TURONIAN (LATE CRETACEOUS) OSTRACODA FROM DOVER, SOUTH-EAST ENGLAND

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A thesis submitted in partial fulfilment of the
requirements of the University of Greenwich
for the Degree of Doctor of Philosophy

SEPTEMBER 1997

the
UNIVERSITY
of
GREENWICH

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ABSTRACT

Ostracod assemblages from samples collected through the Turonian Stage of the Late Cretaceous from Dover, Kent, south-east England, consist of one hundred and three species group taxa. These are described and illustrated. This represents a significant increase in the knowledge of the Turonian fauna, since previous estimates of the number of species present during the Turonian are less than thirty.

This improvement has been brought about by the selection of an appropriate processsing method. Freeze-thaw processing is recommended for chalks and hardgrounds which comprise much of the Turonian Stage. The white spirit, solvent method is shown to be preferable for marls.

Nineteen species and six subspecies are here described as new: *Polycope lunaplena* sp. nov, *Cytherella truncatoides* sp. nov., *Cytherella vulna* sp. nov., *Cytherella weaveri* sp. nov.,*Cytherelloidea granulosa parca* ssp. nov., *Cardobairdia longitecta* sp. nov., *Bairdoppilata turonica* sp. nov., *Pontocyprella robusta cometa* ssp. nov., *Pterygocythereis (Diogmopteron) carolinae* sp. nov., *Bythoceratina (Bythoceratina) saxa* sp. nov., *Bythoceratina (Bythoceratina) staringi conmacula* ssp. nov., *Monoceratina minangulata* sp. nov., *Patellacythere weaveri* sp. nov., *Schuleridea langdonensis* sp. nov., *Karsteneis nodifera tabasca* ssp. nov., *Karsteneis oculocosta* sp. nov., *Karsteneis petasus petasus* sp. et ssp. nov., *Karsteneis petasus antecursor* sp. et ssp. nov., *Karsteneis praekarsteni* sp. nov., *Idiocythere caburnensis* sp. nov., *Isocythereis postelongata* sp. nov., *Mauritsina*? *paradordoniensis* sp. nov., *Rehacythereis stellatus* sp. nov., *Rehacythereis venticursus venticursus* sp. et ssp. nov., *Rehacythereis venticursus patbrowni* sp. et ssp. nov., and one new name, *Bythoceratina (Bythoceratina) antetumida* nom. nov. is introduced for a secondary junior homonym.

By comparison with faunas from Devon and the Czech Republic, the biostratigraphical analysis is shown to only have only local significance due to diachronism of Ostracoda. This diachronism is used to explore migration pathways which suggest that the origin of the Turonian ostracod fauna may have had more than one source.

A model relating ostracod diversity inversely to sea-level is given for the Cenomanian to Santonian stages of the Late Cretaceous which suggests that the sea-level at Dover during the Turonian was greater than previously thought, given its marginal setting.

INTRODUCTION

The Turonian Stage of the Late Cretaceous, as defined biostratigraphically, is approximately coeval with the lithostratigraphical unit of the Middle Chalk Formation. The base of the Middle Chalk, however, is older and lies in the Upper Cenomanian, while the top of the Turonian is now considered to be represented by the lowest beds of the Upper Chalk Formation. The Turonian is characterised by hard nodular chalks which were previously thought not to yield ostracods (Weaver 1982). Improved processing methods have now enabled the recovery of abundant and moderately diverse assemblages (Slipper 1996).

The Ostracoda of the Turonian Stage are important in that they show an essentially new fauna after the Late Cenomanian Oceanic Anoxic Event 2 (OAE2). Whereas in the Cenomanian many species existed which were of short to moderate duration, those first appearing in the Turonian are generally very long ranging. This is true also for species entering in the overlying Coniacian and Santonian. This style of long ranging species which originated in the Turonian is probably a response to the comparatively stable environment of deposition within the white chalk facies which lasted for twenty-five million years. Although sea levels were thought to have fluctuated throughout the Late Cretaceous (Hancock 1990), within this part of the Anglo-Paris Basin, the environment of deposition was always fully marine.

This thesis originated out of the reconnaissance study of Horne *et al.* (1990) who, in a study of the Chalk at Dover, concluded that the Turonian ostracod fauna was probably derived from the Cenomanian stock that survived the OAE in well-oxygenated, shallow-water refuges on the basin margins. They were unable to resolve the problem of identifying the probable source areas, due to a lack of taxonomic and stratigraphical precision. This thesis was originally intended to study the Turonian ostracod fauna of the Anglo-Paris Basin, its taxonomy, biostratigraphy and palaeobiogeography, in order to discover the shallow-water refuges postulated by Horne *et al.* (1990), hence the origins of the Turonian fauna. This original aim proved to be too broad when, through improved processing methods, the diversity of the fauna became apparent. This work then represents a first step towards solving the larger problem. Here is presented an analysis of the taxonomy and biostratigraphy of the Turonian fauna from sections near to Dover, S.E. England.

Although the focus of the present work is on the Turonian Stage, the author has undertaken a survey of the Ostracoda of the Late Cretaceous of Britain, during preparation of the Late Cretaceous chapter of the forthcoming Biostratigraphical Atlas of British Ostracoda, to be published by the British Micropalaeontological Society. This has allowed a much broader view of the fauna in terms of stratigraphical coverage of species which occur in the Turonian; some of this information is included in Chapter 6. Additionally, to broaden the geographical understanding of the British fauna, the author has examined type collections from continental Europe, including those of Pokorný, van Veen, Bonnema, Bosquet and Clarke.

The thesis has been written in the style of a monograph, since the author has agreement in principal from the editors of the Palaeontographical Society, to publish the work in due course. The emphasis is therefore placed upon the systematics section with other chapters being kept concise. Some additional comments have been included which cover aspects of evolution, palaeobiogeography and palaeoecology.

The organisation is as follows: after this introduction is found a list of aims, as modified after transfer from MPhil to PhD. A literature survey is included as a history of research (Ch. 1). The

Turonian Stage of the Late Cretaceous is then examined stratigraphically, discussing the recent changes to the stratigraphical nomenclature (Ch. 2). The trials which were carried out to explore the best treatment for processing Turonian chalks are detailed under methodology (Ch. 3), together with some comments on micropalaeontological techniques. The main systematics section (Ch.4) is followed by the biostratigraphical survey of the more important species (Ch.5). Leading on from this is a discussion of the stratigraphical distribution in terms of palaeoecology (Ch.6). A list of conclusions (Ch. 7) summarises the content of the chapters, in terms of the aims as detailed below.

Aims

- To critically analyse the technical difficulties of extracting Turonian ostracods from the chalks of southern England.
- To document and illustrate systematically the Turonian ostracod fauna from southern England.
- To analyse the Turonian Ostracoda biostratigraphically, and examine the possibility of erecting an ostracod zonation scheme.
- To examine the relationship between the ostracod fauna and the sedimentology, and to assess the use of ostracods as palaeoenvironmental indicators of the chalk seas.
- To assess the palaeobiogeography of the Turonian Ostracoda within a basinal context, detailing, where present, any migration pathways which may give an indication of the origins of the Turonian fauna.

1 HISTORY OF RESEARCH

Very little has been published on the British Turonian Ostracoda, and no comprehensive systematic work has yet been attempted. The first record was that of Jones & Hinde (1890) who described twenty-one species and a further six varieties from Chalk outcrops, mostly *Holaster planus* Zone, at Dunstable and the railway cutting between Luton and New Millend (Bedfordshire), Chinnor (Oxfordshire) and West Wycombe (Buckinghamshire). This level is equivalent to the Kingston Nodular Chalks at Dover. The work is descriptive, with small illustrations, many of which were photographically reduced from the monograph of Jones (1849) and then redrawn.

