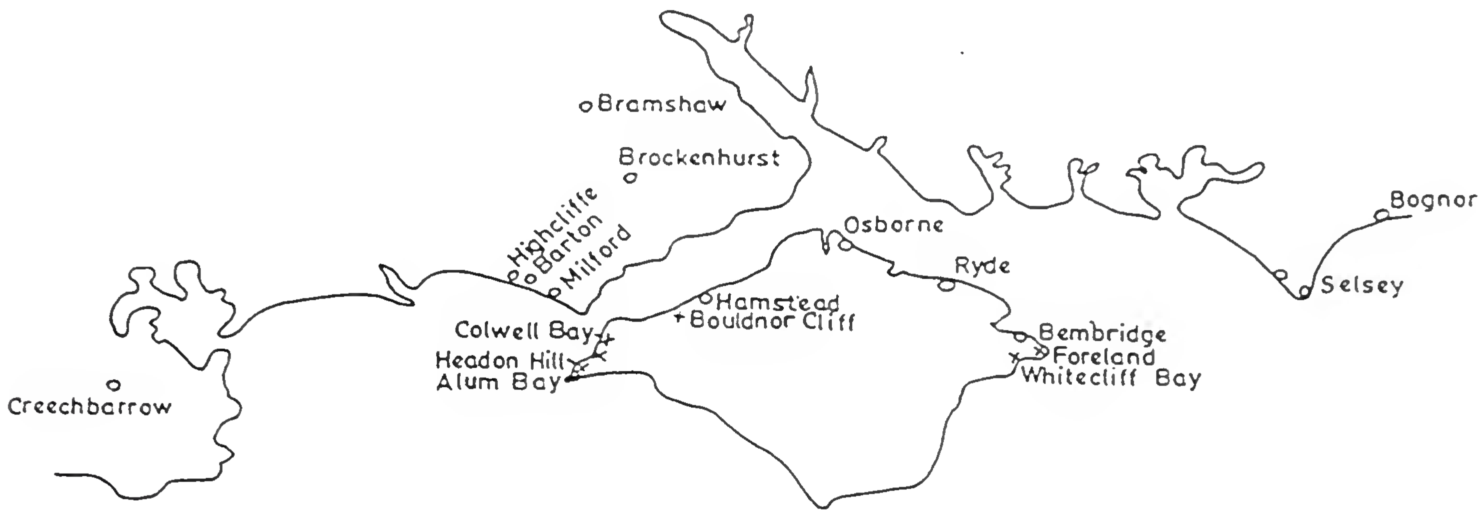


FIG.11. Localities of the Hampshire Basin.

ISLE OF WIGHT

The Isle of Wight forms the southern part of the Hampshire Basin, and the extensive cliffs developed around its coastline give one of the best exposed Cretaceous-Tertiary successions in Europe. The geology of the island is basically very simple (Fig 12): a prominent chalk ridge runs from east to west, from Culver Cliff to the Needles, dividing the island into two, with Tertiary rocks to the north and Cretaceous to the south. The chalk ridge is in fact the most conspicuous part of the Isle of Wight

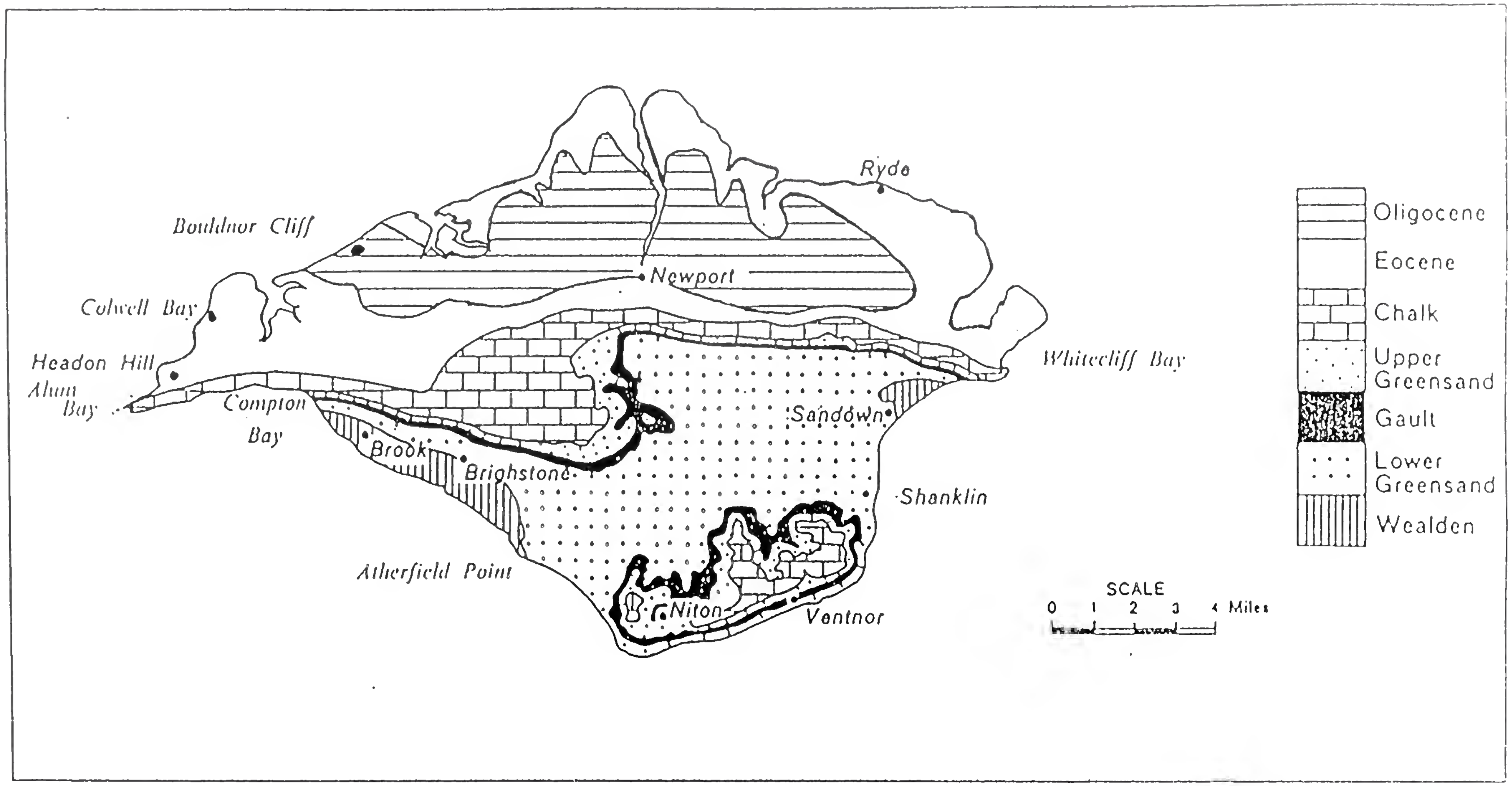


FIG.12. The geology of the Isle of Wight.

monocline, and forms part of the vertical limb of the structure, with anticlines to the south with axial planes outcropping around Sandown and Brighstone, and the Bouldnor Syncline to the north. The monocline is an E-W Miocene structure superimposed upon Cretaceous-Palaeogene WNW-ESE trending folds, and related to basement faulting downthrown to the north.

The majority of the time will be spent examining and collecting from the Tertiary.

CHALE BAY AND ATHERFIELD POINT

This excursion is to visit the Wealden and Aptian between Atherfield Point and Whale Chine (a chine is a small ravine cut into the cliffs by a small stream). The **WEALDEN SHALES** (now referred to as the **VECTIS FORMATION**) at Atherfield Point are the oldest beds to be seen, and have yielded a large ostracod fauna described by Anderson (1967). The beds belong to Anderson's Cypridea valdensis Zone, the youngest of the Wealden ostracod zones. The species present are: *Cypridea caudata* Anderson 1967, *C.fasciata* Anderson 1967, *C.rotundata* Anderson 1967, *C.tenuis* Anderson 1967, *Sternbergella cornigera* (Jones 1888), *Theriosynoceum fittoni* (Mantell 1844), and *Mantelliana mantelli* (Jones 1888). Lower in the succession *Cypridea spinigera* (J.de C. Sowerby 1836) and *Cypridea valdensis* (J.de C. Sowerby 1836) are recorded by Clements (in Lord and Brown1987). This fauna is referred to as "C phase" by Anderson, and is generally thought to indicate non-marine conditions.

The base of the Aptian is marked by the **Perna Bed**, a hard sandstone full of fossils and also the basal bed of the **LOWER GREENSAND**. The overlying **ATHERFIELD CLAY FORMATION** and **FERRUGINOUS SANDS** will be visited. These are all fully marine deposits, and lie within the ammonite zones Deshayesites forbesi and Celoniceras martinoides. Recent stratigraphical work can be seen in Simpson (1985). The ostracods from this section were described by Kaye in 1965. Ostracods are not abundant, and it is essential to collect from freshly exposed sediment because decalcification of microfossils readily occurs on these cliffs. Ostracods can be found at the following levels:

1. Basal Atherfield Clay (5 feet from base)- *Schuleridea sulcata* Kaye 1965 (Type Locality), *Dolocytheridea minuta* Kaye 1963, *Cytheropteron (Eocytheropteron) stchepinskyi* Damotte and Grosdidier 1963, *Orthonotacythere atypica* Kaye 1965 (Type Locality), *Orthonotacythere* sp., *Protocythere croutesensis* Damotte and Grosdidier 1963, *Veenia* cf, *V.florentinensis* Damotte 1961, and *Cythereis geometrica geometrica* Damotte and Grosdidier 1963.
2. 25ft. from base of Atherfield Clay- *Orthonotacythere catalaunica* Damotte and Grosdidier 1963 and *Cythereis* cf. *C.blanda* Kaye 1963.
3. Lower Lobster Bed- *Schuleridea sulcata, Cytheropteron (E) stchepinksyi*, and *Cythereis geometrica geometrica*. These first three levels are all exposed near Atherfield Point.
4. Upper Crioceras Bed, exposed at Whale Chine- *Schuleridea alata* Kaye 1965*, *Cytheropteron (C) rugosa* Kaye 1965*, *Orthonotacythere inornata* Kaye 1965*, *Pseudobythocythere vellicata* (Chapman 1894), *Protocythere derooi* Oertli 1958, *P.gaultina* Kaye 1963, *Veenia compressa* Kaye 1965)*, *Cythereis lamplughi* Kaye 1963, and *Cythereis geometrica fittoni* Kaye 1965*.

COMPTON BAY

At the northern end of Compton Bay Cenomanian rocks of the **UPPER GREENSAND** and **LOWER CHALK** are exposed. The ostracods have been described by Weaver (1982), and the species listed below are taken from Weaver (in Lord and Brown 1987).

