

The Natural History Museum
Micropalaeontology Library

**IN THE FOOTSTEPS OF T.R. JONES:
Lower Palaeozoic of Shropshire
and the Post-Palaeozoic of Avon, Dorset and Kent**

Field Guide for the Thirteenth International Symposium
on Ostracoda

Chatham 1997

Edited by
David J. Siveter and Alan R. Lord

**BRITISH MICROPALAEONTOLOGICAL SOCIETY
FIELD GUIDE No. 10**

Revised and reprinted 2004



000195782

PROTOZOA
SIV

**IN THE FOOTSTEPS OF T.R. JONES:
Lower Palaeozoic of Shropshire
and the Post-Palaeozoic of Avon, Dorset and Kent**

Field Guide for the Thirteenth International Symposium
on Ostracoda

Chatham 1997

*Edited by
David J. Siveter and Alan R. Lord*



**BRITISH MICROPALAEONTOLOGICAL SOCIETY
FIELD GUIDE No. 10: pages 1-65**

Revised and reprinted 2004
ISBN 1 870984 55 2

1870984552

IN THE FOOTSTEPS OF T. R. JONES:
Lower Palaeozoic of Shropshire
and the Post-Palaeozoic of Avon, Dorset and Kent

Edited by
David J. Siveter and Alan R. Lord



Yours very truly
T. R. Jones

BRITISH MICROPALAEONTOLOGICAL SOCIETY
FIELD GUIDE No. 10

CONTENTS

	<i>Page</i>
Introduction	5
Acknowledgements	5
Participants of the Post-Symposium Field Excursion	5
Map of the Field Excursion	6
Thomas Rupert Jones: pioneering studies on ostracods	
<i>by David J. Siveter and Alan R. Lord</i>	7
References	9
Lower Palaeozoic of Shropshire <i>by David J. Siveter</i>	11
Caer Caradoc	15
Comley Quarry	16
Smeathen Wood, Onny Valley area	18
Coates Quarry, Wenlock Edge	18
Lincoln Hill, Ironbridge	19
The Whitcliffe, Ludlow	21
The Goggin Road, Mortimer Forest	21
Deer Park Road, Mortimer Forest	24
Bengry Track, Aymestrey	26
Ludford Lane, Ludlow	26
References	29
Plate 1	34
Upper Triassic of Aust Cliff, Avon <i>by Ian D. Boomer</i>	36
Previous studies	37
Stratigraphical and ecological ranges of ostracods	37
References	39
Plate 1	40
Location of Aust Cliff on the Severn Estuary and Midford near Bath	41
Middle Jurassic of Midford near Bath, Avon <i>by Alan R. Lord</i>	42
References	43
Plate 1	44

Jurassic/Cretaceous of Durlston Bay, Dorset <i>by David J. Horne</i>	46
Studies by T. R. Jones	46
Stratigraphy	47
Stratigraphical and ecological ranges of ostracods	47
References	55
Plate 1	56
Marine Cretaceous of Charing, Kent <i>by Ian J. Slipper</i>	57
The "Chalk-detritus" of T. R. Jones	57
Leacon Hill	62
References	62
Plate 1	64
Photograph of Professor T. Rupert Jones	65

INTRODUCTION

This Field Guide was written for the occasion of the five day post-Symposium field excursion to classic areas of British Geology: the northern Welsh Borderland around Ludlow and the vicinities of Bath and the Severn Estuary in the West Country, Isle of Purbeck on the southern coast of England and Charing in Kent. The Field Guide and its itinerary celebrates the activities and palaeontological contributions of Professor T. Rupert Jones, a leading pioneer of micropaleontological studies and doyen ostracodologist in the second half of the 19th Century. The regions are but five of the many from which Jones obtained his British ostracod material; none-the-less, in spanning Cambrian to Cretaceous strata the areas selected reflect the broad stratigraphic and taxonomic distribution of his interests and published works.

On route from Greenwich to the Welsh Borderland we have the opportunity to acknowledge T.R. Jones by visiting his resting place, at the Church of St Leonard at Chesham Bois in Buckinghamshire. The second and part of the third days of the field trip will be spent sampling Lower Palaeozoic localities around the market towns of Ludlow and Much Wenlock in Shropshire. Sections in the counties of Avon, Dorset and Kent, exposing rocks of Mesozoic age, will be visited on the afternoon of Day 3 and on the 4th and 5th days.

The localities encompass a wide range of palaeoenvironments and offer the opportunity to sample for representatives of most of the major groups of ostracods. These include marine, brackish and freshwater faunas and embrace a variety of clastic and carbonate settings.

Users of this Field Guide should note that access to many of the localities is possible only by prior permission from the relevant landowners. Appropriate safety precautions and regulations should be observed at all times, especially when visiting potentially dangerous localities such as quarries and coastal exposures. It is strongly advised that users of this guide should be conversant with the contents of one of the 'standard' geological field safety guides before undertaking visits to the localities.

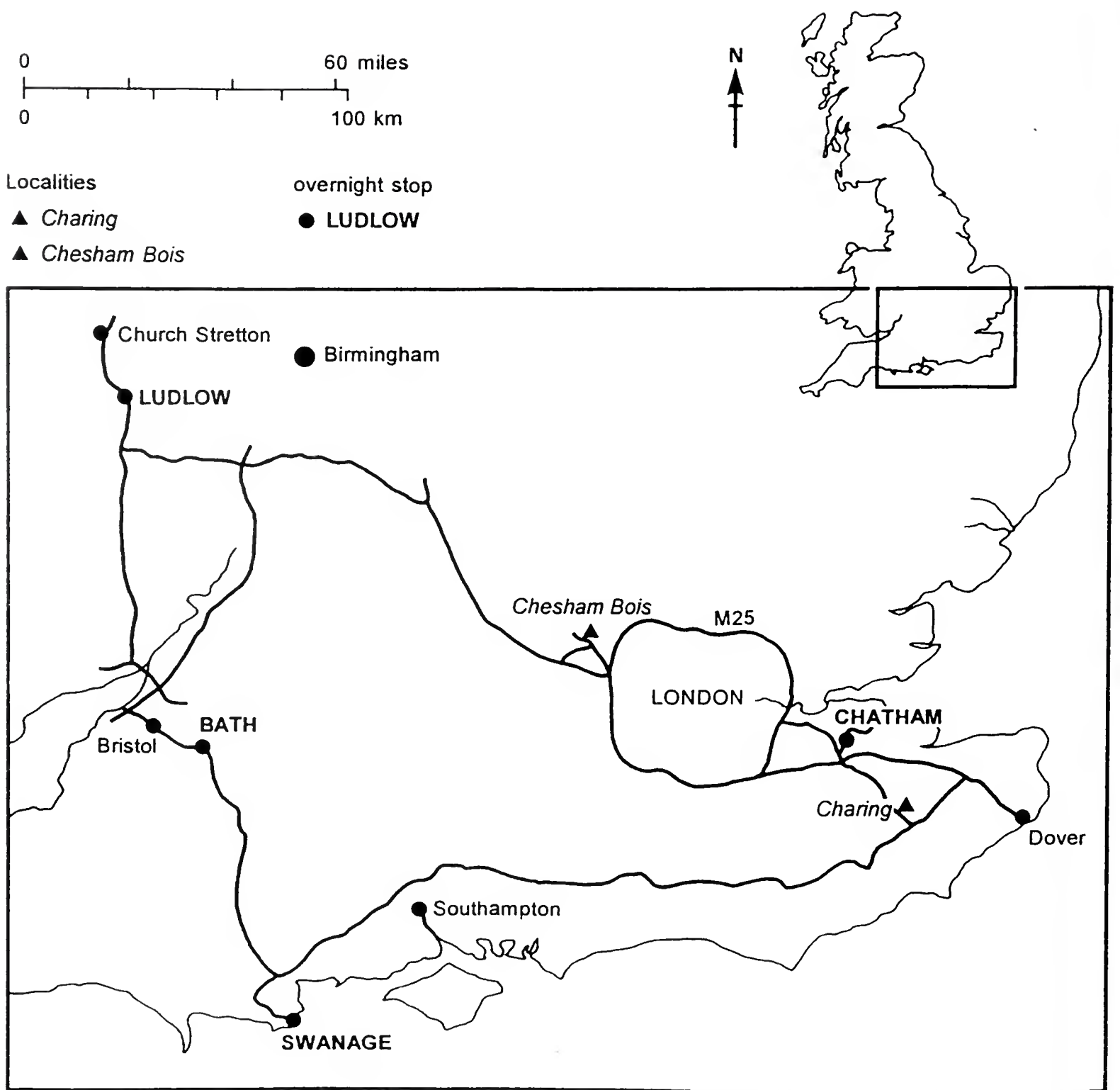
The leaders of the field excursion and the authors of this Field Guide are members of the Organising Committee of the 13th International Symposium on Ostracoda (ISO '97).

Acknowledgements:

We thank the following for permission for access: Bardon Aggregates of Much Wenlock; Major Minton-Beddoes of Cheney Longville; Mr R. Coles of Hinton Charterhouse; Mr R. Derry of Lincoln Hill; the Forestry Commission, Marches Forest District, Ludlow. We are grateful to Dr E.P.F. Rose (Royal Holloway University of London), Colonel in the Territorial Army, for advice on T.R.Jones' military connections. Janet Baker (University College London) and Rod Branson (University of Leicester) kindly helped with the production of this field guide

Participants of the Post-Symposium Field Excursion:

Gerhard & Karin Becker (Germany)
Ian Boomer (United Kingdom)
Guan Shanzheng (People's Republic of China)
David Home (United Kingdom)
Thomas Jellinek (Germany)
Y. Kaseda (Japan)
Masako Kato (Japan)
Alan Lord (United Kingdom)
Ilaria Mazzini (Italy)
David Siveter (United Kingdom)
Ian Slipper (United Kingdom)
Vera Tschigova (Russia)
Aby & Rosaline Weiss (Germany)
Wang Shang-qi (People's Republic of China)



Route and main localities of the Field Excursion *In the footsteps of T. R. Jones*

THOMAS RUPERT JONES: PIONEERING STUDIES ON OSTRACODS

David J. Siveter (University of Leicester)
and Alan R. Lord (University College London)

There were several pioneers in the documentation of British Palaeozoic ostracods. For example, the natural historian James de C. Sowerby, who figured what we now know to be a beyrichiacean valve in Murchison's classic 1839 work on the "Silurian System"; the British Geological Survey palaeontologist James Salter (e.g. 1848); Frederick McCoy (e.g. 1846), sometime Professor of Geology at Queen's University in Ireland; John Young of the Glasgow school and Carboniferous studies (see Robinson 1978a); and the, "ever-present Thomas Rupert Jones" who "served as touchstone and guide" (Robinson 1978a, p. 2). In 1855 Jones published on British Silurian and Ordovician material and in 1856 he described *Leperditia solvensis*, the first ever described bradoriid (supposed) ostracod, from the Cambrian of southwest Wales (see Siveter 1978a, 1978b and Williams & Siveter *in press* for a history of studies on British early Palaeozoic ostracods and bradoriids).

It was T.R. Jones who provided virtually all of what was published on British Palaeozoic ostracods over a period of more than 50 years covering the second half of the 19th Century. Together with sometime co-authors such as the medical practitioner turned geologist Dr Harvey B. Holl of Malvern, and armed with (especially Welsh Borderland) specimens sent for study by worthy amateurs such as George Vine of Sheffield, John Smith of Kilwinning, Scotland, and George Maw of Broseley, Shropshire, Jones chronicled such finds from the early Paleozoic in a large number of papers (e.g. for Welsh Basin material, see Jones 1855, 1856, 1869, 1881a, 1881b, 1881c, 1884, 1887a, 1887b; Jones & Holl 1865, 1869, 1886a, 1886b). He was equally prolific in his reports and monographs of Upper Palaeozoic ostracods: Gooday (1978) and Robinson (1978b, 1978c) list more than 20 papers in which Jones described mostly Carboniferous and also Devonian and Permian taxa from Britain and Ireland. In short, he established the distributional and taxonomic database on British Palaeozoic ostracods which was still the standard point of reference in the mid 20th Century.

It was from Maw's washings of the Silurian 'Wenlock Shale' that Vine picked the ostracod faunas later offered to Jones and Holl for study. The recording of localities and horizons of this material represents the first real use of ostracods as biostratigraphical tools in the British Lower Palaeozoic (see Vine 1882, 1887, 1888; also Smith 1881, 1892). George Maw was an industrialist, a collector, geologist and botanist. He was monographer of the genus *Crocus* and field companion of Sir Joseph Hooker. Maw lived at Benthall Hall on Benthall Edge, between Much Wenlock and Ironbridge, Shropshire. His factory at Jackfield (now a museum), Ironbridge, pioneered and then led the world in the modern manufacture of tiles. He also supplied much of the Silurian material for Davidson's monumental work on British brachiopods (e.g. see Davidson & Maw 1881). Not surprisingly, his method of processing the local Silurian shales for fossils used the "potter's process of leavigation", which was followed by "hand-picking the debris...spread out *thinly* on a slab of slate.." by "women at a wage of 1s. 6d. a day.." (Davidson & Maw 1881, pp. 100-101). T.R. Jones recognised Maw's efforts in providing material by naming ostracod species in his honour.

In fact Jones had commenced his ostracod studies in the Mesozoic and Cenozoic and as his reputation became established his interests widened, including his enormous output on Palaeozoic material outlined above. His first paper was on the Cretaceous (1849), incorporating material from the "Chalk-Detritus" of Charing (see I. J. Slipper herein); this was the first major work on British ostracods and pre-dated Baird's 1850 study of Recent taxa. Work on the Tertiary followed, including a monograph in 1857, and on the Pleistocene (1850). Jones frequently returned to earlier topics and supplementary monographs on the Cretaceous (Jones & Hinde 1890) and Tertiary (Jones & Sherborn 1889) were prepared.

Following retirement, and with failing eyesight, Jones recruited C.D. Sherborn

as his assistant to illustrate the monographic work and their first joint paper (1886) was on the Middle Jurassic (see A. R. Lord herein). Jones' work on non-marine Jurassic and Cretaceous ostracods from southern England is referred to by D. J. Horne (herein), and included important papers on the 'Purbeck' (e.g. 1885) and 'Wealden' (1888). Jones also worked on Upper Triassic and Lower Jurassic material (1894) - Rhaetic and Liassic (see I. D. Boomer herein). Unfortunately collections were muddled, which resulted in the inclusion of Purbeck non-marine taxa with older material, a confusion only finally clarified by Anderson (1964).

As his reputation grew, material was sent to Jones from all over the world and eventually publications covered assemblages ranging in age from Cambrian to Recent, marine and non-marine, from such geographically disparate areas as Siberia and Wyoming. T. R. Jones had a chronological overview of 'Entomostraca' assemblages unique in his generation, but found time also to publish significant work on foraminifera. He had a remarkable publishing record over a period of 56 years, from 1849 (Cretaceous of southern England) to 1905 (Palaeozoic of Maryland). During his long career he authored more than 100 papers and monographs and, with worthies such as H.B. Holl, H.B. Brady, J.W. Kirkby, H. Woodward, C.D. Sherborn and G.J. Hinde, he was joint author of almost half as many again. His pioneering contribution was noted by Robinson (1978a) when the first British Micropalaeontological Society special publication *A Stratigraphical Index of British Ostracoda* was dedicated to his memory.

T.R. Jones was born on October 1st, 1819, in Cheapside, London (Anon 1893). He was the son of John Jones, a silk merchant of London and Taunton, and Rhoda Jones (née Burbury) of Coventry. It was while attending the Reverend John Allen's school at Ilminster in Somerset, and observing the local Early Jurassic fossils, that he became interested in geology. After some years of scientific and medical education, during which time he was apprenticed to doctors in Somerset and Berkshire, in 1850 he was appointed Assistant Secretary to the Geological Society of London. He became Lecturer in Geology at the Royal Military College at Sandhurst in 1858, four years later he was promoted to Professor of Geology and was subsequently appointed to the Staff College at Camberley.

At Sandhurst Jones taught geology as it affected military interest in topography, sanitation and water supply, from 1858 until December 1870 when organisational changes forced his retirement from the Royal Military College (see Rose 1996 and *in press* for details of Jones' role in military education). However, Jones continued to teach at the Staff College until he finally retired in 1882. Geology was an optional study and was essentially abandoned from the curriculum on the retirement of Professor Jones. The value of geology in military education had clearly not been established during his employment. It is difficult not to surmise that the Professor of Geology was more interested in his Entomostraca than in the promotion of military geology!

T.R. Jones was sometime Editor of the *Geological Magazine* and the *Quarterly Journal of the Geological Society*, and from 1879 to 1881 he was President of the Geologists' Association. He was a Fellow of the Geological Society of London and in 1872 was elected a Fellow of the Royal Society. In presenting Professor Jones with the Lyell Medal of the Geological Society of London, the President, Dr. W.T. Blandford, noted his dedication and enthusiasm to his science.

The *Geological Magazine*, with which Jones was associated both as author and first Editor, noted that Jones had passed away "peacefully, after a long and useful life", at "Penbryn", Chesham Bois, Buckinghamshire, on April 13th, 1911, aged 91 (Anon 1911). As a mark of respect for Jones, an appeal was made by Professor W. W. Watts, then President of the Geological Society of London, by which "a committee has been formed to secure the means of providing some memorial in the aid of .." his widow and two daughters, and invalid son, for.. "Never in receipt of more than a very modest income, and only receiving a small pension upon his retirement 30 years ago from the post of Professor of Geology at the Royal Military College, Sandhurst, he was unable to make any suitable provision for his family at his death" (see *The Times*, May 8th 1911, p. 7).

References

- Anderson, F.W. 1964. Rhaetic Ostracoda. *Bull. Geol. Surv. GB.*, **21**, 133-174.
- Anon 1893. Eminent living geologists, No. 7, Professor Thomas Rupert Jones, F.R.S., F.G.S. *Geol. Mag.*, **10**, 1-3.
- Anon 1911. Obituary notice of Professor Thomas Rupert Jones, F.R.S., F.G.S. *Geol. Mag.*, **8**, 193.
- Baird, W. 1850. *The Natural History of the British Entomostraca*, pp. 138-182, pls 18-23. Ray Society, London.
- Davidson, T. & Maw, G.R. 1881. Notes on the physical character and thickness of the Upper Silurian rocks of Shropshire with the Brachiopoda they contain grouped in geological horizons. *Geol. Mag.*, **8**, 100-106.
- Gooday, A. 1978. The Devonian, pp. 101-120. In: Bate, R. H. & Robinson, E. (Eds), A stratigraphical index of British Ostracoda. *Geol. Jl. spec. iss.*, **8**.
- Jones, T.R. 1849. A Monograph of the Entomostraca of the Cretaceous Formation of England. *Monogr. palaeontogr. Soc. London*, **3**, 1-40.
- Jones, T.R. 1850. Description of the Entomostraca of the Pleistocene beds of Newbury, Copford, Clacton, and Grays. *Ann. Mag. Nat. Hist.*, (2), **6**, 25-28.
- Jones, T.R. 1855. Notes on Palaeozoic bivalved Entomostraca, No. II. Some British and foreign species of *Beyrichia*. *Ann. Mag. Nat. Hist.*, (2), **16**, 163-76.
- Jones, T.R. 1856. Notes on the Palaeozoic Bivalved Entomostraca, No. III. Some species of *Leperditia*. *Ann. Mag. Nat. Hist.*, (2), **17**, 81-101.
- Jones, T.R. 1857. A Monograph of the Tertiary Entomostraca of England. *Monogr. palaeontogr. Soc. London*, **9**, 1-68.
- Jones, T.R. 1869. *On the Palaeozoic bivalved Entomostraca*. [Paper read before the Geologists' Association, May 7th 1869.] 15pp, 23 text-figs. Hertford.
- Jones, T.R. 1881a. Notes on the Palaeozoic bivalved Entomostraca, No. XIV. Some Cambrian and Silurian *Leperditia* and *Primitia*. *Ann. Mag. Nat. Hist.*, (5) **8**, 332-50.
- Jones, T.R. 1881b. In Smith, J. Notes on a collection of bivalved Entomostraca and other Microzoa from the Upper Silurian strata of the Shropshire district. *Geol. Mag.*, (2), **8**, 70-75.
- Jones, T.R. 1881c. Notes on some Palaeozoic bivalved Entomostraca. *Geol. Mag.*, (2), **8**, 337-47.
- Jones, T.R. 1884. Notes on the Palaeozoic bivalved Entomostraca, No. XVIII. Some species of the Entomididae. *Ann. Mag. Nat. Hist.*, (5) **14**, 391-403.
- Jones, T.R. 1885. On the Ostracoda of the Purbeck Formation; with notes on the Wealden species. *Q. Jl. geol. Soc. Lond.*, **41**, 311-353.
- Jones, T.R. 1887a. Notes on the Palaeozoic bivalved Entomostraca, No. XXIII. On some Silurian genera and species (continued). *Ann. Mag. Nat. Hist.*, (5) **19**, 177-95.
- Jones, T.R. 1887b. Notes on the Palaeozoic bivalved Entomostraca, No. XXIV. On Some Silurian genera and species (continued). *Ann. Mag. Nat. Hist.*, (5) **19**, 400-16.
- Jones, T.R. 1888. Ostracoda from the Weald Clay of the Isle of Wight. *Geol. Mag.*, dec. 3, **5**, 534-539.
- Jones, T.R. 1894. On the Rhaetic and some Liassic Ostracoda of Britain. *Q. Jl. geol. Soc. Lond.*, **50**, 156-169.
- Jones, T.R. & Hinde, G.J. 1890. A supplementary Monograph of the Cretaceous Entomostraca of England and Ireland. *Monogr. palaeontogr. Soc. London*, **43**, 1-70.
- Jones, T.R. & Holl, H.B. 1865. Notes on the Palaeozoic bivalved Entomostraca, No. VI. Some Silurian species (*Primitia*). *Ann. Mag. Nat. Hist.*, (3), **16**, 414-25.
- Jones, T.R. & Holl, H.B. 1869. Notes on the Palaeozoic bivalved Entomostraca, No. IX. Some Silurian species. *Ann. Mag. Nat. Hist.*, (4), **3**, 211-29.
- Jones, T.R. & Holl, H.B. 1886a. Notes on the Palaeozoic bivalved Entomostraca, No. XX. On the genus *Beyrichia* and some new species. *Ann. Mag. Nat. Hist.*, (5), **17**, 337-63.

- Jones, T.R. & Holl, H.B. 1886*b*. Notes on the Palaeozoic bivalved Entomostraca, No. XXI. On some Silurian genera and species. *Ann. Mag. Nat. Hist.*, (5), **17**, 403-14.
- Jones, T.R. & Sherborn, C.D. 1886. On the Microzoa found in some Jurassic Rocks of England. *Geol. Mag.*, dec. 3, **3**, 271-274.
- Jones, T.R. & Sherborn, C.D. 1889. A supplementary Monograph of the Tertiary Entomostraca of England. *Monogr. palaeontogr. Soc. London*, **42**, 1-68.
- Jones, T.R. 1905. Some Palaeozoic ostracodes from Maryland. *John Hopkins University Circular*, no. 3, 30-33. Baltimore, Maryland.
- McCoy, F. 1846. *A synopsis of the Silurian fossils of Ireland, collected from the several districts ~ R. Griffith, F.G.S., the whole being named and the new species drawn and described by F. McCoy*. 72pp., 5pls., Dublin.
- Murchison, R.I. 1839. *The Silurian System founded on geological researches in the counties of Salop Hereford, Radnor, Montgomery, Caermarthen, Brecon, Pembroke, Monmouth, Gloucester, Worcester and Stafford; with descriptions of the coalfields and overlying formations*, xxxii + 768pp., 37pls., London.
- Robinson, E. 1978*a*. An outline history of ostracod studies, pp. 1-20. *In*: Bate, R. H. & Robinson, E. (Eds.), *A stratigraphical index of British Ostracoda*. *Geol. Jl. spec. iss.*, **8**.
- Robinson, E. 1978*b*. The Carboniferous, pp. 121-166. *In*: Bate, R. H. & Robinson, E. (Eds.), *A stratigraphical index of British Ostracoda*. *Geol. Jl. spec. iss.*, **8**.
- Robinson, E. 1978*c*. The Permian, 167-174. *In*: Bate, R. H. & Robinson, E. (Eds.), *A stratigraphical index of British Ostracoda*. *Geol. Jl. spec. iss.*, **8**.
- Rose, E.P.F. 1996. Geologists and the army in nineteenth century Britain; a scientific and educational symbiosis? *Proc. Geol. Assoc.*, **107**(2), 129-141.
- Rose, E.P.F. *in press*. Geological training for British Army officers; a long-lost cause? *Royal Engineers Jl.*
- Salter, J.W. 1848. *In*: Phillips, J. & Salter, J.W. Palaeontological appendix to Professor J. Phillip's memoir on the Malvern Hills, compared with the Palaeozoic districts of Abberley etc. *Mem. Geol. Surv. G.B., London*, 2, (1), viii-xiv, 331-386, pls 4-30. 46.
- Siveter, D. J. 1978*a*. The Ordovician, pp. 41-56. *In*: Bate, R. H. & Robinson E. (Eds.), *A stratigraphical index of British Ostracoda*. *Geol. Jl. spec. iss.*, **8**.
- Siveter, D. J. 1978*b*. The Silurian, pp. 57-100. *In*: Bate, R. H. & Robinson E. (Eds.), *A stratigraphical index of British Ostracoda*. *Geol. Jl. spec. iss.*, **8**.
- Smith, J. 1881. Notes on a collection of bivalved Entomostraca and other Microzoa from the Upper Silurian strata of the Shropshire district. *Geol. Mag.*, (2), **8**, 70-75.
- Smith, J. 1892. English Upper Silurian Ostracoda. *Trans. Nat. Hist. Soc. Glasg.*, **3**, 134-58.
- Vine, G.R. 1882. Notes on the Polyzoa of the Wenlock Shales, Wenlock Limestone, and shales over Wenlock Limestone from material supplied by G. Maw Esq. *Q. Jl. geol. Soc. Lond.*, **38**, 44-49.
- Vine, G.R. 1887. Notes on the palaeontology of the Wenlock Shales of Shropshire (Mr. Maw's washings, 1880.). *Proc. Yorks. geol. polytech. Soc.*, **9**, 224-48.
- Vine, G.R. 1888. Notes on the distribution of the Entomostraca in the Wenlock Shales. Mr. Maw's washings. Part 1, Buildwas Beds. *Proc. Yorks. geol. polytech. Soc.*, **9**, 393-405.
- Williams, M. & Siveter, D.J. *in press*. Cambrian and Tremadoc bradoriid and phosphatocopid arthropods of Britain. *Monogr. palaeontogr. Soc. London*.

LOWER PALAEOZOIC OF SHROPSHIRE

David J. Siveter (University of Leicester)

Wales and its contiguous margins across the Welsh Borderland and English Midlands to the east and southeast is generally acknowledged to have been the site of an ensialic marginal or back-arc basin on the southern margin of the Iapetus Ocean during late Pre-Cambrian through to late Silurian times. Throughout the Lower Palaeozoic southern Britain south of the Southern Uplands of Scotland, including the Welsh Basin, is believed to have been part of the microcontinent of Avalonia which drifted slowly northwards from initially high, to near equatorial latitudes by the Silurian (e.g. Pickering & Smith 1995). The patterns of distribution of Welsh Basin and other 'North Atlantic' ostracods endorse this palaeogeographical model (Schallreuter & Siveter 1985, Vannier, Siveter & Schallreuter 1989). The later stages of this northerly drift, during late Ordovician to early Devonian times, coincided with the gradual demise of the Iapetus Ocean and the formation of many of the Caledonian structural features with their characteristic NE-SW trend. The sinistral strike-slip related collision between 'European' and North American plates culminated in the formation of the Old Red Sandstone continent.

The axis of the Lower Palaeozoic Welsh Basin is approximately NE-SW, along strike through central Wales. In general the more offshore, deeper water deposits, such as graptolitic shales, turbidites and associated fan deposits occur in central and parts of North Wales (see, for example, the sequence stratigraphic analysis by Woodcock & Gibbons 1988). The more shallow marine, shelly-rich sediments occur in South Wales (typically south of the Tywi lineament), the Welsh Borderland (e.g. Shropshire) and across to the English Midlands, thus reflecting the position of the marginal platform regions. The southern and eastern margins of the basin is more easily defined than the northern margin. Numerous transgressive and regressive sea level pulses combined with local tectonic and (particularly throughout the Ordovician) volcanic events to produce an often complex, lateral and vertical interdigitating facies mosaic throughout the period.

The Welsh Borderland county of Shropshire is small, yet its geology is extremely varied. It has representatives of all the major geological systems except the Cretaceous. The Cambrian sequence of Shropshire (700m) records a gradual, overall transgression in which glauconitic and phosphatic limestones and sandstones and finally shales succeed basal quartzites overlying late Precambrian volcanics. During the Ordovician the eastern Welsh Borderland part of the 'Midland Platform' (i.e. the Church Stretton district of Shropshire) witnessed shallow water deposition of shelly-rich limestones and sandstones. The early Silurian, Llandovery transgression resulted in the submergence of much of the eastern Welsh Borderland and English Midlands platform. Minor regressive events are coincidental with the deposition of Silurian limestone in parts of the Welsh Borderland, including the late Wenlock, reef-bearing Much Wenlock Limestone Formation of Shropshire. During later Ludlow times a regressive pulse began which culminated in the occurrence of reduced marine conditions during the Pridoli and eventually non-marine, fluvial conditions ('Old Red Sandstone') during the latest Silurian-Devonian final demise of the basin. The deeper parts of the Welsh Basin during the Silurian, in central and west Wales, had turbidite and graptolitic mud deposition. It is from these more offshore, basinal slope areas, for example in Powys and 'Denbigh', that pioneer pelagic, myodocope ostracodes have been documented (Siveter 1984, Siveter *et al.* 1987, 1991).

Details of the Cambrian, Ordovician and Silurian sequences of the British Isles are given, for example, in the Special Reports of the Geological Society of London (Cowie *et al.* 1972, Williams *et al.* 1972, Cocks *et al.* 1992) and the Silurian 'Global Standard' volume (Holland & Bassett 1989). Toghill & Chell (1984) provide a general introduction to the geology of Shropshire; reference to more specialist studies are given in under the localities below.