Kaye (1964a) revised much of Jones & Hinde's work, using type material where it could be found. Nine of the species in that revision were from the Turonian Chalk Rock. He reassigned many species and genera, using material from his own collection from a flint meal, from Sonning, Berkshire. This was of Coniacian or Santonian age and some of the species from this locality are not conspecific with Jones & Hinde's original specimens. Neale (1978) illustrated five Turonian species, all from the *Holaster planus* Zone, the range data being taken from King [1968].

The first published records of lower Turonian ostracods were made by Jarvis *et al.* (1988). This study included the uppermost Cenomanian and the first twenty metres of the Turonian, from Akers Steps section at Dover. A link was made between the gradual extinction of species over the boundary interval and the high positive $\delta^{13}C$ excursion, which was thought to be a result of an expanding and intensifying oxygen minimum zone. Twelve Turonian forms were recorded, many of which are now known to range through the remaining Turonian. The work commented on the very low, but gradually increasing, diversity assemblages recovered immediately above the Plenus Marls, suggesting that the new species were filling vacant niches left by the extinctions. A continuation of the Cenomanian-Turonian section (Horne *et al.* 1990) examined the re-colonisation of the chalk sea after the extinction event. Twenty-eight species were recovered, with many towards the top of the section, reflecting a more boreal than tethyan influence. The detailed lithostratigraphy of Horne *et al.* (1990) is good and the biostratigraphy demonstrates the very slow increase in diversity towards the Coniacian. Slipper (1996) has documented the ranges of the Early Turonian fauna in more detail from the Melbourn Rock *s.l.* at Abbots Cliff, Dover. This shows how the recovery after the extinction event was more rapid than previously thought. Slipper (submitted, 1993) illustrated the ranges of fourteen stratigraphically significant Turonian species, and reassessed the species and ranges used by Neale (1978) which were taken from King [1968]. Horne *et al.* (1995) illustrated the variable morphology of *Cytherelloidea kayei* Weaver, which first appears in the Cenomanian and ranges through the Turonian to the Santonian. Slipper (in press, Appended) examined the ostracod fauna across the Turonian-Coniacian boundary from Dover, and showed how statistical clustering divided the assemblages into two significant clusters, just below the accepted stage boundary. A comparison of the faunas from England and Bohemia showed a migration pathway running east to west in the Lower and Middle Turonian, which then reversed at the Middle-Upper Turonian boundary.

On the Continent there have been many works detailing Turonian ostracod faunas in France (Damotte 1962, 1971a; Colin 1974; Babinot 1973; Babinot *et al.* 1982, 1985; Colin & Damotte 1985), Germany (Gründel 1970, 1970a), the Netherlands (Bonnema 1940, 1941) and the Czech Republic (Pokorný 1963, 1963a, 1963b, 1964, 1964a, 1965, 1965a, 1967, 1967a, 1967b, 1967c, 1969; Pokorný & Colin 1976; Pokorný 1977, 1978, 1978a, 1979, 1980, 1980a, 1980b, 1984, 1986, 1987, 1989).

The present work is the first systematic treatment of the British Turonian ostracods and follows on stratigraphically from that of Weaver (1982). The highest samples in the latter work are from 1m above the top of the Plenus Marls, in the Melbourn Rock, while the lowest sample in this work is 1.5 metres above the top of the Plenus Marls.

2 STRATIGRAPHY

Introduction

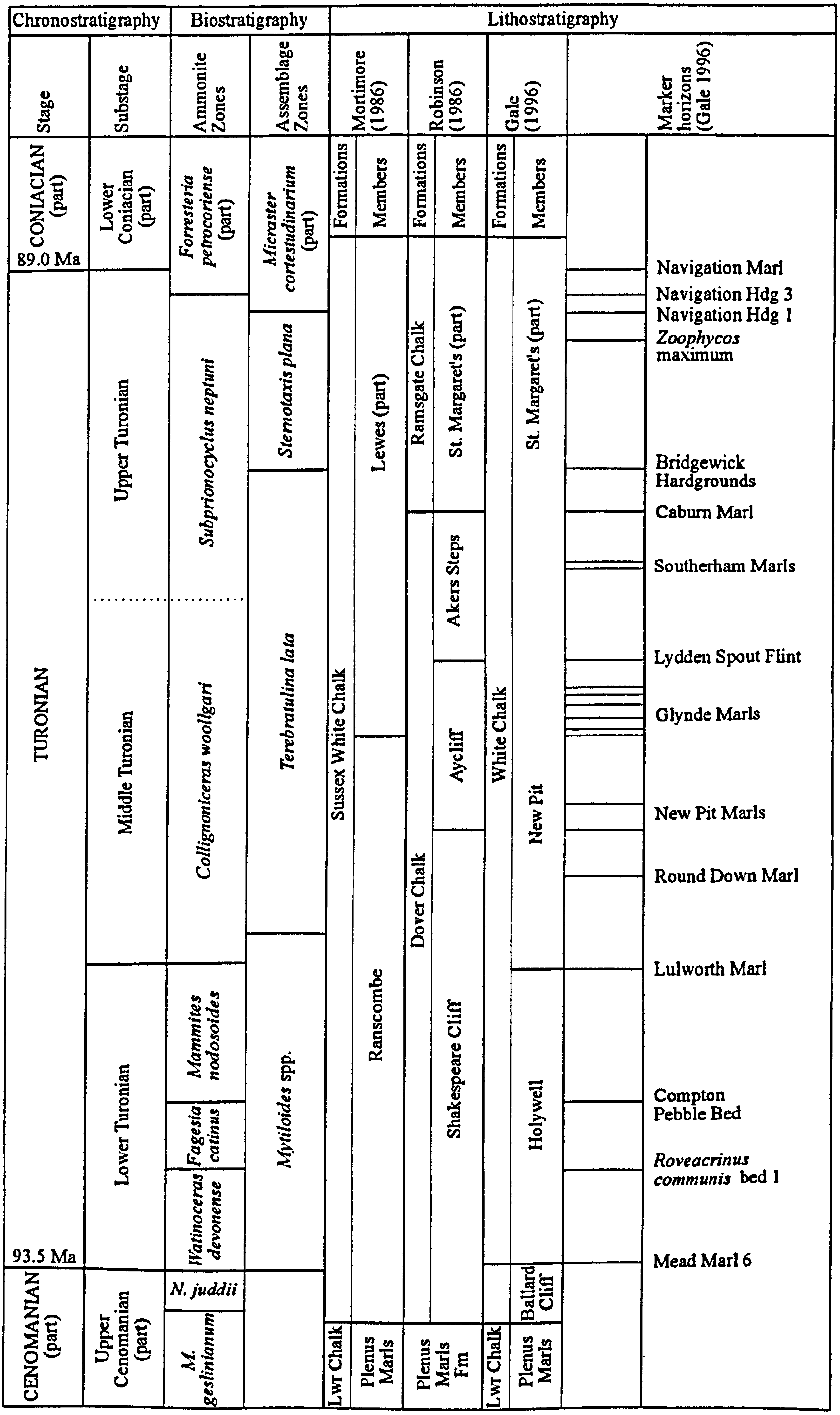
The Upper Cretaceous has been the subject of much attention since the nineteenth century, and there have been many attempts at classifying the succession in terms of both its lithostratigraphy and biostratigraphy. The earliest approach was by Phillips (1821) who proposed a tripartite lithostratigraphical subdivision using the presence or absence of flints and organic remains, this became the basis for the division into Lower, Middle and Upper Chalk. That scheme has been subject to many modifications and name changes, but the underlying lithostratigraphical system is that in use today.