1.Passage Beds; these are of Albian age and are transitional beds between the underlying Gault Clay and the Upper Greensand; age diagnostic species are: *Schuleridea jonesiana* (Bosquet), *Mandocythere harrisiana* (Jones), *Cornicythereis larvivourensis* (Damotte and Grosdidier 1963), and *Cythereis hirsuta* Damotte and Grosdidier 1963; other species are *Cytherella ovata* (Roemer), *Cytherella gruendeli* Weaver 1982, *Cytherella* cf. *C.truncata* (Bosquet), and *Cytherella* cf. *C.contracta* van Veen.
2. Basal Lower Chalk; sample point in marly chalk immediately above a limestone full of phosphatised, broken, shell debris; this point is 5m. above the base of the Lower Chalk. Age diagnostic species are: *Schuleridea jonesiana, Neocythere vanveeni* (Mertens), and *Mandocythere harrisiana*

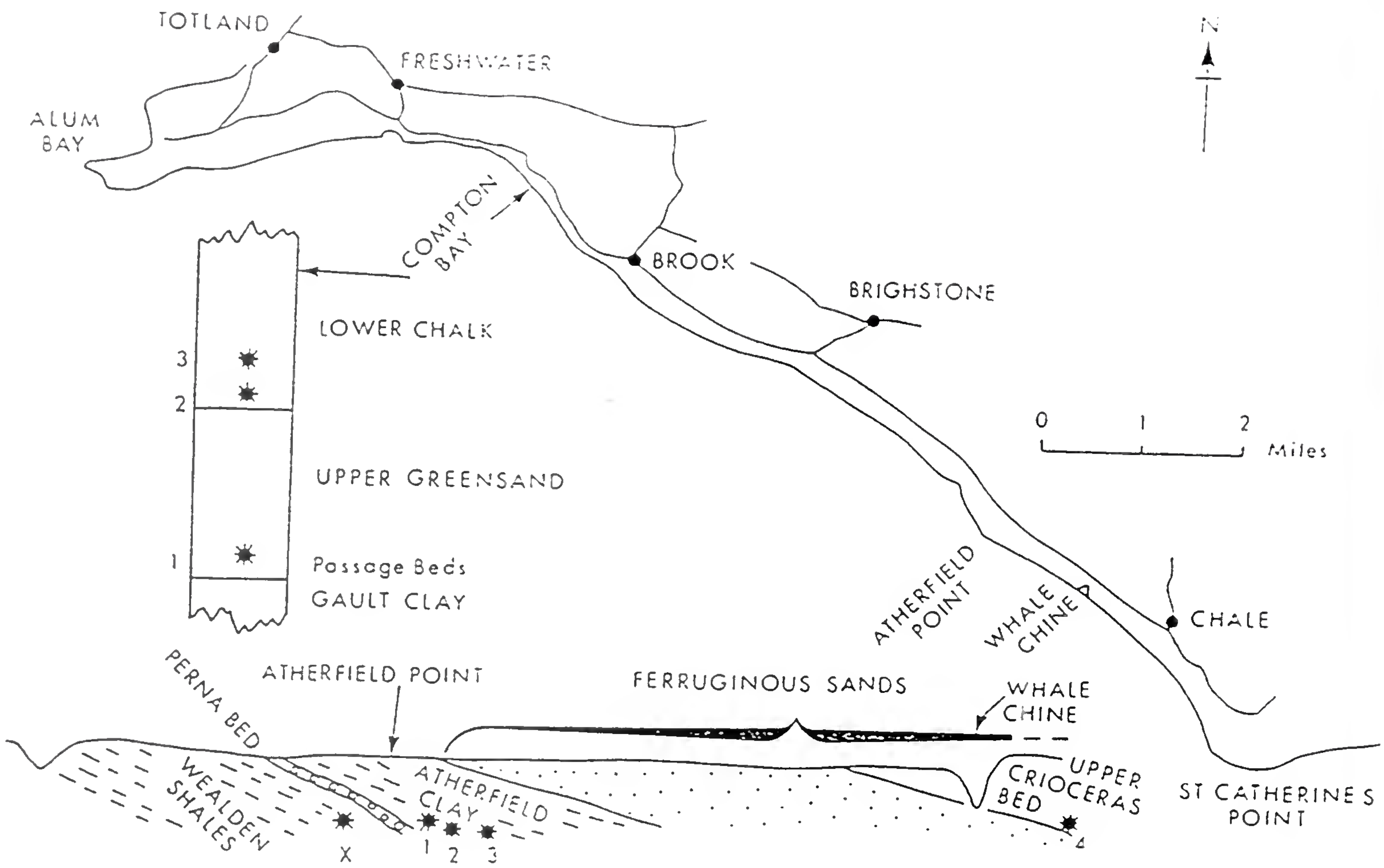


FIG.13. Sketch map of the coast between Whale Chine and Compton Bay, with sampling points.

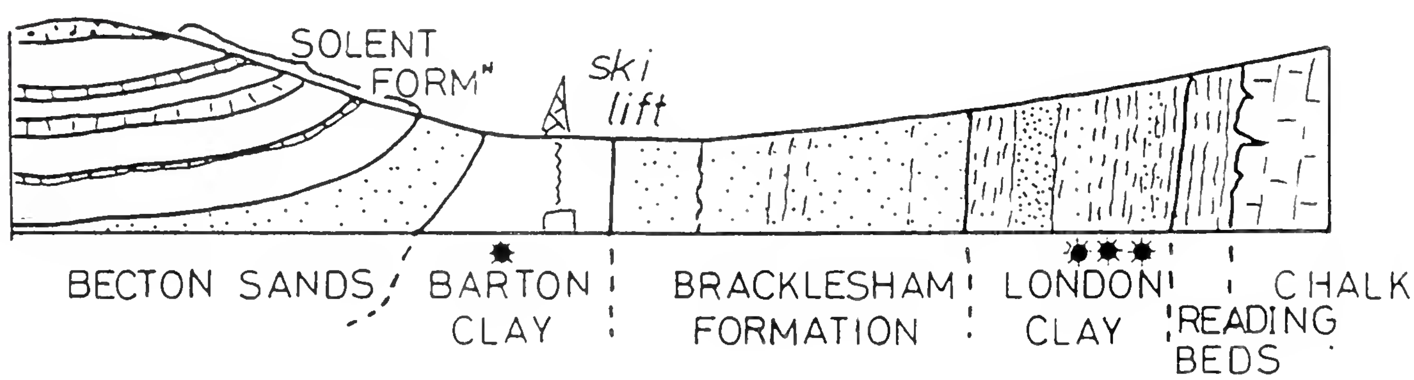


FIG.14. Sketch section of Alum Bay and Headon Hill, with some sampling points.

(Jones); other species are: *Macrocypris muensteriana* Jones and Hinde, *Bairdoppilata pseudoseptentrionalis* Mertens, *Cytherella ovata, C.gruendeli, C.* cf. *contracta, Monoceratina umbonata* (Williamson) and *Cytheropteron pitsonensis* Weaver 1982.

3. Lower Chalk; sample point approximately 13m. from base of Lower Chalk within the Orbirhynchia mantelliana marls. Age diagnostic species are: *Cythereis humilis* Weaver 1982, *Neocythere semiconcentrica* (Mertens), *Cornicythereis larivourensis, Mandocythere inferangulata* (Donze), and *M.harrisiana* (Jones); other species are: *Bairdoppilata pseudseptentrionalis, Cytherella ovata, C.* cf. *contracta, C.* cf. *truncata, C.gruendeli, Cytherelloidea stricta* (Jones and Hinde), *Pontocyprella harrisiana* (Jones), *Saide* cf. *S.nettgauensis* Grundel, *Rehacythereis paranuda* Weaver 1982, and *Monoceratina umbonatoides* Kaye.

ALUM BAY

The southern end of Alum Bay is formed by the prominent chalk cliffs ending in sea stacks called the Needles. Some 10m. of the chalk is accessible, yielding fossils of the **Belemnitella mucronata Zone.** This is overlain unconformably by the **READING BEDS**, which can be seen to infill pipes cut into the chalk. The plane of unconformity is vertical because this is the steep limb of the monocline, so the whole succession is vertical. The line of the chalk cliffs facing Alum Bay coincides with the plane of unconformity due to the erosion of the much softer Tertiary sediments forming the cliffs of the bay. The Reading Beds are of continental origin and have not yielded any ostracods.

The overlying **LONDON CLAY FORMATION** has yielded a small fauna of ostracods, and samples will be collected from Divisions A3 **(Cytheretta venablesi Zone)**, B1 and B2 **(Cytheretta scrobiculoplicata Zone)**. The base of A3 is a silty sandy clay, with *Cytheridea unispinae* Eagar 1965; 10m. from the base sandy clayey silts with *Pholadomya* and the worm tubes of *Ditrupa* contain an ostracod fauna dominated by *Leguminocythereis* cf. *striatopunctata* (Roemer 1838). A pebble bed marks the top of Division A3, the overlying B1 contains the 'Planktonic Datum' of Wright 1972, yielding planktonic forams and the ostracod *Cytheretta scrobiculoplicata* (Jones 1857). Samples collected in the lower part of Division B2 from silty clays with the bivalves *Pinna* and *Arctica*, and the gastropod *Turritella*, contain an undescribed species of *Hermanites* , which characterises this horizon, as well as *C.scrobiculoplicata*. The beds of the succeeding **BRACKLESHAM GROUP** are mostly sands, with some pipe clays and lignites. They are partly of continetal origin but the presence of dinoflagellates indicates marine influences; calcareous faunas are absent, so no samples will be collected from this group. The famous Alum Bay coloured sands come from these horizons, and can be purchased in various shaped glass containers.

The second Tertiary horizon to be sampled is the **BARTON CLAY**. Now that the section at Barton is so poorly exposed, this section in Alum Bay is the best for sampling this horizon. The ostracod fauna of the Barton Clay is fairly uniform throughout the formation, so detailed sampling is not required. It is amongst the richest of the English Palaeogene and belongs to the **Cytheretta laticosta Zone**; the common species are: *Cytheretta laticosta* (Reuss 1850), *Cytheridea intermedia* (Reuss 1850), *Krithe bartonensis* (Jones 1857), *Leguminocythereis haskinsi* Keen 1978, *Pterygocythereis fimbriata bartonensis* Keij 1957, *Schizocythere batjesi* Keij 1957, and *Schuleridea (Aequacytheridea) perforata perforata* (Roemer 1838). Other ostracods which are usually present are: *Cytherella compressa* (von Munster 1830), *Cytherella muensteri* (Roemer 1838), *Eocytheropteron* cf. *grekoffi* (Margerie 1961), *Eopaijenborchella eocaenica* (Triebel 1949), *?Idiocythere bartoniana* Haskins 1971* *Monsmirabilia triebeli* Keij 1957, *Oertliella aculeata* (Bosquet 1852), *Paracypris contracta* (Jones 1857), *Quadracythere nodosa* Haskins 1971*, and *Sphenocytheridea gracilis unicostata* Haskins 1969. Rarer species are: *Bairdopilata gliberti* Keij 1957, *Cytheretta costellata antecalva* Keen 1972, *Flexus solentensis solentensis* Keen 1972, *Haplocytheridea angusta* Haskins 1969, *Occultocythereis costalia costalis* Haskins 1971, and *Pterygocythereis cornuta* (Romer 1838). The Barton Clay was deposited in a shallow sea of probably 50-100m. depth. The section at Alum Bay finishes with a series of white sands referred to as the Becton Sands.The crustacean burrow *Ophiomorpha nodosa* Lundgren is recorded from these otherwise unfossiliferous sands and is usually taken to be indicative of littoral marine conditions. The Barton sea thus became very shallow and eventually gave way to the marsh and swamp conditions of the overlying Headon Beds of Headon Hill.