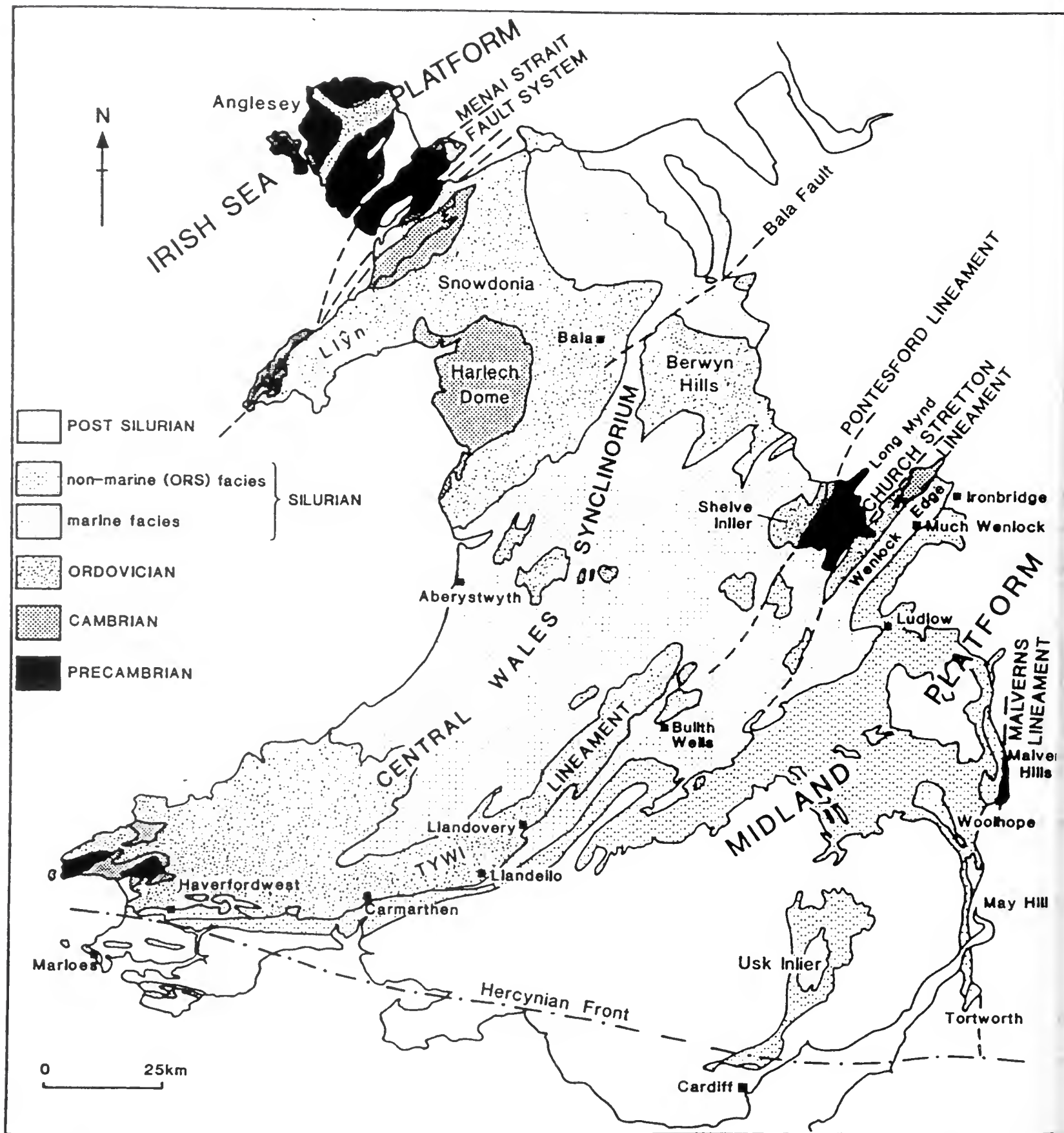


Fig. 1. Distribution of Precambrian and Lower Palaeozoic rocks of the Welsh depositional basin (after Bassett *et al.* 1986).

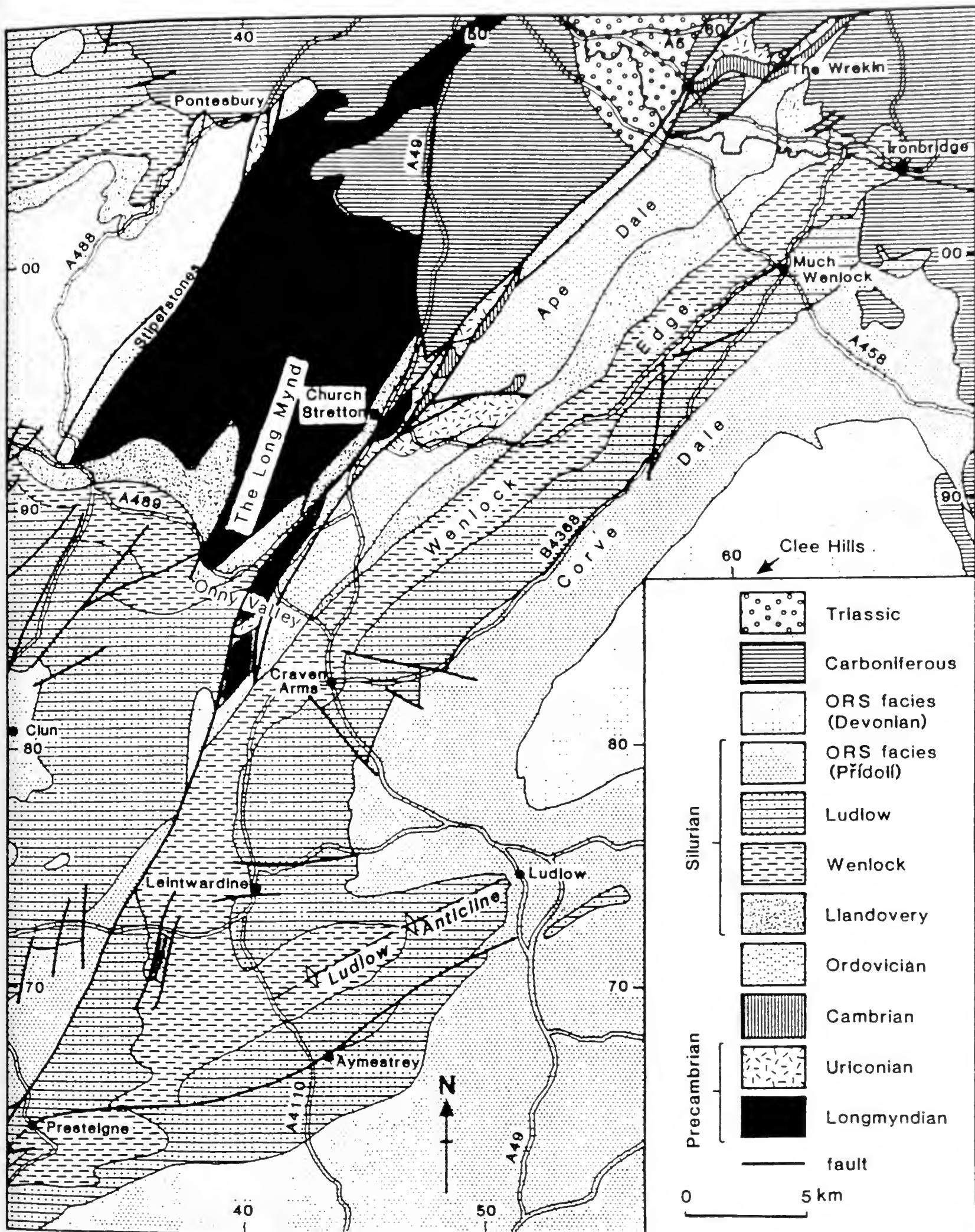


Fig. 2. General geological map of part of Shropshire (from Siveter *et al.*, 1989)

SYSTEM	SERIES	SUBSTAGES /STAGES	LITHOSTRATIGRAPHY		
SILURIAN	PRIDOLI	Stages not yet defined	Ledbury Formation Temeside Shales Formation Downton Castle Sandstone Fm { Sandstone Mbr. Platyschisma S.Mbr. Ludlow B.B. Mbr.		
			LUDLOW	Ludfordian	Upper Whitcliffe Formation Lower Whitcliffe Formation Upper Leintwardine Formation Lower Leintwardine Formation
				Gorstian	Upper Bringewood Formation Lower Bringewood Formation Upper Elton Formation Lower Elton Formation
	WENLOCK	Homerian	Much Wenlock Limestone Formation Coalbrookdale Formation { Farley Member Apedale Member		
		Sheinwoodian	Buildwas Formation		
	LLANDOVERY	Telychian	Purple Shales Pentamerus Beds		
		Aeronian	Kenley Grit		
	ORDOVICIAN	CARADOC	Onnian	Onny Shale Formation	
			Actonian	Acton Scott Formation	
			Marshbrookian	Cheney Longville Formation	
Woolstonian			Alternata Limestone Formation		
Longvillian			Horderley Sandstone Formation		
Soudleyan			Glenburrell Formation		
Harnagian			Smeathen Wood Formation		
Costonian			Coston Formation		
TREMADOC		Migneintian Cressagian	Shinerton Shales		
CAMBRIAN		MERIONETH	Stages not yet defined	Bentleyford Shales Shoot Rough Road Shales	
	ST. DAVID'S	Upper Comley Group			
	COMLEY	Lower Comley Limestone Lower Comley Sandstone Wrekin Quartzite			
PRE-CAMBRIAN	Series not yet defined	Longmyndian	Wentnor Group Bridges Formation Bayston-Oakswood Formation		
			Stretton Group Portway Formation Lightspout Formation Synalds Formation Burway Formation Stretton Shale Formation		
			Uriconian Volcanics		

Fig. 3. Stratigraphy of the Precambrian and Lower Palaeozoic of eastern Shropshire.

The seminal studies of T.R. Jones and his associates on the early Palaeozoic ostracods of Britain, and in particular those from sequences in the Welsh Borderland, are summarized by Siveter & Lord (herein). The taxonomic scope, biostratigraphy, palaeoecology and palaeogeographical significance of the ostracods and bradoriids of the Welsh Basin are now known in some detail (e.g. see Siveter 1974, 1978a, 1978b, 1980, 1984, 1988, 1989, Siveter *et al.* 1987, 1991, Jones 1986, 1987, Lundin *et al.* 1991, Williams *et al.* 1994, Siveter & Williams 1995, Williams & Siveter *in press* and references therein). The lists of taxa in the ostracod faunas discussed below are not complete; rather, they indicate the more distinctive or common taxa. Many of the species, especially the non-palaeocopes are not yet described or require revision.

Maps for this part of the Welsh Borderland are:

- Geological Survey Map of Wales (1:250,000) and of Mid Wales & Marches (Sheet 52N 04W; 1:250,000).
- Geological Survey sheets (1:25,000 or 1:50,000) for Leintwardine-Ludlow (Special sheet: parts of 50 47, 57), Church Stretton (SO 49), Craven Arms (SO 48), Telford (SJ 60 and parts of SJ 61, 70 and 71) and Shrewsbury (152).
- Ordnance Survey 1:50,000 sheets for Ludlow & Wenlock Edge (137), Shrewsbury (126) and Stafford (127).

Caer Caradoc (SO 477 952).

This well known local landmark lies 0.5 km east of Church Stretton, Shropshire.

The summit of the whale-back shaped hill of Caer Caradoc has an Iron Age camp and affords magnificent views of the central Shropshire countryside. From here it is possible to demonstrate the close relationship between geology, topography and scenery across an area boasting a Pre-Cambrian through to Carboniferous sequence (see Greig *et al.* 1968).

Caer Caradoc consists essentially of late Precambrian (the so-called Uriconian) volcanics. Several of the adjacent hills, which lie along the western part of the NE-SW orientated Church Stretton fault lineament, are of similar composition: Ragleth Hill immediately to the south-east; The Lawley immediately to the north-west; and The Wrekin, situated some 20km NE along strike.

To the west of Caer Caradoc is the late Pre-Cambrian clastic sequence of the flat topped Long Mynd, which forms a skyline feature rising to 517m. The intervening, flat, narrow ground of the Church Stretton rift valley is floored by Silurian and glacial drift. Northwards is the town of Shrewsbury, in the plain of the River Severn.

Eastwards from Caer Caradoc an attenuated succession of Cambrian and Ordovician (Caradoc Series) sediments dip eastwards to underlie the Silurian in Ape Dale. The NE-SW ridge of Hoar Edge, flanking the eastern side of The Lawley is formed of basal Caradoc Hoar Edge Grit. Much of the valley of Ape Dale is formed in the relatively soft, dominantly shaley lower Silurian (Kenley Grit, Pentamerus Beds, Purple Shale, Buildwas Formation, Coalbrookdale Formation). Flanking Ape Dale to the east is the prominent, long wooded scarp of Wenlock Edge, formed of late Wenlock carbonates (Much Wenlock Limestone Formation).

East of Wenlock Edge the gentle south-easterly regional dip is continued through the sequence of upper Silurian to Devonian sediments in which several horizons form prominent scarp features parallel to Wenlock Edge and alternate with softer lithologies forming intervening vales. Thus, the 'Aymestry Limestone' (Upper Bringewood Formation, Ludlow Series) forms a fairly continuous scarp between the shales of the Elton formations, which occupy Hope Dale and the dip slope of Wenlock Edge, and the upper Ludlow siltstones and Old Red Sandstone facies Prídolí sandstones of Corvedale. Eastwards, basal Devonian sandstones form a scarp encircling the Old Red Sandstone plateau dominated by the Brown Clee (540m) and

Titterstone Clee (533m) summits, which are topped by Carboniferous limestones, sandstones, Coal Measures and basalts.

The two scarps produced by the Much Wenlock Limestone Formation and Aymestry Limestone respectively can be traced from the area of Wenlock Edge southward into the horse-shoe shaped outcrop of the Silurian of the Ludlow anticline. The axis of the fold is centred on Ludlow itself and its core, in the Vale of Wigmore, consists of soft shales of the Wenlock Series Coalbrookdale Formation.

Comley Quarry (SO 4845 9647)

Old quarry, immediately N of minor road at Comley hamlet, about 1350m NE of the summit of Caer Caradoc Hill, Shropshire.

Lower Comley Sandstone and Lower Comley Limestones, Lower Comley Group, early Cambrian; and Quarry Ridge Grits, Upper Comley Group, middle Cambrian.

This is a classic exposure defining part of the British early Cambrian (Comley 'Series'). It has the middle Cambrian (St David's 'Series'), glauconitic Quarry Ridge Grits of the Upper Comley Group resting unconformably on early Cambrian Lower Comley Group. The latter here consists of Lower Comley Limestones (divisions Ac3-Ad above Red *Callavia* Sandstone Ac2 division; Cobbold 1927, 1933) above the glauconitic and burrowed Lower Comley Sandstone (Ab-Ac1 divisions).

The Red *Callavia* Sandstone is a calcareous sandstone containing shell debris of trilobites, brachiopods and conoidal fossils and the bradoriid *Indiana lentiformis* (Cobbold, 1921). The latter also occurs in the Caerfai Bay Shales, Caerfai Group of Pembrokeshire and has facilitated demonstration of the existence of the early Cambrian in South Wales (Siveter & Williams 1995).

All British and North American bradoriids and associated phosphatocopids have recently been monographed (Siveter & Williams 1997, Williams & Siveter *in press*). Chinese bradoriid material has recently been used to demonstrate that the group belongs outside the Ostracoda (Hou *et al.* 1996).

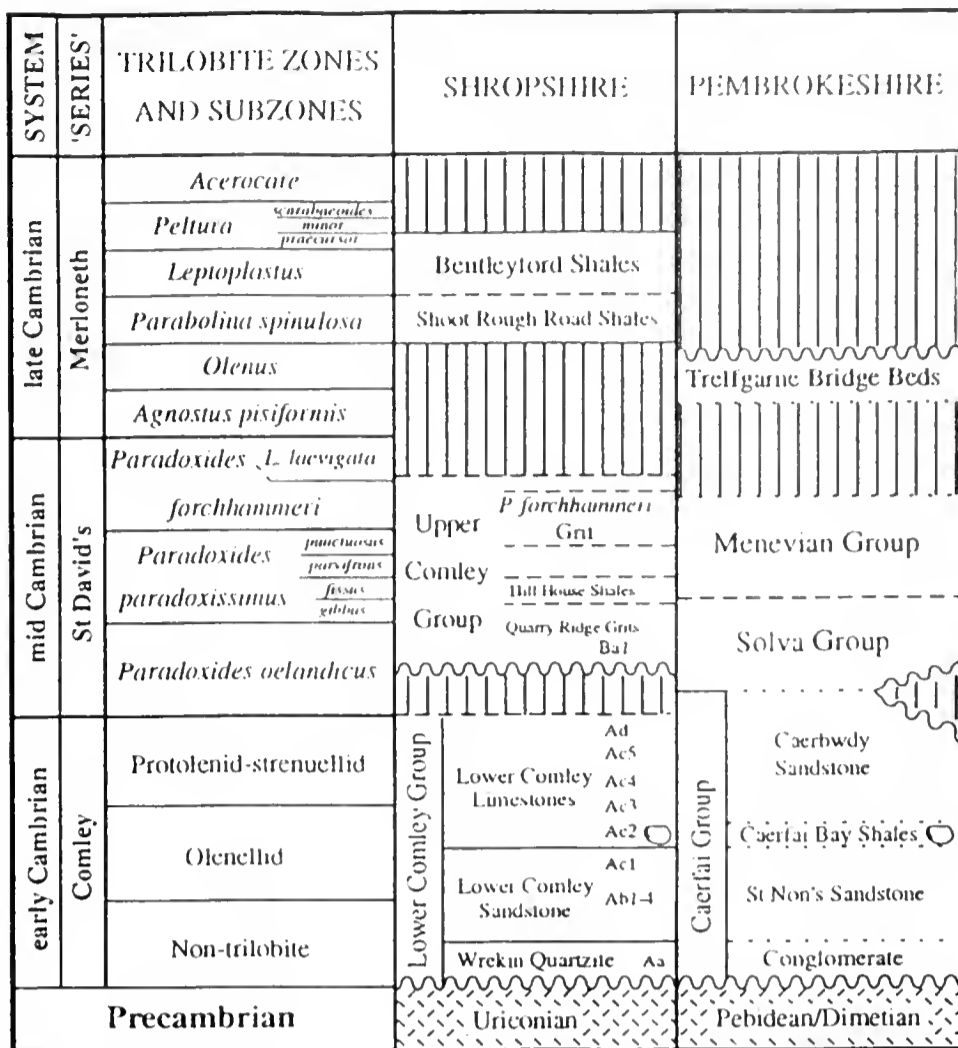


Fig. 3. Stratigraphy of the Cambrian of Pembrokeshire and Shropshire (from Siveter & Williams 1995).

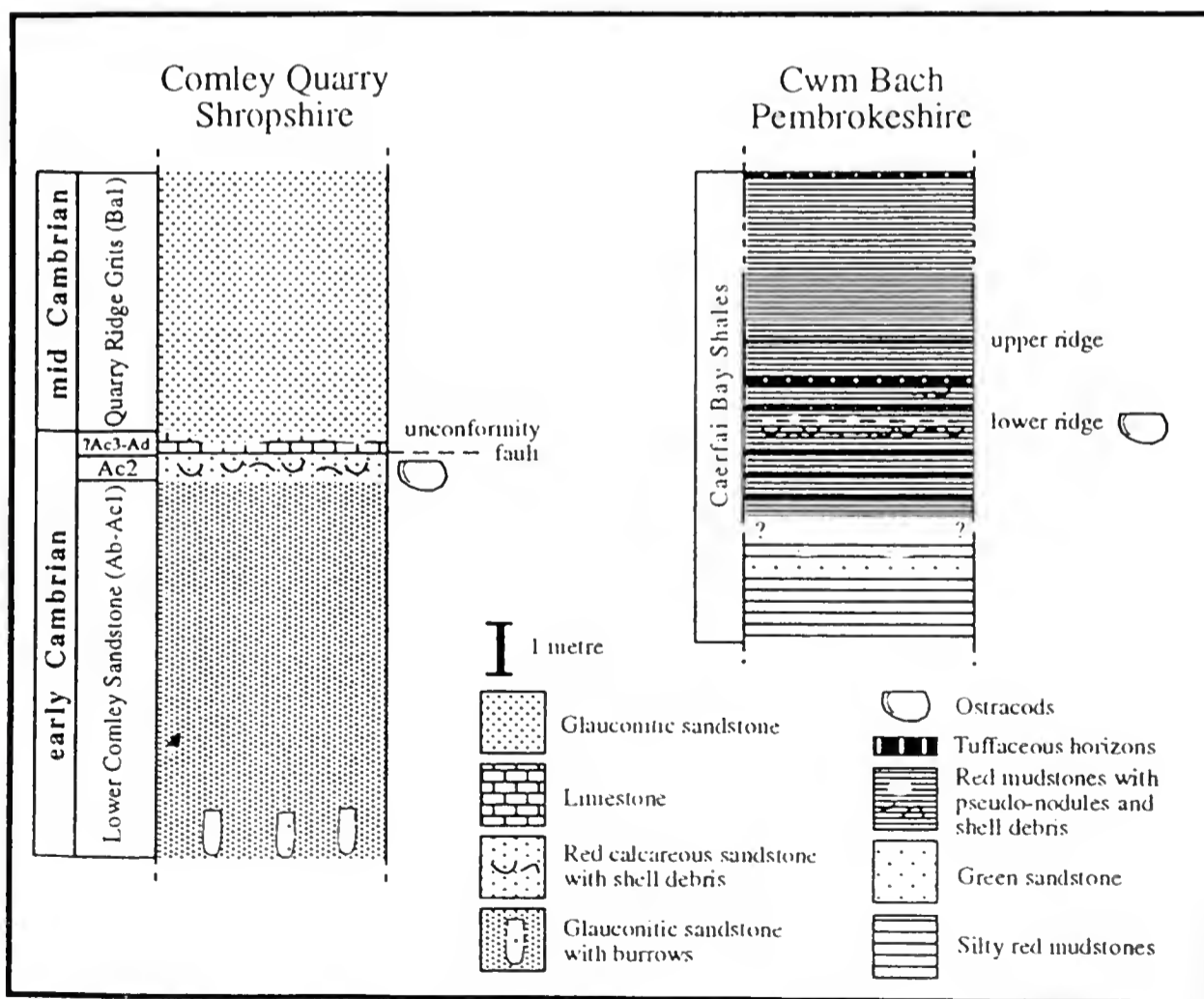


Fig. 4. Stratigraphy at Comley Quarry, Shropshire and on the west side of Cwm Bach, Pembrokeshire (from Siveter & Williams 1995). The fault produces minor repetition of the Lower Comley Limestones.

Smeathen Wood, Onny Valley area (SO 4060 8548)

Trackside excavation, about 200m W of Wood House and 1.5 km NW of Cheney Longville, Shropshire.

Smeathen Wood Formation, Harnagian Substage, Burrellian Stage, Caradoc Series, Ordovician.

In Shropshire the Ordovician essentially occurs in two areas, to the east and west of the Precambrian sediments of the Long Mynd massif. To the east and southeast of the Long Mynd the Ordovician crops out in the Wrekin-Caer Caradoc-Onny Valley region of east Shropshire, on the eastern side of the Church Stretton fault complex (see Greig *et al.* 1968; Fortey *et al.* 1995). In this region the Ordovician sequence belongs entirely to the Tremadoc and Caradoc series. The latter, which markedly oversteps older units (as seen in the the Onny Valley; see Toghil 1992), consists of shallow shelf marine sands and muds with shelly dominated assemblages containing trilobites (especially trinucleids), bryozoans, tentaculitids, ostracods and especially brachiopods. By contrast the more basinal Ordovician to the west of the Long Mynd, which comprises the area of the Shelve inlier, is much more stratigraphically complete and lithologically varied and also includes some volcanic horizons.

At Smeathen Wood the Smeathen Wood Formation ('Harnage Shales' of traditional literature) consists of friable, olive-grey shales and mudstones with a diverse, brachiopod and trilobite-rich macrofauna and moulds of ostracods visible to the naked eye. Large and well preserved specimens of the palaeocope *Harperopsis scripta* (Harper, 1947; see Jones & Siveter 1983, Jones 1986) are relatively common. The other ostracods at this newly exposed locality have not yet been identified, but at nearby localities (e.g. Hope Bowdler road cutting 2km east of Church Stretton) the same formation has produced the following additional ostracodes (see Siveter 1978a; Jones & Siveter 1983; Jones 1984, 1986, 1987): *Duringia triformosa* Jones, 1984; hollinacean gen. et sp. nov. A (of Jones 1986); *Ogmoopsis (Quadridigitalis) siveteri* Jones, 1986; *Sigmoopsis (Sigmoopsis) duftonensis* (Reed, 1910); *Varilatella (Varilatella) bulbosa* Jones, 1986; *Vitella fecunda* Siveter, 1983; *Ulrichia ? bicornis* (Jones, 1855).

Coates Quarry, Wenlock Edge (SO 6045 9935)

Quarry on N side of B4371 road, about 1.7km SW of Much Wenlock, Shropshire.

Much Wenlock Limestone Formation, Homeric Stage, Wenlock Series, Silurian.

The middle Silurian, reef-bearing Much Wenlock Limestone Formation at Coates Quarry accumulated in a shelf setting (The 'Midland Platform') on the eastern flanks of the Anglo-Welsh Basin (see Siveter *et al.* 1989). This late Wenlock development of patch reefs extends to Walsall and Dudley in the West Midlands of England and, via south Welsh Borderland inliers, to Usk in South Wales (Bassett 1974). Locally, such reefs occur in the northern one-third and upper part of the outcrop of the Much Wenlock Limestone Formation along Wenlock Edge, between between Easthope and Ironbridge (Shergold & Bassett 1970, Scoffin 1972, Bassett *et al.* 1975, Bassett 1974, 1976). They probably developed in shallow (maximum 30m), oxygenated, but relatively calm waters in which their growth rate and pattern was determined by local factors of mud supply and where the occurrence of bentonites can often be correlated with reef demise (Scoffin 1972).

Reef limestones are not developed in the Much Wenlock Limestone Formation to the southwest of Easthope, either along Wenlock Edge (which extends to the Onny Valley near Craven Arms) or in the Leintwardine or Ludlow districts of the Ludlow anticline. Those areas are thought to have occupied slightly more offshore, deeper water shelf sites. At coeval horizons some 30-40km to the west of Wenlock Edge, for example in the Long Mountain, dark graptolitic shales represent basin slope and basin

facies.

Along Wenlock Edge the smaller reefs are typically ovoid and average about 3m high and 12m wide; the larger reefs are generally much more irregularly developed. The reef margins interdigitate with bedded inter-reef limestones which embrace a range of biomicrite and biosparite lithofacies including crinoidal, tabular and especially nodular limestones. Off-reef talus is also represented.

The role of framebuilders and binders of the bioherms is taken by a wide variety of colonial tabulate (e.g. *Heliolites*, *Favosites*, *Halysites*, *Thecia*) and colonial (*Arachnophyllum*) and solitary rugose (*Ketophyllum*) corals, stromatoporoids (e.g. *Stromatopora*, *Actinostroma*), calcareous algae (*Girvanella*, *Rothpletzella*, *Wetheredella*) and bryozoans (*Hallopora*, *Rhombopora*, *Fistulipora*, *Fenestella*). The reef matrix consists of carbonate mud and many unitary organisms such as crinoids (e.g. *Mastigocrinites*), gastropods (e.g. *Poleumita*), rare molluscs and trilobites (e.g. *Calymene*, *Dalmanites*, *Encrinurus*) and especially brachiopods (e.g. *Isorthis*, *Resserella*, *Leptaena*, *Atrypa*, *Strophonella*, *Eospirifer*, *Howellella*, *Sphaerirhynchia*) and ostracods, all of which lived in and around the reefs.

As seen in rock thin section, ostracods are commonly present in the bedded limestones but are virtually impossible to extract isolated. Best yields are obtained by sampling the shaly and bentonitic horizons.

Ostracod fauna: See Siveter 1974, 1980, 1988, 1989; Lundin *et al.* 1991; Lundin & Petersen 1993.

Beyrichia clausa Jones & Holl, 1886; *Beyrichia* sp. nov.; *Strepula concentrica* Jones & Holl, 1886; beyrichiacean gen. nov. F (of Siveter 1978b); *Thlipsura corpulenta* Jones & Holl, 1869; *Wenlockiella phillipsiana* (Jones & Holl, 1869).

Lincoln Hill, Ironbridge (SJ 6693 0381).

Steeply dipping bedding planes at old workings on SW side of Lincoln Hill, about 250m N of River Severn at Ironbridge, Shropshire.

Much Wenlock Limestone Formation, Homeric Stage, Wenlock Series, Silurian.

Lincoln Hill is the northernmost outcrop of the Much Wenlock Limestone Formation, which also forms the scarp of Benthall Edge to the southwest across the River Severn valley (Bassett *et al.* 1975). The latter, known locally as the 'Ironbridge Gorge', is a glacial overflow feature and is the birthplace of the world's 18th-19th century industrial revolution. Until his retirement in 1886 George Maw, the Victorian polymath and scientific collaborator of T. R. Jones, lived at Benthall Hall (SJ 657 026) on Benthall Edge.

Lincoln Hill lies just to the west of Ironbridge town and forms the eastern flank of Coalbrookdale, a valley cut in Carboniferous strata and the site of the Iron-works factory of the famous Derby industrial family dynasty. The extraction of limestone at Lincoln Hill, obtained from both open cast and underground workings, originally served both industrial and agricultural needs in the area. The locality " ..is exactly behind the Swan Hotel, Ironbridge" said Smith in his 1881 (see also 1892) description of Welsh Borderland Silurian localities from which he obtained "Bivalved Entomostraca" to send to T.R. Jones for identification. The Swan Inn exists today, and the steeply dipping, weathered bedding planes of the old limestone workings of Lincoln Hill, form one of the richest sources of British Silurian ostracods.

Fossils are best obtained from samples collected from shaley partings and weathered bedding planes. The locality has yielded abundant palaeocope and non-palaeocope faunas. Macrofossils are equally very diverse and include many of the 70 or so brachiopod species recorded from the Much Wenlock Limestone Formation (e.g. *Atrypa*, *Eospirifer*, *Cyrtia*, *Gypidula*, *Howellella*, *Isorthis*, *Meristina*, *Resserella*, *Strophonella*, *Sphaerirhynchia*; e.g. see Bassett 1970-74), together with rugose and

tabulate corals, bryozoa, trilobites and gastropods.

Ostracod fauna: See Siveter 1974, 1978b, 1980, 1988, 1989; Lundin & Peterson 1975, 1993; Lundin *et al.* 1991.

Amphitoxotis repanda Siveter, 1980; *Beyrichia clausa* Jones & Holl, 1886; *Bolbiprimitia* sp. nov.; *Garniella concinna* (Jones & Holl, 1886); *Garniella* sp. nov.; *Gongylostonyx exaggeratus* Siveter, 1980; *Sleia pauperata* (Jones, 1869); *Sarmatotoxotis phracta* Siveter, 1980; *Strepsula concentrica* Jones & Holl, 1886; *Tinotoxotis velivola* Siveter, 1980; beyrichiacean gen. nov. F (of Siveter 1978b); '*Wenlockiella phillipsiana* (Jones & Holl, 1869); '*Longiscula*' *smithii* (Jones, 1887); '*Macrocypris*' *vinei* (Jones, 1887); *Thlipsura corpulenta*; Jones & Holl, 1869; *Silensis longus* Abushik, 1971; '*Beyrichia*' *admixa* Jones & Holl, 1886; primitiopsacean spp.; *Aechmina cuspidata* Jones & Holl, 1869.