The earliest biostratigraphical scheme of the Chalk was achieved in France; the Cretaceous was divided into six stages by d'Orbigny (1842), the upper three consisted of Cenomanian, Turonian and Senonian. The Turonian Stage was first described from the Touraine region in Northern France. The type area is in the Loire-Cher Valley between Saumur and Montrichard.

Absolute dating using ^{40}Ar/^{39}Ar laser fusion of sanidines from bentonite deposits, interbedded with fossiliferous sediments, has been used in the Western Interior of America (Obradovich 1993) to determine a time scale for the Cretaceous period. In that scheme the Turonian Stage is given as 93.3 ±0.2 Ma to 88.7 ±0.5 Ma. This period of 4.6 m.y. is by far the longest duration for the Turonian so far determined. Previous estimates vary from 1.5 m.y. (Hallam *et al.* 1985) to 2.9 m.y. (Haq *et al.* 1987). More recently Gradstein *et al.* (1994) have concurred with Obradovich (1993) with values of 93.5 ±0.2 Ma to 89.0 ±0.5 Ma, a duration of 4.5 m.y. for the Turonian.

2.1 Definition

The definition of the Turonian Stage is moving towards ratification at the International Geological Congress, to be held in Beijing in 1997. At present it remains as firm recommendations made by the Turonian and Coniacian working groups after the last International Symposium on Cretaceous stage Boundaries in 1995 which was held in Brussels (Bengtson 1996). The base of the Stage is to be defined as the first appearance of the ammonite *Watinoceras devonense* at the base of Bed 86 in the Pueblo section in Colorado. The base of the Coniacian, and therefore the top of the Turonian, is to be defined by the incoming of the inoceramid *Cremnoceramus rotundatus* (*sensu* Tröger *non* Fiege) (Kauffman *et al.* 1996). In the British sections ammonites are very scarce, so the best approximation for the base of the Turonian is the flood occurrence of *Mytiloides* spp. which can be recognised internationally (Hancock 1984). At Dover the basal beds are condensed when compared to the sections at Eastbourne, and not all of the marker horizons are identifiable. The boundary is placed at the fourth hardground above Plenus Marls bed 8, within the Ballard Cliff Member. The top of the Stage has previously been placed below Navigation Hardground 3 (Birkelund *et al.* 1984), where the ammonite *Forresteria (Harleites) petrocoriensis* (Coquand) has been found, but using the range of *C. rotundatus* of Mortimore (1986, fig. 12, the new proposed definition places the base of the Coniacian slightly higher, at the level of the Navigation Marl. The subdivision of the Turonian into Lower, Middle and Upper, though still contentious, is becoming accepted using the ammonite zonation of Hancock (1991). The other scheme which is still in use is the traditional bivalve, brachiopod and echinoid division of assemblage zones. Near the top of the Turonian, beneath the Navigation Hardground 1 is an internationally recognisable flood occurrence of the trace fossil *Zoophycos*. It is at this point in the section where the ostracods show a diversity maximum and also a small faunal turnover.



Text-fig. 2.1 Stratigraphy of the Turonian Stage of southern England.

2.2 Lithostratigraphy

The lithostratigraphy also is in a state of flux. Since the two schemes presented by Mortimore (1986) and Robinson (1986) for the South Downs and North Downs respectively, there has been much discussion as to the status of Bed, Member, and Formation names in the Anglo-Paris Basin (Gale *et al.* 1987; Mortimore 1987; Robinson 1987; Mortimore & Pomerol 1987; Mortimore 1988).

Recently Gale (1996) has erected a new lithostratigraphical scheme for the Turonian of southern England adapting names from Mortimore (1986) and Robinson (1986) and introducing two new names. A comparison of these schemes, together with the biostratigraphy and chronostratigraphy is shown in Text-fig. 2.1.

In the sections at Dover, above the Plenus Marls are twelve metres of a very characteristic bioclastic nodular chalk with hardgrounds, first termed the "Grit Bed" by Price (1877) and subsequently "Melbourn Rock" by Hill (1886). This use has been followed by Jukes-Browne & Hill (1903), Robinson (1986), Gale *et al.* (1993) and Slipper (1996). Mortimore (1986), however, defines the Melbourn Rock as consisting of only the basal hardgrounds, which are developed over 1.2m at Dover. Gale (1996) argues for the name Ballard Cliff Member to be used on the southern coast, restricting the use of Melbourn Rock to Cambridgeshire, where it is typically developed. The Ballard Cliff Member of Gale (1996) at Eastbourne encompasses the zones of *M. geslinianum* (*pars*), *N. juddii* and the lowest 1m of *W. devonense*. At Dover, however, the condensation is such that the Ballard Cliff Member is wholly Cenomanian.

The Turonian then has at its base eleven metres of nodular intraclastic chalk which is characterised as the Holywell Member. This contains rhythmically bedded chalks and marls with inoceramid and microcrinoid debris. A unique horizon is the *Filograna avita* bed, where serpulid worms are found densely encrusting *Mytiloides* shells

(Gale 1996). The overlying New Pit Member has at its base the Lulworth Marl, which is characterised by absence of intraclasts and *Mytiloides* shell beds. It is also rhythmically bedded, and at Dover is nodular in the lower part. Important marker beds are the New Pit Marls and the Glynde Marls, the first flint enters the section near the top of the Member.

The base of the overlying St. Margaret's Member is stated by Gale (1996) to be at the onset of nodularity, which is variable according to location. This interpretation of the members of the Turonian by Gale (1996) is a significant departure from previous schemes since it decouples the gross lithologies from the marker horizons. The members are then lithological units which may be diachronous, rather than the schemes of Mortimore (1986) and Robinson (1986), where the members are tied in to time lines as represented by marker horizons; that approach results in members being correlated beyond the bounds of their facies, and then not possessing the features upon which they were first described. The approach of Gale (1996) is to be preferred where members have local significance. The St. Margaret's Member consists of nodular chalks with flaser marls and marl seams, the first of which, the Southerham Marl can be traced basin-wide. Flints are common towards the top of the Member.

2.3 Biostratigraphy

Gale (1996) has erected a five-fold division of the Turonian using collected ammonites (Text-fig. 2.1). The base of the Turonian occurs at 10cm above Mead Marl 4 at Beachy Head, at the first appearance of *Watinoceras devonense*. At Dover this corresponds to a level just above the basal hardgrounds. In the Lower Turonian there are two further ammonite zones, a short zone defined by the appearance of *Fagesia catinus*, which at Dover is interpreted as being at the base of the first bed which contains abundant *Roveacrinus communis*. The remainder of the Lower Turonian consists of the *Mammites nodosoides* Zone. The base of the Middle Turonian is defined by incoming of the ammonite *Collignoniceras woollgari* at a horizon above the second abundant occurrence of *Roveacrinus communis* which occurs above the Lulworth Marl. The exact position of the base of the Upper Turonian is difficult to determine at Dover due to lack of ammonite records, but Gale (1996) has shown the first *Subprionocyclus neptuni* at a level between the Southerham Marls and the Lydden Spout Flint, near to the change in lithology to more nodular horizons. Since the Coniacian is now defined by the appearance of the inoceramid *C. rotundatus* at a level above the Navigation Marl, this leaves a short interval at the top of the Turonian of the zone of *Forresteria (H.) petrocoriense* above the Navigation Hardground 3, which was previously incorporated within the Coniacian.