HEADON HILL

The Upper Eocene beds exposed on Headon Hill between Alum Bay and Totland Bay are amongst the most fascinating in the whole of the English Palaeogene. They were deposited in a variety of environments, ranging from lacustrine to various types of coastal lagoons or bays. They show rapid lateral and vertical changes, and the collecting will be organised to illustrate these facies changes. Environmental studies have been carried out by many workers, the most recent being on the Foraminifera (Murray and Wright 1974) and on the Ostracoda (Keen 1975, 1977b). The ostracod assemblages recognised by Keen are given in Figs 15-18. The section has deteriorated in recent years, but by some digging the beds described below can be sampled.

Cyrena pulchra Bed. (Fig.20). This is located immediately above the lowest of the freshwater limestones of the **LOWER HEADON BEDS.** This limestone, similar to many present in the Headon Beds, is soft, buff-coloured, and contains abundant freshwater gastropods of the genera *Galba* and *Planorbina*. The ostracods belong to Assemblage I of Keen (1975, 1977b), with common *Cypridopsis*. The population structure suggests little post-mortem movement, so the molluscan and ostracod faunas represent an autocthonous indigenous fauna. Immediately above the limestone, the basal green clay of the Cyrena pulchra Bed contains many small fragments of *Galba*; the most abundant ostracod is *Neocyprideis*, with common *Cytheromorpha*, but with very rare freshwater ostracods. Population structure suggests that the first two ostracods are autocthonous, but the freshwater ostracods are derived. Ascending the succession, *Neocyprideis* declines in numbers and eventually disappears, while *Cytheromorpha* becomes dominant. Towards the top freshwater ostracods become common, but as they are represented mostly by broken valves and instars, they are taken to represent fluvially transported material. The section can be interpreted (Keen 1977b) as a shallow freshwater lake situated near a coastline; the sea breached a barrier some distance away, leading to a rapid rise in salinity as the lake became converted into a lagoon. This caused the death of the freshwater animals and the introduction of a mesohaline fauna (Ostracod Assemblage IV). The sea connection was short lived, the lagoon began to silt up, and freshwater influence increased (Assemblage III). Towards the top of the section fluviatile influence was strong, introducing transported shells into the lagoon. Finally, the reappearance of *Neocyprideis* near the top of the section indicates further breaching by the sea. This section indicates how susceptible the area was to minor coastal changes, which gave rise to quite dramatic environmental changes.

MIDDLE HEADON BEDS. These beds were deposited predominantly in open polyhaline lagoons, but occasional horizons with freshwater ostracods suggest periodic conversion into coastal lakes. Two horizons will be sampled to yield the typical ostracods of Assemblage Va, the **Venus Bed** and the **Oyster Bed.** A third horizon, the **Batillaria Bed**, is a clayey sand full of gastropods, and is the best level for collecting populations of *Neocyprideis colwellensis*.. It is also the type horizon for "*Bradleya*" *favosa* Haskins 1971.

UPPER HEADON BEDS. The most prominent unit at Headon Hill is the Upper Headon Limestone, or **Hatherwood Limestone Member** (after Daley and Insole 1984). This consists of some 9m. of limestone, with pisolite beds, laminated sinter beds, lignites, and marls. It is usually fossiliferous, with freshwater gastropods, *Chara* and vertebrate remains. The ostracods mostly belong to Assemblage I, although there is one horizon, the **Theodoxus Bed**, which contains ostracods of Assemblage IV. Murray and Wright (1974) record very tiny foraminifers from the limestones, and interpreted the succession as being deposited in a lagoon of near normal marine salinity. However, the evidence from the molluscs, ostracods, vertebrates, and charaphytes, points overwhelmingly to the predominance of freshwater conditions. The foraminifers do suggest the presence of lagoonal conditions close by, and it is likely that they were windblown into the area. The Hatherwood Limestone is only developed at Headon Hill; it is totally absent in Totland Bay (Fig. 21), disappearing in a matter of a hundred meters or so (needless to say, no exposures!). To the north and east of Headon Hill its place appears to be taken by a series of white and chocolate-coloured sands with ripple drift bedding, mud drapes, and rare seams of brackish-water molluscs. These sands have been named the **Linstone Chine Member** by Daley and Insole (1984); they are poorly developed at the south west corner of Headon Hill where they are never more than 40cm. thick, thickening northwards to Hatherwood Point where they are 240cm. thick, always

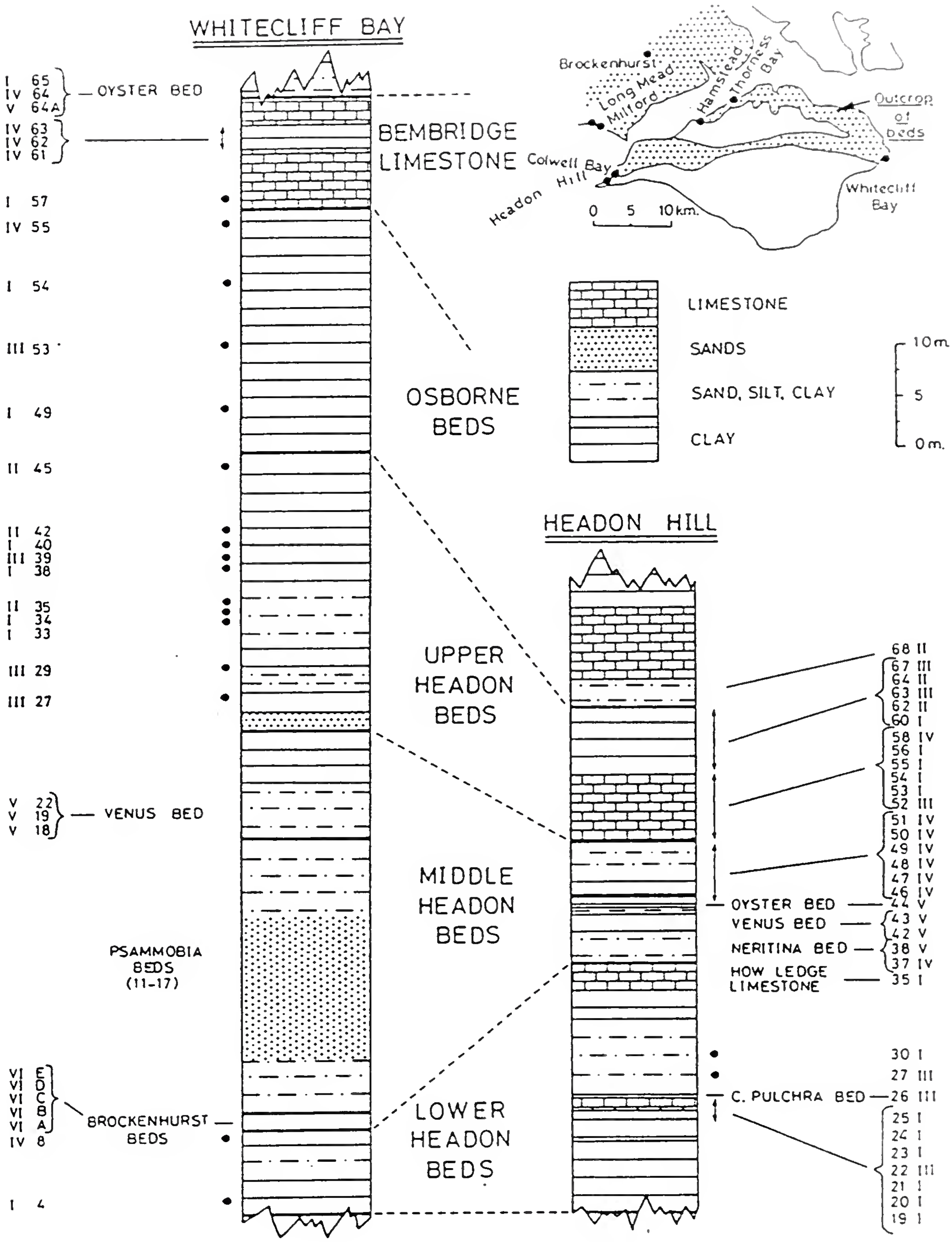


FIG.15. The Headon-Bembridge Beds at Headon Hill and Whitecliff Bay; arabic numerals indicate sampling points of Keen, 1977b, roman numerals the assemblages to which they belong. (From Keen, 1977b).