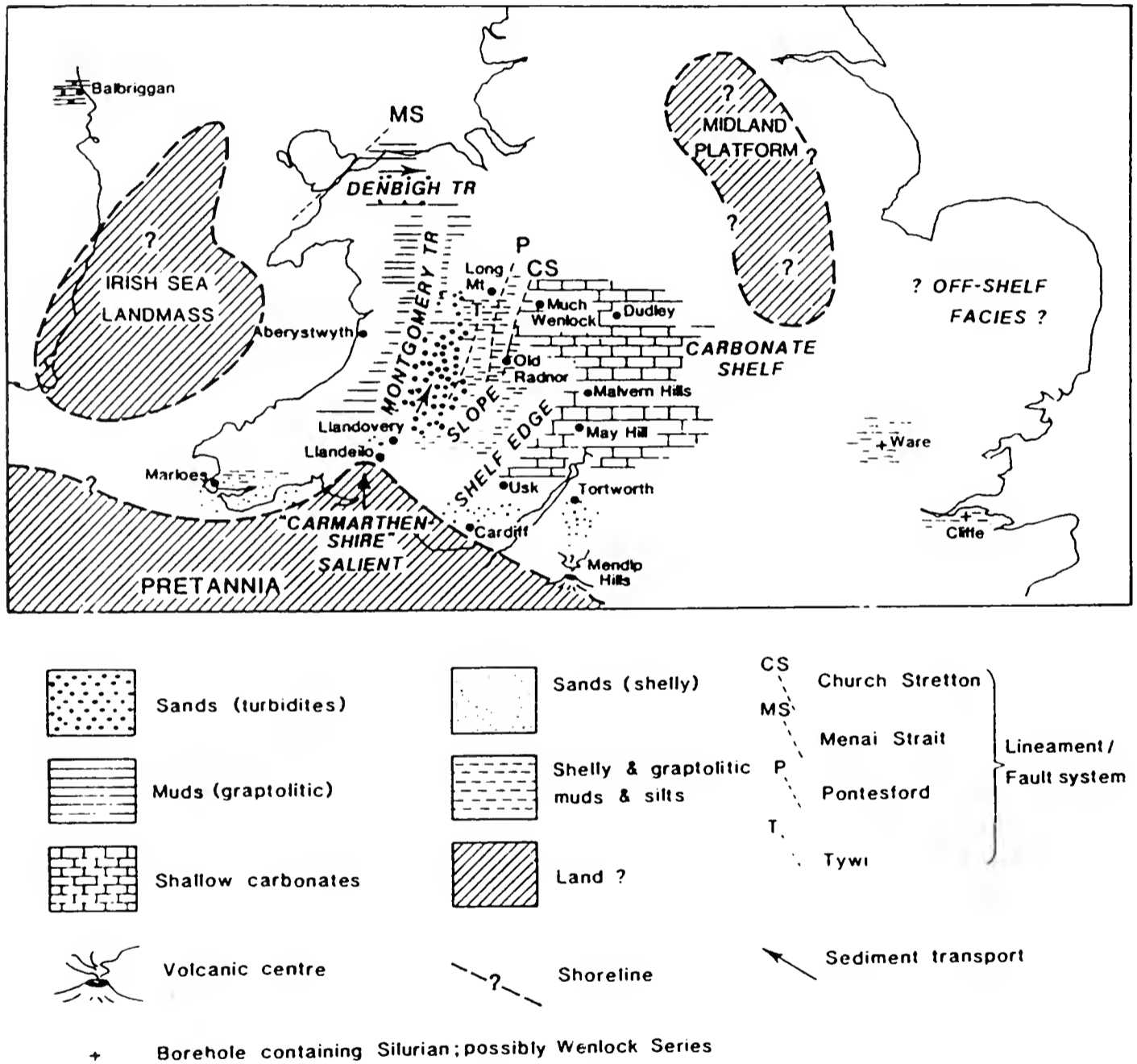


Fig. 5. Generalised palaeogeography for southern Britain in the late Wenlock (from Siveter *et al.* 1989).

The Whitcliffe, Ludlow (SO 5053 7430)

From this area of Common land there is a splendid view over Ludlow town and the surrounding landscape. The vantage point lies on the axial trace of the Ludlow anticline, which plunges at about 5°ENE through Ludlow itself. Beyond Ludlow, the general regional dip and younging direction of strata is northwest to southeast.

Due north of Ludlow basal Devonian sediments form the prominent wooded scarp which, regionally, encircles the Old Red Sandstone plateau containing the Clee Hills (see Allen 1974, 1985; Allen & Tarlo 1963). To the east-northeast the skyline is dominated by Titterstone Clee Hill which, like the Brown Clee Hill synclinal outlier in the far distance to the northeast, is capped by Carboniferous limestones, sandstones, coal measures and basalts. Looking north-northwest, the scarp of Wenlock Edge (Much Wenlock Limestone Formation) and the adjacent, parallel, middle Ludlow Series scarp (Upper Bringewod Formation) are seen dipping gently south-eastwards towards the upper Ludlow siltstones and Old Red Sandstone facies (Prídolí) sandstones occupying the valley of Corve Dale.

Various outcrops occur along the Whitcliffe, which forms the southern margin to the River Teme between Dinham Bridge and Ludford Bridge, Ludlow. Those localities show many sections of Ludfordian Stage stratigraphical units of the type Ludlow Series (Holland *et al.* 1963; see also Siveter *et al.* 1989, Lawson & White 1989); namely, the Lower and Upper Leintwardine and Lower and Upper Whitcliffe formations.

The Goggin Road, Mortimer Forest (SO 4720 7189 to SO 4765 7170).

Exposures and excavations alongside the Goggin Road forestry track, on the southwest slopes of High Vinnals Hill, Mortimer Forest, near Ludlow.

Top of Much Wenlock Limestone Formation, Homeric Stage, Wenlock Series; and Lower, Middle and Upper Elton and Lower Bringewod formations, Gorstian Stage, Ludlow Series.

These fossil-rich exposures, dipping gently 10°-16° ESE, collectively display the most complete sequence available through the latest Wenlock Series and Gorstian Stage of the type Ludlow Series. The sequence, about 200 m thick and extending over more than 1.5 km, includes a basal boundary stratotype, basal boundary reference sections and body stratotypes for formations in the Elton and Bringewod groups (Lawson 1973a, White & Lawson 1978; see also Lawson & White 1989 and Siveter *et al.* 1989).

The top Much Wenlock Limestone Formation, occurring in the topographically lowest part of the section, consists predominantly of nodular limestones. The succeeding Elton Group consists of soft, easily weathered, pale olive-grey mudstones and siltstones with some more calcareous and flaggy horizons. Bentonites are common throughout the middle and upper Elton formations, but their provenance is not readily identifiable. Graptolites are particularly common: *Saetograptus varians varians*, *Saetograptus chimera chimera*, *Saetograptus chimera semispinosus*, *Spinograptus spinosus* and *Pristiograptus dubius* occur in the Middle Elton and, *inter alia*, *Pristiograptus tumescens* is fairly common in the Upper Elton (e.g. SO 4760 7190).

There is a scattered and diverse shelly macrofauna. The Lower Elton (e.g. SO 4732 7178), some 45m thick, yields the brachiopods *Amphistrophia funiculata*, *Atrypa reticularis*, *Craniops implicatus*, *Dicoelosia biloba* and *Gypidula galeata*, together with *Dalmanites myops* and tabulate and rugose corals. Orthoconic nautiloids, brachiopods such as *Aegiria grayi*, *Shagmella ludloviensis* and *Lingula lata* and trilobites such as *Dalmanites*, *Raphiophorus*, *Acidaspsis* and *Leonaspis* occur in beds of the Middle Elton (c. 85m thick) and/or Upper Elton (partly faulted out; 19m recorded). The deep cutting

in the middle part of the Middle Elton (locality A12-14 of White & Lawson 1978; SO 4746 7170) is richly fossiliferous and shows bentonites.

The faunal change signifying the Elton/Bringewood boundary involves a marked reduction in the abundance of *Pristiograptus tumescens* and the introduction of several brachiopods, especially strophomenids such as *Leptostrophia filosa* and *Leptaena depressa* (see Siveter *et al.* 1989, fig. 44). Lithologically there is a 2m transitional sequence, passing into 17m of hard, irregularly bedded calcareous siltstones of the Lower Bringewood Formation. At the top of the section faulting cuts out part of the Lower Bringewood strata and reintroduces Upper Elton beds.

The section also contains abundant palynomorphs, especially chitinozoans and acritarchs (Sutherland 1994, Mullins 1996). Ostracods occur through the sequence but lack documentation.

The rocks at Goggin Road are interpreted as sedimentation on predominantly the outer shelf area of the eastern margin of the Welsh depositional basin (see Siveter *et al.* 1989, figs. 8-10, Bassett *et al.* 1992). The lithofacies changes from the late Wenlock carbonate to the Gorstian fine clastic to carbonate-rich clastic regimes, may represent shifts in sea level (e.g. see Hurst 1975*a*, 1975*b*, Bassett 1976). Alternatively, these lithofacies may be associated with changing climatic and oceanic conditions (Jeppson 1990, Jeppson *et al.* 1995).

From the summit of High Vinnals there is a spectacular panorama of south Shropshire and beyond.

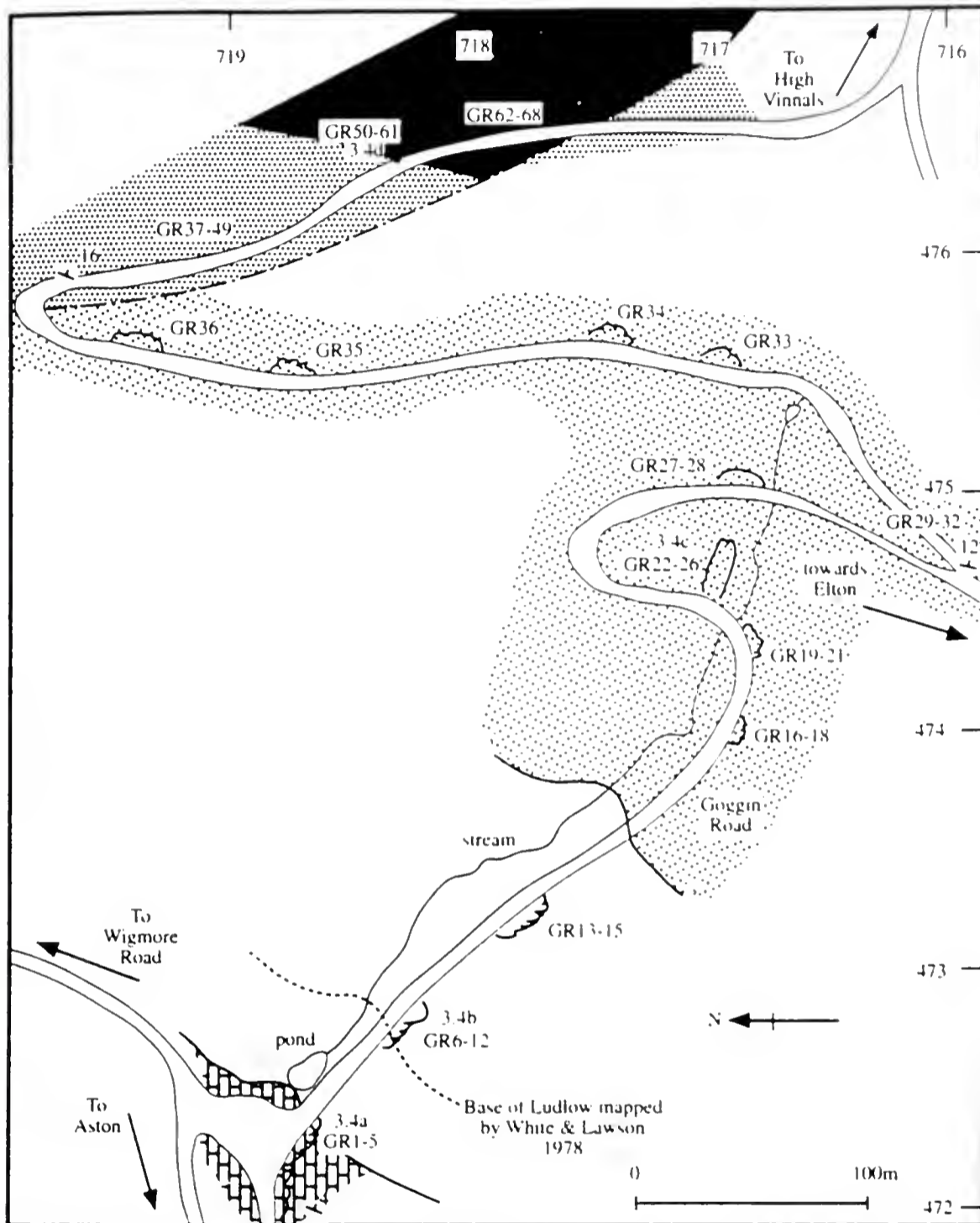


Fig. 6. Geology along the Goggin Road, Mortimer Forest, Ludlow Anticline (Sutherland 1994; modified after White & Lawson 1978, Siveter *et al.*, 1989).

Deer Park Road, Mortimer Forest (SO 4845 7135 to SO 4899 7111).

Exposures and excavations along the north side of Deer Park Road forestry track, Haye Park, Mortimer Forest, near Ludlow.

Lower and Upper Bringewood formations, Gorstian Stage, and Lower and Upper Leintwardine and Lower Whitcliffe formations, Ludfordian Stage, Ludlow Series.

This fossil-rich locality, extending for some 550m, provides one of the most complete sections available through the mid and late part of the type Ludlow Series. It contains several basal boundary reference sections and body stratotypes for formations in the Bringewood, Leintwardine and Whitcliffe Groups (Lawson 1973a, White & Lawson 1978, Cherns 1988, Lawson & White 1989, Siveter *et al.* 1989).

The section exposes about 84m of strata dipping gently 10°-15° ESE. Some 21m of the upper part of the Lower Bringewood Formation is exposed, consisting of irregularly bedded, olive-grey, calcareous siltstones containing, in particular, brachiopods such as *Strophonella euglypha*, *Atrypa reticularis*, *Leptaena depressa*, *Sphaerirhynchia wilsoni* and *Pholidostrophia lepisma* and corals such as *Rhabdocyclus* and *Favosites*. Near the top of the formation calcareous nodules are quite common and about 4m below the junction with the Upper Bringewood Formation there is a 10cm thick bentonite.

The Upper Bringewood consists of hard, grey, silty and in places nodular limestones. Only the lowermost 2m and highest 5m of the formation were recorded, the intervening 10m being unexposed (White & Lawson 1978). Chitinozoans are abundant and diverse in both the Lower and Upper Bringewood formations (Sutherland 1994). The diverse Upper Bringewood macrofauna, typified by the brachiopods *Kirkidium knightii*, *Shagamella ludloviensis*, *Amphistrophia funiculata*, *Leptostrophia filosa*, *P. lepisma* and *S. euglypha* and tabulate and rugose corals, is common up to the sharp lithological boundary with the overlying flaggy calcareous siltstones of the Lower Leintwardine Formation (20m thick). The latter contain trilobites (*Proetus obconicus*, *Warbergella ludlowensis* and *Alcymene*), the zonal graptolite *Saetograptus leintwardinensis* and especially brachiopods (e.g. *Microsphaeridiorhynchus nucula*, *Howellella elgans*, *Dayia navicula*, *Salopina lunata*, *Isorthis orbicularis*, *Shalera ornatella* and *Shagamella ludloviensis*).

The Upper Leintwardine Formation is represented by merely 3.5 m of calcareous siltstones, immediately west of a tiny man-made cut through the section. The unit is differentiated by the occurrence of a varied macrofauna which includes the palaeocope *Neobeyrichia lauensis* and other ostracods and the acme of *Aegiria grayi* and the trilobites *Encrinurus stubblefieldi* and *Alcymene puellaris*. The large, distinctive *N. lauensis* and/or its ostracod associates provide one of the best correlative tools in the type Ludlow, and can be traced into sequences in Sweden, the East Baltic and Podolia in the former USSR (see Siveter 1989). The Deer Park Road section ends in greyish, flaggy, Lower Whitcliffe calcareous siltstones (21m) with abundant *Protochonetes ludloviensis* and *M.? nucula*, together with *D. navicula*, *Orbiculoidea rugata*, the worm tube *Serpuloides longissimus*, the bivalve *Fuchsella amygdalina* and orthoconic nautiloids.

The rocks at Deer Park Road represent a variety of subtly different, relatively shallow water environments on the eastern, Midland Platform of the Welsh depositional basin (Cherns 1988, Siveter *et al.* 1989, Bassett *et al.* 1992). During mid Ludlow (e.g. Upper Bringewood Formation) times the Ludlow area was an inner shelf region (Watkins & Aithie 1980). The limestones at Deer Park Road represent relatively low energy, back-barrier deposits. The transition into the calcareous siltstone Leintwardine Group signifies an increased influx of silt and frequency of skeletal sands deposition and a general lowering of depositional energy levels.

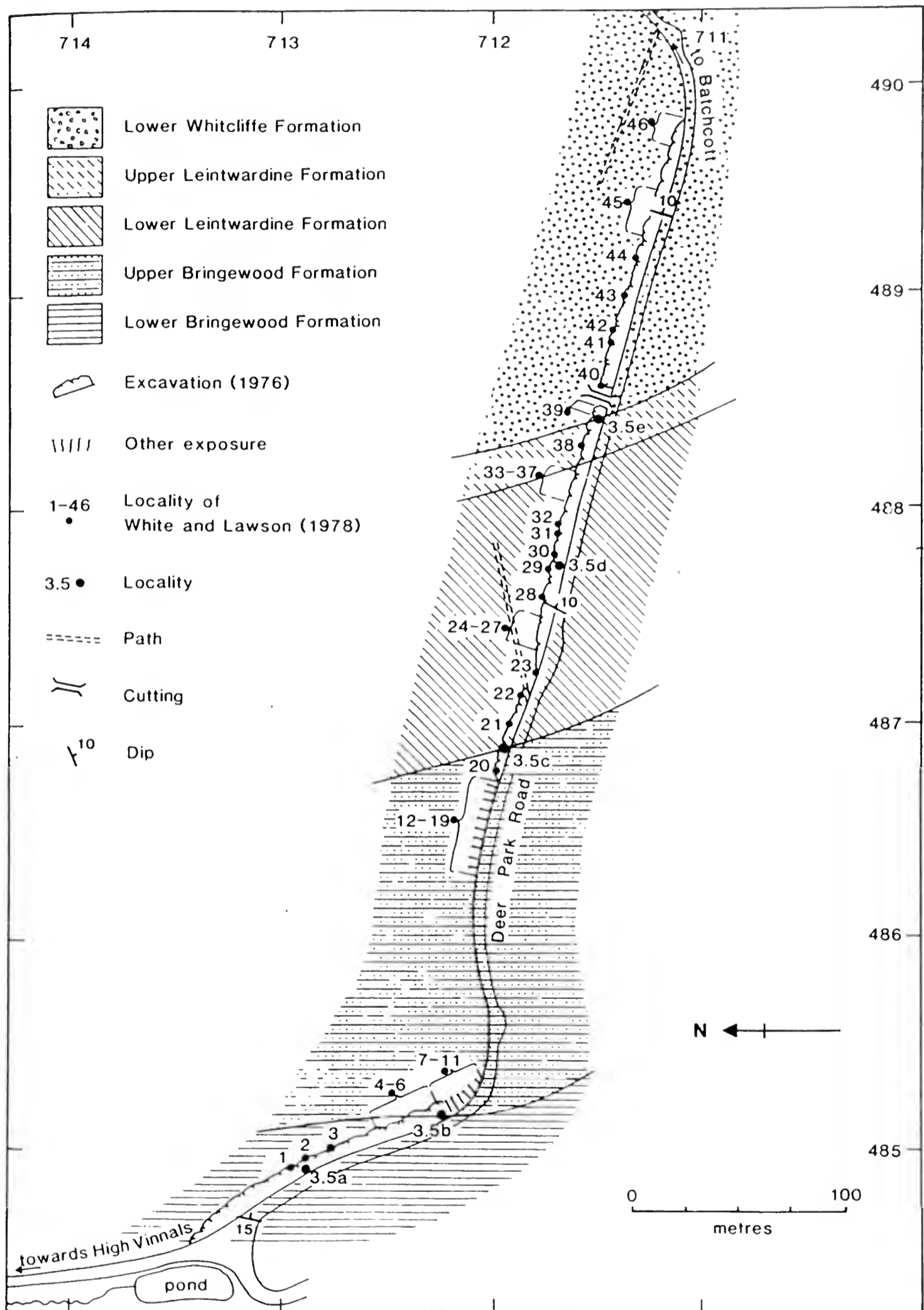


Fig. 7. Geology along the Deer Park Road, Mortimer Forest, Ludlow Anticline (Siveter *et al.*, 1989; modified after White & Lawson 1978).

Bengry Track, Aymestrey (SO 4228 6544)

Exposure at E end of track, about 200m W of the Riverside (formerly the Crown) Inn at Aymestrey, Hereford & Worcester.

Upper Leintwardine Formation, Ludfordian Stage, Ludlow Series, Silurian.

This locality is just one of many trackside and old quarry exposures between the A4110 road bridge over the River Lugg at Aymestrey and nearby Beechenbank Wood (SO 4248 6547 to SO 4178 6567). Overall these outcrops expose Elton and Bringewood (Gorstian Stage) and Leintwardine groups (Ludfordian Stage) of the Ludlow Series. Bengry Track, across Beechenbank Wood and above the 'Main' Quarry, was excavated by the Forestry Commission in 1965-6. Originally Bengry Track exposed the Upper Elton to Upper Leintwardine formations but now, apart from a small, ostracod-rich quarry in the Upper Leintwardine Formation, that track section is badly degraded.

The geology of this part of Aymestrey was fully documented by Lawson (1973*b*; see also Siveter *et al.* 1989). Contributions about the local facies and faunas have also been made by Newell (1966), Watkins & Aithie (1980), Cherns (1988) and Sutherland (1994).

The irregularly bedded, grey-olive siltstones of the Upper Leintwardine Formation contain an abundant ostracod fauna, consisting of beyrichiaceans and many indeterminate ('smooth') non-palaeocopes. Most common is the largest British palaecope species, *Nodibeyrichia lauensis*, an index fossil for the Leintwardine beds in the Welsh Borderland, the Baltic and Ukraine. The ostracods are concentrated in the decalcified, so-called 'gingerbread' bands; preservation of the moulds can be exceptionally fine (Siveter 1982). Macrofossil associates include the brachiopod *Aegiria* and the trilobite *Alcymene*.

Collectively, this complex of outcrops at Aymestrey have historical, stratigraphical, palaeontological and palaeogeographical importance. They feature in some of the earliest geological literature about the Silurian System (Murchison 1839); as Murchison indicated, elucidation of the local geology owed much to his friend the Rev. T.T. Lewis of Aymestrey. The outcrops include the type section for Murchison's (1839) 'Aymestry Limestone' (Upper Bringewood Formation of present usage). The rich, dominantly shelly biota includes a globally unique occurrence of a form of early non-vascular marine plant, the non-calcified dasyclad *Inopinatella lawsoni* Elliot, 1971. Furthermore, facies patterns (e.g. the rapid lateral change of the Upper Bringewood limestone into siltstone) indicate that Aymestrey was at a pivotal site, at the shelf edge of the Midland Platform, during Ludlow times; the deeper basinal facies of the Anglo-Welsh basin lie to the west.

Ostracod fauna: See Siveter 1974, 1978*b*, 1980, 1982, 1988, 1989.

Atterdagia versiculus Siveter, 1980; *Calcaribeyrichia* sp. nov.; *Embryotoxotis convallis* Siveter, 1980; *Hemsiella* ? sp. nov.; *Neobeyrichia confluens* Shaw, 1971; *Neobeyrichia lauensis* (Kiesow, 1888); *Neobeyrichia scissa* Martinsson, 1962; *Sleia equestris* Martinsson, 1962; *Lophoctenella* cf. *L. scanensis* (Kolmodin, 1869); plus numerous undescribed non-palaecope taxa.

Ludford Lane, Ludlow (SO 5124 7413 to SO 5120 7410)

Sections along Whitcliffe Road, both at its junction with the A49 Leominster road ('Ludford Corner') and for about 100m to the west-southwest ('Ludford Lane'), Ludlow, Shropshire.

Upper Whitcliffe Formation, Ludfordian Stage, Ludlow Series and Ludlow Bone Bed,

Platyschisma Shale and Sandstone members, Downton Castle Sandstone Formation, Prídolí Series, Silurian.

This world famous locality was traditionally regarded as the reference section for the Silurian-Devonian boundary in Britain (the base of the Old Red Sandstone facies 'Downtonian'). It displays the basal boundary stratotype for the Downton Group (Prídolí Series, Silurian) resting on a body stratotype for the Upper Whitcliffe Formation (Ludlow Series). Its Downton Group contains the earliest known land animals in the world, early land plants, unusual arthropods and the famous Ludlow Bone Bed containing fish remains.

Both the Ludford Lane and Ludford Corner exposures show the top Upper Whitcliffe Formation overlain by the low part of the Downton Castle Sandstone Formation. The geology and palaeontology of this classic locality have been documented for more than 150 years, since the time of Murchison (1839; see also Ellis & Slater 1906, White 1950, Holland *et al.* 1963, Allen 1974, Bassett *et al.* 1982, Lawson & White 1989, White & Lawson 1989, Siveter *et al.* 1989, and especially Miller 1995 and references therein). The historical background of the study of the site and its key role in the complex development of the concept and age of the Downton Group are detailed in particular by White (1950) and Bassett *et al.* (1982).

The Ludlow Bone Bed Member, occupying a distinctive cleft along the section, consists of some 0.2m of lenticular and ripple laminated siltstones containing several thin layers of discontinuous vertebrate sands, the basal one of which is *the* Ludlow Bone Bed s.s. These bone beds are mostly fish remains of acanthodian scales and agnathan denticles (e.g. White 1950, Turner 1973). The Platyschisma Shale Member (up to 2m) comprises parallel- and cross-laminated and unlaminated mudstones and shales with subordinate siltstones. The overlying Sandstone Member, consisting mostly of thicker sandstones and siltstones alternating with thin mudstones, is best seen high in the outcrop along the A49 at Ludford Corner and is also present at the top of the Ludford Lane section.

The olive calcareous siltstones of the Upper Whitcliffe Formation (>0.5m seen) have a fully marine fauna which includes articulate and inarticulate brachiopods, bivalves, bryozoa and also the ostracod *Calcaribeyrichia torosa*. Some of these faunal elements also occur in the overlying Ludlow Bone Bed Member but in general the Downton Castle Sandstone Formation is characterised by a reduced diversity assemblage of different aspect. At the base of the Downton Castle Sandstone Formation several brachiopods disappear and *Modiolopsis* bivalves, the inarticulate brachiopod *Lingula minima* and biostratigraphically important ostracods, including *Frostiella groenvalliana*, *Londinia arisaigensis* and *Nodibeyrichia verrucosa* enter the sequence. Associates in that Formation include fish remains, gastropods (*Turbocheilus* (= *Platyschisma*) *helicites* and *Loxonema* sp.), eurypterids (Kjellesvig-Waering 1961) and fragments of early land plants such as *Cooksonia* (e.g. see Lang 1937, Bassett *et al.* 1982, Jeram *et al.* 1990, Edwards *et al.* 1996). The Ludlow Bone Member at Ludford Corner has yielded centiped myriapod and trigonotarbid arachnid cuticles, the earliest direct evidence of terrestrial animals (Jeram *et al.* 1990).

Conodonts are rare, but include the *Ozarkodina* cf. *crispa* from just below the top of the Whitcliffe Formation and *Ozarkodina confluens*, *Ozarkodina excavata*, *Coryssognathus dubuis* and *Ozarkodina remscheidensis eosteinhornensis* in the Ludlow Bone Bed Member (Miller 1995). In the basal few metres of the Downton Castle Sandstone Formation land-derived spores substantially increase in numbers and marine phytoplankton, principally acritarchs, show a corresponding decrease (Richardson & Lister 1969, Richardson & Rasul 1990).

Based on a complex web of correlation, mainly involving ostracods and also conodonts, the base of the Downton Castle Sandstone can be correlated across to North America and, via fully marine Baltic sequences, to the base of the type Prídolí Series in the Czech Republic (Martinsson 1963, 1967, Shaw 1969, Siveter 1978b, 1989, Bassett *et al.* 1982, Hansch *et al.* 1991, Hansch & Siveter 1994, Miller 1995). No measurable amount of time is missing at the base of the Downton Group in its main outcrop.

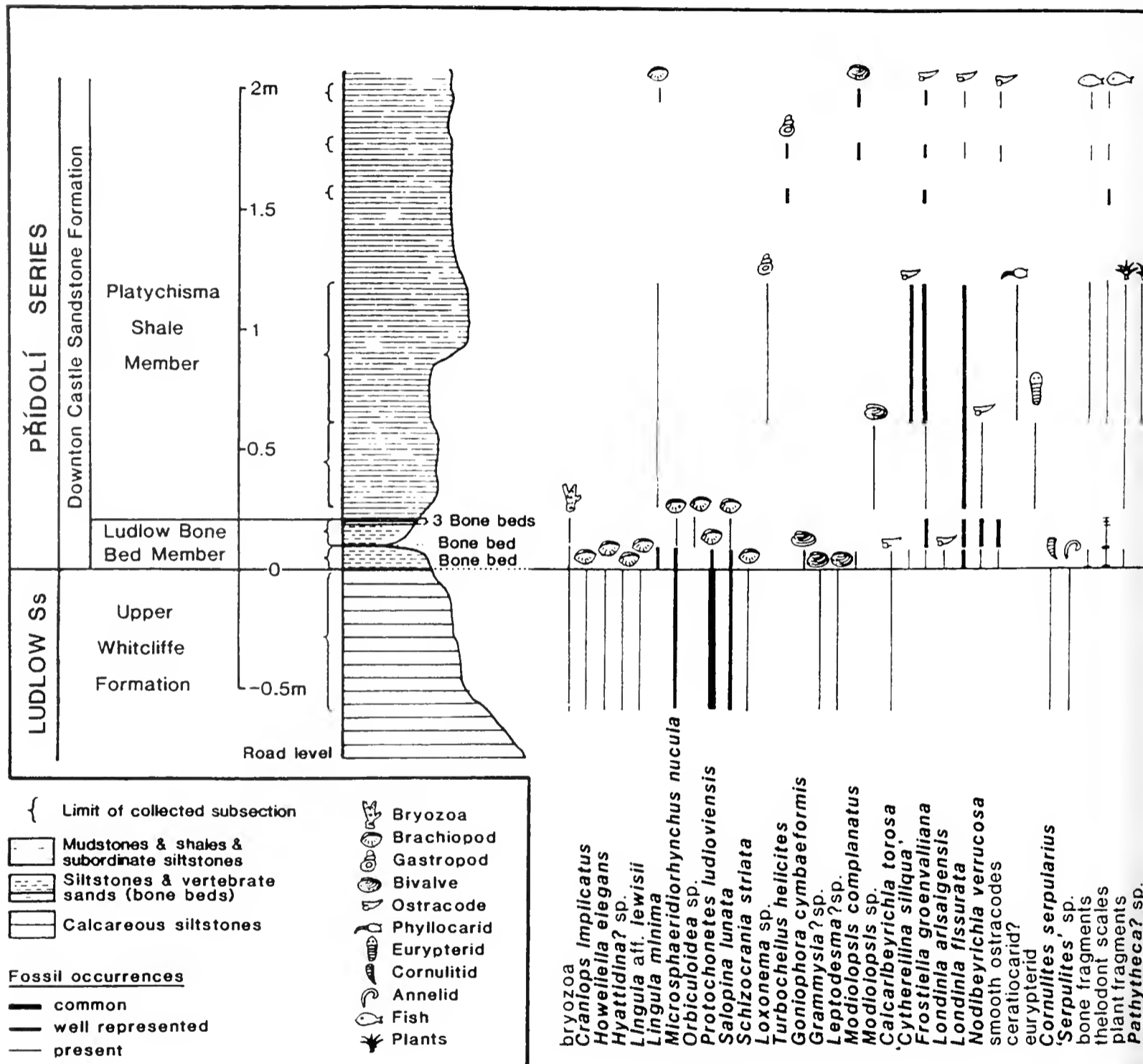


Fig. 8. Lithological and faunal succession across the Ludlow/Prídolí boundary along the north side of Ludford Lane, Ludlow (Siveter *et al.* 1989; modified from Bassett *et al.* 1982).