The traditional scheme of assemblage zones has some parallels with the ammonite zonation and the lithological scheme, but the boundaries do not coincide. The lowest assemblage zone is that of *Mytiloides* spp., a concept which has come to replace the zone of *Inoceramus labiatus* due to the latter being diachronous across the basin. The *Mytiloides* spp. Zone, spans the interval from the base of the Turonian up to a horizon 3m above the Lulworth Marl, it extends both below and above the *M. nodosoides* Zone. The *Terebratulina lata* Zone extends up through the Middle Turonian and much of the Upper Turonian to terminate at the base of the *Sternotaxis plana* Zone at the Bridgewick Hardgrounds which was used traditionally as the boundary between the Middle and Upper Chalk.

3 METHODOLOGY

INTRODUCTION

Given that the Turonian forms some of the most spectacular outcrops of Chalk on the coast of southern England, including Beachy Head in Sussex, and the White Cliffs of Dover in Kent, it is surprising that it has not been studied in any great detail for its ostracod fauna. However it is the very nature of the Turonian that it is more resistant to erosion, and therefore able to form precipitous cliffs, that makes it challenging for micropalaeontological work.

This chapter concentrates on a series of trials which were run in the first year of the study, to try to discern the most suitable method for processing the hard nodular chalks which are typical of the Turonian in southern England. A suite of different rock types are processed with a set of techniques and the results are analysed.

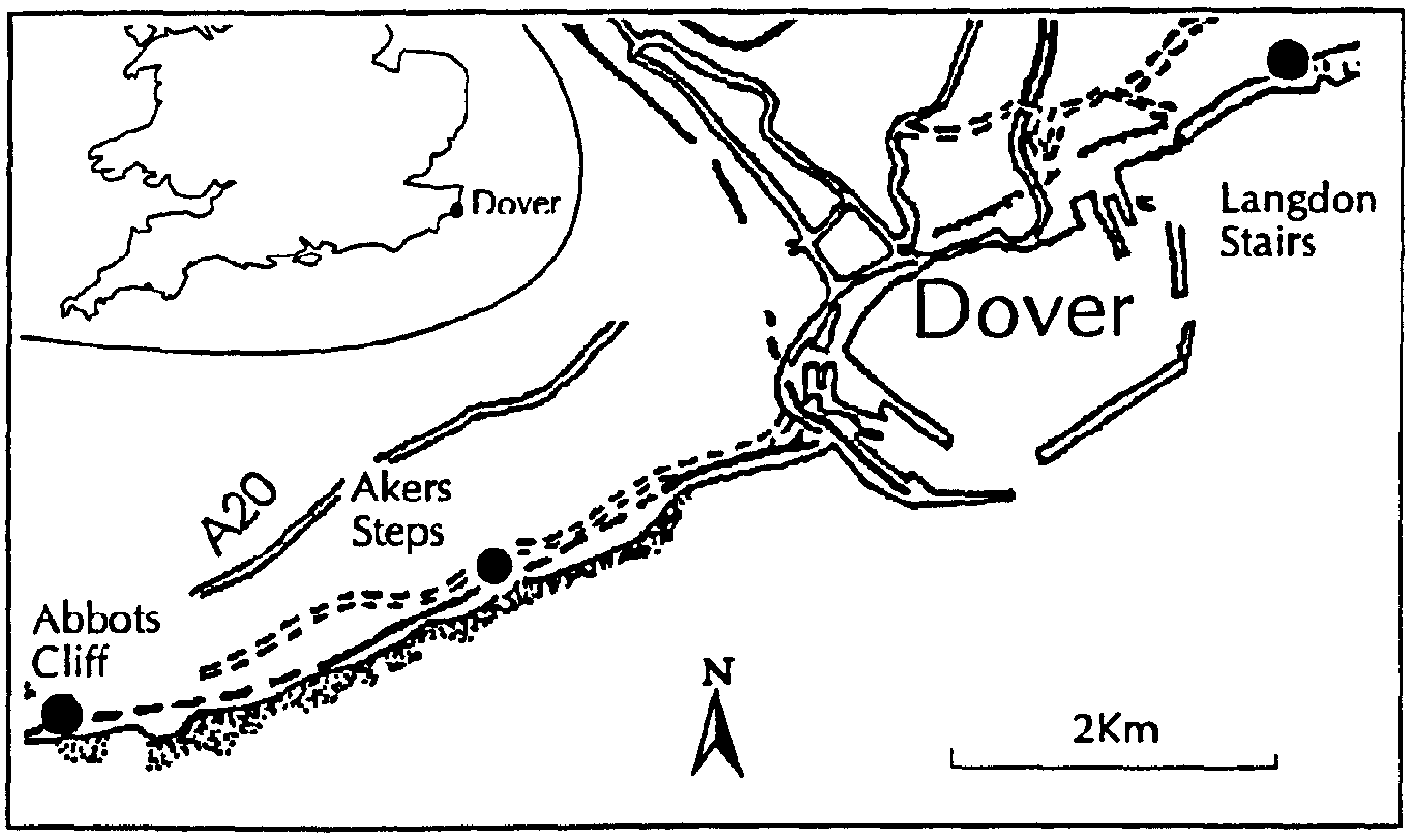
3.1 Material

The ostracod material described in this work from Kent were all collected by the author between 1987 and 1992. The author has also used material from the collection of Dr. D.J.Horne. Assemblages on numbered slides are housed the author's collection in the School of Earth and Environmental Sciences, University of Greenwich.

3.1.1 Localities

The Turonian Chalk is exposed in several places along the south coast of England including the cliff sections at Beer in Devon, Culver cliff on the Isle of Wight, Eastbourne, Sussex, and around Dover in Kent. Initial reconnaissance samples from the two sites in the centre of the basin (Eastbourne and Culver Cliff) have shown poor recovery, so the current work focuses on the sections around Dover which were the subject of the earlier study by Horne *et al.* (1990). No single section at Dover is complete, but the small easterly dip in the beds successively brings down all of the Turonian to accessible sites.

The sampled localities are listed in stratigraphical order. The following information is given: locality number, geographical location, National Grid Reference and the lithostratigraphical position. The location of the sections are given in Text-fig. 3.1. Detailed stratigraphical logs with sampled horizons marked are given in Text-figs 3.2-3.4.