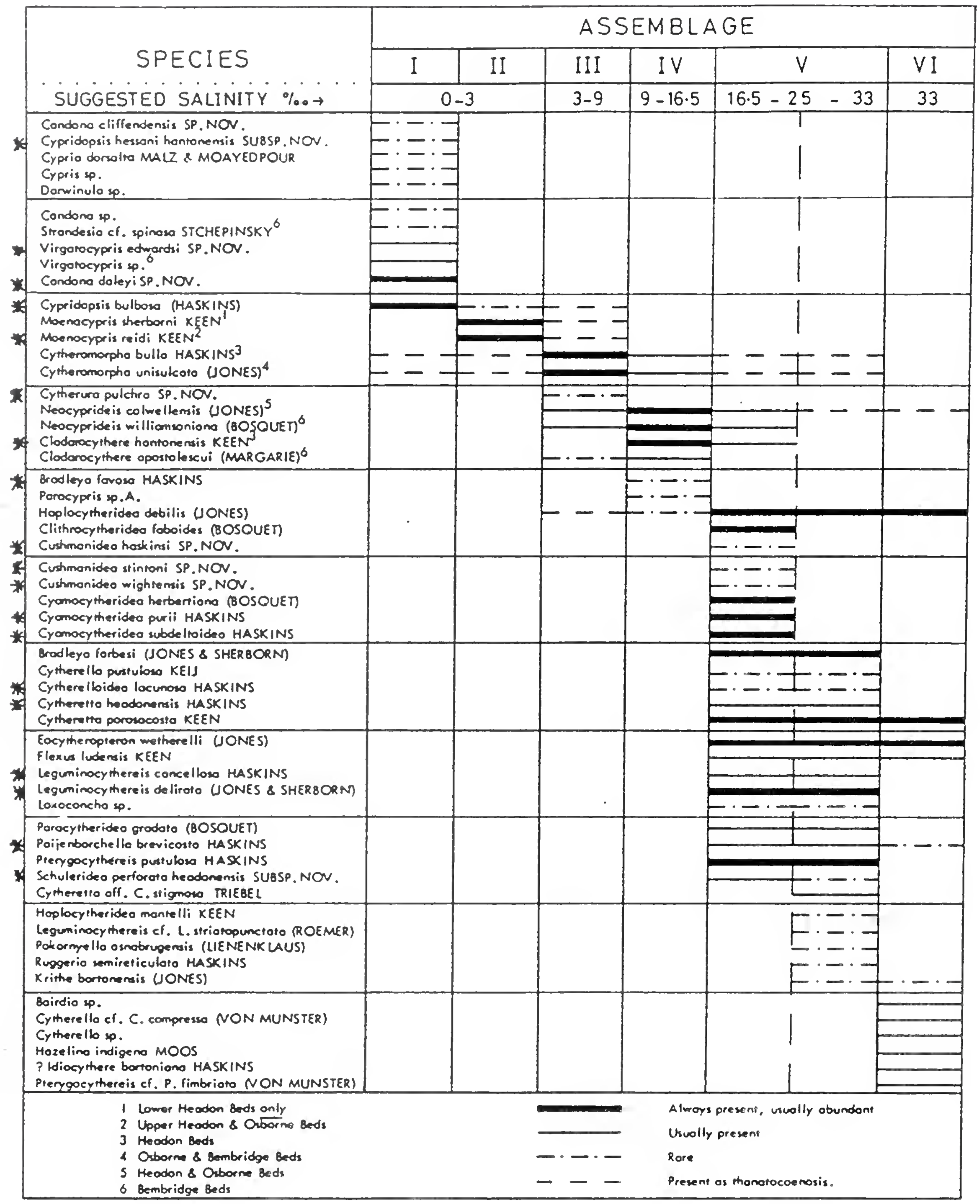


FIG.16. Ostracod Assemblages from the Headon-Bembridge Beds, with suggested salinities. (From Keen, 1977b). Asterisk indicates Headon Hill is the type locality for species.

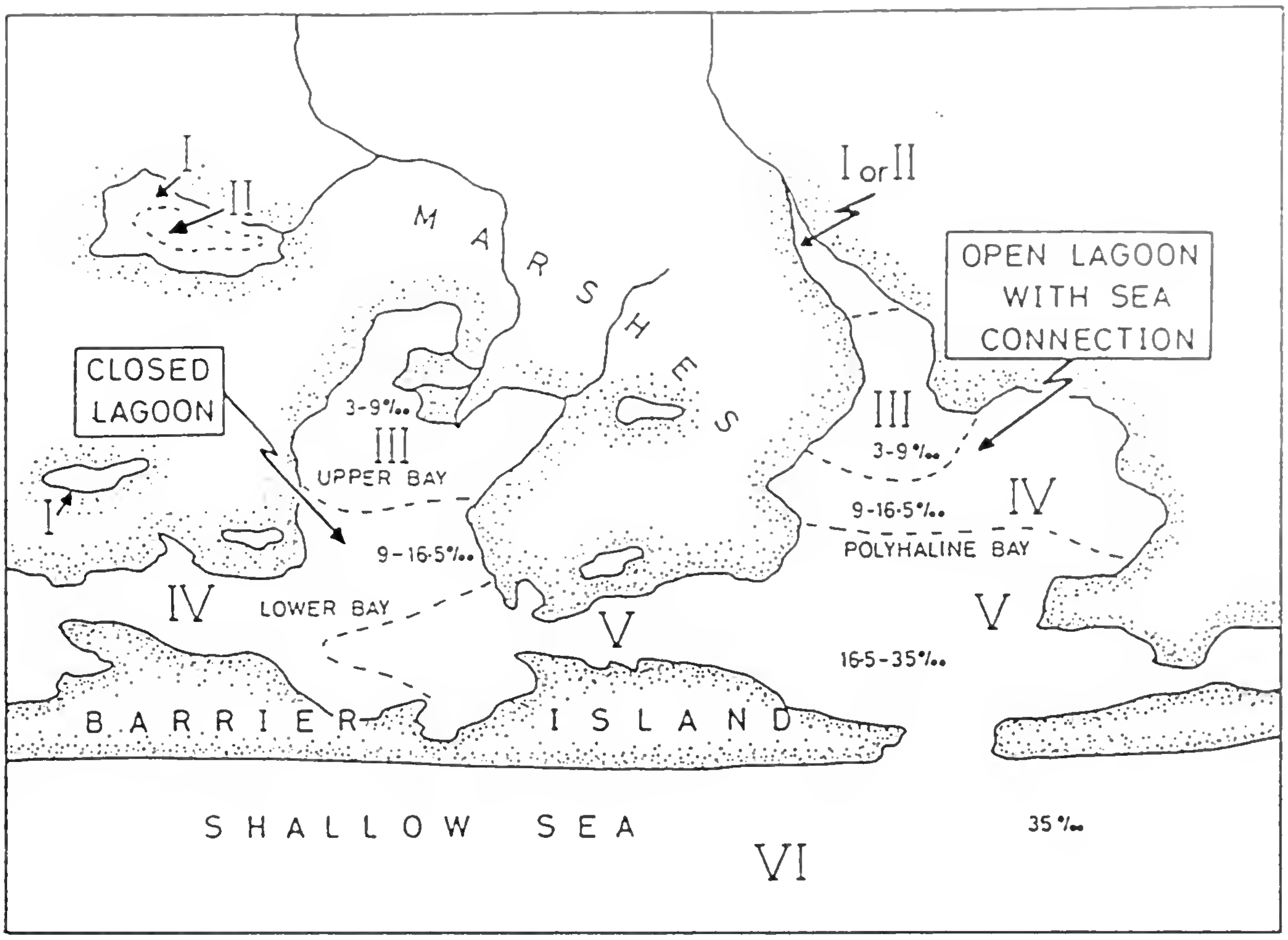


FIG.17. Suggested environments of the ostracod assemblages. (From Keen, 1977b).

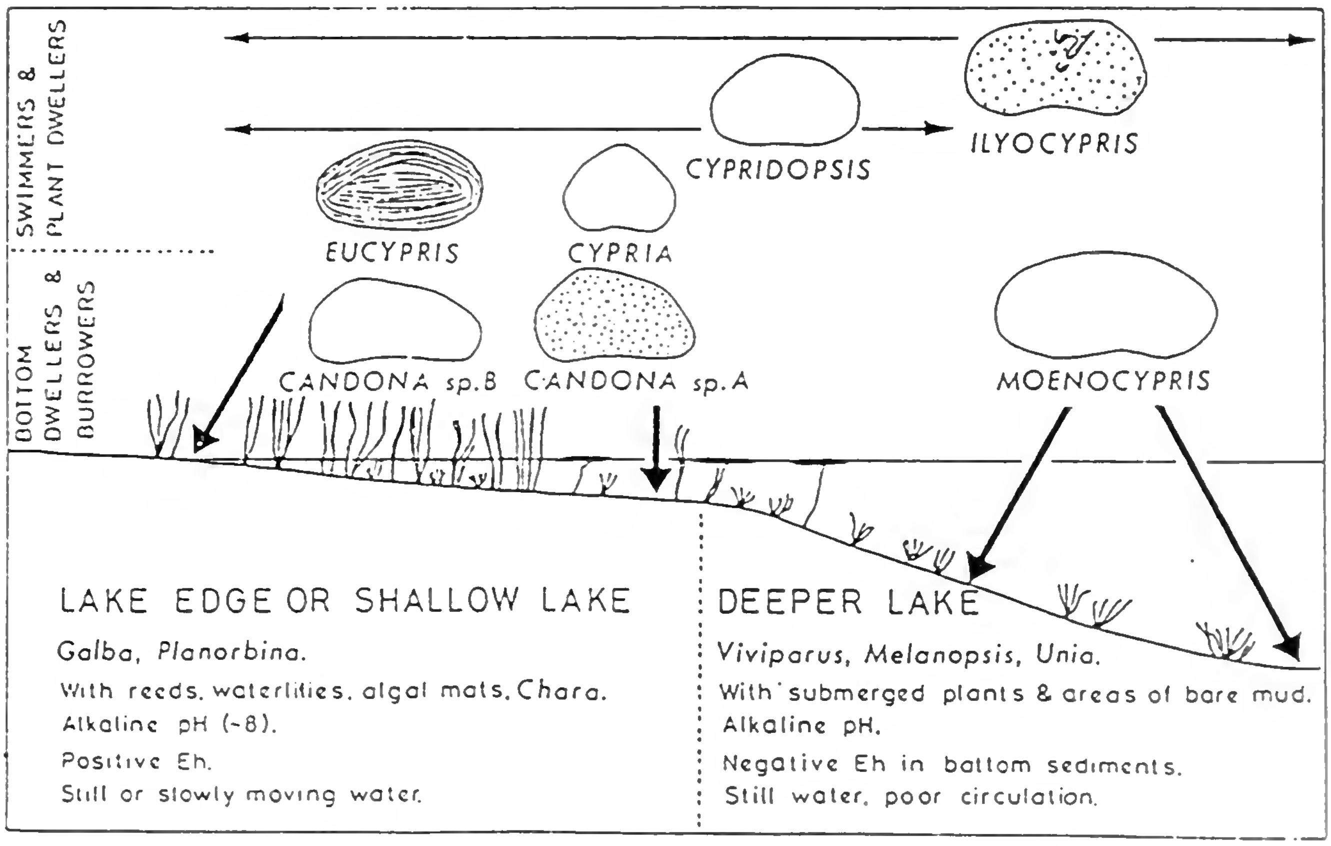


FIG.18. Suggested habitats of the freshwater assemblages. (From Keen, 1975).