This overall regressive sequence formed on the eastern, Midland Platform of the remnant Welsh depositional basin (Siveter *et al.* 1989, Bassett *et al.* 1992). The sediments indicate a fairly quick but fluctuating change from a relatively shallow, mainly clear but sometimes turbid proximal shelf environment (conquinoid siltstones of the Whitcliffe Group) to near shore, perhaps coastal plain conditions (Sandstone Member, Downton Castle Sandstone Formation) (see Watkins 1979, Allen & Tarlo 1963, Allen 1974, 1985, Bassett *et al.* 1982, Miller 1995).

The notable faunal and sedimentological change at the base of the Ludlow Bone Bed Member is ascribed by most authors to a sudden regression and transgression (see Miller 1995, pp. 368-9) and the sediments themselves may reflect shallow subtidal to low intertidal conditions, recurrent storm reworking and the accumulation of vertebrate-rich lags (Smith & Ainsworth 1989). The presence of land animals and land plants implies proximity to shore.

The Platyschisma Shale Member probably represents intertidal environments. The occurrence of complete hummocky cross-stratification sequences in the Sandstone Member at Ludford Corner indicate shallow marine, subtidal to intertidal, storm generated conditions (Siveter *et al.* 1989, Smith & Ainsworth 1989). Overall, the sedimentary and restricted faunal characteristics of the Sandstone Member suggest the formation of sand bodies in a marine influenced environment close to land.

Ostracod fauna: See Martinsson 1963, 1967; Shaw 1969; Siveter 1974, 1978b, 1980, 1988, 1989; Bassett *et al.* 1982; Hansch *et al.* 1991; Hansch & Siveter 1994, Miller 1995.

Upper Whitcliffe Formation: *Calcaribeyrichia torosa* (Jones, 1855); *Hemsiella* cf. *H. maccoyiana* (Jones, 1855).

Ludlow Bone Bed Member: *Calcaribeyrichia torosa* (Jones, 1855); *Frostiella groenvalliana* Martinsson, 1963; *Londinia arisaigensis* (Copeland, 1964); *Londinia fissurata* Shaw, 1969; *Lophoctenella* sp.; *Nodibeyrichia verrucosa* Shaw, 1969.

Platyschisma Member: *Frostiella groenvalliana* Martinsson, 1963; *Leperditia* sp.; *Londinia arisaigensis* Copeland, 1964); *Londinia fissurata* Shaw, 1969; *Nodibeyrichia verrucosa* Shaw, 1969.

The beyrichiaceans listed above are accompanied throughout by indeterminate, smooth non-palaeocopes.

References

- Abushik, A.F. 1971. Ostracoda from Silurian-Lower Devonian key sections of Podolia. *In: Abushik, A. F., Gusseva, E. A. & Zanina, I. E. Palaeozoic ostracodes from key sections in the European part of the USSR*, 7-133, pls. 1-46. Nauka, Moscow. [In Russian].
- Allen, J.R.L. 1974. Sedimentology of the Old Red Sandstone (Siluro-Devonian) in the Clee Hills area, Shropshire, England. *Sedimentary Geol.*, **12**, 73-167.
- Allen, J.R.L. 1985. Marine to fresh water: the sedimentology of the interrupted environmental transition (Ludlow-Sieginian) in the Anglo-Welsh Basin. *Phil. Trans. Roy. Soc. Lond.*, **B 309**, 85-104.
- Allen, J.R.L. & Tarlo, L.B. 1963. The Downtonian and Dittonian facies of the Welsh Borderland. *Geol. Mag.*, **100**, 129-155.
- Bassett, M.G. 1970-74. The articulate brachiopods from the Wenlock Series of the Welsh Borderland and South Wales. *Palaeontogr. Soc. Monogr.*, London: Part 1, 1-26, 1970; Part 2, 27-78, 1972; Part 3) 79-122, 1974; pls. 1-22.
- Bassett, M.G. 1974. Review of the stratigraphy of the Wenlock Series in the Welsh Borderland and South Wales. *Palaeontology*, **11**, 745-77.

- Bassett, M.G. 1976. A critique of diachronism, community distribution and correlation at the Wenlock-Ludlow boundary. *Lethaia*, **9**, 207-218.
- Bassett, M.G., Bevins, R.E., Gibbons, W. & Howells, M.F. 1986. A geotraverse through the Caledonides of Wales. In: Fettes, D.J. & Harris, A.L. (eds), *Synthesis of the Caledonian rocks of Britain*, 29-75. Reidal Publ. Co.
- Bassett, M.G., Bluck, B.J., Cave, R., Holland, C.H. & Lawson, J.D. 1992. Silurian, in *Atlas of Palaeogeography and Lithofacies* (eds J.C.W. Cope, J.K. Ingham and P.F. Rawson). *Mem. Geol. Soc., Lond.*, No. **13**, pp. 37-56.
- Bassett, M.G., Cocks, L.R.M., Holland, C.H., Rickards, R.B. & Warren, P.T. 1975. The Type Wenlock Series. *Rep. Inst. Geol. Sci.*, No. **75**, 13, 19pp.
- Bassett, M.G., Lawson, J.D. & White, D.E. 1982. The Downton Series as the fourth Series of the Silurian. *Lethaia*, **15**, 1-24.
- Cherns, L. 1988. Faunal and facies dynamics in the upper Silurian of the Anglo-Welsh Basin. *Palaeontology*, **31**, 451-502.
- Cobbold, E.S. 1921. The Cambrian horizons of Comley (Shropshire) and their Brachiopoda, Pteropoda, Gasteropoda, etc. *Quart. Jl Geol. Soc. Lond.*, **76** (for 1920), 325-386.
- Cobbold, E.S. 1927. The stratigraphy and geological structure of the Cambrian area of Comley (Shropshire). *Quart. Jl Geol. Soc. Lond.*, **83**, 551-573.
- Cobbold, E.S. 1933. Notes on Comley Quarry, near Church Stretton, Shropshire. *Rep. Brit. Assoc.* (for 1933), 473-476.
- Cocks, L.R.M., Holland, C.H. & Rickards, R.B. 1992. A revised Correlation of Silurian Rocks in the British Isles. *Spec. Rep. Geol. Soc. Lond.*, No **21**, 32 pp.
- Copeland, M.J. 1964. Stratigraphic distribution of Upper Silurian Ostracoda, Stonehouse Formation, Nova Scotia. In: Canadian Fossil Ostracoda, some Silurian species. *Bull. geol. Surv. Can.*, **117**, 1-13, pl. 1.
- Cowie, J.W., Rushton, A.W.A. & Stubblefield, C.J. 1972. A correlation of Cambrian rocks in the British Isles. *Spec. Rep. Geol. Soc. Lond.*, no. **2**, 42 pp.
- Edwards, D., Davies, K.L., Richardson, J.B., Wellman, C.H., & Axe, L. 1996. Ultrastructure of *Synoisporites downtonensis* and *Retusotrilites* cf. *coronadus* in spore masses from the Prídolí of the Welsh Borderland. *Palaeontology*, **39**, 783-800.
- Ellis, G.L. & Slater, I.L. 1906. The highest Silurian rocks of the Ludlow district. *Quart. Jl Geol. Soc. Lond.*, **62**, 195-222.
- Fortey, R.A., Harper, D.A.T., Ingham, J.K., Owen, A.W. and Rushton, A.W.A. 1995. A revision of Ordovician series and stages from the Historical type area. *Geol. Mag.*, **132**(1), 15-30.
- Greig, D.C., Wright, J.E., Hains, B.A. & Mitchell, G.H. 1968. Geology of the country around Chuch Stretton, Craven Arms, Wenlock Edge and Brown Clee. *Mem. Geol. Surv. U.K.*, xiii +379pp.
- Hansch, W. & Siveter, D. J. 1994. '*Nodibeyrichia jurassica*' and associated beyrichiacean ostracode species and their significance for the correlation of late Silurian strata in the Baltic and Britain. *Jl. Micropal.*, 81-91, 2 pls, 1 fig.
- Hansch, W., Siveter, D. J. & Miller, G. 1991. On *Frostiella groenvalliana* Martinsson. *Stereo-Atlas Ostracod Shells*, **18**, 125-134, 2pls.
- Harper, J. C. 1947. *Tetradella complicata* (Salter) and some Caradoc species of the genus. *Geol. Mag.*, **84**, 345-353, pl. 10.
- Holland, C.H., Lawson, J.D. & Walmsley, V.G. 1963. The Silurian rocks of the Ludlow District. *Bull. Brit. Mus. (Nat. Hist.)*, *Geol.*, **8**, 93-171.
- Holland, C. H. & Bassett, M. G. (Eds) 1989. A Global Standard for the Silurian System. *Nat. Mus. Wales, Geol. Ser.*, no. **9**, 325 pp. Cardiff.
- Hou Xianguang, Siveter, David. J., Williams M., Walossek, D. & J. Bergström, J. 1996. Appendages of the arthropod *Kunmingella* from the early Cambrian of China: its bearing on the systematic position of the Bradoriida and the fossil record of the Ostracoda. *Phil. Trans. R. Soc. Lond. B*, **351**, 1131-1145.
- Hurst, J.M. 1975a. The diachronism of the Wenlock Limestone. *Lethaia*, **8**, 301-314.
- Hurst, J.M. 1975b. Wenlock carbonate, level bottom, brachiopod-dominated communities from Wales and the Welsh Borderland. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **17**, 227-255.

- Jeppsson, L. 1990. An oceanic model for lithological and faunal changes tested on the Silurian record. *Jl Geol. Soc. Lond.*, **147**, 663-674.
- Jeppsson, L., Aldridge, R.J. & Dorning, K.J. 1995. Wenlock (Silurian) oceanic episodes and events. *Jl Geol. Soc. Lond.*, **152**, 487-498.
- Jeram, A.J., Selden, P.A. & Edwards, D. 1990. Land animals in the Silurian: arachnids and myriapods from Shropshire, England. *Science*, **250**, 658-661.
- Jones, C.R. 1984. On *Duringia triformosa* Jones sp. nov. *Stereo-Atlas Ostracod Shells*, **11** (4), 13-16, 2 pls.
- Jones, C.R. 1986. Ordovician (Llandeilo and Caradoc) beyrichiocope Ostracoda from England and Wales. Part 1. *Monogr. palaeontogr. Soc. London*, 1-76, pls. 23-30 (Publ. no. 569, part of **138**, for 1984).
- Jones, C.R. 1987. Ordovician (Llandeilo and Caradoc) beyrichiocope Ostracoda from England and Wales. Part 2. *Monogr. palaeontogr. Soc. London*, 77-114, pls. 1-22 (Publ. no. 571, part of **139**, for 1985).
- Jones, C.R. & Siveter, D. J. 1983. On *Harperopsis scripta* (Harper). *Stereo-Atlas Ostracod Shells*, **10** (2), 5-12, 2 pls.
- Jones, T.R. 1855. Notes on Palaeozoic bivalved Entomostraca, No. II. Some British and foreign species of *Beyrichia*. *Ann. Mag. Nat. Hist.*, (2), **16**, 163-76.
- Jones, T.R. 1869. *On the Palaeozoic bivalved Entomostraca*. [Paper read before the Geologists' Association, May 7th 1869.] 15pp, 23 text-figs. Hertford.
- Jones, T.R. 1887a. Notes on the Palaeozoic bivalved Entomostraca, No. XXIII. On some Silurian genera and species (continued). *Ann. Mag. Nat. Hist.*, (5) **19**, 177-95.
- Jones, T.R. 1887b. Notes on the Palaeozoic bivalved Entomostraca, No. XXIV. On Some Silurian genera and species (continued). *Ann. Mag. Nat. Hist.*, (5) **19**, 400-16.
- Jones, T.R. & Holl, H.B. 1869. Notes on the Palaeozoic bivalved Entomostraca, No. IX. Some Silurian species. *Ann. Mag. Nat. Hist.*, (4), **3**, 211-29.
- Jones, T.R. & Holl, H.B. 1886a. Notes on the Palaeozoic bivalved Entomostraca, No. XX. On the genus *Beyrichia* and some new species. *Ann. Mag. Nat. Hist.*, (5), **17**, 337-63.
- Jones, T.R. & Holl, H.B. 1886b. Notes on the Palaeozoic bivalved Entomostraca, No. XXI. On some Silurian genera and species. *Ann. Mag. Nat. Hist.*, (5), **17**, 403-14.
- Kiesow, J. 1888. Ueber Gotländische Beyrichien. *Zeitschrift der Deutschen geologischen Gesellschaft*, **40**, 1-16, pls. 1, 2.
- Kjellesvig-Waering, E.N. 1961. The Silurian Eurypterida of the Welsh Borderland. *Jl Paleontol.*, **35**, 789-835.
- Lang, W.H. 1937. On the plant remains from the Downtonian of England and Wales. *Phil. Trans. R. Soc. Lond.*, **B 227**, 245-291.
- Lawson, J.D. 1973a. New exposures on forestry roads near Ludlow. *Geol. Jl*, **8**, 279-284.
- Lawson, J.D. 1973b. Facies and faunal changes in the Ludlovian rocks of Aymestrey, Herefordshire. *Geol. Jl.*, **8**, 247-78.
- Lawson, J.D. & White, D.E. 1989. The Ludlow Series in the Ludlow area, in *A global standard for the Silurian System* (eds M.G. Bassett and C.H. Holland). National Museum of Wales, Geological series, Cardiff, No. **9**, pp. 73-90.
- Lundin, R.F. & Peterson, L.E. 1975. *Thlipsura* Jones & Holl: a redescription of the type-species. *Bull. Amer. Paleont.*, **65**, no. 282, 87-107.
- Lundin, R. F. & Petersen, L. E. 1993. On *Wenlockiella phillipsiana* (Jones & Holl). *Stereo-Atlas Ostracod Shells*, **20** (12):49-54.
- Lundin, R.F., Petersen, L. E. & Siveter, D. J. 1991. Non palaeocope ostracod biostratigraphy of the type Wenlock Series, Silurian, of the Welsh Borderland. *Jl. Micropal.*, **9** (2) (for 1990), 173-189.
- Martinsson, A. 1962. Ostracodes of the Family Beyrichiidae from the Silurian of Gotland. *Bull. geol. Insm Univ. Uppsala*, **41**, 1-369, 203 figs.
- Martinsson, A. 1963. *Kloedenia* and related ostracod genera from the Silurian and Devonian of the Baltic area and Britain. *Bull. geol. Insm. Univ. Uppsala*, **42**, 1-63.

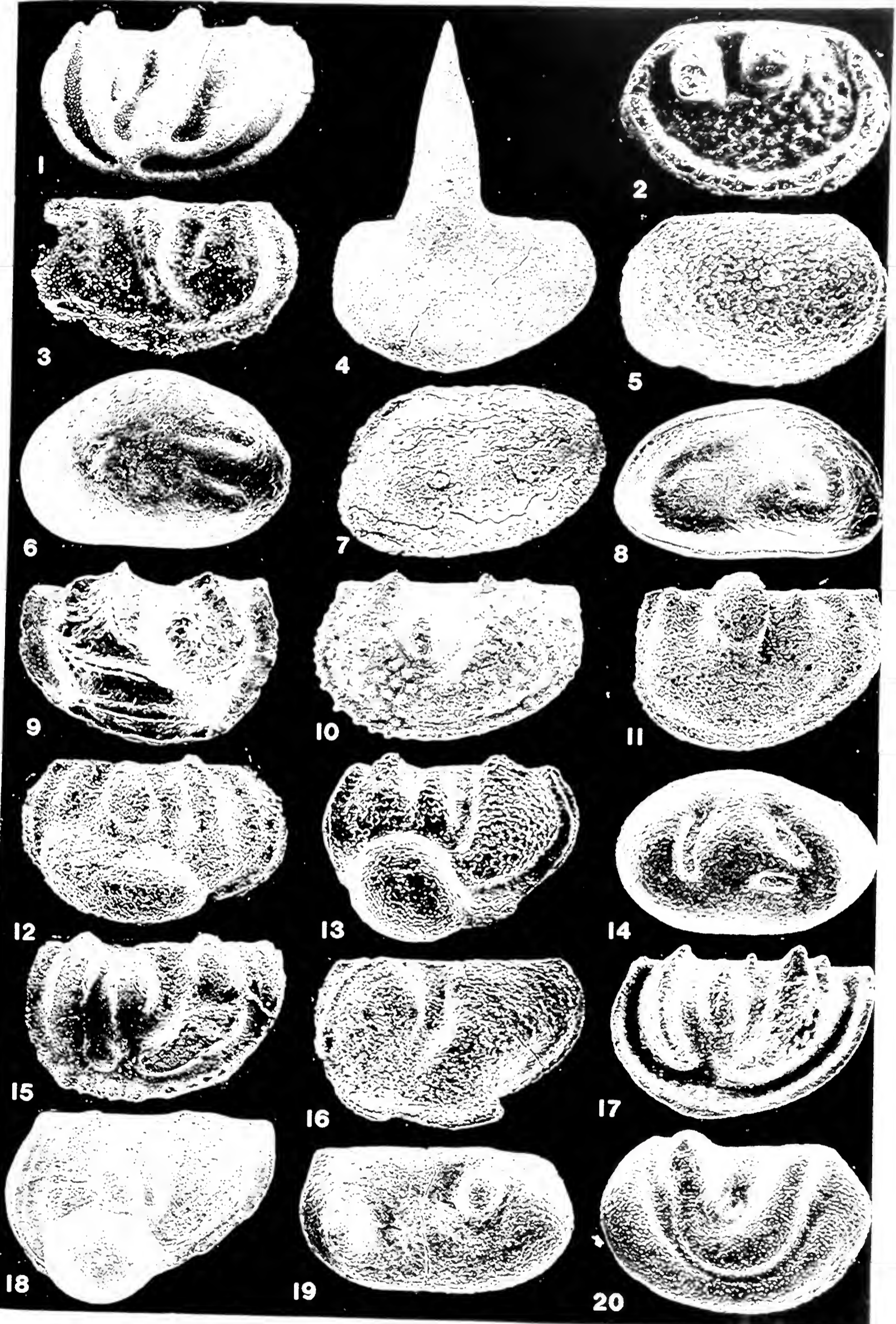
- Martinsson, A. 1967. The succession and correlation of ostracod faunas in the Silurian of Gotland. *Geol. För. Stockh. Förh.*, **89**, 350-86.
- Miller, C.G. 1995. Ostracode and conodont distribution across the Ludlow/Prídolí boundary of Wales and the Welsh Borderland. *Palaeontology*, **38**, 341-384.
- Mullins, G.L. 1996. Palynology of the Lower and Middle Elton Formations (Ludlow Series, Silurian) in the Ludlow type area, Shropshire. Unpublished Ph. D. Thesis, University of Leicester, 168 pp. + 6 appendices.
- Murchison, R.I. 1839. *The Silurian System founded on geological researches in the counties of Salop Hereford, Radnor, Montgomery, Caermarthen, Brecon, Pembroke, Monmouth, Gloucester, Worcester and Stafford; with descriptions of the coalfields and overlying formations*, xxxii + 768pp., 37pls., London.
- Newell, G. 1966. A faunal and sedimentary study of the Aymestry Limestone and adjacent beds in parts of Herefordshire and Shropshire. Unpublished Ph.D thesis, University of Manchester.
- Pickering, K.T. & Smith, A.G. 1995. Arcs and backarc basins in the early Palaeozoic Iapetus Ocean. *The Island Arc*, **4**, 1-67.
- Reed, F.R.C. 1910. New fossils from the Dufton Shales, Pt. 2. *Geol. Mag.*, **7**, 214-220, 2 pls.
- Richardson, J.B. & Lister, T.R. 1969. Upper Silurian and Lower Devonian spore assemblages from the Welsh Borderland and South Wales. *Palaeontology*, **12**, 201-252.
- Richardson, J.B. & Rasul, S.M. 1990. Palynofacies in a late Silurian regressive sequence in the Welsh Borderland and Wales. *Jl Geol. Soc. Lond.* **147**, 675-686.
- Schallreuter, R.E.L. & Siveter, D.J. 1985. Ostracods across the Iapetus Ocean. *Palaeontology*, **28**, 577-598.
- Scoffin, T.P. 1972. The conditions of growth of the Wenlock reefs of Shropshire, England. *Sedimentology*, **17**, 173-219.
- Shaw, R. W. L. 1969. Beyrichiacean ostracodes from the Downtonian of Shropshire. *Geol. För. Stockh. Förh.*, **91**, 52-72.
- Shaw, R. W. L. 1971. Ostracoda from the Underbarrow, Kirkby Moor and Scout Hill Flags (Silurian) near Kendal, Westmorland. *Palaeontology*, **14**, 595-611.
- Shergold, J.H. & Bassett, M.G. 1970. Facies and faunas at the Wenlock/Ludlow boundary of Wenlock Edge, Shropshire. *Lethaia*, **3**, 113-42.
- Siveter, D.J. 1974. *The superfamily Beyrichiacea (Ostracoda) from the Silurian and Devonian Systems of Britain*. Unpublished Ph.D. Thesis. Univ. of Leicester, 2 vols. 428pp., 57pls.
- Siveter, D.J. 1978a. The Ordovician, pp. 41-56. *In*: Bate, R. H. & Robinson E. (Eds.), A stratigraphical index of British Ostracoda. *Geol. Jl. spec. iss.*, **8**.
- Siveter, D.J. 1978b. The Silurian, 57-100. *In*: Bate, R. H. & Robinson E. (Eds), A stratigraphical index of British Ostracoda. *Geol. Jl. spec. iss.*, **8**.
- Siveter, D.J. 1980. British Silurian Beyrichiacea (Ostracoda). *Monogr. palaeontogr. Soc. London*, **133** (for 1979), (1), 1-76, pls. 1-27.
- Siveter, D.J. 1982. Casts illustrating fine ornament of a Silurian ostracod. *In*: Bate, R. H., Robinson, E. & Sheppard, L. M. (Eds). *Fossil and Recent Ostracods*, 105-122, 5pls. British Micropal. Soc., London.
- Siveter, D.J. 1983. On *Vitella fecunda* Siveter sp. nov. *Stereo-Atlas Ostracod Shells*, **10** (3), 13-16, 1pl.
- Siveter, D.J. 1984. Habitats and modes of life of Silurian Ostracodes. *In*: Bassett, M. G. & Lawson, J. D. (Eds.), *The Autecology of Silurian Organisms. Spec. pap. Palaeontol.*, no **32**, 71-85, 2pls.
- Siveter, D. J. 1988. *Ostracoda: The Lower Palaeozoic of the Northern Welsh Borderland and South Wales*. 52pp., 2pls. Field Guide No. 2. British Micropalaeont. Soc.
- Siveter, D.J. 1989. Ostracodes. *In*: Holland, C. H. & Bassett, M. G. (Eds), A Global Standard for the Silurian System. *Nat. Mus. Wales, Geol. Ser.*, no. **9**, 252-264, 4 figs. Cardiff.
- Siveter, D.J., Owens, R.M.R. & Thomas, A.T. 1989. Silurian Field Excursions: A Geotraverse across Wales and the Welsh Borderland. *Nat. Mus. Wales, Geol. Ser.*, no. **10**, 133pp., 121 figs., 3 pls. Cardiff.

- Siveter, D.J., Vannier, J.M.C. & Palmer, D. 1987. Silurian myodocopid ostracodes: their depositional environments and the origin of their shell microstructures. *Palaeontology*, **30**, 783-813, 10 figs, pls. 83-88.
- Siveter, D.J., Vannier, J.M.C. & Palmer, D. 1991. Silurian myodocopes: pioneer pelagic ostracodes and the chronology of an ecological shift. *Jl. Micropal.*, **10**, 151-173, 3pls.
- Siveter, D.J. & Williams, M. 1995. An early Cambrian assignment for the Caerfai Group of South Wales. *Jl Geol. Soc. Lond.*, **152**, 221-224.
- Siveter, D.J. & Williams, M. 1997 (*in press*). Cambrian Bradoriida and Phosphatocopida (Arthropoda) of North America. *Spec. Pap. Palaeontology*.
- Smith, J. 1881. Notes on a collection of bivalved Entomostraca and other Microzoa from the Upper Silurian strata of the Shropshire district. *Geol. Mag.*, (2), **8**, 70-75.
- Smith, J. 1892. English Upper Silurian Ostracoda. *Trans. Nat. Hist. Soc. Glasg.*, **3**, 134-58.
- Smith, R.D.A. & Ainsworth, R.B. 1989. Hummocky cross-stratification in the Downton of the Welsh Borderland. *Jl Geol.Soc. Lond.*, **146**, 897-900.
- Sutherland, S.J.E. 1994. Ludlow chitinozoans from the type area and adjacent regions. *Palaeontogr. Soc. Monogr.*, London, no. 594 for **148**, 104 pp.
- Toghill, P. 1992. Onny Valley, Shropshire Geology Teaching Trail. *Geol. Assoc. Guide*, no. 45, 21pp.
- Toghill, P. & Chell, K. 1984. Shropshire geology - stratigraphic and tectonic history. *Fld. Studies*, **6**, 59-101.
- Turner, S. 1973. Siluro-Devonian vertebrates from the Welsh Borderland. *Jl Geol.Soc. Lond.*, **129**, 557-584.
- Vannier, J.M.C., Siveter, D.J. & Schallreuter, R.E.L. 1989. The composition and palaeogeographical significance of the Ordovician ostracode faunas of Southern Britain, Baltoscandia and Ibero-America. *Palaeontology*, **32**, 163-222, 38 figs., pls 24-30.
- Watkins, R. 1979. Benthic community organisation in the Ludlow Series of the Welsh Borderland. *Bull. Brit. Mus. Nat. Hist. (Geol.)*, **31**, 175-280.
- Watkins, R. & Aithie, C.J. 1980. Carbonate shelf environments and faunal communities in the Upper Bringewood Beds of the British Silurian *Palaeogeography, Palaeoclimatology, Palaecology*, **29**, 341-368.
- White, E.I. 1950. The vertebrate faunas of the Lower Old Red Sandstone of the Welsh Borders. *Bull. Brit. Mus. (Nat.Hist.), Geol.*, **31**, 175-280.
- White, D.E. & Lawson, J.D. 1978. The stratigraphy of new sections in the Ludlow Series of the type area. *Rep. Inst. Geol.Sci.*, **78/30**. 10 pp.
- White, D.E. & Lawson, J.D. 1989. The Prídolí Series in the Welsh Borderland and south-central Wales, in A global standard for the Silurian System (eds M.G. Bassett and C.H. Holland). *Nat. Mus. Wales, Geol. Ser.*, No. **9**, pp. 131-141. Cardiff.
- Williams, M. & Siveter, D.J. *In Press* Cambrian and Tremadoc bradoriid and phosphatocopid arthropods of Britain. *Palaeontogr. Soc. Monogr.*, London.
- Williams, M., Siveter, D.J., Rushton, A.W.A. & Berg-Madsen, V. 1994. The Upper Cambrian bradoriid ostracod *Cyclotron lapworthi* is a hesslandonid. *Trans. Roy. Soc. Edinb., Earth Sci.*, **85**, 123-130.
- Williams, A., Strachan, I. Bassett, D.A., Dean, W.T., Ingham, J. K., Wright, A.D., & Whittington, H.B. 1972. A correlation of Ordovician rocks in the British Isles. *Spec. Rep. Geol. Soc. Lond.*, no. **3**, 74pp.
- Woodcock, N.H. & Gibbons, W. 1988. Is the Welsh Borderland fault system a terrane boundary? *Jl Geol. Soc. Lond.*, **145**, 915-23

Explanation of Plate 1

Cambrian bradoriid and Ordovician and Silurian ostracods from the Welsh Borderland

- Fig. 1 *Harperopsis scripta* (Harper, 1947). BGS GSM 74875A, cast of male left valve external mould, holotype, x18. Harnage Shales, Caradoc Series; 150m E of Cwms Cottage, Caer Caradoc hill track, 2.5km NE of Church Stretton, Shropshire (SO 4816 9493).
- Fig. 2 *Ulrichia? bicornis* (Jones, 1855). BM OS 6673, cast of left valve external mould, x74. Smeathen Wood Formation (= 'Harnage Shales'), Caradoc Series; exposure on south side of B4372 road, 180m WNW of Hope Bowdler Church, Shropshire (SO 4739 9244).
- Fig. 3 *Varilatella (Varilatella) bulbosa* Jones, 1986. BM OS 12609, cast of male right valve external mould, holotype, x25. Horizon and locality as for Fig. 2.
- Fig. 4 *Aechmina cuspidata* Jones & Holl, 1869. BM OS 6639, left valve, x36. Much Wenlock Limestone Formation, Wenlock Series; old quarries between Cother Wood and Croft Farm, 0.5m W of Malvern, Hereford & Worcester (SO 757 464).
- Fig. 5 *Primitiopsis valida* (Jones & Holl, 1886). BM OS 6656, female carapace, right lateral view, x45. Lower Elton Formation, Ludlow Series; stream section, about 600m NW of Upper Millichope, Shropshire (SO 5785 8987).
- Fig. 6 *Thlipsura corpulenta* Jones & Holl, 1869. BM OS 6642, carapace, left lateral view, x45. Much Wenlock Limestone Formation, Wenlock Series; Lincoln Hill, about 250m N of River Severn at Ironbridge, Shropshire (SJ 6693 0381).
- Fig. 7 *Indiana lentiformis* (Cobbold, 1921). BU 51, carapace, right lateral view, holotype, x3.7. Red *Callavia* Sandstone (Ac2), Olenellid Zone, Comley 'Series'; Comley Quarry, Shropshire (SO 4845 9647).
- Fig. 8 *Octonaria octoformis* Jones, 1887. BM OS 6648, carapace, right lateral view, x36. Farley Member, Coalbrookdale Formation, Wenlock Series; about 100m west of Brower's Brook, Benthall Edge, Ironbridge, Shropshire (SJ 6664 0352).
- Fig. 9 *Strepula concentrica* Jones & Holl, 1886. BM IO 4756, female right valve, x43. Much Wenlock Limestone Formation, Wenlock Series; small quarry, N side of A458 road, crest of Harley Hill, about 1.2km NW of Much Wenlock, Shropshire (SJ 6110 0034).
- Fig. 10 *Beyrichia clausa* Jones & Holl, 1886. BM OS 6562, male carapace, left lateral view, x22. Horizon and locality as for Fig. 6.
- Fig. 11 *Frostiella groenvalliana* Martinsson, 1963. BM OS 6619, cast of external mould of tecnomorphic left valve, x24. Platyschisma Shale Member, Downton Castle Sandstone Formation, Pridoli Series; about 1.5m above Ludlow Bone Bed Member, N side of Ludford Lane, about 70m W of junction with A49 road, Ludlow, Shropshire (SO 5119 7413).