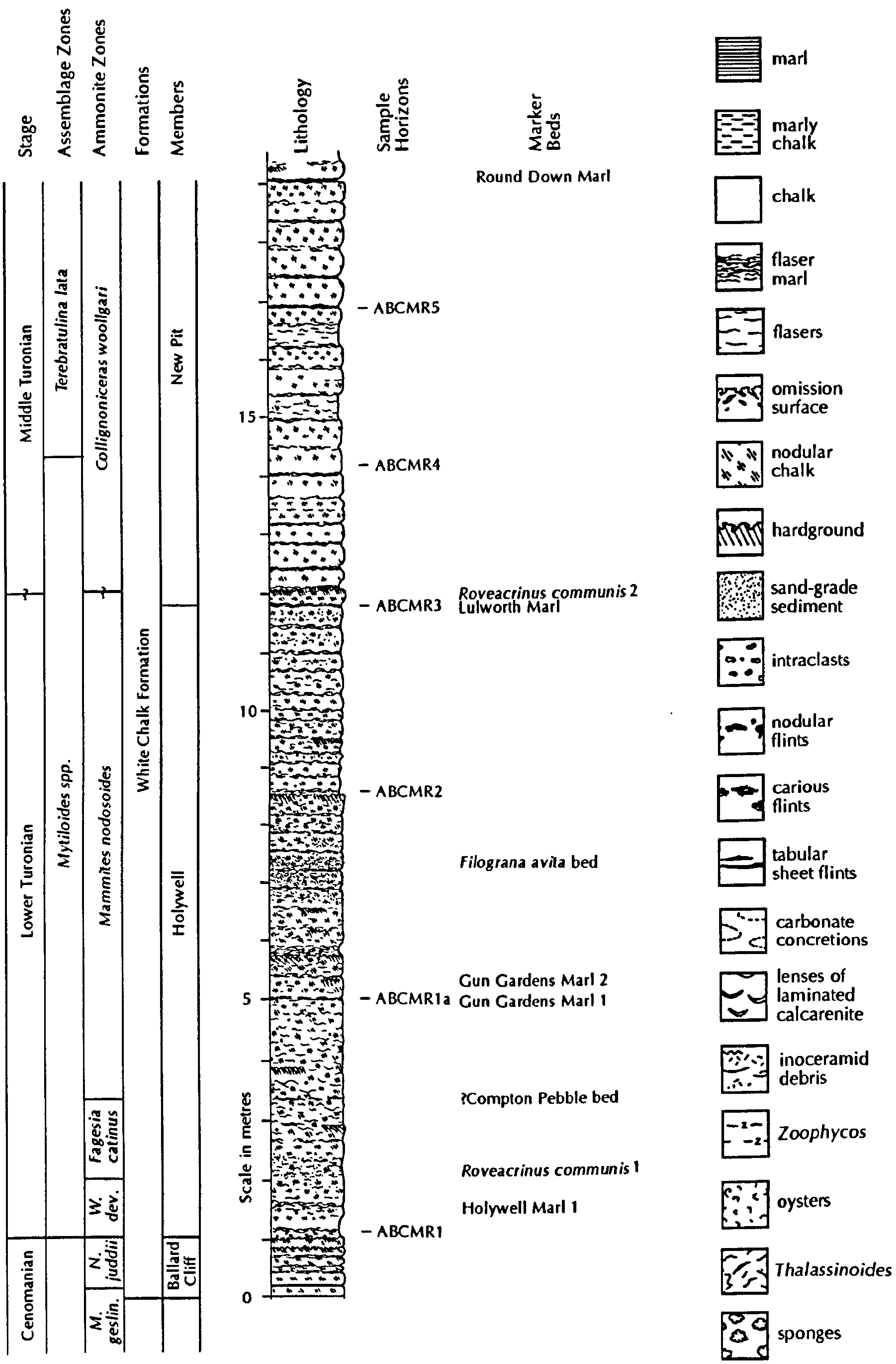


Text-fig. 3.1 Location map of the Dover area showing three collection sites of Abbots Cliff, Akers Steps and Langdon Stairs.

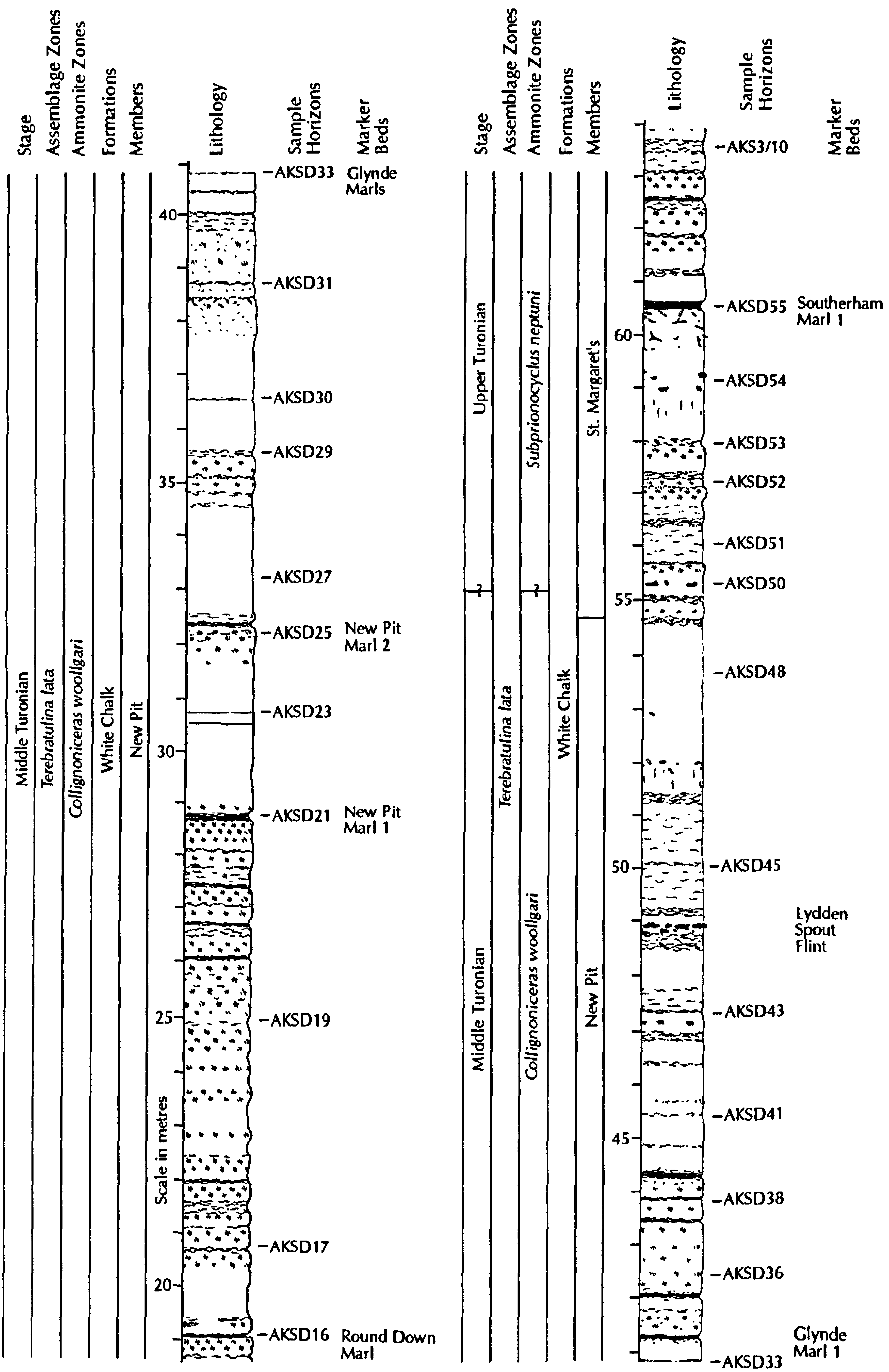
Locality 1. Abbots Cliff path. TR 268385. Ballard Cliff, Holywell, and part of the New Pit Member, White Chalk Formation. Nineteen metres from the Upper Cenomanian and lowest Turonian up to the Round Down Marl, Middle Turonian can be sampled. The treacherous path to this section makes sampling difficult. Text-fig. 3.2.

Locality 2. Akers Steps. TR 297394. This section encompasses 45m of chalk between the Round Down Marl and the Southerham Marls, including the upper part of the New Pit Member, and the lower part of the St. Margaret's Member, White Chalk Formation. Part of the Middle and Upper Turonian are exposed, all within the *T. lata* Zone. Access to this path may now be restricted due to the Channel Tunnel workings. Generally not in a good state of repair. Text-fig. 3.3.