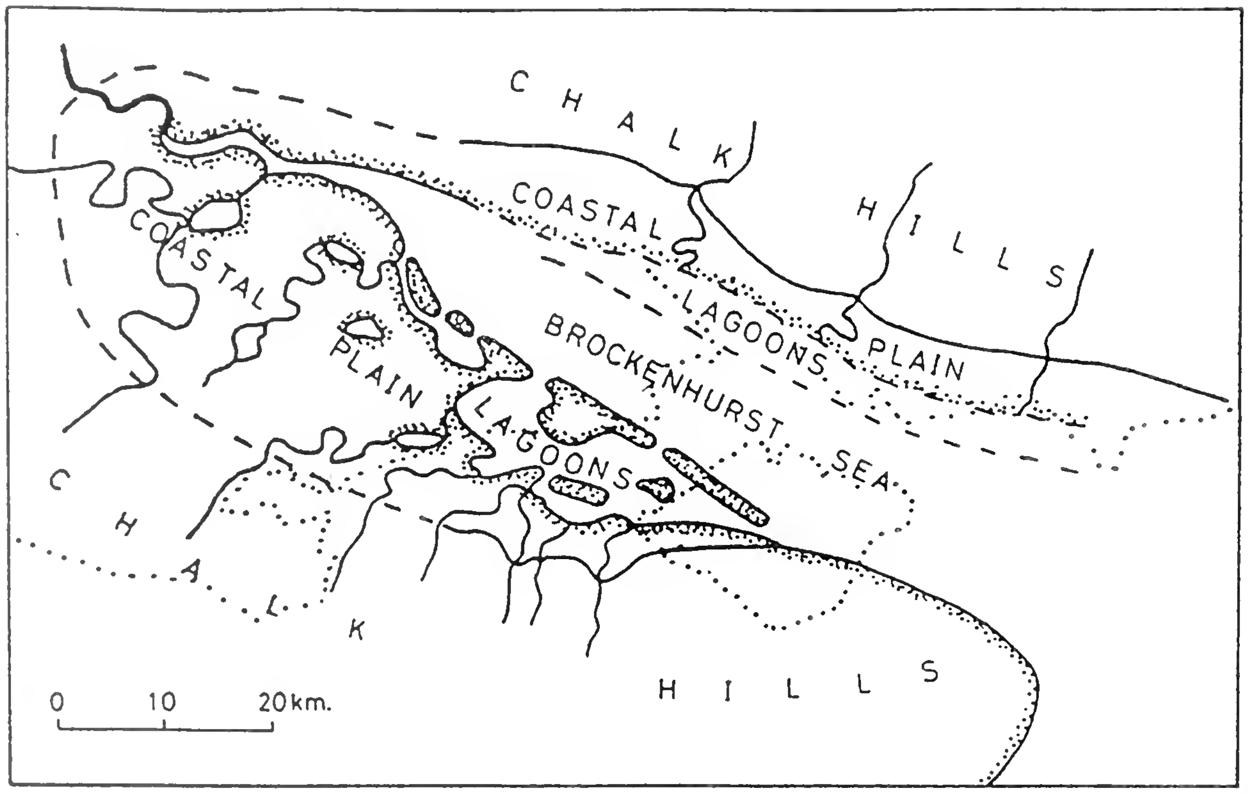


FIG.19. The palaeogeography of the Hampshire Basin during the time of deposition of the Brockenhurst Bed. (From Keen, 1977b).

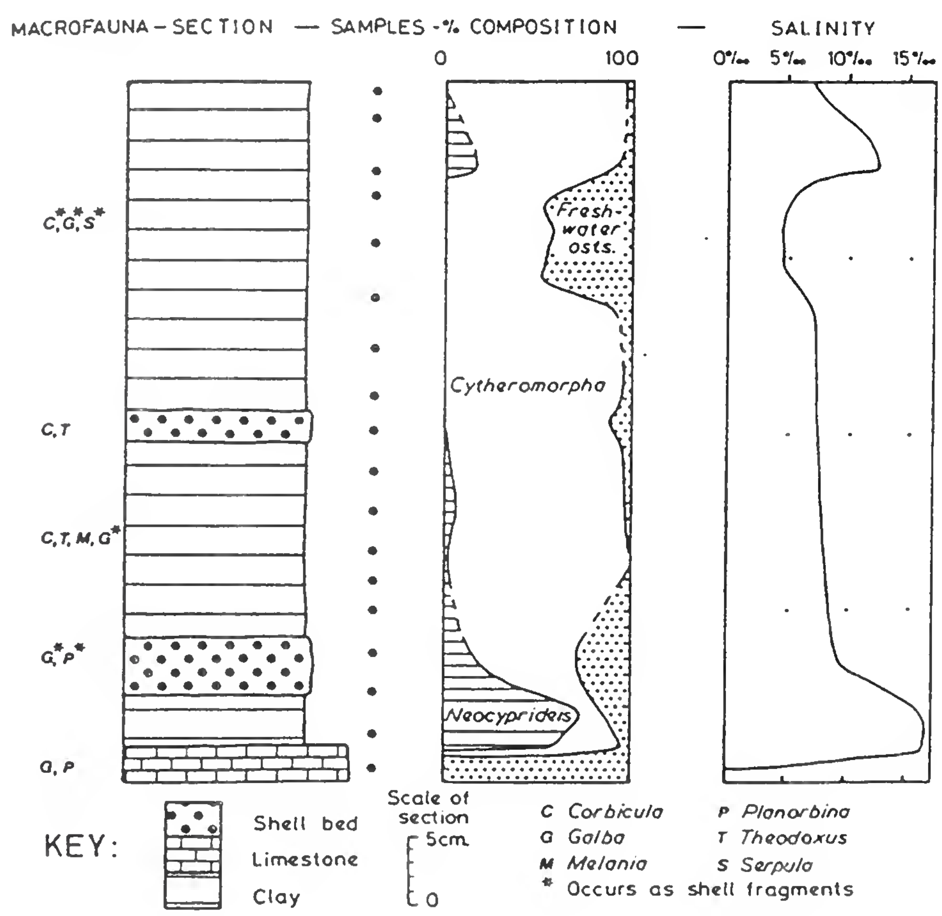
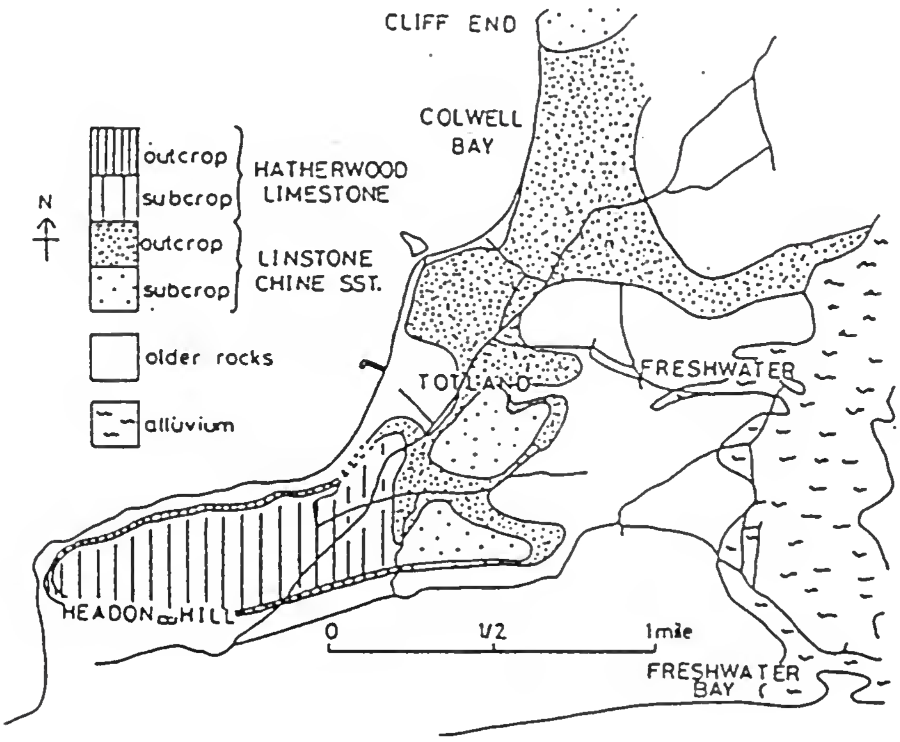


FIG.20. Section through the Cyrene pulchra Bed of Headon Hill. (From Keen, 1977b).

with a gradational contact with the overlying limestone. In Colwell Bay the Linstone Chine Member is over 4m. thick, and the limestone is mostly absent. These two members may be partially lateral equivalents, or the limestone may have been removed by erosion before deposition of the succeeding beds. The former of these interpretations is prefered, and it is envisaged that an enclosed lagoon existed to the north and east, with an area in the southwest cut off from this lagoon where lacustrine conditions predominated (Fig.21). Samples can be collected from the softer limestones and the Thedoxus Bed. The beds of predominantly grey clays and shales above the Hatherwood Limestone are poorly exposed at present; they contain the freshwater gastropod *Viviparus*, and the bivalve *Erodona*. The ostracods from these beds belong primarily to Assemblage II, dominated by *Moenocypris reidi* Keen 1972 (Type locality), with some brackish influence indicated by the presence of Assemblage III with *Cytheromorpha*.. The final horizon to be sampled is the Bembridge Limestone, normally very poorly exposed but recently excavated to give reasonable collecting opportunities. This is exposed at grid ref. 317863. Ostracods of Assemblage I can be found.



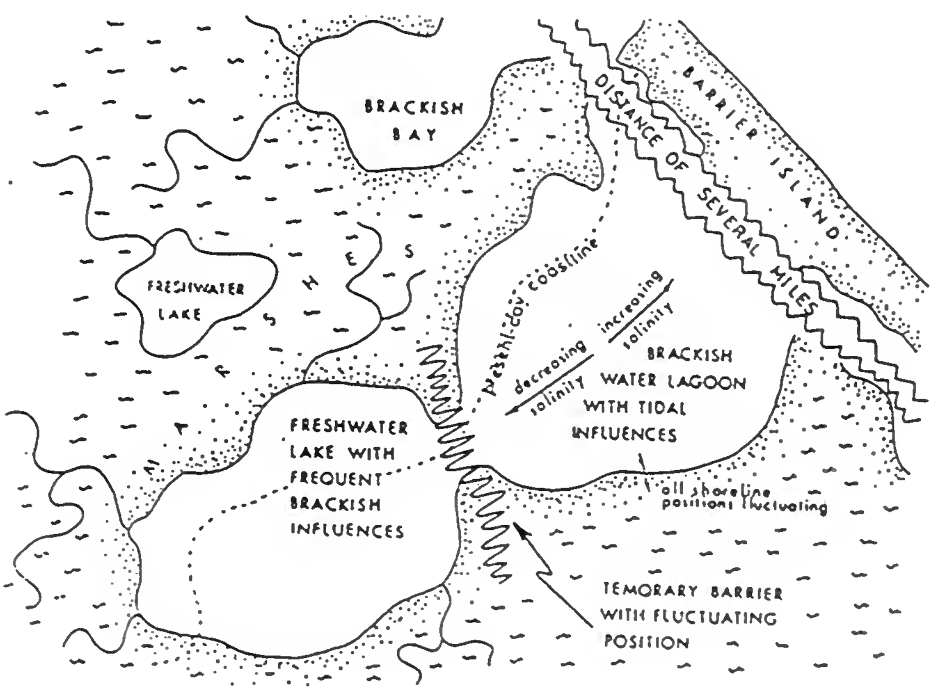


FIG.21a. The outcrop of the Hatherwood Limestone and Linstone Chine Member around Totland.
FIG.21b. The geography at the time of deposition of the two members.