- Fig. 12 *Londinia arisaigensis* Copeland, 1964. BM OS 6612, cast of external mould of female left valve, x20. Horizon and locality as for Fig. 11.
- Fig. 13 *Amphitoxotis repanda* Siveter, 1980. BM OS 6523, holotype, female left valve, x38. Horizon and locality as for Fig. 6.
- Fig. 14 *Primitivothlipsurella v-scripta* Jones & Holl, 1869. BM OS 6645, left valve, x45. Much Wenlock Limestone Formation, Wenlock Series; old quarries N of old road across Hobbs' Ridge, about 0.7km NE of Longhope, May Hill inlier, Gloucestershire (SO 6946 1953).
- Fig. 15 *Neobeyrichia lauensis* (Kiesow, 1888). BM OS 6593, cast of external mould of tecomorphic left valve, x19. Upper Leintwardine Formation, Ludlow Series; track, about 300m W of the Riverside (formerly the Crown) Inn at Aymestrey, Hereford & Worcester (SO 4228 6544).
- Fig. 16 *Xysistia auricularis* (Jones, 1887). BM OS 12266, male left valve, x42. Coalbrookdale Formation, Wenlock Series; Storridge road cutting, Malverns area, Hereford & Worcester (SO 4758 4853).
- Fig. 17 *Sleia pauparata* (Jones, 1869). BM OS 6400, male left valve, x40. Horizon and locality as for Fig. 6.
- Fig. 18 *Craspedobolbina interrupta* (Jones, 1887). BM In 27474, lectotype, female carapace, left lateral view, x19. Buildwas Formation, Wenlock Series, Buildwas, Shropshire.
- Fig. 19 *Parulrichia diversa* (Jones & Holl, 1886). BM OS 6649, right valve, x42. Buildwas Formation, Wenlock Series; bluff on E bank of Harley Brook, about 220m S of junction with Merrishaw Brook, near Domas, Shropshire (approximately SJ 592 003).
- Fig. 20 *Bollia bicollina* Jones & Holl, 1886. BM OS 6638, x43. Buildwas Formation, Wenlock Series; bluff on E bank of Harley Brook, near Domas, Shropshire (SJ 5922 0030).

BGS: British Geological Survey, Keyworth

BM: Natural History Museum, London

BU: Lapworth Museum, University of Birmingham

UPPER TRIASSIC OF AUST CLIFF, AVON

Ian D. Boomer (University of East Anglia)

The coastal exposures of the Severn Estuary in Somerset and Avon are a proposed stratotype for the Triassic-Jurassic boundary. The late Triassic (Rhaetian) age sequence, formerly the Rhaetic Beds, now constitutes the Penarth Group and is locally exposed along the the South Wales, Devon, Somerset and Avon coasts of the Severn Estuary and inland around Gloucestershire. These deposits are also known landwards below the Jurassic of the Wessex Basin and to the west and south in the Bristol and English channels. The typical Upper Triassic sedimentary sequence in the Bristol Channel area is summarised in Figure 1. Unfortunately, only the lowest stratigraphic levels of the Penarth Group are accessible at Aust Cliff.

As with many fossil groups of this age it is often difficult to distinguish true ostracod evolutionary events (appearances, extinctions) from the colonisation history within latest Triassic assemblages due to the global rise in sea-level which influenced this area of the British Isles at that time. The Penarth Group broadly represents a transgressive sequence which ultimately resulted in deposition of the shales, mudstones and limestones of the Liassic group.

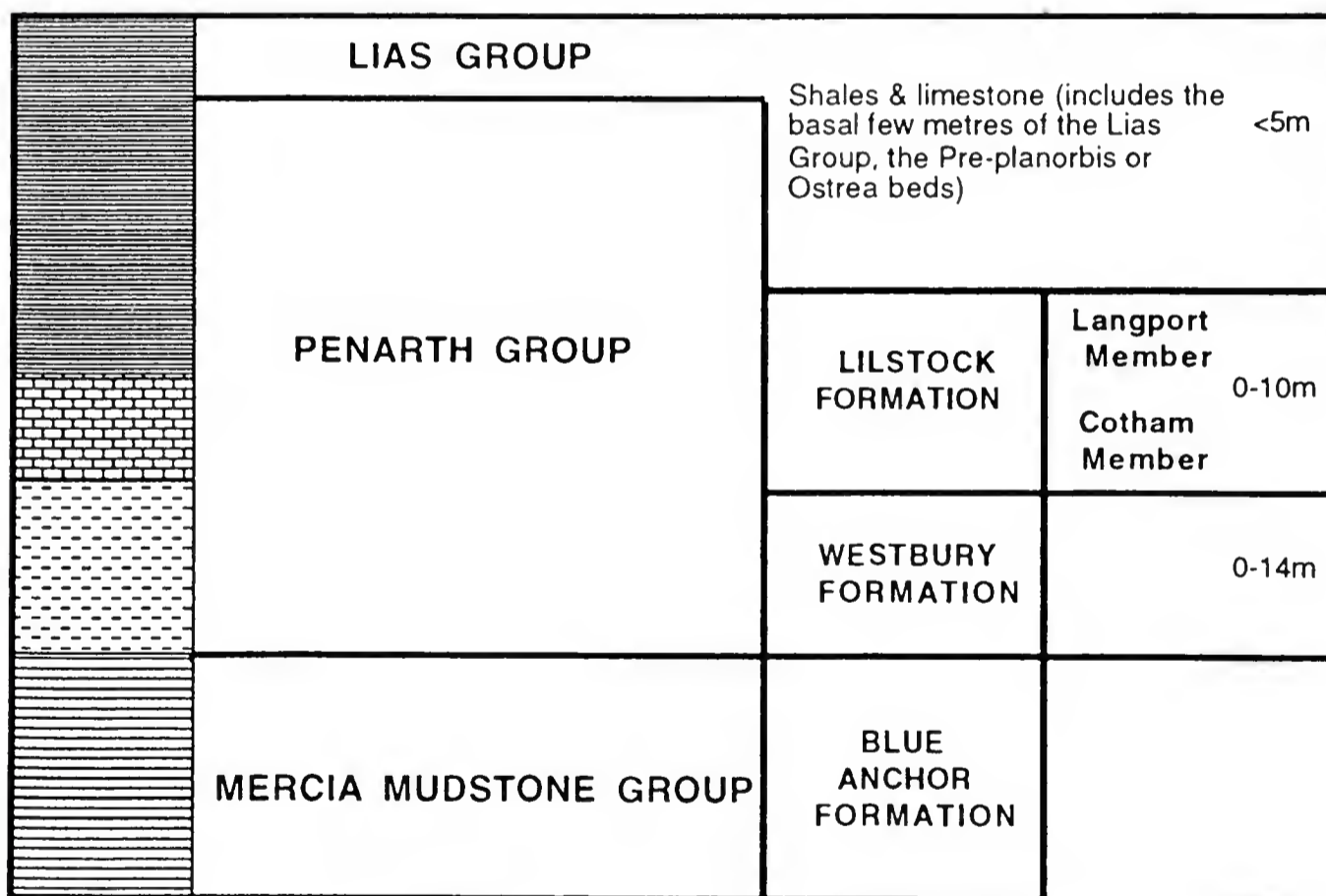


Figure 1. Stratigraphical summary of Penarth Group, Bristol Channel.

Previous Studies

Latest Triassic ostracod assemblages have been described from the European Alps (Kristan-Tollmann 1971, Bolz, 1971a, 1971b), the Middle East (Kristan-Tollmann *et al.* 1980) and through to the Far East (Gramm 1975) and South East Asia (Kristan-Tollmann & Hasibuan 1990). Those assemblages are considered to be exclusively marine whereas the records from the British Isles are mainly of marginal marine/lagoonal through to brackish/freshwater aspect. The earliest papers dealing with British Triassic ostracods were those of Duff (1942), Brodie (1845), Jones (1894), Anderson (1964) and Field (1966).

Ostracod assemblages from the British Penarth Group are generally sparse and of low diversity although high abundance levels are not uncommon. The best known ostracod assemblages come from the Bristol Channel sections and the stratigraphical distribution of ostracods in those sections was described by Lord & Boomer (1990); two of the range-charts from that paper are reproduced in Figure 2. Ainsworth (1989, 1990, Ainsworth *et al.* 1989) also recorded ostracods from the Penarth Group encountered in exploration wells from offshore western Ireland. The stratigraphical review undertaken by Bate (1978) has recently been revised (Ainsworth & Boomer *in press*).

Stratigraphical and ecological ranges of ostracods

British Triassic ostracods generally belong to smooth unornamented or weakly ornamented genera and are often preserved as carapaces. Thus, there are few external features to aid specific (and in some cases generic) identification while the carapaces deny us access to the often taxonomically significant internal features such as the muscle scars and hingement.

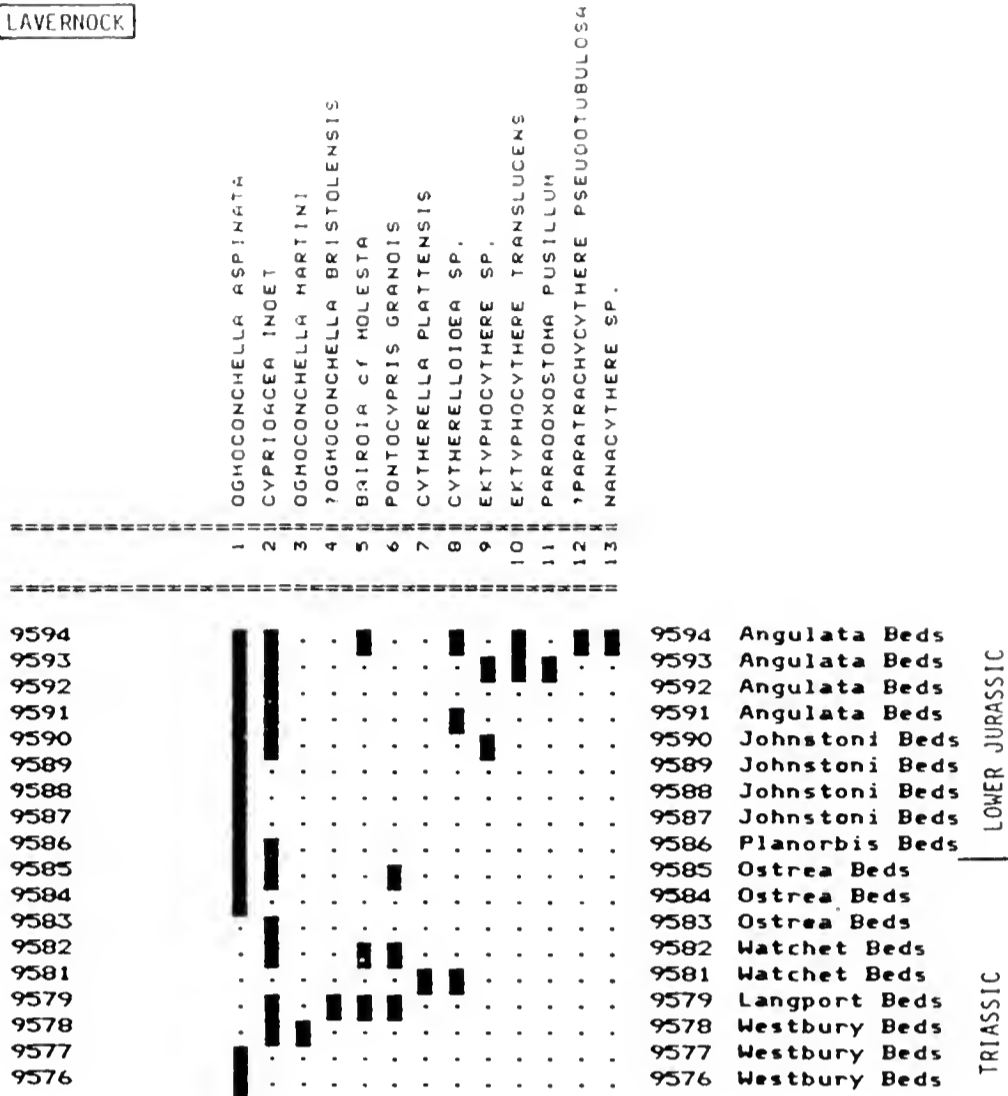
Most British Triassic ostracod assemblages have been attributed to non-marine, brackish or marginal marine/lagoonal environments. The non-marine taxa are represented by species of *Darwinula* and *Lutkevichinella*; the latter is generally considered to be a limnocytherid and resembles the extant genus *Limnocythere*.

The brackish water assemblages generally comprise a mixture of low salinity and more marine taxa. It is important in such cases to consider the taphonomy of the assemblage. We should also consider the possibility that some degree of reworking or contemporaneous mixing has occurred. One genus, *Rhombocythere*, is only known from the Triassic and its ecology has been inferred indirectly from its having been found in association with *Darwinula*. It did not survive into the marine conditions of the Early Jurassic and is considered to be restricted to freshwater and probably brackish water environments.

The marine assemblages generally comprise species which either survived into, or have descendants within, the Lias. Some of these marine species may have been capable of withstanding reduced salinity conditions, being found with *in-situ* freshwater assemblages. It is also probable that some 'marine' taxa were capable of withstanding hypersaline, lagoonal, conditions and this may explain some of the high abundance monospecific floods of metacopine species recorded in the uppermost Penarth Group and Lower Lias. The Metacopina are unornamented marine ostracods with ovate, inflated carapaces and often dominate Liassic assemblages until their final global extinction in the earliest Toarcian. There is probably one metacopine genus, *Ogmoconchella*, present in the assemblages of the Penarth Group.

There are two other main groups of marine ostracods in the British Rhaetian, the Cytheracea, essentially represented by *Ektypocythere*, and the Platycopina represented by the genera *Cytherella* and *Cytherelloidea/Leviella*. There is little evidence that any of these genera inhabited anything other than shelf sea environments.

LAVERNOCK



WATCHET

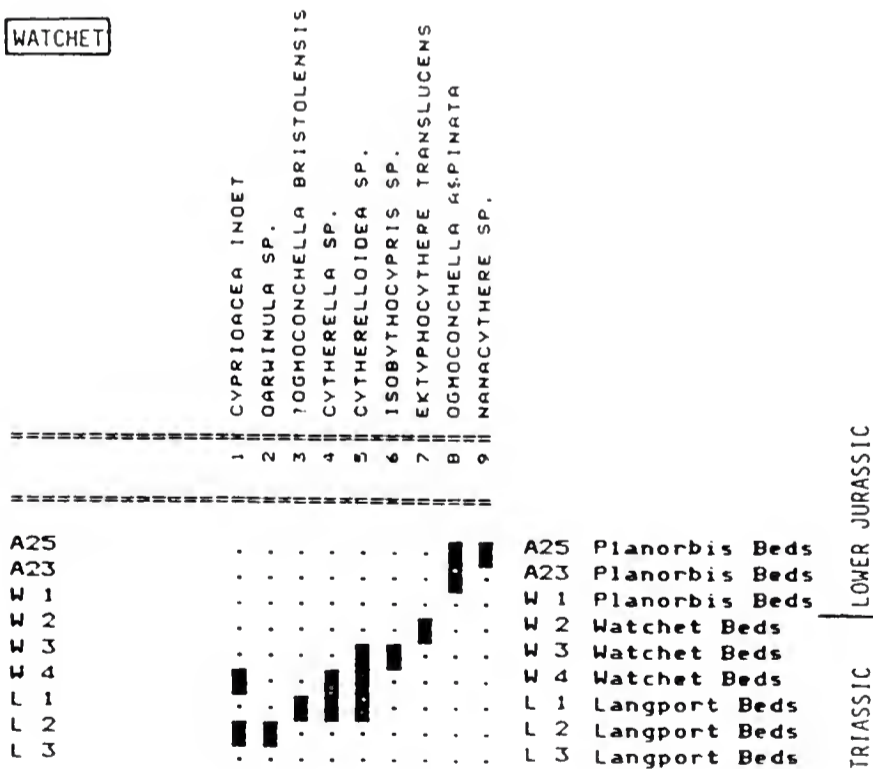


Figure 2. Range-charts of ostracods across the Triassic/Jurassic boundary at Watchet and Lavernock (from Lord & Boomer 1990).

References

- Ainsworth, N.R. 1989. Rhaetian, Hettangian and Sinemurian Ostracoda from the Fastnet Basin, offshore southwest Ireland. *Bull. Geol. Surv. Ireland*, **1989/4**, 107-150.
- Ainsworth, N.R. 1990. Uppermost Rhaetian to Lower Bajocian Ostracoda from the Porcupine, Slyne, Erris and Donegal basins, offshore west Ireland. *Bull. Geol. Surv. Ireland*, **1990/4**, 169-200.
- Ainsworth, N.R. & Boomer, I. *in press*. The Triassic. In Athersuch, J., Keen, M. and Wilkinson, I. (eds). *A Stratigraphical Index of British Ostracoda*, 2nd edition. Chapman & Hall. London.
- Ainsworth, N.R., O'Neill, M. & Rutherford, M.M. 1989. Jurassic and Upper Triassic biostratigraphy of the North Celtic Sea and Fastnet basins, 1-44. In Batten, D. and Keen, M.C. (eds). *Northwest European micropalaeontology and palynology*. Ellis Horwood Ltd., Chichester.
- Anderson, F.W. 1964. Rhaetic Ostracoda. *Bull. Geol. Surv. GB.*, **21**, 133-174.
- Bate, R.H. 1978. The Trias, pp.175-188. In Bate, R.H. & Robinson, E. (Eds). A stratigraphical index of British Ostracoda. *Geol. Jl. spec. iss.*, **8**.
- Bolz, H. 1971a. Die Zlambach-Schichten (alpine Obertrias) unterbesonderer Berücksichtigung der Ostracoden, 1: Ostracoden der Zlambach-Schichten, besonders Bairdiidae. *Senck. Leth.*, **52**, 129-283.
- Bolz, H. 1971b. Late Triassic Bairdiidae and Healdiidae, 717-745. In Oertli, H. J. (ed.). *Colloque sur la Paleoecologie des Ostracodes*.
- Brodie, P.B. 1845. *A history of the fossil insects in the secondary rocks of England*. John van Voorst, London, 130 pp + 10 plates.
- Duff, P. 1842. *Sketch of the Geology of Moray*. Oliver and Boyd, Edinburgh.
- Field, R.A. 1966. Species of the Family Cytherellidae (Ostracoda) from the Lower Lias of South Dorset, England. *Senck. leth.*, **47**, 87-105.
- Gramm, M.N. 1975. Marine Triassic Cytheracea (Ostracoda) from South Primorye (Soviet far east). *Palaeont. Abh. A*, **151**, 102-110.
- Jones, T.R. 1894. On the Rhaetic and some Liassic ostracoda of Britain. *Quart. Jl Geol. Soc., Lond.*, **50**, 156-169.
- Kristan-Tollman, E. 1971. Weitere Beobachtungen an skulptierten Bairdiidae (Ostracoda) der alpinen Trias. *N. Jb. Geol. Palaont. Abh*, **139**, 57-87.
- Kristan-Tollman, E. and Hasibuan, F. 1990. Ostracoden aus der Obertrias von Misol (Indonesien). *Mitt. osterr. geol. Ges*, **82**, 173-181.
- Kristan-Tollman, E., Tollmann, A. and Hamedani, A. 1980. Beiträge zur Kenntnis der Trias von Persien. *Mitt. osterr. geol. Ges*. **73**, 163-235.
- Lord, A.R. & Boomer, I.D. 1990. The occurrence of ostracods in the Triassic/Jurassic boundary interval. *Les Cahiers de l'Université Catholique de Lyon, Série Sciences*, **3**, 119-126.

Explanation of Plate 1

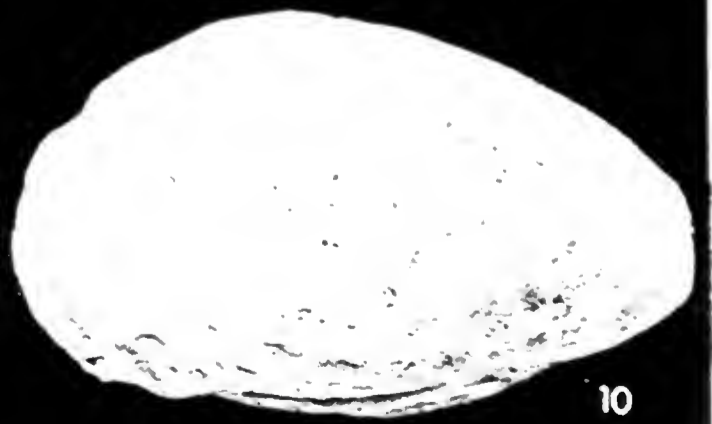
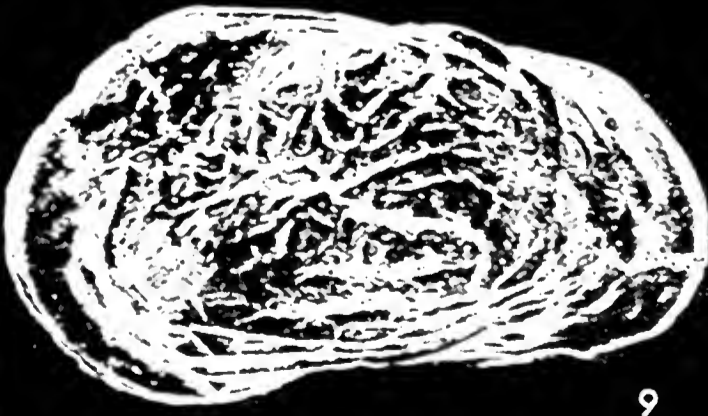
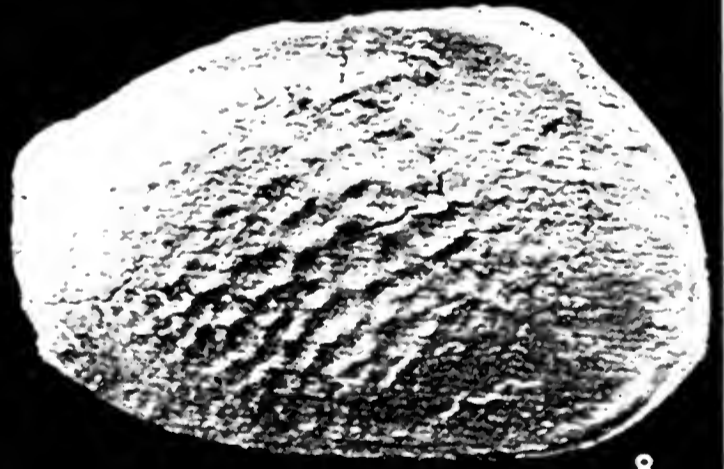
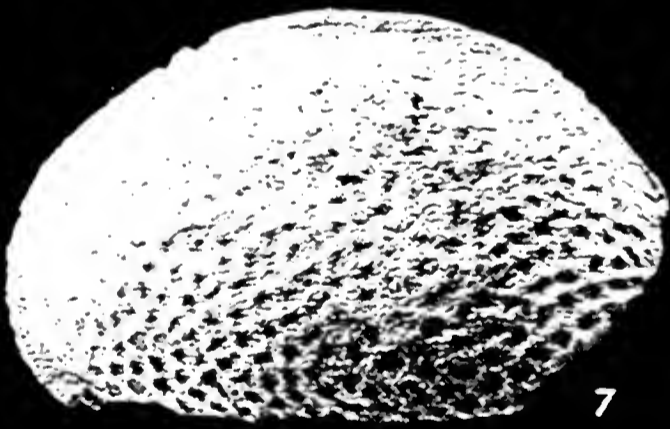
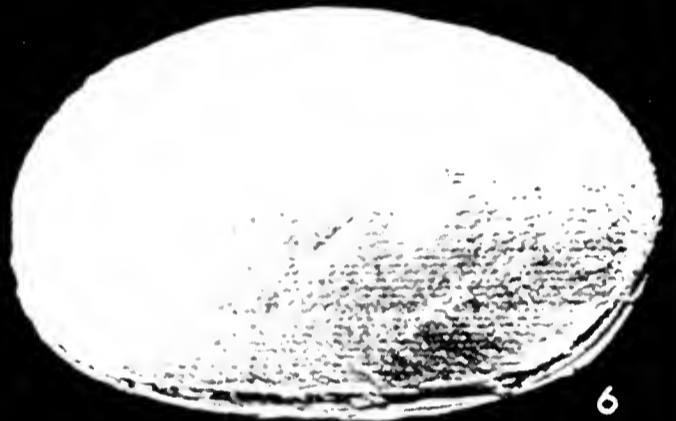
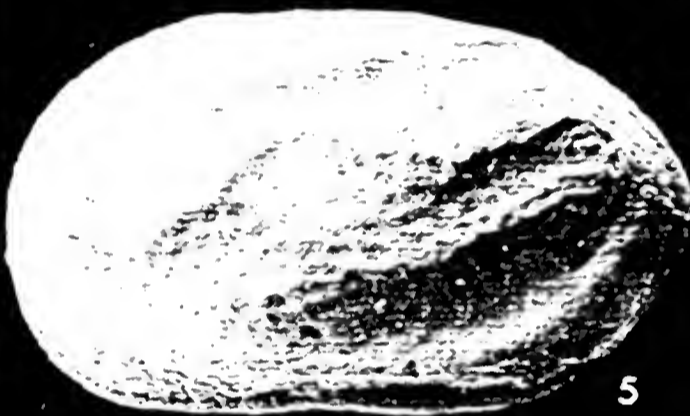
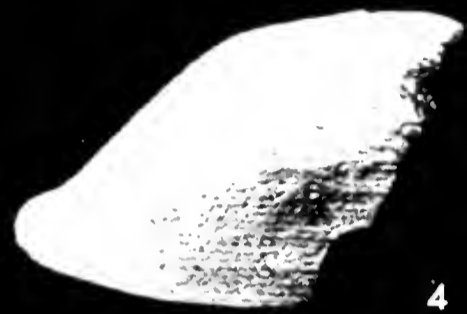
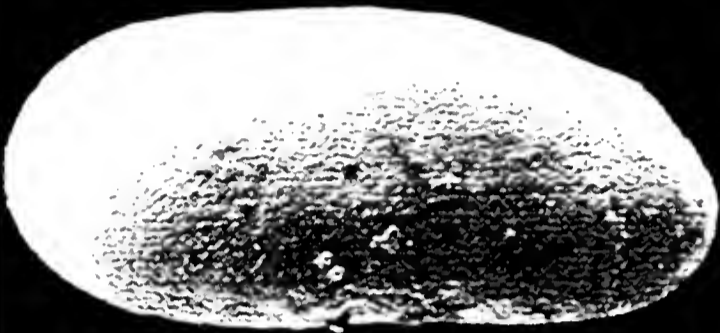
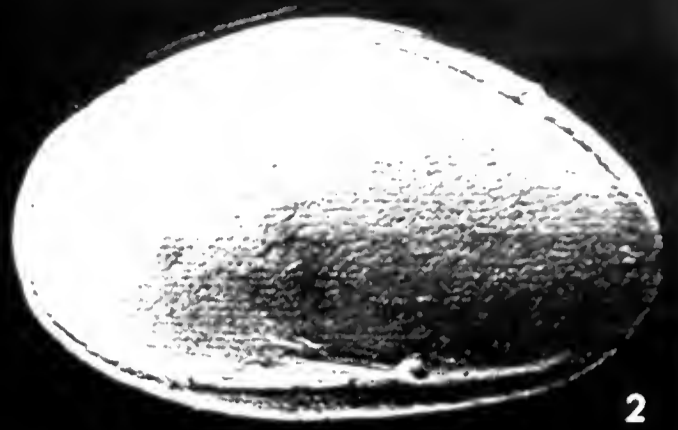
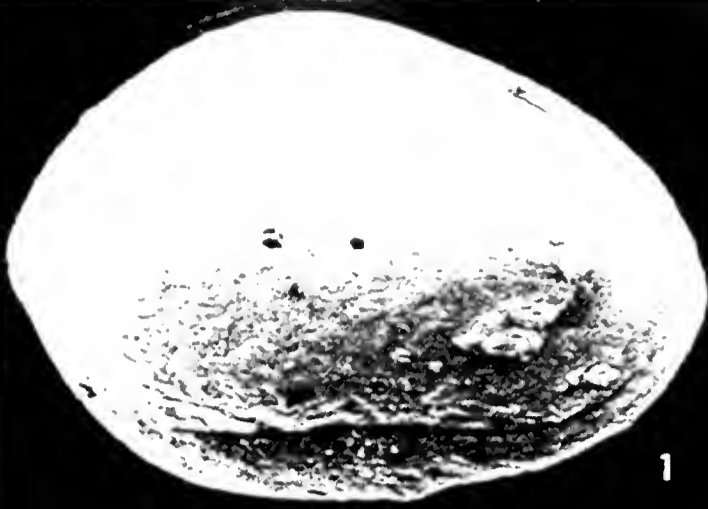
Rhaetian ostracods from Britain and offshore Ireland

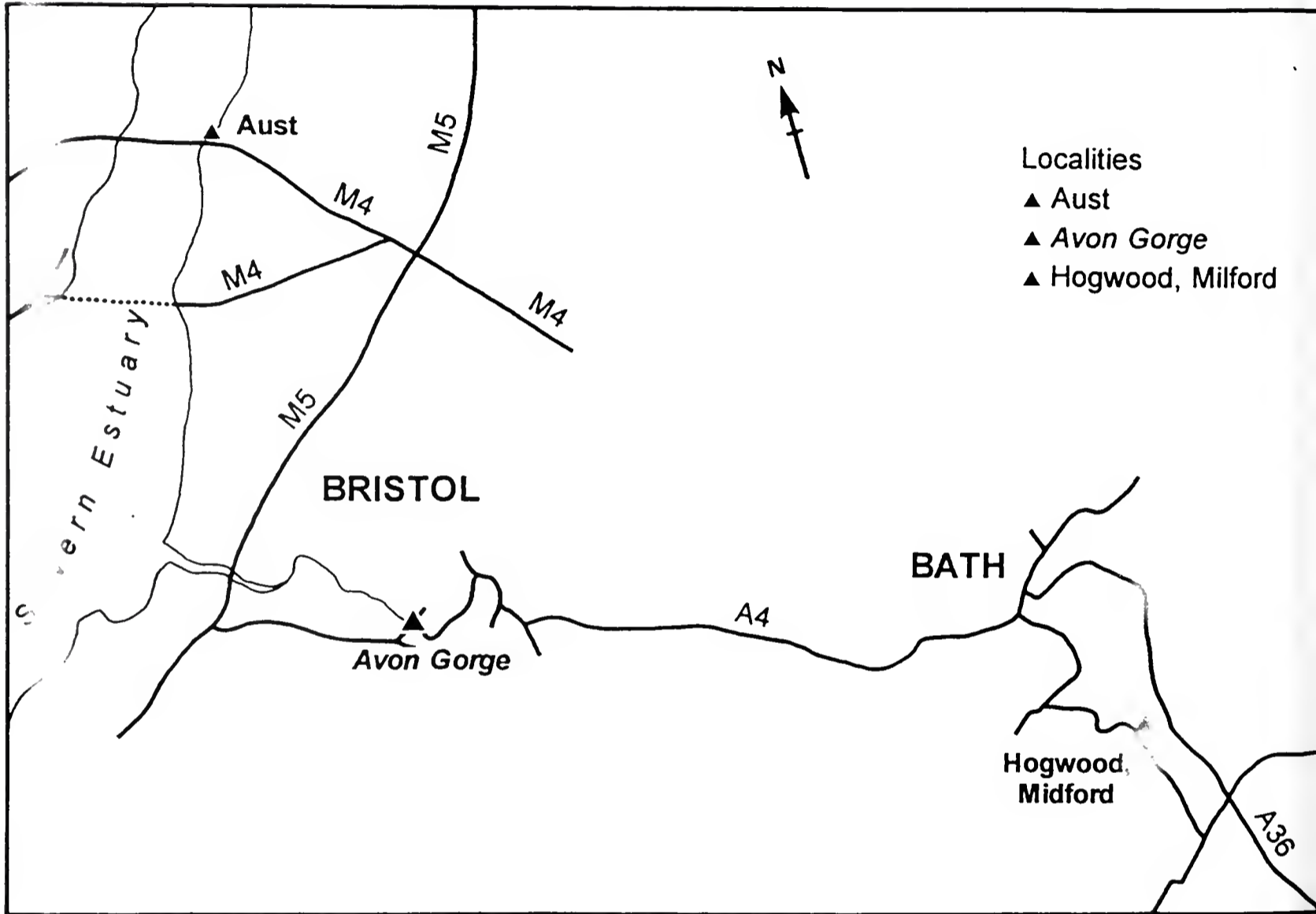
- Fig. 1. *Ogmoconchella martini* (Anderson). GSM Mik (J) 280001, holotype, carapace, right lateral view; 540µm long. Westbury Formation, Penarth Group, Avon, England.
- Fig. 2. *Ogmoconchella bristolensis* (Anderson). GSM Mik (J) 284001, holotype, carapace, right lateral view; 540µm long. Rhaetian, Warwickshire, England.
- Fig. 3. *Darwinula liassica* Jones. GSM Mik (J) 270001, carapace, right lateral view; 610µm long. Rhaetian, Bristol, Avon, England.
- Fig. 4. *Bairdia* sp. Fragment of right valve. 550µm long. Top of Cotham Member, Lilstock Formation, Penarth Group, Long Itchington, Leicestershire, England.
- Fig. 5. *Cytherelloidea* cf. *pulchella* Apostolescu. GSM Mik (J) 289001, carapace, left lateral view; 580µm long. Rhaetian, Glamorgan, Wales.
- Fig. 6. *Cytherella plattensis* Anderson. GSM Mik (J) 287001, holotype, carapace, left lateral view; 700µm long. Rhaetian, Glamorgan, Wales.
- Fig. 7. *Allocythereis combrookensis* Anderson. Left valve, lateral view; 490µm long. Top of Cotham Member, Lilstock Formation, Penarth Group, Long Itchington, Leicestershire, England.
- Fig. 8. *Rhombocythere penarthensis* Anderson. GSM Mik (J) 272001, holotype, carapace, right lateral view; 880µm long. Rhaetian, Glamorgan, Wales.
- Fig. 9. *Lutkevichinella fastigata* Ainsworth. TCD 28226, carapace, left lateral view; 670µm long. Rhaetian, Donegal Basin, offshore Ireland.
- Fig. 10. *Ektyphocythere cookiana* (Anderson). GSM Mik (J) 276001, holotype, carapace, left lateral view; 490µm long. Westbury Formation, Penarth Group, Avon, England.