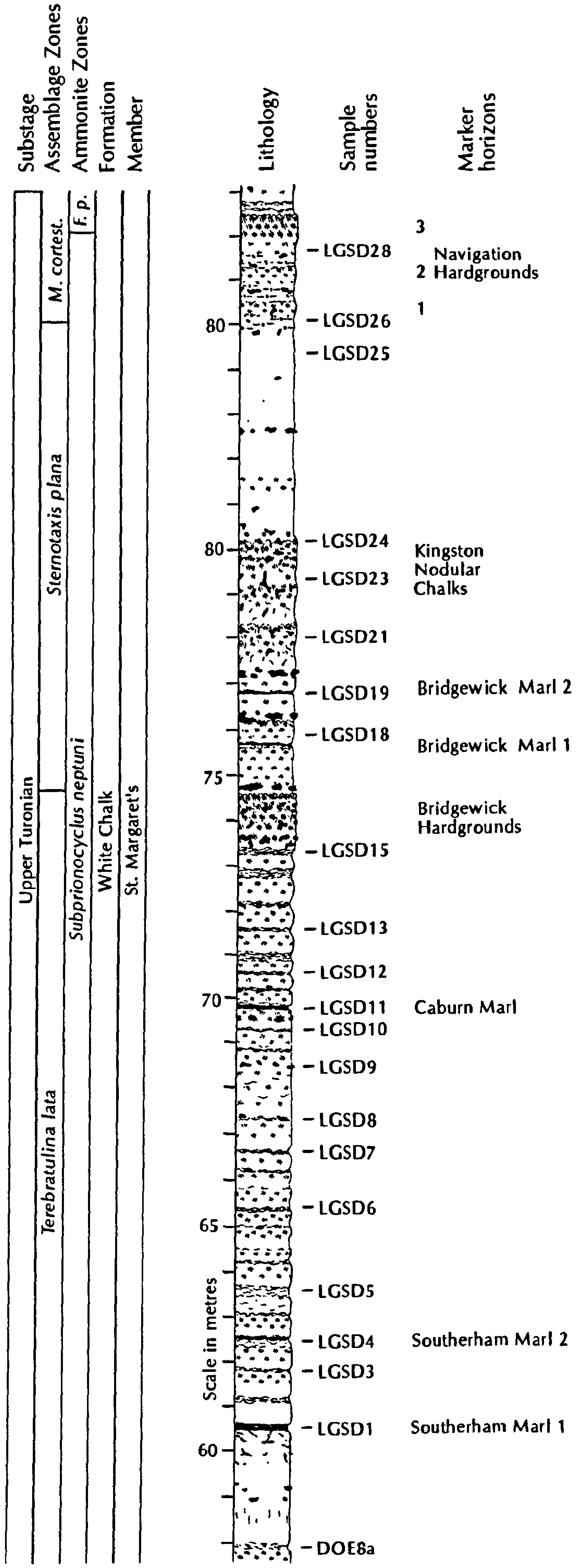
Locality 3. Langdon Stairs. TR 345425. Thirty metres of chalk from the Southerham Marls up to the Navigation Marl. St. Margaret's Member, White Chalk Formation; all Upper Turonian, containing part of *T. lata* Zone, the *S. plana* Zone and part of the *M. cortestudinarium* Zone. Overlapping samples were taken at the Southerham Marls from Akers Steps and from Langdon Stairs. Text-fig. 3.4.



Text-fig. 3.2 Stratigraphy of Abbots Cliff (Gale 1996), showing sampled horizons.



Text-fig. 3.3 Stratigraphy of Akers Steps (Gale 1996), showing sampled horizons. For key to lithologies see Text-fig. 3.2.



Text-fig. 3.4 Stratigraphy of Langdon Stairs (Gale 1996), showing sampled horizons. For key to lithologies see Text-fig. 3.2.

3.2 Experimental Techniques

Slipper (1996) has shown the increase in species yield obtained using appropriate methods of sample processing. The background to that work, which consists of a comparative analysis of different types of chalks, is presented here.

One of the main difficulties with Turonian chalks is the predominance of nodular horizons and hardgrounds, both of which are considerably harder than the marly chalks of the Cenomanian and the white chalks of the Coniacian and younger rocks. The difficulty encountered in extracting ostracod faunas from these more indurated beds may be responsible for the relatively little micropalaeontological work which has been done so far.

3.2.1 Chalk Lithologies

The first year of this study was spent in examining various standard techniques to determine the most appropriate method for breaking down Turonian chalks. Five methods were used on four of the main rock types, these were chosen for their variety of hardness:

- **Marly Chalk.** Plenus Marls bed 1, Upper Cenomanian, from Shakespeare Cliff, Dover. A soft marly chalk which represents the easily dissagregated marls found throughout the Cenomanian and Turonian.

- **White Chalk.** Middle Turonian white chalk with flints, 1m below Southerham Marl 1; sample from Langdon Stairs, Dover. This is characteristic of majority of the Turonian chalks; in terms of ease of processing, it is mid-way between a soft marl and a more indurated hardground.

- **Hardground.** Upper Turonian Navigation Hardground 1, a nodular chalk with mineralised surfaces. Hard chalks, with apparently little potential for microfossil recovery.

- **Chalkstone.** A sample of Chalk Rock from Berkshire donated by D.S.Wray; Upper Turonian. Effectively a limestone, this represents the extreme of lithification within the Upper Cretaceous.

3.2.2 Processing Methods

Approximately 2Kg of each rock type was collected and divided in half. One half was split into five 200g sub-samples, one for each of the chosen processing methods. The other half has been retained for reference.

For all five methods, the pre-treatment on each of the rock types was the same. The field sub-samples were broken down into pieces 2-3cm in size, any fine material created at this stage was discarded as this was likely to contain only crushed fragments. The broken pieces were then spread on a large plate and dried in a fan oven at 60°C, for 24 hours. Higher temperatures are likely to bake the chalks making them harder to break down.

- **Hydrogen peroxide.** Rock chips are covered in 12% H_2O_2 and allowed to soak for 2-3 hours. Water is then added and boiled on a hot plate for 20 minutes (Sohn *et al.* 1965). The action of oxidation and the creation of bubbles causes expansion in the pore spaces of the rock, which aid dissagregation.

- **Glauber Salt - Freeze Thaw.** Using a supersaturated solution of glauber salts (sodium sulphate decahydrate, natural mineral is called mirabilite), the rock is soaked for 2-3 hours in an oven. Just before the liquid starts to crystallise, the solution is poured off and the sample deep frozen. After 3-4 hours the sample is re-heated, water added and boiled for a short time (Surlyk 1972). The mirabilite crystallises in the pore spaces and physically breaks the rock apart.

- **White Spirit.** Turpentine substitute or white spirit is poured over the warm rock chips and allowed to soak for 1 hour. It is then filtered off, and with care may be used again. Water and soda crystals are added and boiled (Weaver 1982). The solvent appears to weaken the clay structures, such that when the water is added to drive out the solvent, the clay layers are left unsupported and break apart.

- **Physical breakdown.** After breaking into smaller pieces the rock chips are placed in a bowl of water and gently crushed using a hammer shaft. A crude method, used as a last resort when all others fail.

- **Bleach.** Sodium hypochlorite in solution as household bleach is used as an alternative to hydrogen peroxide (Hoffmeister 1960). A similar vigorous oxidation occurs as in the hydrogen peroxide method.

3.2.3 The Microwave oven

In many stages of these processing techniques, much use has been made of an ordinary domestic microwave oven, rated at 600W. A few points relating to this are worth detailing, firstly outlining the advantages and then some of the disadvantages of this technique.

3.2.3.1 Advantages. The glauber salt thawing process may be speeded up considerably by use of the microwave. Once the sample has been removed from the deep freeze, it is topped up with water and placed in the microwave oven. There is sufficient room for three samples in 250ml beakers, they require approximately 15 minutes on the high setting to be brought to near boiling point.