COLWELL BAY

The section exposed in this bay is shown on Fig.22, together with the collecting points. This is the type locality for several species of Tertiary ostracods. The first horizons to be sampled will be the **Venus Bed**, and the overlying **Oyster Bed**, members of the Middle Headon Beds already sampled at Headon Hill. The ostracods belong to Assemblage Va, but contain fewer low salinity elements such as *Neocyprideis*, and more higher salinity elements such as *Cytheretta*. than at Headon Hill. This is the type locality for *Haplocytheridea debilis* (Jones 1857) and *Cytheretta porosacosta* Keen 1972. The Oyster Bed can be seen to infill a channel cut into the underlying beds near the collecting point. A third sample will be collected from blue clays 200m. above the Oyster Bed, yielding Assemblage IV with *Neocyprideis colwellensis* (Jones 1857) (Type locality). The overlying beds can be examined during a walk to the far end of the bay at Cliff End. The **Linstone Chine Member** is seen to be about 4m. in thickness, divisible into two units: a lower unit of laminated sands and clays, and an upper unit of white sands. Evidence of intraformational erosion can be seen by the presence of "pebbles"of clay and rotted pebbles of limestone. At Cliff End a 50cm. thick buff coloured limestone occurs above the Linstone Chine Member, and represents the Hatherwood Limestone studied at Headon Hill. This is the best horizon for collecting freshwater ostracods of Assemblage I, and is the type locality for *Candona cliffendensis* Keen 1977.

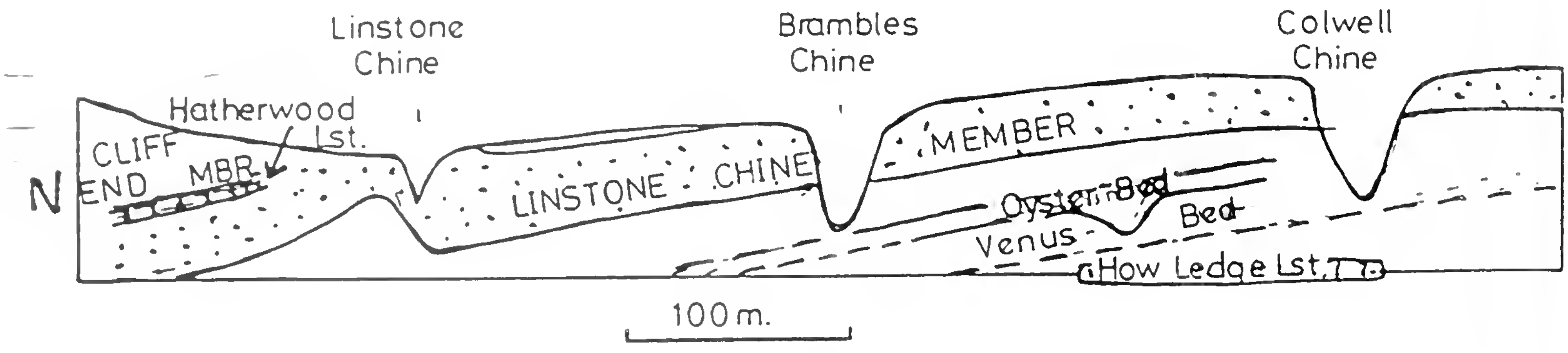


FIG.22. Section at Colwell Bay, with collecting points.

BOULDNOR CLIFF

The beds exposed at Bouldnor Cliff are the only definite Oligocene deposits in Britain. The section is now very overgrown so that access to the various horizons is difficult and time consuming. For these reasons it is only intended to visit and collect from the top of the cliff at Grid Ref.386906. It is hoped to provide samples from lower horizons. The succession at Bouldnor Cliff is given in Fig.23. The beds to be visited are the **Cerithium Bed** and the overlying **Corbula Bed**. As the names suggest,these contain brackish water molluscs such as *Pirenella* (= *Cerithium*), *Nystia*, and *Polymesoda*, with marine forms such as *Corbula* and *Athleta*.. The ostracod fauna is dominated by *Hemicyprideis montosa* (Jones and Sherborn 1889) and *Hemicyprideis elongata* Keen 1972*; other ostracods are: *Cladarocythere apostolescui* Margerie 1961, *Clithrocytheridea faboides* (Bosquet 1852), *Cyamocytheridea punctatella producta* Margerie 1961, *Cytheridea pernota* Oertli and Keij 1956, *Cytheromorpha zinndorfi* (Lienenklaus 1905), *Echinocythereis hamsteadensis* Keen 1972*, *Hammatocythere hebertiana* (Bosquet 1852) *Loxoconcha nystiana* (Bosquet 1852), and *Neocyprideis williamsoniana* (Bosquet 1852). All of these species are found in the Sannoisian Beds of the Paris Basin, allowing accurate correlation of the strata. The deposits accumulated in polyhaline lagoons, with fairly low salinity suggested by the abundance of *Hemicyprideis* and weak ornamentation of *Hammatocythere* and *Loxoconcha* (see Keen 1971, 1972a, 1982). Samples from the **Nematura Bed** and the **White Band** contain abundant *H.montosa*, while the **Waterlily Bed** is the type horizon for *Moenocypris forbesi* (Jones 1856).

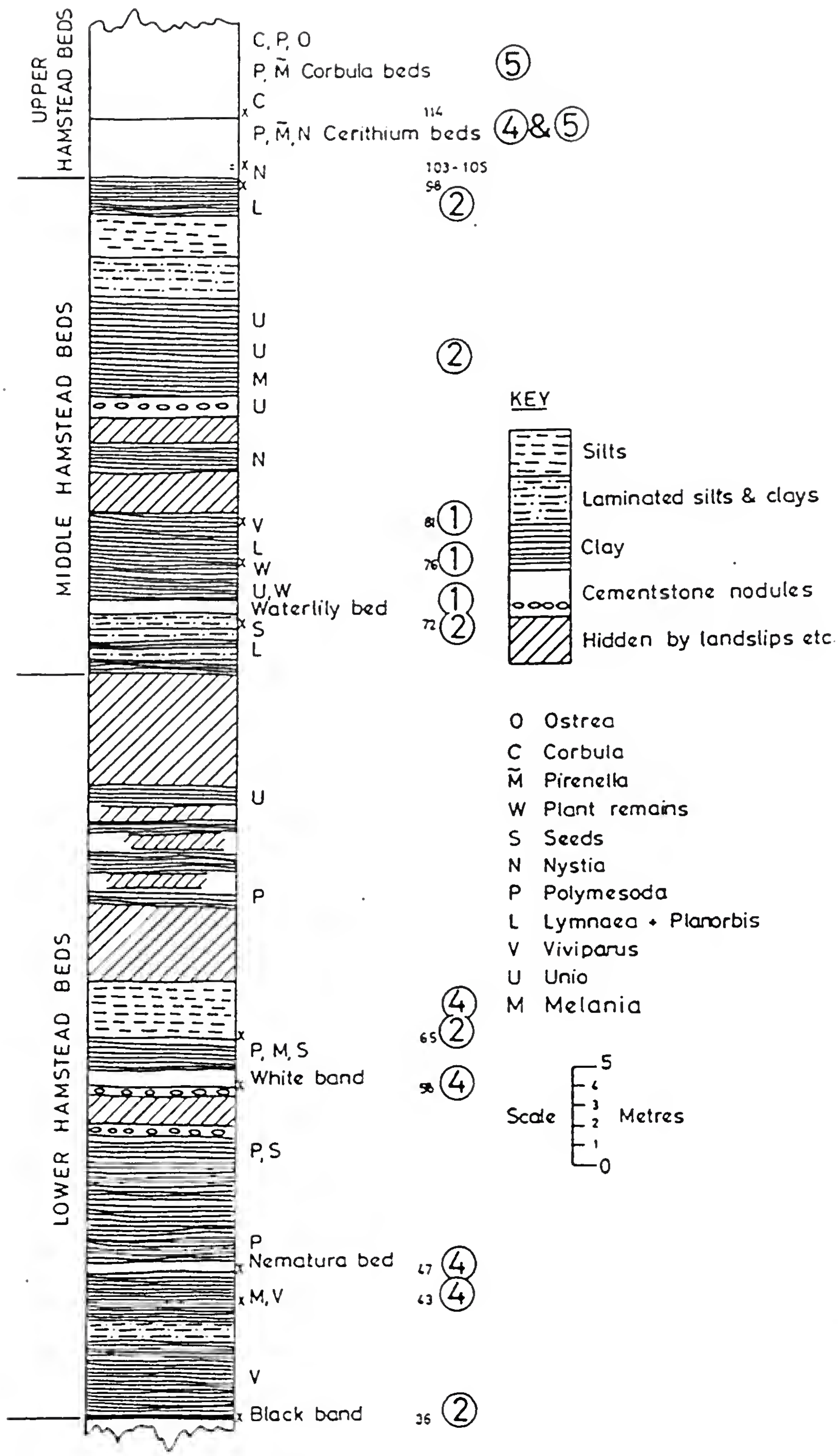


FIG.23. Section of the Hamstead Beds at Bouldnor Cliff, with sampling points. Large numbers refer to the ostracod assemblages of Fig.24, small numbers refer to samples of Keen 1972a. (From Keen, 1972a).