GSM Mik (J): British Geological Survey, Keyworth.

TCD: Trinity College Dublin, Ireland

The other figured specimens are in the authors collection.





Location of Aust Cliff on the Severn Estuary and Midford near Bath

MIDDLE JURASSIC OF MIDFORD NEAR BATH, AVON

Alan R. Lord (University College London)

T.R. Jones was responsible for two papers on Middle Jurassic ostracods which, although not extensive, laid the monographic foundation of our present knowledge. The first paper (Jones 1884) concerned material from a borehole at Richmond, Surrey and described and figured 17 new species of *Bairdia*, *Cytheridea*, *Cythere*, *Cytherella* and *Macrocypris*. Later, Jones & Sherborn (1888) described and figured 62 species and varieties, 56 new, of Bathonian age ostracod from the Fullers Earth of Midford and the Bradford Clay of Bradford-on-Avon, both in the Bath area. The generic taxa recognised were as in the 1884 paper with the addition of *Bythocypris* and *Cythereis*. Jones & Sherborn noted the occurrence of their taxa from other localities in the Cotswolds, to the north of Bath, and in an earlier note (Jones & Sherborn 1886) had listed other records from the Bath area. It was not until sixty years later that these taxa were again recorded and discussed (Sylvester-Bradley 1948).

The collections of Jones (1884) and Jones & Sherborn (1888) are housed in The Natural History Museum, London and were revised by Bate (1969a). Sixteen of the species were refigured and ranges recorded by Bate (1978).

In the nineteenth century numerous small quarries, pits and cuttings existed for building and agricultural purposes, and for the new railway and canal systems. The existence of such exposures is part of the explanation for Bath giving its name to the Bathonian stage. Few of these exposures exist now, and sections in argillaceous sediments are especially rare. At the time of the 1969 European Micropalaeontological Colloquium, R.H. Bate was able to take delegates to Coombe Hay Mine, south-west of Bath, for the Fullers Earth Clay and to the Canal Quarry, Bradford-on-Avon for Bradford Clay. However, the former has been closed for some years and the latter infilled. Bate (1969b) recorded the following taxa.

Coombe Hay Mine (marine):

- | | |
|--|--|
| <i>Acanthocythere sphaerulata</i> (Jones & Sherborn) | <i>Asciocythere obovata</i> (J & S) |
| <i>Bairdia hilda</i> Jones | <i>Bairdia juddiana</i> Jones |
| <i>Bairdia sherborni</i> Bate | <i>Caytonidea terraefullonicae</i> (J & S) |
| ' <i>Cythere</i> ' <i>corrosa</i> J & S | <i>Cytherella fullonica</i> J & S |
| <i>Cytherelloidea catenulata</i> (J & S) | <i>Cytherelloidea refecta</i> (J & S) |
| ' <i>Cytheridea</i> ' <i>aequabilis</i> J & S | ' <i>Cytheridea</i> ' <i>coarctata</i> J & S |
| ' <i>Cytheridea</i> ' <i>eminula</i> J & S | ' <i>Cytheridea</i> ' <i>punctiputeolata</i> J & S |
| ' <i>Cytheridea</i> ' <i>retorrída</i> J & S | ' <i>Cytheridea</i> ' <i>spinifastigiata</i> J & S |
| ' <i>Cytheridea</i> ' <i>spinigrata</i> J & S | <i>Cytherura bathonica</i> Bate |
| <i>Cytherura mediojurassica</i> Bate | <i>Ekryphocythere parva</i> (Oertli) |
| <i>Eocytheridea</i> sp. | <i>Fastigatocythere juglandica</i> (Jones) |
| <i>Glyptocythere guembeliana</i> (Jones) | <i>G. oscillum</i> (J & S) |
| <i>G. persica</i> (J & S) | <i>Hadrocytheridea dolabra</i> (J & S) |
| <i>Hekistocythere venosa</i> Bate | <i>Looneyella subtilis</i> Oertli |
| <i>Lophocythere acutiplicata</i> (J & S) | <i>Lophocythere bradiana</i> (Jones) |
| <i>Lophocythere fulgurata</i> (J & S) | <i>Lophocythere ostreata</i> (J & S) |
| <i>Lophocythere septicostata</i> Bate | <i>Lophocythere</i> sp. |
| <i>Micropneumatocythere limaciformis</i> (J & S) | <i>Monoceratina visceralis</i> (J & S) |
| <i>Micropneumatocythere vulsa</i> (J & S) | <i>Oligocythereis fullonica</i> (J & S) |
| <i>Orthonatocythere</i> sp. | <i>Paracypris terraefullonicae</i> (J & S) |
| <i>Paracytheridea?</i> <i>blakei</i> Bate | <i>Parariscus bathonicus</i> Oertli |
| <i>Platycythere</i> sp. | <i>Polycope fungosa</i> Bate |
| <i>Praeschuleridea subtrigona</i> (J & S) | <i>Progonocythere stilla</i> Sylvester-Bradley |
| <i>Rectocythere sugillata</i> (J & S) | <i>Schuleridea</i> (E.) <i>horatiansa</i> (J & S) |
| <i>Terquenulla blakeana</i> (Jones) | <i>Trachycythere</i> sp. |

Canal Quarry (marine, becoming brackish at top of section):

<i>Bisulcoocypris</i> sp.	<i>Cytherelloidea jugosa</i> (Jones)
<i>Fastigatocythere juglandica</i> (J & S)	<i>Klieana levis</i> (Oertli)
<i>Lophocythere fulgurata</i> (J & S)	<i>Lophocythere scabra</i> Triebel
<i>Marslatourella bullata</i> Bate	<i>Metacytheropteron drupaceum</i> (Jones)
<i>Micropnematocythere subconcentrica</i> (Jones)	<i>Oligocythereis fullonica</i> (J & S)
<i>Paracypris terraefullonicae</i> (J & S)	<i>Pichottia magnamuris</i> Bate
<i>Progonocythere stilla</i> Sylvester-Bradley	

The majority of Jones & Sherborn's species were described from Midford, from unknown exposures. An old trench has been found during reconnaissance for the excursion in Hogwood, south of Midford [ST 774 595]. The trench exposes clay and this will be excavated for sampling. Time did not permit prior sample investigation. The Jurassic geology of the area has been described by Green & Donovan (1969).

References:

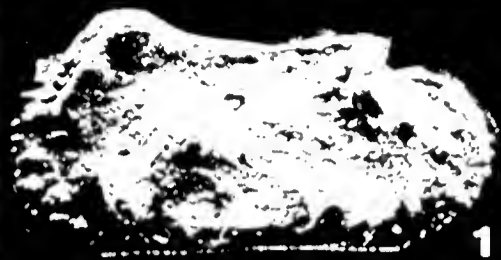
- Bate, R.H. 1969a. Some Bathonian Ostracoda of England with a revision of the Jones 1884 and Jones & Sherborn 1888 Collections. *Bull. Brit. Mus. (Nat. Hist.), Geol.*, **17**: 377-437.
- Bate, R.H. 1969b. pp. 38-40 *In*: Barnard, T. (Ed.) 11th European Micropalaeontological Colloquium, England, 20th-28th September 1969.
- Bate, R.H. 1978. The Jurassic Part II - Aalenian to Bathonian, pp. 213-258. *In*: Bate, R.H. & Robinson, E. (Eds) A stratigraphical index of British Ostracoda. *Geol. Jl. spec. iss.*, **8**.
- Green, G.W. & Donovan, D.T. 1969. The Great Oolite of the Bath area. *Bull. Geol. Surv. Gt Brit.*, **30**: 1-63.
- Jones, T.R. 1884. Notes on the Foraminifera and Ostracoda from the Deep Boring at Richmond. *Quart. Jl Geol. Soc., Lond.*, **11**(4), 765-777.
- Jones, T.R. & Sherborn, C.D. 1886. On the Microzoa found in some Jurassic Rocks of England. *Geol. Mag.*, dec. 3, **3**(6), 271-274.
- Jones, T.R. & Sherborn, C.D. 1888. On some Ostracoda from the Fullers-earth Oolite and Bradford Clay. *Proc. Bath Nat. Hist. Antiquarian Fld Club*, **6**(3), 49-278.
- Sylvester-Bradley, P.C. 1948. Bathonian ostracods from the Boueti Bed of Langton Herring, Dorset. *Geol. Mag.*, **85**, 185-204.

Explanation of Plate 1

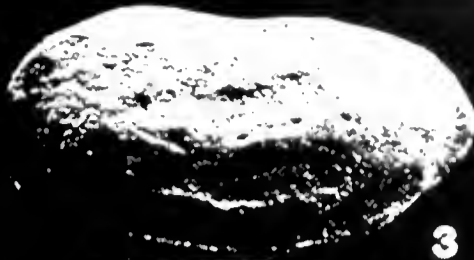
Bathonian ostracods from southern England

Material figured by Bate (1978); no locality or horizon information given in most cases.

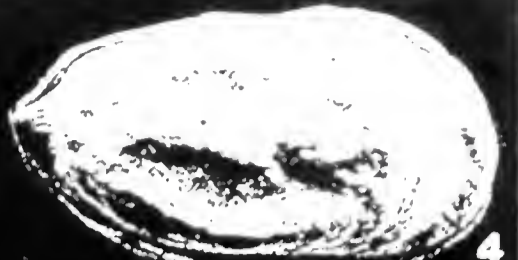
- Figs 1, 2. *Oligocythereis fullonica* (Jones & Sherborn). 1. In 42066, left valve, lateral view; 610µm long. 2. OS 9087, right valve, internal view; 610µm long.
- Figs 3, 4. *Glyptocythere oscillum* (Jones & Sherborn). 3. OS 9036, left valve, male, lateral view; 740µm long. 4. OS 9037, carapace, juvenile, right lateral view; 540µm long.
- Fig. 5. *Micropneumatocythere subconcentrica* (Jones). OS 9041, left valve, female, lateral view; 490µm long.
- Fig. 6. *Glyptocythere guembeliana* (Jones). No catalogue number, right valve, male, lateral view; 900µm long.
- Figs 7, 8. *Lophocythere fulgurata* (Jones & Sherborn). 7. OS 9068, left valve, lateral view; 710µm long. 8. OS 9069, Right valve, lateral view; 630µm long.
- Fig. 9. *Glyptocythere persica* (Jones & Sherborn). I 1834, Holotype, right valve, lateral view; 700µm long.
- Figs 10, 11. *Terquemula acutiplicata* (Jones & Sherborn). 10. OS 9077, left valve, lateral view; 610µm long. 11. OS 9076, right valve, lateral view; 640µm long.
- Fig. 12. *Fastigatocythere juglandica* (Jones). OS 9078, carapace, female, right lateral view; 790µm long.
- Figs 13, 14. *Terquemula bradiana* (Jones). 13. SAC.670.C3, carapace, female, left lateral view; 610µm long. 14. SAC.670.C4, carapace, female, right lateral view; 610µm long.
- Fig. 15. *Lophocythere ostreata* (Jones & Sherborn). I 1833, holotype, right valve, lateral view; 810µm long.
- Fig. 16. *Cytherelloidea refecta* (Jones & Sherborn). Io 3932, paralectotype, left valve, male, lateral view; 710µm long.
- Figs 17, 18. *Glabellacythere dolabra* (Jones & Sherborn). 17. I 1859, paralectotype, carapace, male, right lateral view; 730µm long. 18. I 1851, lectotype, right valve, female, lateral view; 640µm long.
- Fig. 19. *Praeschuleridea subtrigona* (Jones & Sherborn). OS 9108, carapace, female, left lateral view; 510µm long.
- Figs 20, 21. *Schuleridea (Eoschuleridea) trigonalis* (Jones). 20. In 48998, carapace, female, left lateral view; 670µm long. 21. In 49001, right valve, female, lateral view; 660µm long. Fullers Earth, Vernham Wood, Odd Down, Bath.
- Fig. 22. *Terquemula bradiana* (Jones) morphotype B of Bate (1978). SAB.1958.C2, female, left view; 570µm long.



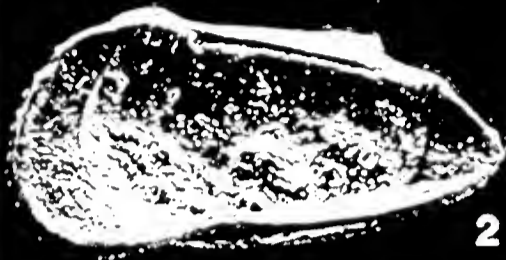
1



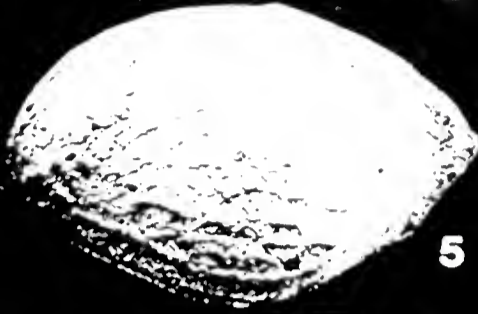
3



4



2



5



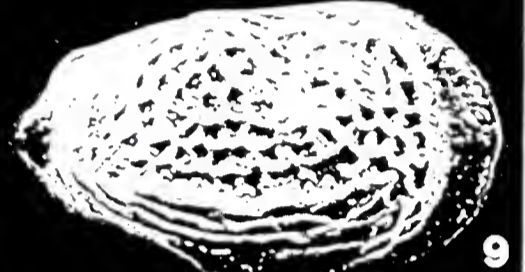
6



7



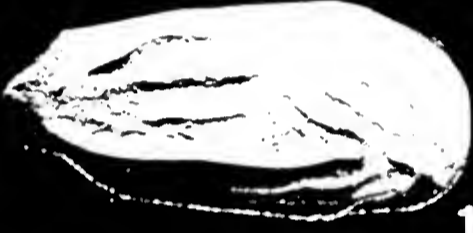
8



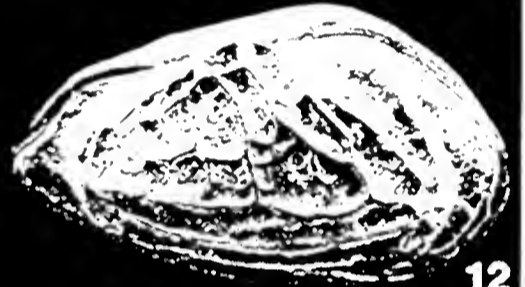
9



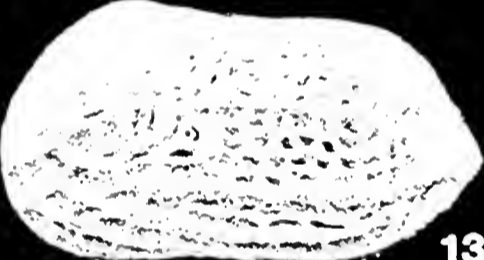
10



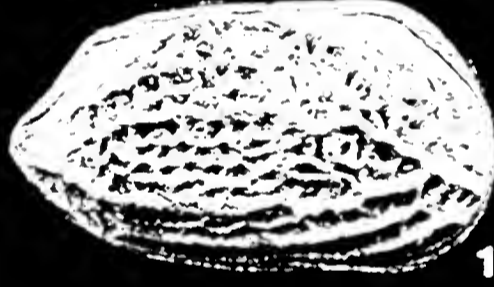
11



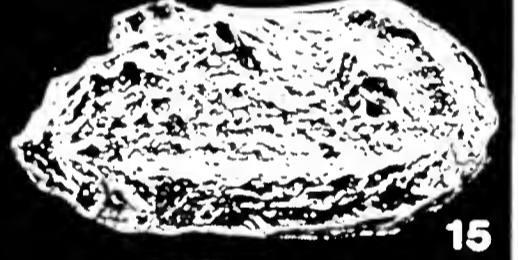
12



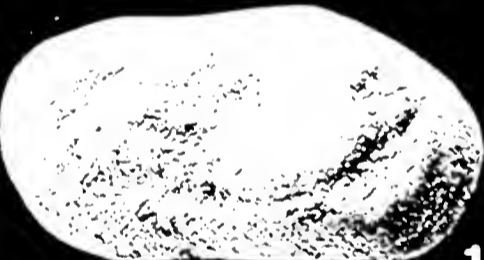
13



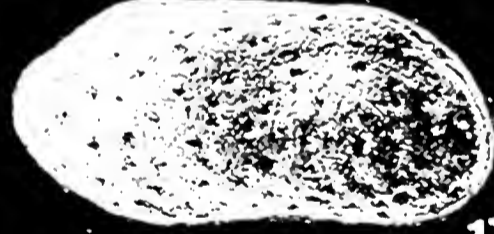
14



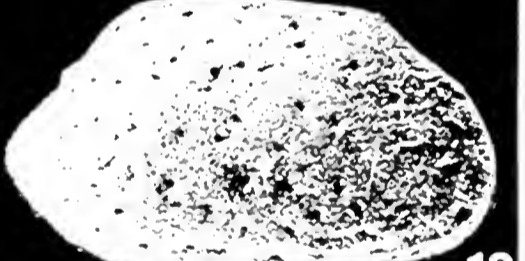
15



16



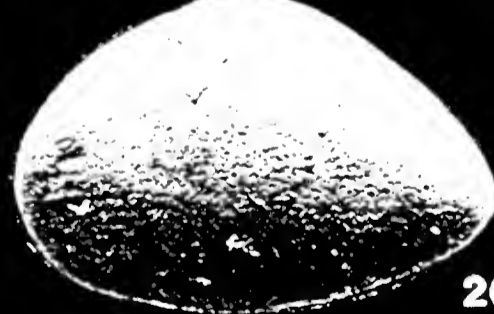
17



18



19



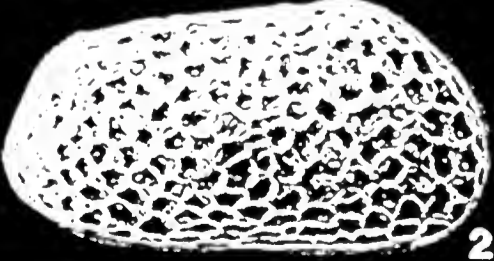
20



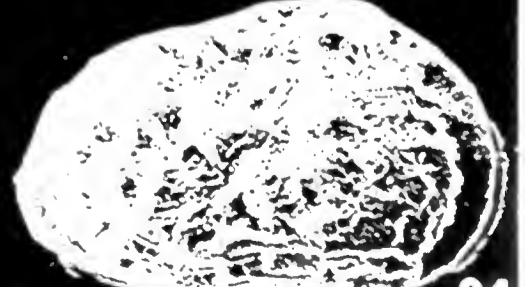
21



22



23



24

- Fig. 23. *Caytonidea terraefullonicae* (Jones & Sherborn). Io 3919, paralectotype, right valve, female, lateral view; 490µm long.
- Fig. 24. *Rectocythere sugillata* (Jones & Sherborn). Io 3939, paralectotype, right valve, lateral view; 510µm long.

JURASSIC/CRETACEOUS OF DURLSTON BAY, DORSET

David J. Horne (University of Greenwich)

Durlston Bay (Fig. 1) in Dorset is the type locality for the non-marine "Purbeck Beds", which represent predominantly carbonate depositional environments (including evaporitic gypsum) in the Weald and Wessex basins of southern England, spanning the Jurassic-Cretaceous boundary. The marine Portland Limestone Group (Upper Jurassic) lies below, and the non-marine and predominantly terrigenous Wealden Group (Lower Cretaceous) above.

Studies by T.R. Jones

Jones (1885) reviewed previous work on English Purbeck and Wealden ostracods, undertook systematic revision of several taxa and presented the first significant attempt to use ostracods for correlation between the "Wealden" of England and Germany; indeed, this represents one of the first serious utilisations of ostracods of any age for biostratigraphical correlation. This work included a stratigraphically detailed list of ostracods from the Purbeck Beds of Durlston Bay, divided into Lower, Middle and Upper Purbeck (Fig. 2). The material on which the list was based came from a variety of sources, including collections by J. Morris, J.C. Mansel-Pleydell, Prof. E. Renevier, the Reverend O. Fisher and Horace B. Woodward.

Particularly fascinating is the following record of *Cypridea fasciculata* from the Middle Purbeck Beds of Durlston Bay: "Near Swanage. Specimens chipped off a large block of Purbeck Limestone (bearing vermiform markings and two large pachydactylous trifold footmarks), which formerly stood in the Hall of the Geological Society's Apartments in Somerset House, before the removal to Burlington House" (Jones 1885, p. 323). Jones, quoting from a letter by H.B. Woodward (dated 26/10/1884), goes on to explain that this block belongs to the "Toad's Eye Limestone (No.68)" within the Corbula Beds of the Middle Purbeck. At the start of the list, records of *Cypridea punctata* and *C. punctata* var. *posticalis* from "Near Peverel (*sic*) Point" and "W. of Flagstaff; below other marl" are not attributed to any collector or museum, so we may assume that Jones himself collected these specimens in Durlston Bay. The systematic section includes the descriptions of several important new taxa, the biostratigraphical value of which remains undiminished today. Among these are *Cypridea dunkeri*, *Theriosynoecum forbesii* (described under *Metacypris*) and *Cypridea posticalis* (described as *C. punctata* var. *posticalis*).

Ostracoda from the Purbeck Beds of Durlston Bay (after Jones 1885):

Ostracoda from the Upper Purbeck Beds

Jones 1855

Cypridea punctata (Forbes)
Cypridea punctata (Forbes) var. *posticalis* sp. nov.
Cypridea ventrosa sp. nov.
Cypridea Dunkeri sp. nov.
Cyprione Bristovii sp. nov.
Darwinula leguminella (Forbes)

Modern taxonomic assignation

Cypridea propunctata S-Bradley, 1949
Cypridea posticalis Jones, 1885
Cypridea ventrosa Jones, 1885
Cypridea dunkeri Jones, 1885
Darwinula oblonga (Roemer, 1839)
Darwinula leguminella (Forbes, 1855)

Ostracoda from the Middle Purbeck Beds

Jones 1885

Cypridea granulosa var. *fasciculata* (Forbes)
Cypridea ventrosa sp. nov.
Cypridea ventrosa sp. nov. var. *globosa* var. nov.
Cyprione Bristovii sp. nov.
Cypridea punctata (Forbes)
Cypridea tuberculata (Sowerby)
Cypridea granulosa var. *paucigranulata* var. nov.
Darwinula leguminella (Forbes)
Metacypris Forbesii sp. nov.

Modern taxonomic assignation

Cypridea gran.fasciculata (Forbes 1855)
Cypridea ventrosa Jones, 1885
Cypridea ventrosa Jones, 1885
Darwinula oblonga (Roemer, 1839)
Cypridea propunctata S-Bradley, 1949
C. tuberc. lagtonensis Anderson, 1971
Cypridea granulosa (Sowerby) *s.l.*
Darwinula leguminella (Forbes, 1855)
Theriosynoecum forbesi (Jones, 1885)

Ostracoda from the Lower Purbeck Beds

Jones 1885

Cypris purbeckensis Forbes

Modern taxonomic assignation

Mantelliana purbeckensis (Forbes, 1855)

Stratigraphy

The "Purbeck Beds" are now regarded by some authors (e.g. Allen & Wimbledon 1991) as the Purbeck Formation, retaining the old subdivisions of Lower, Middle and Upper Purbeck. Others (e.g. Clements 1992) regard them as the Purbeck Limestone Group, subdivided into the Lulworth Formation below and the Durlston Formation above; this latter scheme is adopted herein. Durlston Bay (Fig. 1) is the type locality for the Purbeck Limestone Group. The section has been described in detail by Clements (1992) who provided detailed lithostratigraphical logs (reproduced herein, Fig. 3). In addition he gave information on the distribution of ostracods and gastropods within the Durlston Bay succession. In Clements' scheme the lowest unit of the Durlston Formation is the Cinder Member, the well-known "Cinder Bed" (an oyster lumachelle). This transgressive unit represents a major marine incursion and has been regarded by some authors as marking the Jurassic-Cretaceous boundary, although its apparent diachroneity across the Wessex and Weald basins probably renders it unsuitable for this purpose. No consensus has yet been reached, in fact, on the position of the Jurassic-Cretaceous boundary (and the base of the Berriasian stage) in the non-marine sequences of the Weald and Wessex basins, although macrofossil, ostracod, charophyte and palynological evidence have all been brought to bear on the problem (see, e.g., Wimbledon & Hunt 1983, Allen & Wimbledon 1991, Feist, Lake & Wood 1995).

Stratigraphical and ecological ranges

Clements (1992) discussed briefly the ostracod biozonation schemes of Anderson (1941, 1985), Anderson & Bazley (1971) and Sylvester-Bradley (1949), pointing out that they were difficult to relate to the actual rock sequence in Durlston Bay. Horne (1995) reviewed Anderson's work on English Purbeck-Wealden ostracods and proposed a revised biozonation based on Anderson's data. The Purbeck Limestone Group falls entirely within the *Theriosynoecum forbesi* Zone of Horne (1995). The Lulworth Formation equates to the *Cypridea dunkeri* Subzone (below) and the lower part of the *Cypridea granulosa* Subzone (above); the Durlston Formation equates to the upper part of the *Cypridea granulosa* Subzone (below) and at least the lower part (if not all) of the *Cypridea propunctata* Subzone (above). Horne's *Cypridea granulosa* Subzone is the exact equivalent of the combined *Cypridea granulosa granulosa* and *Cypridea granulosa fasciculata* zones of Anderson & Bazley (1971). Clements (1992) observed that the *C. granulosa granulosa* / *C. granulosa fasciculata* boundary is particularly useful and easy to recognise in Dorset. This boundary lies about 5m below the Cinder Member at Durlston Bay and is also marked by the presence of the very short-ranging *Cypridea posticalis*, a species with considerable potential for correlation in Europe (Allen & Wimbledon 1991, Horne 1995).

Clements' is undoubtedly the best, most detailed stratigraphical description of the ostracods of the stratotype of the Purbeck Limestone Group; nevertheless it presents one or two problems which have yet to be resolved. He did not list *Cypridea propunctata*, a puzzling omission since this is a typical "Upper Purbeck" species (see, e.g., Anderson 1985) and Durlston Bay is its type locality (Sylvester-Bradley 1949). It is presumably included in what Clements (1992, p. 183) referred to as: "*Cypridea* (LV>RV). This group includes a large variety of forms, not otherwise delimited, which have a normal (left over right) valve overlap, and mainly simple ornament". Clements (1992) recorded "*Cypridea menevensis* Group" throughout the Durlston Formation. It is not clear how this group relates to *C. menevensis sensu* Anderson (1985), a species whose first appearance was one of those used by Horne (1995) to define the base of his *Theriosynoecum alleni* Zone and *Cypridea menevensis* Subzone. If *C. menevensis sensu* Anderson (1985) does occur in the stratotype of the Durlston Formation, it would show the top of the Wessex Basin "Purbeck" to be younger than

that in the Weald Basin. In other words the "Upper Purbeck" at Durlston Bay would equate to the lower part of the Ashdown Formation (= "Fairlight Division") of the Weald. Such an equivalence has been suggested by others (e.g., Morter 1984; Read, in the preface to Anderson 1985), but whether or not it is supported by ostracod data is still an open question. Horne (1995, fig.5) attempted to reconcile some of these views by showing the Purbeck-Wealden junction to be synchronous in the Weald and Wessex basins, with the *Theriosynoecum forbesi* Zone and *Cypridae menevensis* Subzone extending higher, into the Ashdown Formation. The problem is unlikely to be resolved without a detailed reappraisal of the taxonomy and stratigraphical ranges of the ostracods. Clements' *Cypridea menevensis* Group may be (or at least include) the form which Anderson (1985) recorded in the "Middle and Upper Purbeck Beds" as *C. penshurstensis*.