A second and more general use is in any heating process of the sample in a liquid state. Standard methods of sample heating using metal bowls on either hot plates or Bunsen flames risk the sample sticking to the bottom of the vessel. This requires constant stirring, a process which is bound to increase the destructiveness of the method. Since no direct heat is applied in the microwave oven, there is little possibility of the sample sticking to the side of the beaker, thus no stirring is needed. The gentler nature of this method substantially increases the chance of more delicate specimens being recovered at the sieving stage.

3.2.3.2 Disadvantages. There are, however, certain disadvantages involved in the use of the microwave oven. If the beaker should dry out during the heating, the resulting mud will tend to be ejected from the beaker as the more viscous material boils. This problem has two serious effects; cross contamination from the other samples in the oven, and possible damage to the magnetron.

Secondly, doubts have been raised as to the safety aspects of using the microwave with residual amounts of white spirit in the pore spaces. The auto-ignition point of white spirit, 232^{O}C, has not been reached in any of the trials run so far; no sample has ignited through simple heating. Concern must then lie with the generation of fumes whose flash point is 44^{O}C. During heating the temperature of the samples rise above this critical point, so it is important to ensure that all sources of ignition are removed from the path of the fumes. Examination of the chamber construction shows that fumes are extracted immediately, and do not pass over any electrical components. With this arrangement the fumes are unlikely to be ignited, thus the risk of fire is removed.

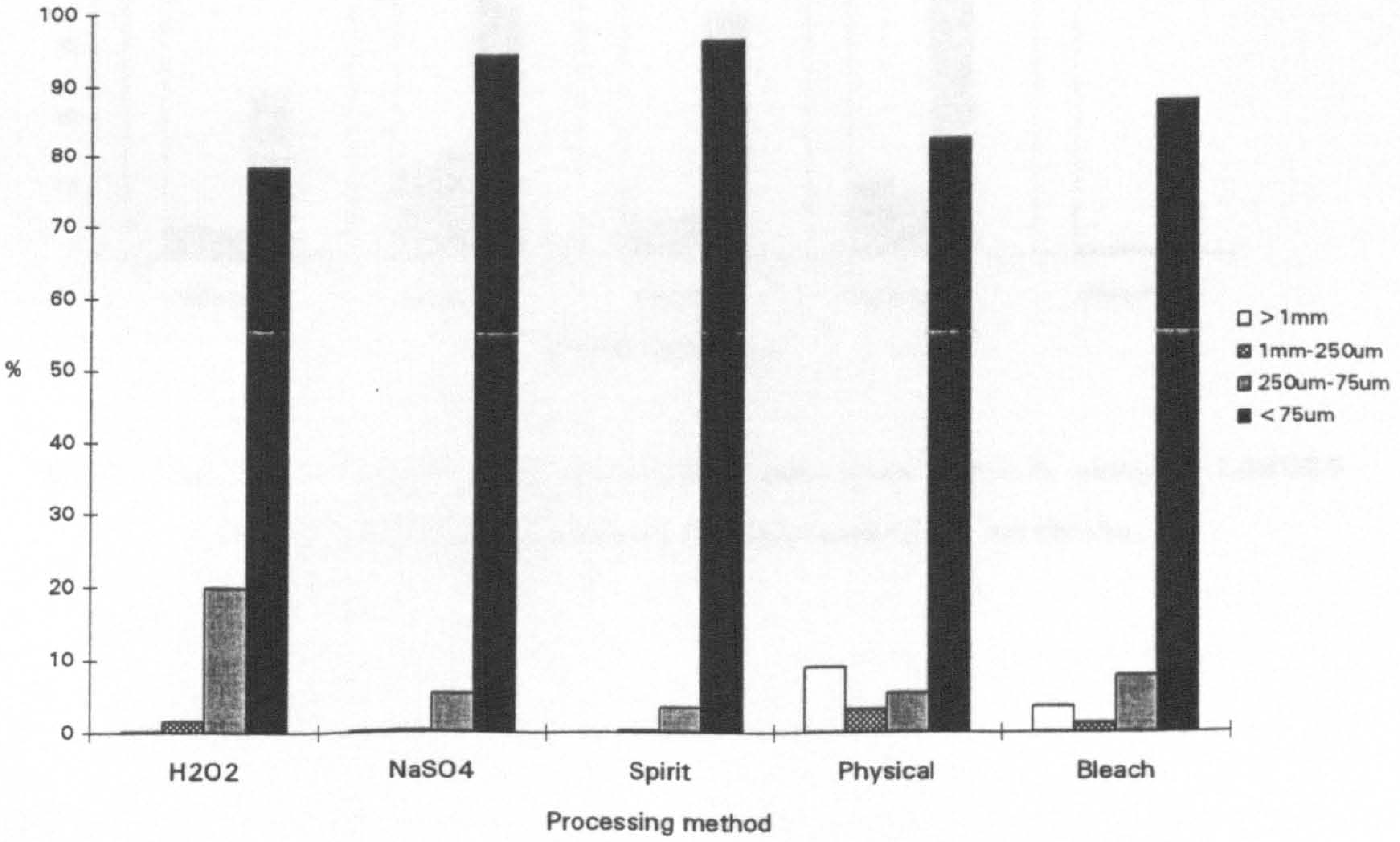
3.2.4 Effectiveness of the methods

To assess the different methods simply in terms of their ability to break down the rock types, a particle size analysis was done using a normal nest of sieves used for separating the various fractions prior to picking. Four grain sizes were considered: >1mm, 1mm-250μm, 250µm-75µm, <75µm. The first three were determined by measurement, while the last (silt and clay fraction) was calculated as the total weight of the sample less the three measured fractions. Sieves used were manufactured by Endecotts Ltd of London, to BS410/1986, that is 20cm diameter, brass frame, brass or stainless steel mesh. The nest was placed in a sieve shaking machine, manufactured by Endecotts, model EFL. Each sample was subjected to fifteen minutes agitation on the sieve shaker. Each fraction was then removed from the sieve by inverting on a large sheet of paper, and brushing the back of the sieve with a brass brush. The individual fractions were weighed to four decimal places using a Stanton electronic balance. The weight of the weighing vessel being subtracted in each case.

The results are shown as a series of histograms in Text-figs 3.5-3.8.