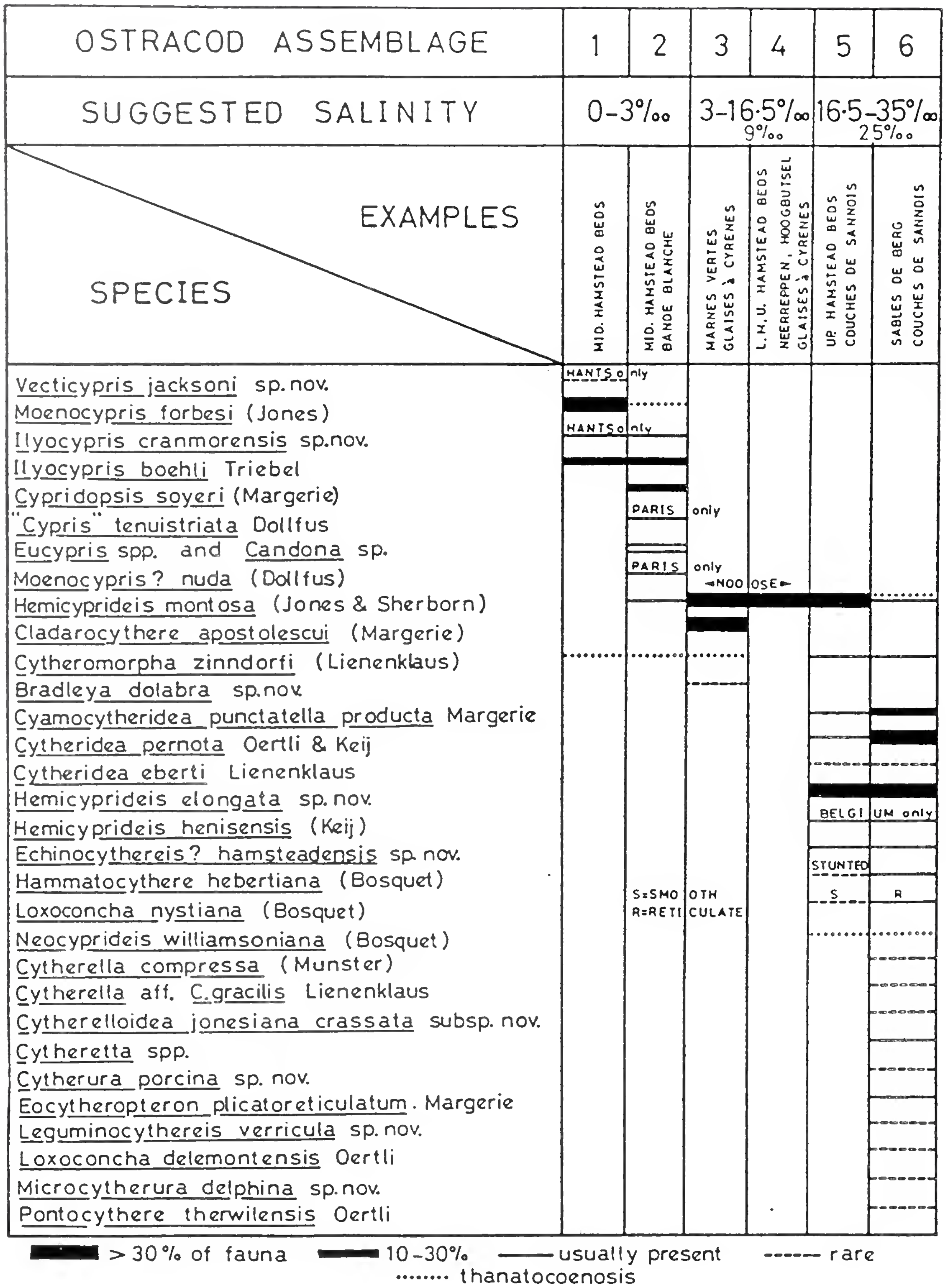


FIG.24. Sannoisian ostracod assemblages, (From Keen, 1972a).

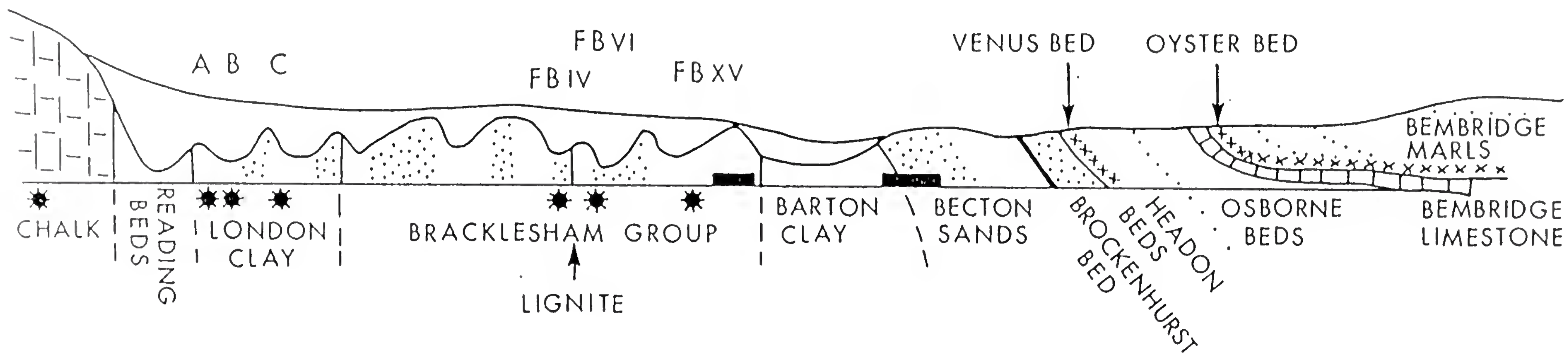


FIG.25. Sketch section of Whitecliff Bay, with collecting points.

WHITECLIFF BAY

The section at Whitecliff Bay is probably the most complete single sequence of Palaeogene rocks in Europe. As at Alum Bay, the succession in the main bay is vertical, becoming horizontal towards Bembridge Foreland (Fig.25). The chalk at the south-western end of the bay is formed of B.mucranata Zone chalk, but is not worth sampling due to its hardness and poor ostracod fauna. At low tide it is possible to walk round the point, cross Whitecliff Ledge and sample lower zones of the chalk. However, as the main emphasis of the excursion is to sample the Tertiary at this locality, a single sample will be collected from near the top of the A.quadrata Zone, which is of late Campanian age. The ostracods are typical of the Upper Chalk, dominated by Cytherella and bairdiids. The following species might be present: *Bairdoppilata septentrionalis*, *Cardobairdia minuta*, *Cytherella* spp., including C.ovata, *Phacorhabdotus lonsdaleiana*, and rare specimens of *Cythereis*, *Isocythereis*, and *Oertliella*.

Returning to the Palaeogene, the first horizon to be sampled will be the **LONDON CLAY FORMATION.** The exposures in the cliffs are often disappointing due to weathering, so when ever possible it is best to collect samples from foreshore exposures uncovered by the tides. However, it is impossible to predict which parts of the London Clay might be exposed, so the exact horizons sampled will depend upon conditions at the time of the visit. The lowest 45m. belong to the **Cytheretta venablesi Zone**, yielding rare *Trachyleberidea prestwichiana* (Jones and Sherborn 1889) and *Cytherella londinensis* Jones 1857. The base of the succeeding **zone of Cytheretta scrobiculoplicata** is drawn at the planktonic datum of Wright (1972), which coincides with the base of Division B of King (1981). The ostracod fauna is not abundant, but *Cytheretta scrobiculoplicata* (Jones 1857) and *Leguminocythereis* cf. *L.striatopuntata* (Roemer 1838) may be found, with *Cytheropteron brimptoni* Bowen 1953, *Cytheridea primitia* Haskins 1969, and *Loxoconcha sulcata* Haskins 1971 (Type Locality). The base of Division C (King 1981) is marked by a thin but distinctive pebble bed; a fossiliferous unit with *Pholadomya* and *Ditrupa* occurring 4m. above the base will be sampled, which contains rare specimens of *Echinocythereis* sp.A, indicating the presence of this ostracod zone. The succeeding yellow sands of Division C2 and D were formerly referred to as the **BAGSHOT SANDS**; they have not yielded any calcareous fossils, and the presence of bioturbation and cross bedding indicates deposition in a littoral environment.

The **BRACKLESHAM GROUP** consists mostly of marine sandy clays, unlike their time equivalents in Alum Bay, and yield rich ostracod faunas at certain levels. The sequence has now been divided into a series of formations (Fig.X), but in Whitecliff Bay it is still useful to refer to the individual numbered beds described by Fisher in 1862. The horizons to be sampled are indicated on Fig.25,26, and the distribution of the common ostracod species of the Bracklesham Group are shown in Fig.27

. The first horizon to be sampled is Fisher Bed IV at the top of the **WITTERING FORMATION.** This bed yields rare Nummulites planulatus and is therefore of Cuisian age. The ostracods indicate the **Novocypris whitecliffensis Zone**, with *Monsmirabilia corpuscula* Haskins 1968, *Cytheridea primitia* Haskins 1969, *Cytheridea rigida punctata* Haskins 1969, *Leguminocythereis bullata* Haskins 1970, and *Novocypris whitecliffensis* (Haskins 1968). This is the type locality and horizon for all these species. Fisher Beds VI and VII in the **EARNLEY FORMATION** are the next horizons to be sampled, are of Lutetian age, and belong to the **Cytheretta eocaenica ostracod zone.** The succeeding **zone of Cytheridea rigida rigida** ranges from Fisher Bed IX to XVII, which coincides with the Selsey Formation. Beds rich in *Nummulites variolarius* will be sampled, yielding very rich ostracod faunas (see Fig.Y). These beds are the type locality and horizon for *Cytheridea rigida rigida* Haskins 1969 and *Paracytheridea oertlii* Haskins 1970. **The BARTON CLAY** is not very well exposed and will not be sampled. The **BECTON SAND**, as at Alum Bay, contains no calcareous fossils, and indicates shallowing of the sea with a barrier island complex. Behind this barrier island the Headon Beds were deposited.

The **LOWER HEADON BEDS** of Whitecliff Bay are much thinner than at Headon Hill and yield poor ostracod faunas of ostracods of Assemblage IV. The base of the **MIDDLE HEADON BEDS** is formed by the **BROCKENHURST BEDS**. These contain a truely marine fauna, although still rather restricted, of Assemblage VI. Unfortunately the construction of a path down to the beach has now obliterated the only decent area for collecting microfossils, and, although the beds can still be examined in the cliffs,