Purbeck-Wealden ostracod assemblages are predominantly non-marine, bearing in mind that this can include saline lakes as well as freshwater lakes, temporary as well as permanent water bodies. The late F.W Anderson recognised alternating assemblages which he called "C-phase" (= dominated by *Cypridea*) and "S-phase" (= dominated by other genera), combinations of which he described as faunicycles (e.g. Anderson & Bazley 1971). Many authors have disagreed with Anderson's palaeoecological interpretations: he regarded certain genera as "marine" (e.g. *Theriosynoecum*) and considered *Cypridea* to be a non-marine, but not truly freshwater, genus. By comparison with living relatives, we can be fairly certain that Purbeck-Wealden *Darwinula* and *Theriosynoecum* inhabited fresh or slightly saline non-marine waters. Their reproductive strategies involve brood care of the youngest juvenile stages by the adult females; such ostracods are confined to permanent water bodies. The extinct *Cypridea* is more difficult to interpret, but is best regarded as a non-marine genus with species inhabiting a variety of temporary and permanent fresh water bodies. It may have been one of the first ostracods with the ability to lay desiccation-resistant eggs, a strategy widely employed by non-marine cypridoideans today and which enables them to colonise ephemeral pools, survive long periods of drought and achieve wide dispersal. The alternations of C-phase and S-phase assemblages may therefore relate to the influence of climatic variation on the relative abundance of permanent and temporary water bodies in the Purbeck-Wealden.

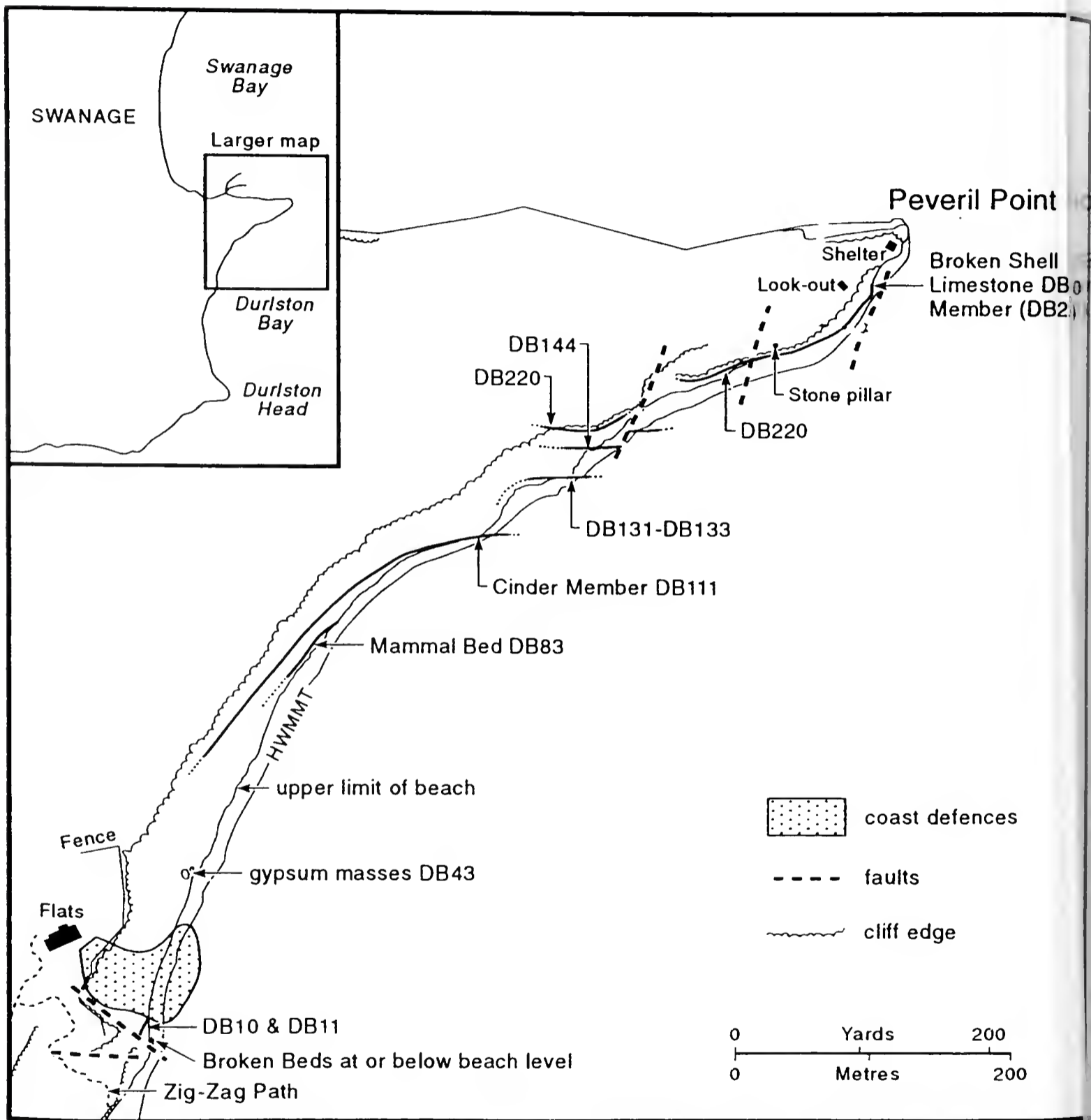


Fig. 1. Location map of Durlston Bay, Dorset (Clements 1992).

Lithostratigraphical divisions			Subzones of Horne (1995)	Zones of Clements (1992)
Upper Purbeck	Durlston Formation	Purbeck Limestone Group	<i>Cypridea propunctata</i> Subzone	<i>Cypridea setina</i> Zone
Middle Purbeck				<i>Cypridea vidrana</i> Zone
	Lulworth Formation		<i>Cypridea granulosa</i> Subzone	<i>C. granulosa fasciculata</i> Zone
			<i>C. granulosa granulosa</i> Zone	
Lower Purbeck			<i>Cypridea dunkeri</i> Subzone	<i>Cypridea dunkeri</i> Zone

Fig. 2. Comparison of lithostratigraphical divisions of the "Purbeck Beds" with ostracod biozonations of Clements (1992) and Horne (1995).

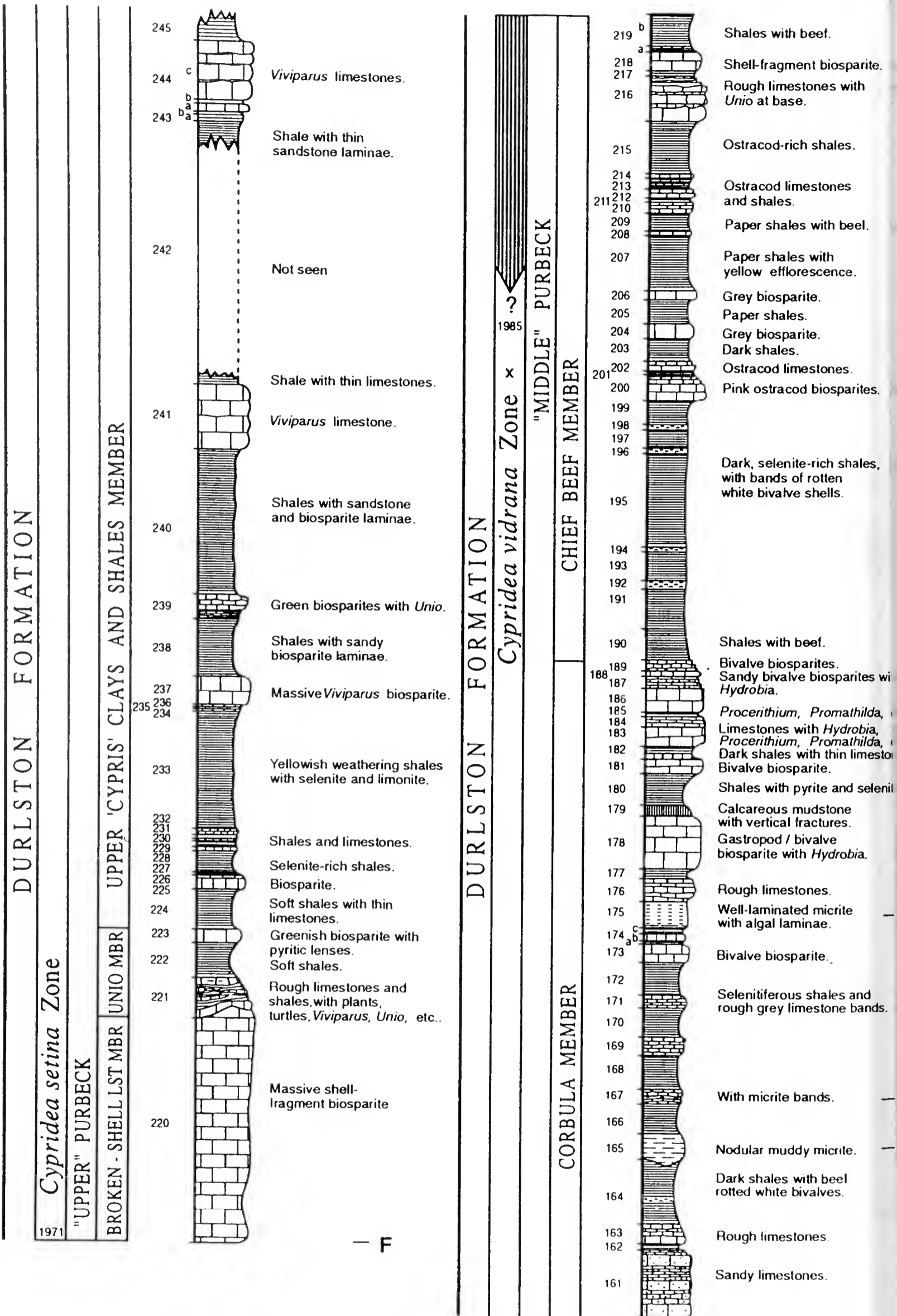


Fig. 3. Lithostratigraphic log of the type-section of the Purbeck Limestone Group, northern Durlston Bay, Dorset (Clements 1992).

DURLSTON FORMATION

Cypridea granulosa fasciculata Zone

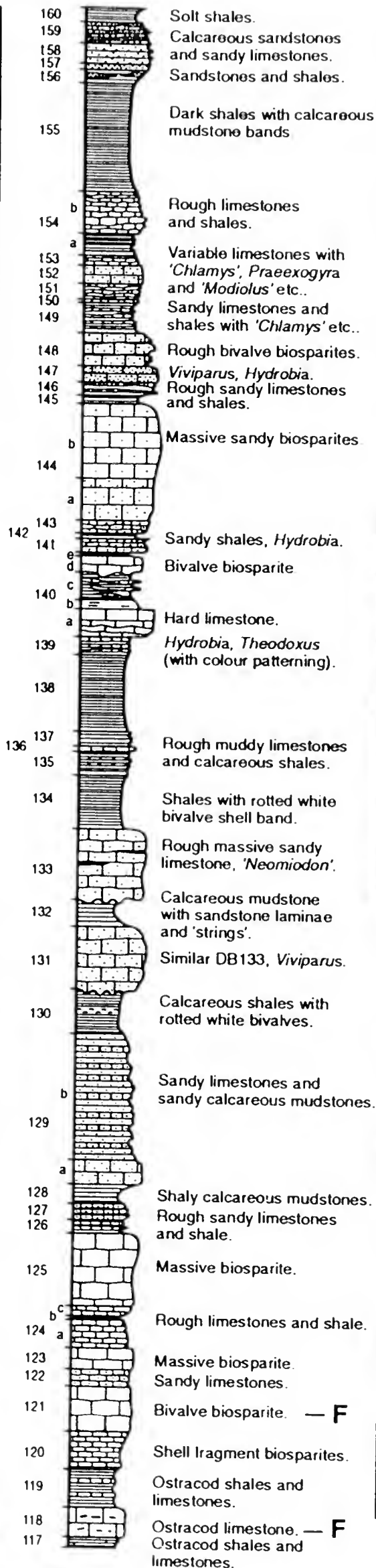
1971
Cypridea vidrana Zone

"MIDDLE" PURBECK

INTERMARINE MEMBER (or UPPER BUILDING STONES)

SCALLOP MBR

CORBULA MEMBER



LULWORTH FORMATION

Cypridea granulosa granulosa Zone

1971

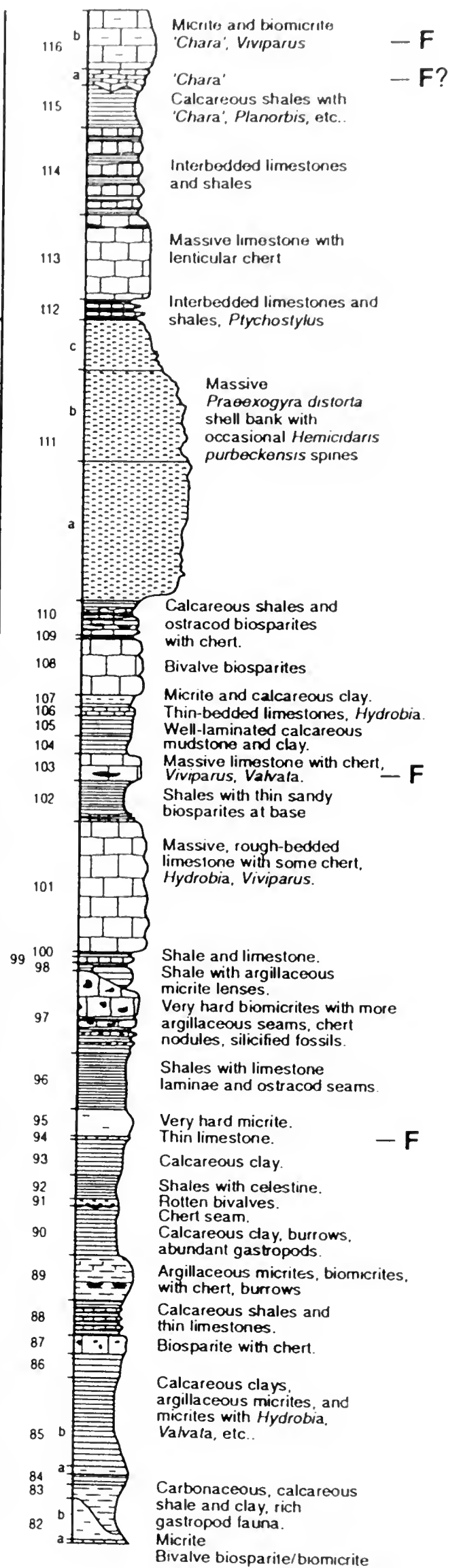
"MIDDLE" PURBECK

MARLY FRESHWATER BEDS

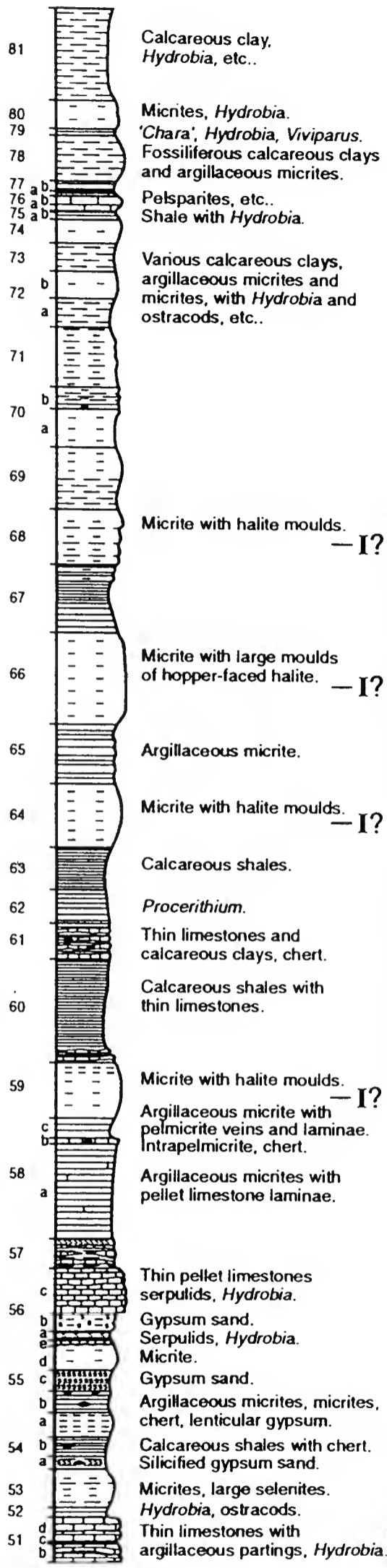
CHERTY FRESHWATER MEMBER

CINDER MEMBER

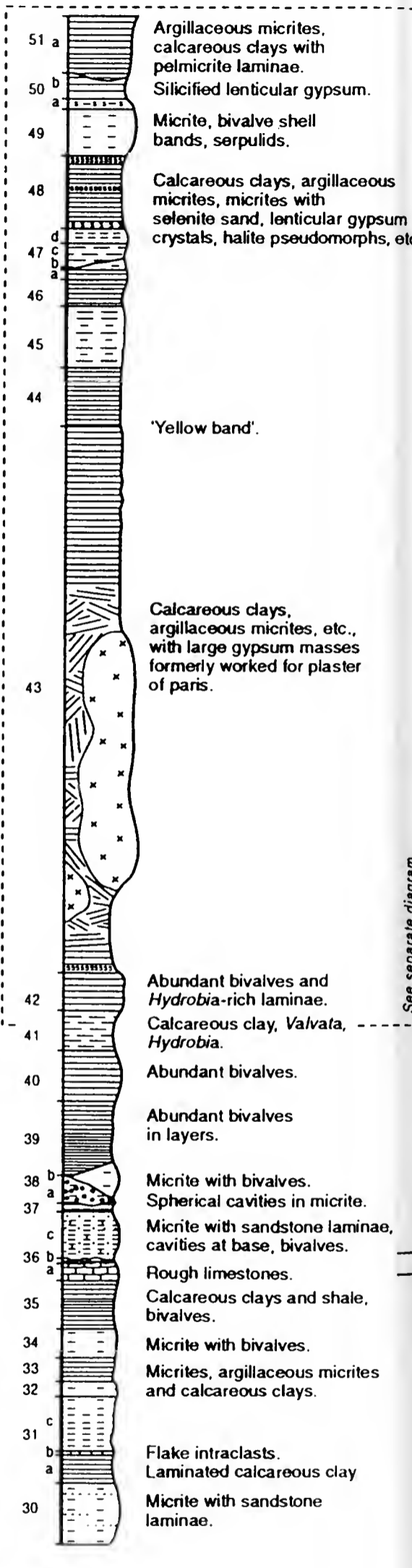
INTERMARINE MEMBER



LULWORTH FORMATION
Cypridea dunkeri Zone
 "LOWER" PURBECK
 SOFT COCKLE MEMBER
 "MIDDLE" PURBECK
 MARLY FRESHWATER MBR
 1971
 /1985
granulosa granulosa Zone



LULWORTH FORMATION
Cypridea dunkeri Zone
 "LOWER" PURBECK
 SOFT COCKLE MEMBER
 "CYPRIS" FREESTONES MBR
 HARD COCKLE MEMBER



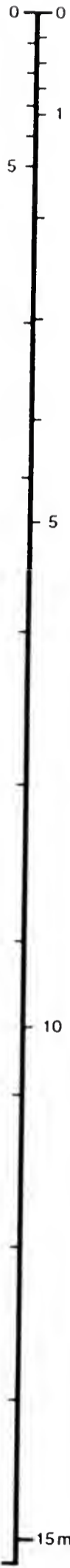
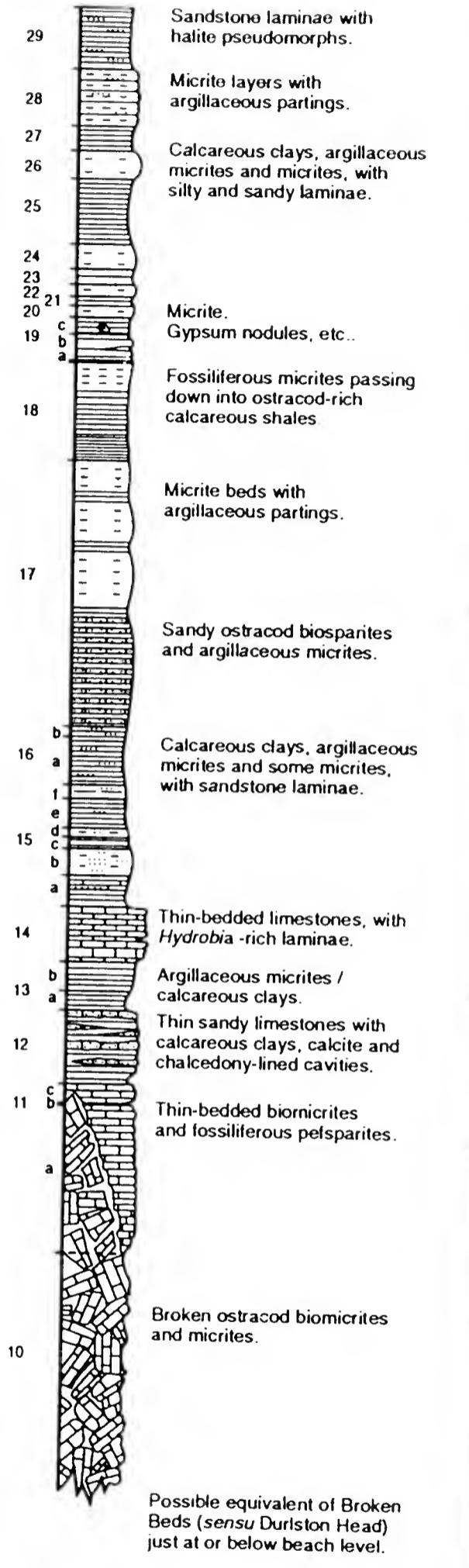
See separate diagram

LULWORTH FORMATION

Cypridea dunkeri Zone

"LOWER" PURBECK

BROKEN BEDS MEMBER - 'CYPRIS' FREESTONES MEMBER



- F** footprints
 - I** insects
 - A** *Archaeoniscus*
 - Shale, calcareous shale
 - Clay, calcareous clay (well-laminated)
 - Clay, calcareous clay (poorly laminated)
 - Argillaceous micrite (well-laminated)
 - Argillaceous micrite (poorly laminated)
 - Micrites (well-laminated)
 - Micrites (poorly laminated)
 - Limestones other than micrites (thinly bedded)
 - Limestones other than micrites (roughly bedded)
 - Limestones other than micrites (massive)
 - Sandstone
 - Sandy
 - Chert
 - Massive gypsum
 - Gypsum 'sand'
 - Spherical hollows
- Combinations of symbols are used

- X Lowest record of *Cypridea setina*
- + Highest record of *C. granulosa fasciculata*
- ** Lowest definite record of *C. granulosa fasciculata*
- *** Lowest record of *C. granulosa aff. fasciculata*
- † Lowest definite record of *C. granulosa s.s.*

NAMED BEDS

- DB 244 - Upper Purbeck Marble
- DB 241 - Lower Purbeck Marble
- DB 221 (top) - Crocodile Bed
- DB 183 - Toad's-Eye Limestone
- DB 97 - Flint Bed or Cherty Freshwater Bed
- DB 83 - Mammal Bed

References

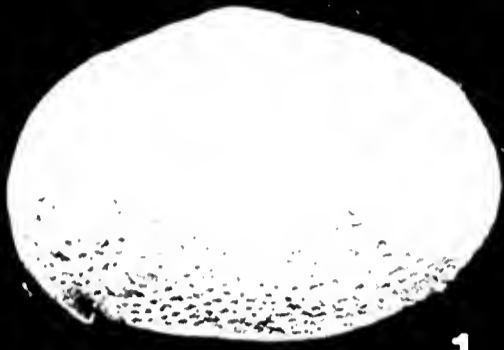
- Allen, P. & Wimbledon, W.A. 1991. Correlation of NW European Purbeck-Wealden (Non-marine Lower Cretaceous) as seen from the English type areas. *Cretaceous Research*, **12**, 511-526.
- Anderson, F.W. 1941. Ostracoda from the Portland and Purbeck Beds at Swindon. *Proc. Geol. Assoc.*, **51**, 373-384.
- Anderson, F.W. 1985. Ostracod faunas in the Purbeck and Wealden of England. *Jl Micropalaeont.*, **4** (2), 1-67.
- Anderson, F.W. & Bazley, R.A.B. 1971. The Purbeck Beds of the Weald (England). *Bull. Geol. Surv. Gt Brit.*, **34**, 1-173.
- Clements, R.G. 1992. Type-section of the Purbeck Limestone Group, Durlston Bay, Swanage, Dorset. *Proc. Dorset Nat. Hist. Arch. Soc.*, **114**, 181-206.
- Feist, M., Lake, R.D. & Wood, C.J. 1995. Charophyte biostratigraphy of the Purbeck and Wealden of southern England. *Palaeontology*, **38**, 407-442.
- Horne, D.J. 1995. A revised ostracod biostratigraphy for the Purbeck-Wealden of England. *Cretaceous Research*, **16**, 639-663.
- Jones, T.R. 1885. On the Ostracoda of the Purbeck Formation; with notes on the Wealden species. *Quart. Jl Geol. Soc., Lond.*, **41**, 311-353.
- Morter, A.A. 1984. Purbeck-Wealden Beds Mollusca and their relationship to ostracod biostratigraphy, stratigraphical correlation and palaeoecology in the Weald and adjacent areas. *Proc. Geol. Assoc.*, **95**, 217-234.
- Sylvester-Bradley, P.C. 1949. The ostracod genus *Cypridea* and the zones of the Upper and Middle Purbeckian. *Proc. Geol. Assoc.*, **60**, 125-153.
- Wimbledon, W.A. & Hunt, C.O. 1983. The Portland-Purbeck junction (Portlandian-Berriasian) in the Weald, and correlation of latest Jurassic-early Cretaceous rocks in southern England. *Geol. Mag.*, **120**, 267-280.

Explanation of Plate 1

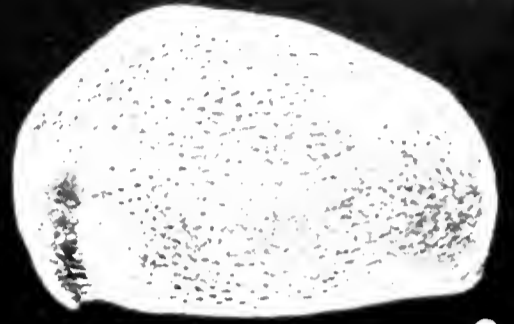
Some ostracods typical of the "Purbeck Beds"

- Fig. 1. *Cypridea granulosa fasciculata* (Forbes, 1855). Mik(M) 390, left valve, neotype, 1150 μ m long.
- Fig. 2. *Cypridea propunctata* Sylvester-Bradley, 1949. Mik(M) 3196, left valve, 865 μ m long.
- Fig. 3. *Cypridea dunkeri dunkeri* Jones, 1885. Mik(M) 738, right valve, 840 μ m long.
- Fig. 4. *Cypridea dunkeri carinata* Martin, 1940. Mik(M) 3151, right valve, 880 μ m long.
- Fig. 5. *Cypridea tuberculata langtonensis* Anderson, 1971. Mik(M) 3207, left valve, holotype, 970 μ m long.
- Fig. 6. *Cypridea posticalis* Jones, 1885, Mik(M) 1020, left valve, lectotype, 1085 μ m long.
- Fig. 7. *Darwinula oblonga* (Roemer, 1839). Mik(M) 33324, left valve 1150 μ m long.
- Fig. 8. *Darwinula leguminella* (Forbes, 1855). Mik(M) 3323, left valve, 620 μ m long.
- Fig. 9. *Cypridea ventrosa* Jones, 1885. Mik(M) 3205, left valve, 1040 μ m long.
- Fig. 10. *Galliaecytheridea postsinuata* Wolburg, 1962. Mik(M) 3263, male LV, 1140 μ m long.
- Fig. 11. *Mantelliana purbeckensis* (Forbes, 1855). Mik(M) 2682, left valve, 1125 μ m long.
- Fig. 12. *Theriosynoecum forbesi* (Jones, 1885). Io 681, female left valve, paralectotype, 900 μ m long.

All figured specimens are in the Anderson Collection, British Geological Survey, Keyworth, except Fig. 12, which is in the Jones Collection, Natural History Museum, London.



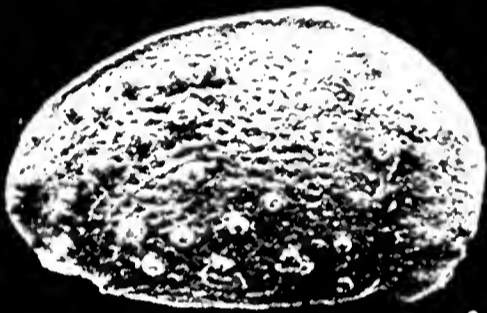
1



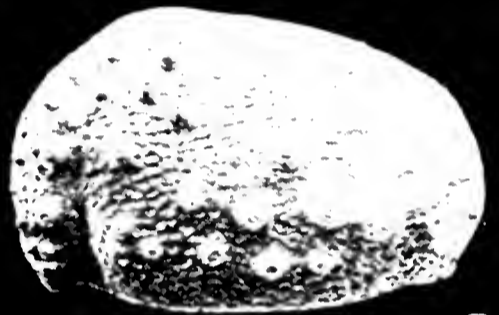
2



3



4



5



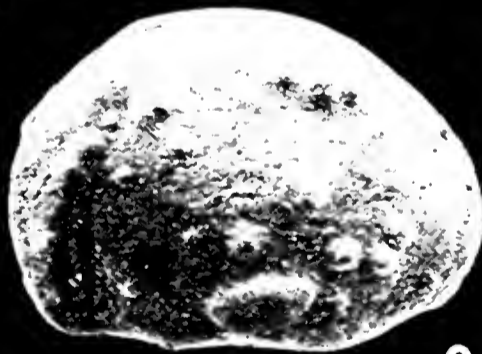
6



7



8



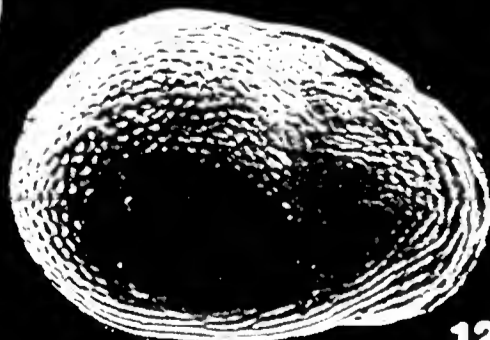
9



10



11



12

MARINE CRETACEOUS OF CHARING, KENT

Ian J. Slipper (University of Greenwich)

The "Chalk-detritus" of T.R. Jones

The first work to be published on ostracods by T. R. Jones, indeed the first systematic treatment of British Cretaceous Ostracoda, was the Palaeontographical Society's Monograph for 1849 - The Entomostraca of the Cretaceous Formation of England. While that work described species from various Cretaceous horizons, including the Greensand, Gault, Chalk-Marl and White Chalk from localities across England from Folkestone to Flamborough, Jones noted that 'the most abundant supply of these [Entomostraca] and other Cretaceous animalcules is obtained from the "Chalk-detritus" of Charing, Kent'. Of the twenty-six species listed by Jones for the English Cretaceous, in his synoptical table, twenty were reported from the "Chalk-detritus".

Samples of the "Chalk-detritus" and its fauna were supplied to Jones by Mr. William Harris, a solicitors clerk who lived in the village of Charing. It seems that Mr. Harris distributed material from this locality freely to those interested, which at the time included Dr. Gideon Mantell and Mr. W. C. Williamson of Manchester. An earlier publication by Williamson (1848) has the first mention of the "Chalk-detritus" where five species of ostracod were first noted. Williamson states that the deposit, discovered by Mr. Harris at the foot of the chalk hills, was a soft white clay about a foot thick, which rested upon the Greensand. The origin of the deposit was thought to be the result of hill wash.

The only description of the location of the "Chalk-detritus" is given by Jones (1849) as reported by Mr. Harris -

'The village of Charing stands on a bank of "chalk-detritus", composed of fragments of white and grey chalk, which gradually decrease in size from blocks of one or two feet in diameter, lying at the top, to very minute fragments, succeeded by still finer particles forming a clay-bed, which, in general reposes on the Chlorite-marl (Glaucinite). This bank extends from the southern escarpment of the adjacent hills, which form part of the northern boundary of the Weald of Kent, in a gradual descent southward for more than half a mile, where a hollow is formed occupying an area of about fifteen acres, and surrounded by chalk-detritus, except at one point, where a rivulet carries off the streams from the chalk-hills. In this hollow beneath the vegetable soil, and also under the banks of detritus, lies the clay-bed above mentioned, varying from one to twelve feet in depth, of a greyish colour and tough consistence, and containing nodules of undecomposed white and grey chalk and of ochreous and argillaceous substances. This bed abounds with many varieties of Amorphozoa, Zoophyta, Annelida, Polythemia, and Entomostraca, Conchifera, Brachiopoda, and Cephalopoda; also with bones, teeth, and scales of fish.'

Using the map which would have been available at the time, the Ordnance Survey sheet 81 for Canterbury published in 1819, part of which is reproduced below, only one area near Charing fulfils the requirements of the location.

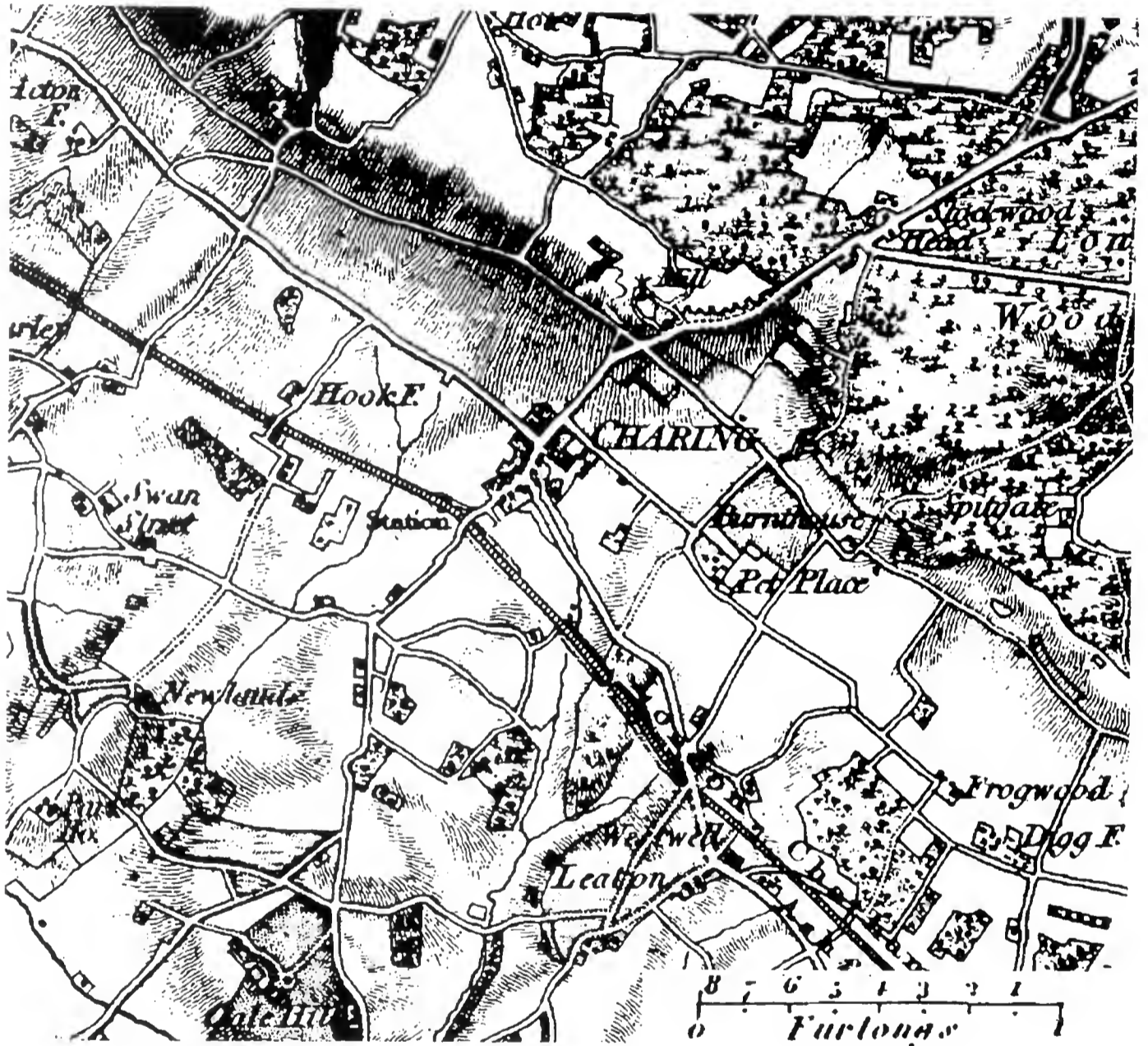


Fig. 1. Ordnance Survey sheet 81 Canterbury, first published 1819, reprinted 1970. The line of the railway was added in 1889.

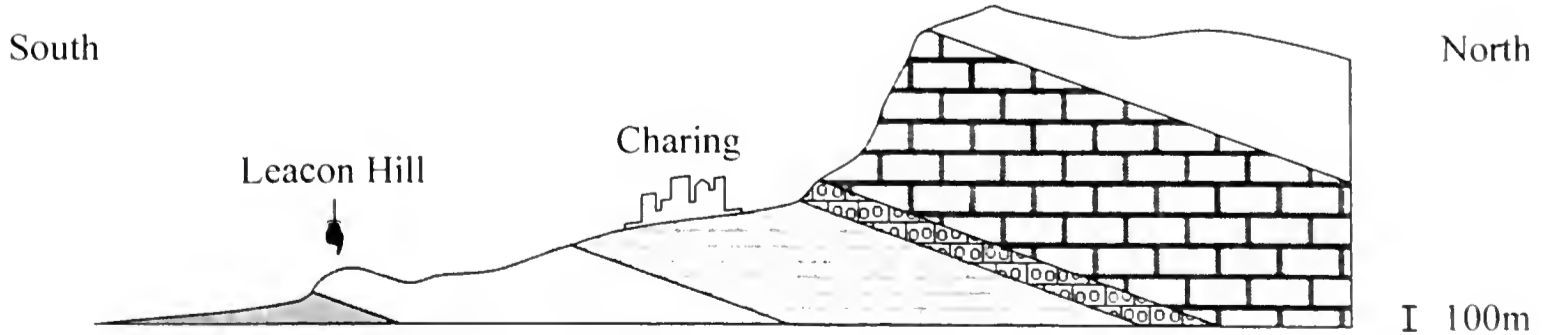
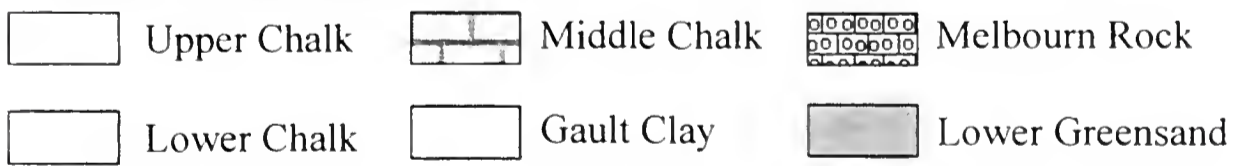
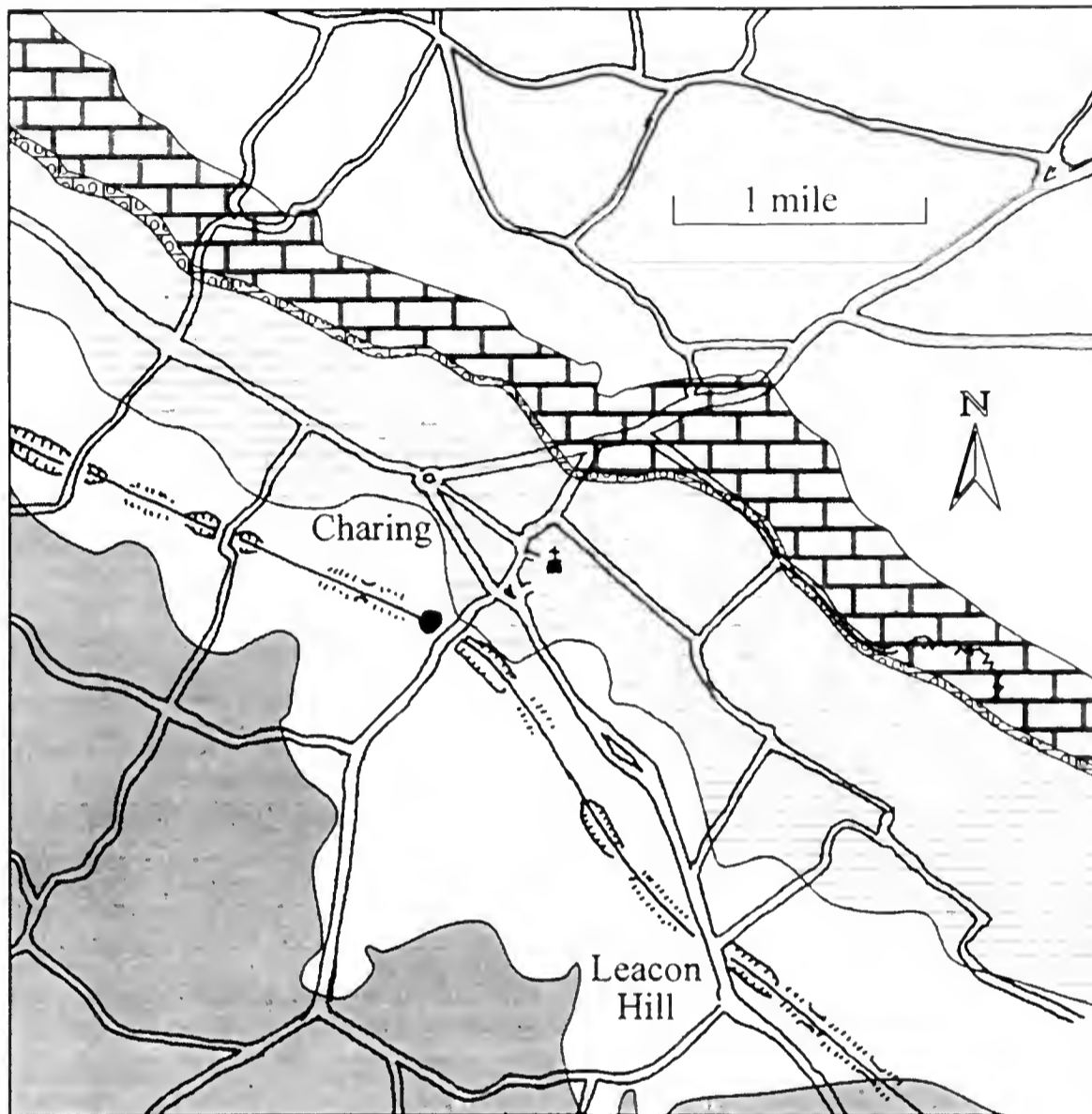
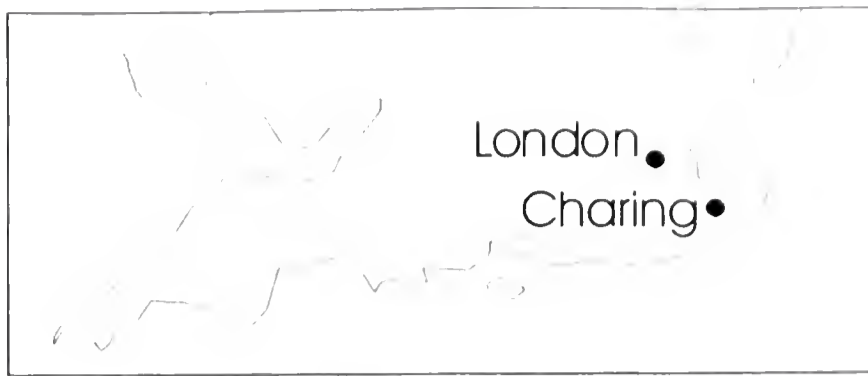


Fig. 2. Geology of the area around Charing and Leacon Hill, Kent.

CHRONOSTRATIGRAPHY		BIOSTRATIGRAPHY		LITHOSTRATIGRAPHY		
UPPER CRETACEOUS PAIRS	CONIACIAN 89		<i>Micraster coranguinum</i>	U CHALK	Seaford	
			<i>Micraster cortestudinarium</i>		Lewes	
	TURONIAN 93.5		<i>Sternotaxis plana</i>	MID CH	New Pit	
			<i>Terebratulina lata</i>		Holywell	
			<i>Mytiloides spp.</i>			
	CENOMANIAN 98.9	UPPER		<i>Neocardioceras juddii</i>	LOWER CHALK	Plenus Marls
				<i>Metoicoceras geslinianum</i>		Grey Chalk
				<i>Calycoceras guerangeri</i>		
		MIDDLE		<i>Acanthoceras jukesbrownei</i>		Chalk Marl
				<i>Acanthoceras rhotomagense</i>		
		LOWER		<i>Cunningtoniceras inerme</i>		Glaucinitic Marl
				<i>Mantelliceras dixonii</i>		
				<i>Mantelliceras mantelli</i>		
	LOWER CRETACEOUS PAIRS	ALBIAN 112	UPPER	<i>Stoliczkaia dispar</i>	GAULT CLAY	Upper Gault Clay
<i>Mortoniceras inflatum</i>						
MIDDLE			<i>Euhoplites lautus</i>	Lower Gault Clay		
			<i>Euhoplites loricatus</i>			
			<i>Hoplites dentatus</i>			
LOWER			<i>Douvilleiceras mammillatum</i>	Folkestone Sands		
		<i>Leymeriella tardefurcata</i>				
APTIAN 121		UPPER	<i>Hypacanthoplites jacobi</i>	LOWER GREENSAND GROUP	Sandgate Beds	
			<i>Parahoplites nutfieldensis</i>		Hythe Beds	
			<i>Cheloniceras martinoides</i>			
		LOWER	<i>Tropæum bowerbanki</i>		Atherfield Clay	
			<i>Deshayesites deshayesi</i>			
			<i>Prodeshayesites fissicostatis</i>			

Fig. 3. Generalised stratigraphy of the Cretaceous of Charing, Kent

To the west of the village of Charing about half a mile (four furlongs) from the escarpment, on the south side of the road, two small rivulets run across the fields of Hook Farm. The area of the east rivulet is now occupied by the new Maidstone road, to the south-east of the roundabout, and a small estate of houses which has been built on its north side. The land to the north of the west rivulet now has an hotel built upon it. It is most likely that the original site of the "Chalk-detritus" is now inaccessible. It is possible however, that other localities may be found by searching along the foot-hills of the Chalk escarpment to the east and west of the village, at a similar topographic level.

The view from Charing shows how closely the topography is linked to the underlying geology (see map and section, Fig. 2). In the broad sense, this locality is on the northern limb of the Weald anticline, with beds dipping gently at about two degrees to the north-east. The Lower Cretaceous sediments of the Lower Greensand and the Gault form the low lying area to the south and west of Charing. These consist mostly of sands and clays. With the onset of carbonate sedimentation in the Upper Cretaceous, the resultant rocks become more resistant to erosion. Charing itself is built on the apron of Cenomanian Chalk/Marl beneath the escarpment. At the base of the hill is a hard nodular band, the Melbourn Rock, which marks the base of the Middle Chalk. The nodular chalks and hardgrounds of the Turonian Stage form the escarpment, which can be traced to the cliffs at Dover on the North Downs, and round to Beachy Head, Sussex, on the South Downs. The Upper Chalk of the Coniacian and Santonian Stages make up the cap and the dip slope of the escarpment.

The fact that the fauna discovered by T.R. Jones was so diverse is due mostly to the derived nature of the sediment. The action of erosion on the Gault, Chalk/Marl, and White Chalk and subsequent deposition at the base of the escarpment on the Greensand has conveniently processed the material, but unfathomably mixed up the faunas from the Lower and Upper Cretaceous. The importance of the "Chalk-detritus" then is not its stratigraphical position, but that it is the type locality of a number of Cretaceous species which were first described by Williamson and T. R. Jones.

Jones' original work (1849, 1870 and 1875) was amplified by Jones & Hinde (1890) with fifty-five species recorded from the British Cretaceous. This latter work contained more precise locality descriptions and linked the ostracod finds to macrofaunal zones. Little further work was done until the 1960's when Kaye published a series of papers on both Lower and Upper Cretaceous faunas, revising much of the early work. Neale (1978) then illustrated the more stratigraphically useful species for the Cretaceous, while Wilkinson & Morter (1981) and Wilkinson (1988; 1990) have documented the ostracod biostratigraphy of the Albian Gault Clay from eastern England. The fauna of the Cenomanian Lower Chalk and Plenus Marls has been detailed by Weaver (1982), while the recovery after the Cenomanian-Turonian boundary event has been described by Horne *et al.* (1990) and Slipper (1996).

Ostracod fauna

Species from the "Chalk-detritus" vary in age from Middle Albian, through the Cenomanian and Turonian to the Coniacian Stage. Those reported by Jones (1849) are listed here with recent nomenclatural changes.

Schuleridea jonesiana (Bosquet, 1852); *Neocythere* (*Neocythere*) *vanveenae* Mertens, 1956; *Neocythere* (*Centrocythere*) *denticulata* (Mertens, 1956); *Neocythere* (*Physocythere*) *virginea* (Jones, 1849); *Bythoceratina* (*Bythoceratina*) *umbonata* (Williamson, 1848); *Mandocythere harrisiana* (Jones, 1870); *Platycythereis gaultina* (Jones, 1849); *Amphicytherura chelodon* (Marsson, 1880); *Protocythere albae* Damotte & Grosdidier, 1963; *Cythereis folkestonensis* Kaye, 1964; *Phacorhabdotus lonsdaleiana* (Jones, 1849); *Curfsina nuda* (Jones & Hinde, 1890); *Cythereis thoerenensis* Triebel, 1940; *Pterygocythereis robusta* (Jones & Hinde, 1890); *Macrosarisa siliqua* (Jones, 1849); *Pontocyprrella harrisiana* (Jones, 1849);

Dolocytheridea bosquetiana (Jones & Hinde, 1890); *Cytherella ovata* (Roemer, 1841); *Cytherelloidea stricta* (Jones & Hinde, 1890); *Cytherelloidea granulosa* (Jones, 1849); *Pontocyprella bosquetiana* (Jones, 1849).

Leacon Hill (TQ 9625 4770)

Just over a mile to the south of Charing is Leacon Hill, composed entirely of Gault Clay (see the geological map and cross section, Fig. 2). This locality was sampled by Jones and mentioned in the 1849 monograph as containing eight species. This site is now occupied by a public house, which has recently been converted into a Chinese restaurant. All of the species recovered from Leacon Hill were also found in the "Chalk-detritus".

Ostracod fauna

Neocythere (*Centrocythere*) *denticulata* (Mertens, 1956); *Cythereis folkestonensis* Kaye, 1964; *Cythereis thoerenensis* Triebel, 1940; *Pontocyprella harrisiana* (Jones, 1849); *Cytherella ovata* (Roemer, 1841); *Cytherella* cf. *truncata* (Bosquet, 1847); *Cytherelloidea stricta* (Jones & Hinde, 1890).

Postscript

The association between T.R. Jones and W. Harris went beyond just scientific collaboration, since it is recorded that Jones married Harris' daughter Mary. In 1841 Mary was 10 years old and living with her parents, William and Hannah, at Lion House in Charing. It would have been not long after this when Jones first met her, since the material from Charing was distributed in about 1845. By 1861, Mary had married and moved out, William had retired from the solicitors firm to become a 'Gentleman, FGS'. The delightful village of Charing then holds many associations with T.R. Jones. We finish the excursion where T. R. Jones began both his married life and his long association with Ostracoda.

MAPS

Geological Survey sheet (1:50,000) for Maidstone (288)

Ordnance Survey (1:25,000) sheet for Headcorn & Charing (1230)

Ordnance Survey (1:50,000) sheet for Ashford & Romney Marsh area (189)

Ordnance Survey reprint of 1st edition of the one-inch sheet for Canterbury (81)

References

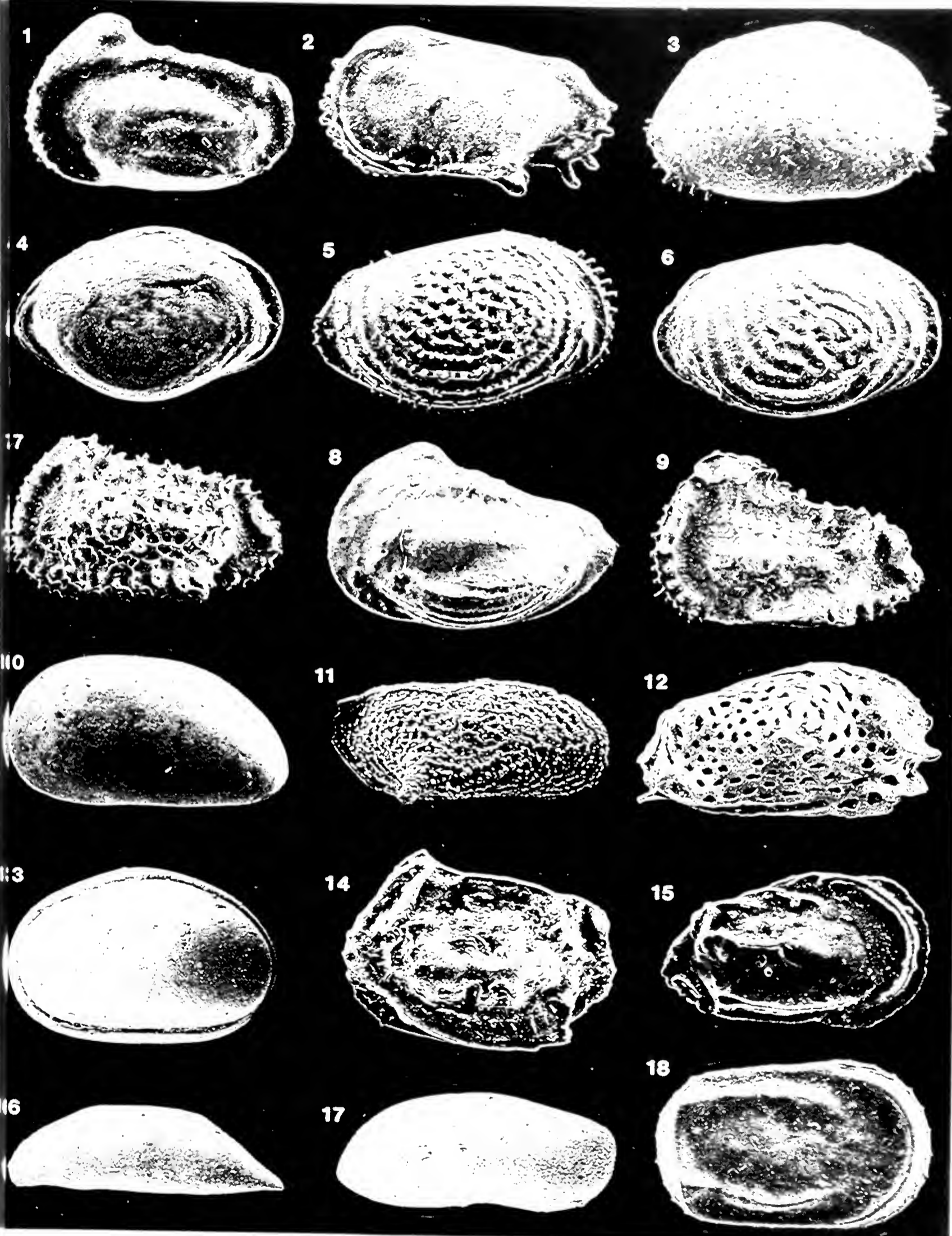
- Horne, D.J., Jarvis, I. & Rosenfeld, A. 1990. Recovering from the effects of an Oceanic Anoxic Event: Turonian Ostracoda from S.E. England. Pp. 122-138, *In* Whatley, R.C. & Maybury C. (Eds), *Ostracoda and Global Events*. Chapman & Hall.
- Jones, T.R. 1849. A monograph of the Entomostraca of the Cretaceous Formation of England. *Monogr. palaeontogr. Soc. London*, **3**(1), 1-40, 7 pls.
- Jones, T.R. 1870. Notes on the Cretaceous Entomostraca. *Geol. Mag.*, **7**(2), 74-77.
- Jones, T.R. 1875. Entomostraca. *In* Wright, J. & Jones, T.R. Systematic lists illustrative of the flora, fauna, palaeontology and archaeology of the north of Ireland. *Proc. Belfast Nat. Fd Club*, **1**, (Appendix 3).
- Jones, T.R. and Hinde, G.J. 1890. A supplementary monograph of the Cretaceous Entomostraca of England and Ireland. *Monogr. palaeontogr. Soc. London*, **43**, i-viii, 1-70, 4 pls.

- Neale, J.W. 1978. The Cretaceous, pp. 325-384. *In* Bate, R. & Robinson, E. (Eds). A stratigraphical index of British Ostracoda. *Geol Jl spec. iss.*, **8**.
- Slipper, I.J. 1996. Early Turonian Ostracoda: The Melbourn Rock fauna from Abbots Cliff, Dover, England. Pp. 49-57, 2 pls. *In* Keen, M.C. (Editor). *Proc. 2nd European Ostracodologists Meeting, Univ. Glasgow, 1993*.
- Weaver, P.P.E. 1982. Ostracoda from the British Lower Chalk and Plenus Marls. *Monogr. palaeontogr. Soc. London*, **135**, 1-127, pls 1-20.
- Wilkinson, I. P. 1988. Ostracoda across the Albian/Cenomanian boundary in Cambridgeshire and Western Suffolk, eastern England. Pp. 1229-1244, *In* Hanai, T., Ikeya, N. & Ishizaki, K. (Eds). *Evolutionary Biology of Ostracoda its fundamentals and applications. Developments in Palaeontology and Stratigraphy*, **11**.
- Wilkinson, I. P. 1990. The biostratigraphical application of Ostracoda in the Albian of eastern England. *Cour. Foursch.Senck.*, **123**, 239-258.
- Wilkinson, I. P. & Morter, A.A. 1981. The biostratigraphical zonation of the East Anglian Gault by Ostracoda, pp. 163-176. *In* Neale, J.W. & Brasier, M.D. (Eds), *Microfossils from Recent and Fossil Shelf Seas*. Ellis Horwood.
- Williamson, W.C. 1848. On some of the microscopical objects found in the mud of the Levant, and other deposits with remarks on the mode of formation of calcareous and infusorial siliceous rocks. *Mem. Lit. Phil. Soc. Manchester*, **2(8)**, 1-128.

Explanation of Plate 1

Cretaceous Ostracoda taxa found in the "Chalk-detritus" of Charing by Jones (1849)

- Fig. 1 *Mandocythere harrisiana* (Jones, 1870). BM OS 7546, left valve, female, 813µm long. Speeton Clay, Mid Albian.
- Fig. 2 *Pterygocythereis robusta* (Jones & Hinde, 1890). BM Io 1574, left valve, 760µm long. Upper Chalk, Norwich.
- Fig. 3 *Schuleridea jonesiana* (Bosquet, 1852). ST 5.5 23/2, right valve, 750µm long. Gault Clay, Folkestone.
- Fig. 4 *Neocythere (Physocythere) virginea* (Jones, 1849). BM In 51656, lectotype, juvenile carapace, right lateral view, 526µm long. Upper Chalk, Gravesend.
- Fig. 5 *Neocythere (Centrocythere) denticulata* (Mertens, 1956). ST 5.5 23/5, right valve, 670µm long. Gault Clay, Folkestone.
- Fig. 6 *Neocythere (Neocythere) vanveenae* Mertens, 1956. ST 1.5 23/3, right valve, 615µm long. Gault Clay, Folkestone.
- Fig. 7 *Cythereis hirsuita* Damotte & Grosdidier, 1963. ST 4.5 23/3, left valve, 1020µm long. Gault Clay, Folkestone.
- Fig. 8 *Protocythere albae* Damotte & Grosdidier, 1963. ST 5.5 23/11, left valve, 770µm long. Gault Clay, Folkestone.
- Fig. 9 *Rehacythereis luermanna*e (Triebel, 1940). ST 4.5 23/23, left valve, 850µm long. Gault Clay, Folkestone.
- Fig. 10 *Dolocytheridea bosquetiana* (Jones & Hinde, 1890). ST 1.5 23/14, left valve, 760 µm long. Gault Clay, Folkestone.
- Fig. 11 *Bythoceratina umbonata* (Williamson, 1848). BM OS 13117, right valve, 600µm long. Cenomanian, Dover.
- Fig. 12 *Platycythereis gaultina* (Jones, 1849). ST 7.5 23/10, right valve, 540µm long. Gault Clay, Folkestone.
- Fig. 13 *Cytherella ovata* (Roemer, 19841). IJS 15/17, carapace, left lateral view, 925 µm long. Upper Turonian, Dover.
- Fig. 14 *Amphicytherura chelodon* (Marsson, 1880). BM Io 1560, left valve, 530µm long. Upper Chalk, Norwich.
- Fig. 15 *Phacorhabdotus lonsdaleiana* (Jones, 1849). BM In 39012, lectotype, right valve, 557µm long. Upper Chalk, Norwich.
- Fig. 16 *Macrosarisa siliqua* (Jones, 1849). IJS 19/13, left valve, 1187µm long. Middle Turonian, Dover.
- Fig. 17 *Pontocyprella harrisiana* (Jones, 1849). IJS 19/22, right valve, 680µm long. Middle Turonian, Dover.
- Fig. 18 *Cytherelloidea stricta* (Jones & Hinde, 1890). ST 4.5 23/19, right valve, 566µm long. Gault Clay, Folkestone.



1

2

3

4

5

6

7

8

9

10

11

12

13

14

15

16

17

18



Professor T. Rupert Jones F.R.S.