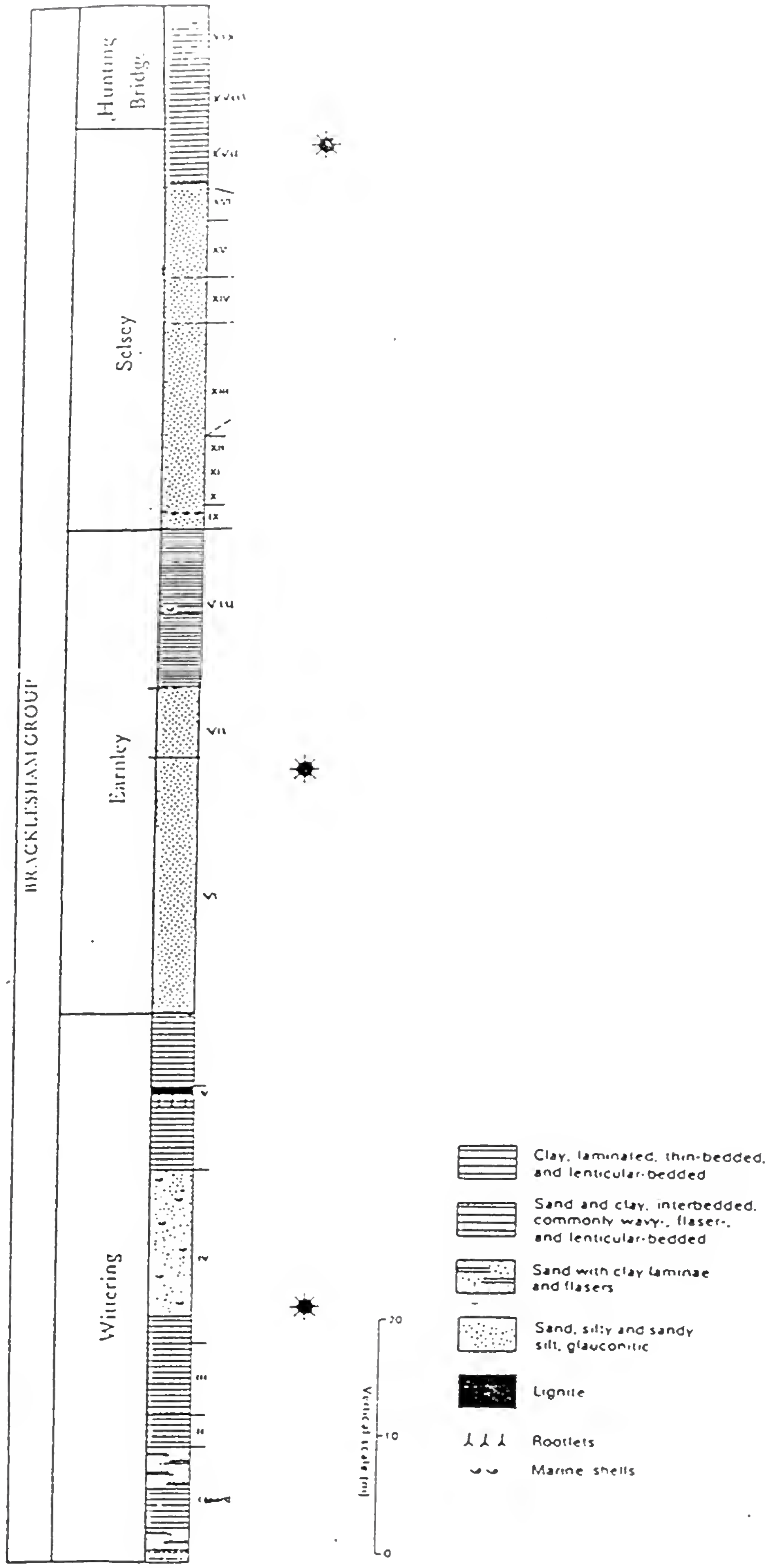


FIG.26. The Bracklesham Group of Whitecliff Bay, with collecting points.

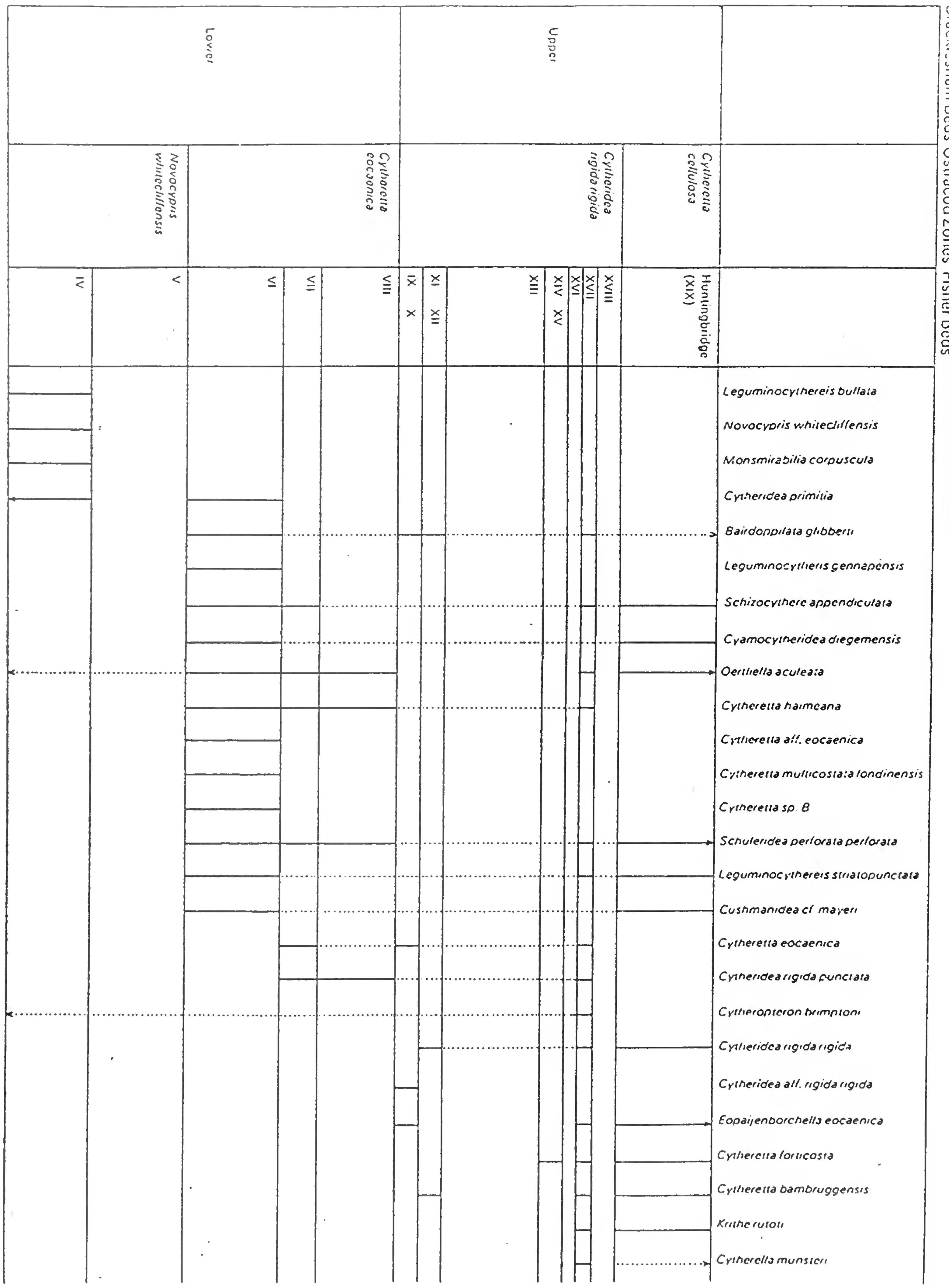


FIG.27. The distribution of ostracods in the Bracklesham Group.

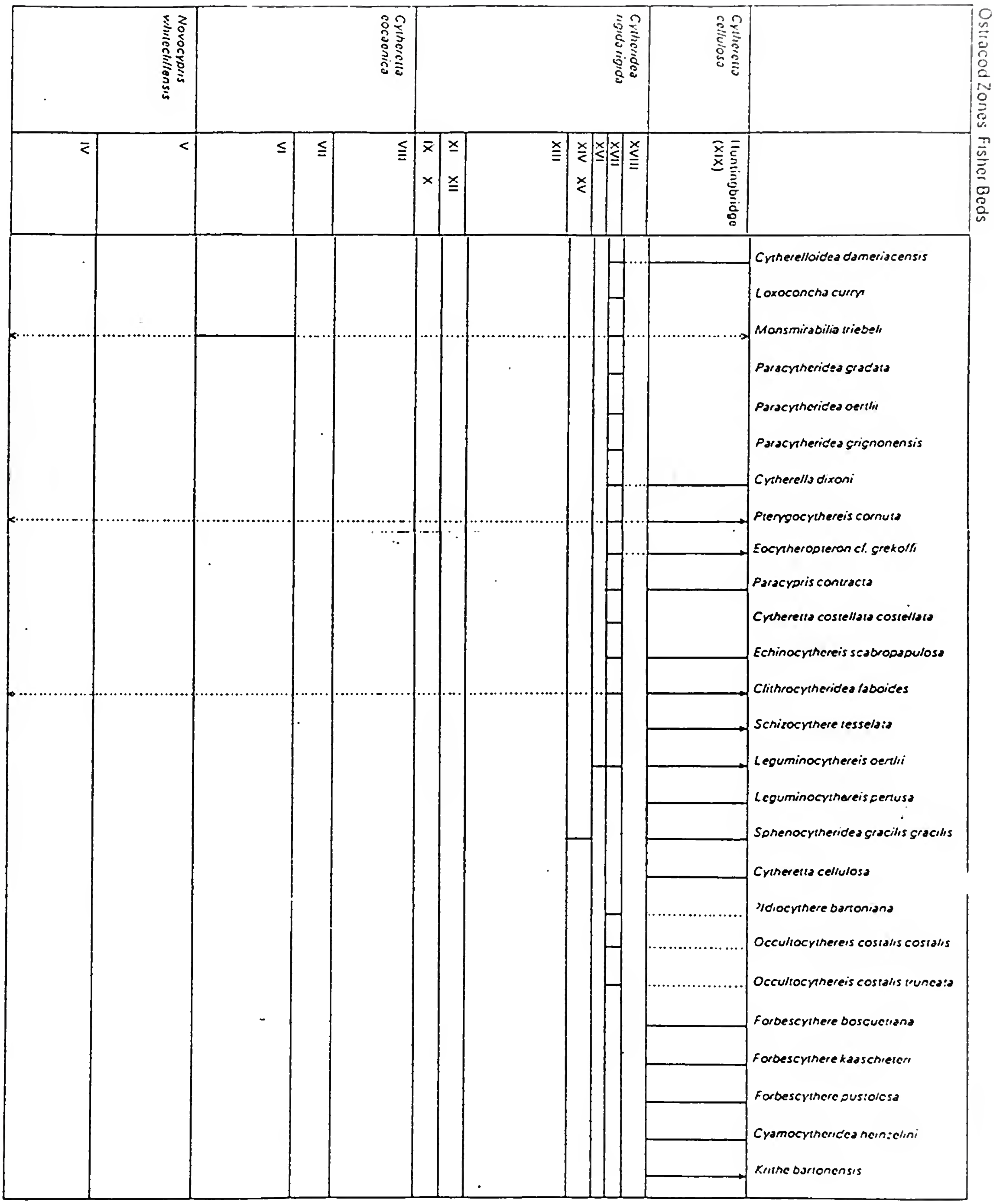


FIG.27. The distribution of ostracods in the Bracklesham Group.

samples taken there have been badly weathered and will not yield any ostracods. The so called "Barren Sands" above the Brockenhurst Beds contain moulds of marine fossils, but no calcareous fauna; they represent a barrier complex. Above them the **Venus Bed** yields ostracods of Assemblage Vb, indicating higher polyhaline conditions than at Headon Hill or Colwell Bay. This is the type locality for *Haplocytheridea mantelli* Keen 1973. The **UPPER HEADON** and **OSBORNE BEDS** may be sampled, and will yield ostracod Assemblages I,II, and III. The next beds to examined in detail however, will be the **BEMBRIDGE LIMESTONE.** This is generally a hard limestone with freshwater shells, but the softer layers yield freshwater ostracods; a prominent marl in the upper half contains *Neocyprideis williamsoniana* (Bosquet 1852), believed to be the descendant of *N.colwellensis* (Jones 1857). Finally, the **BEMBRIDGE OYSTER MARL** will be sampled, with its brackish-water ostracod fauna dominated by *Haplocytheridea debilis* (Jones 1857). This horizon represents a weak marine incursion which can be recognised as far west as Bouldnor Cliff. Some stratigraphers place the base of the Oligocene at this horizon; the ostracod fauna is essentially the same as that of the Middle Headon Beds and is placed in the **Haplocytheridea debilis Zone.** The great break in the ostracod fauna lies between this level and the next marine horizon, the Cerithium Beds of the Upper Hamstead Beds.

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