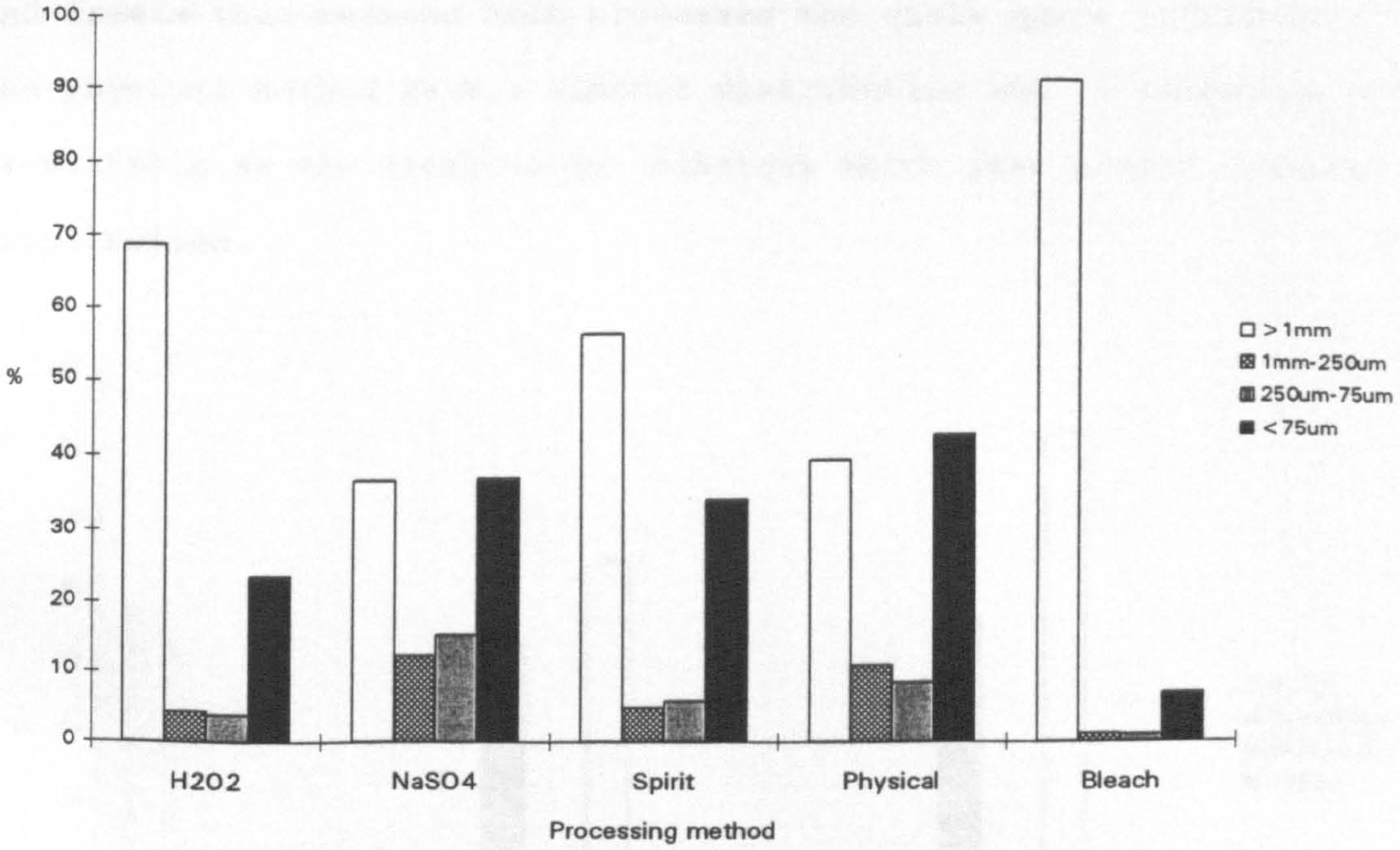
3.2.5 Discussion of Methods

A method was deemed to be successful if the mode, as determined by particle size analysis, is in the silt and clay fraction, indicating that majority of the rock has been thoroughly disaggregated. This is demonstrated in Text-fig. 3.5 for the breakdown of the marl; almost any technique, therefore, will break down this rock type. The most complete disintegration was achieved by the spirit method, followed by freeze-thaw and hydrogen peroxide. Both the physical and bleach methods show weakly bimodal results, indicating that these techniques left some material unprocessed. The effectiveness of the white spirit method on the marl is accounted for by the high clay content of that rock type.



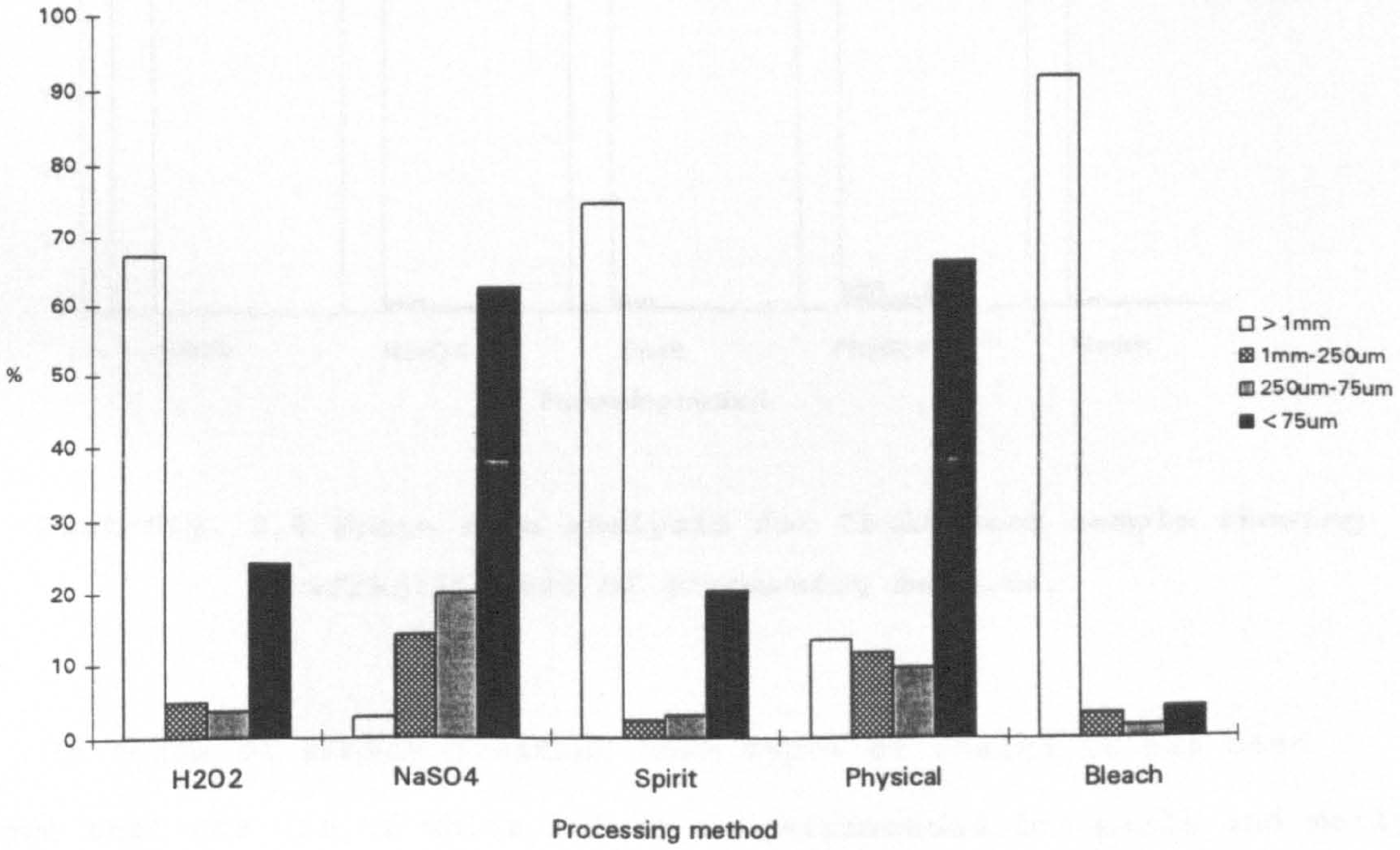
Text-fig. 3.5 Grain size analysis for Plenus Marl bed 1 showing effectiveness of processing methods.

Bimodal results indicate partial breakdown, usually with one mode in the clay and one in the coarsest fraction. This is very clearly seen in Text-fig. 3.6, for the hardground. None of the methods were able to disaggregate this rock type completely, though freeze-thaw, physical crushing and white spirit gave the best results. Hydrogen peroxide left a considerable fraction unprocessed, while bleach had little effect at all. This reflects the much harder nature of hardgrounds, where the mechanical methods are superior to the chemical methods.



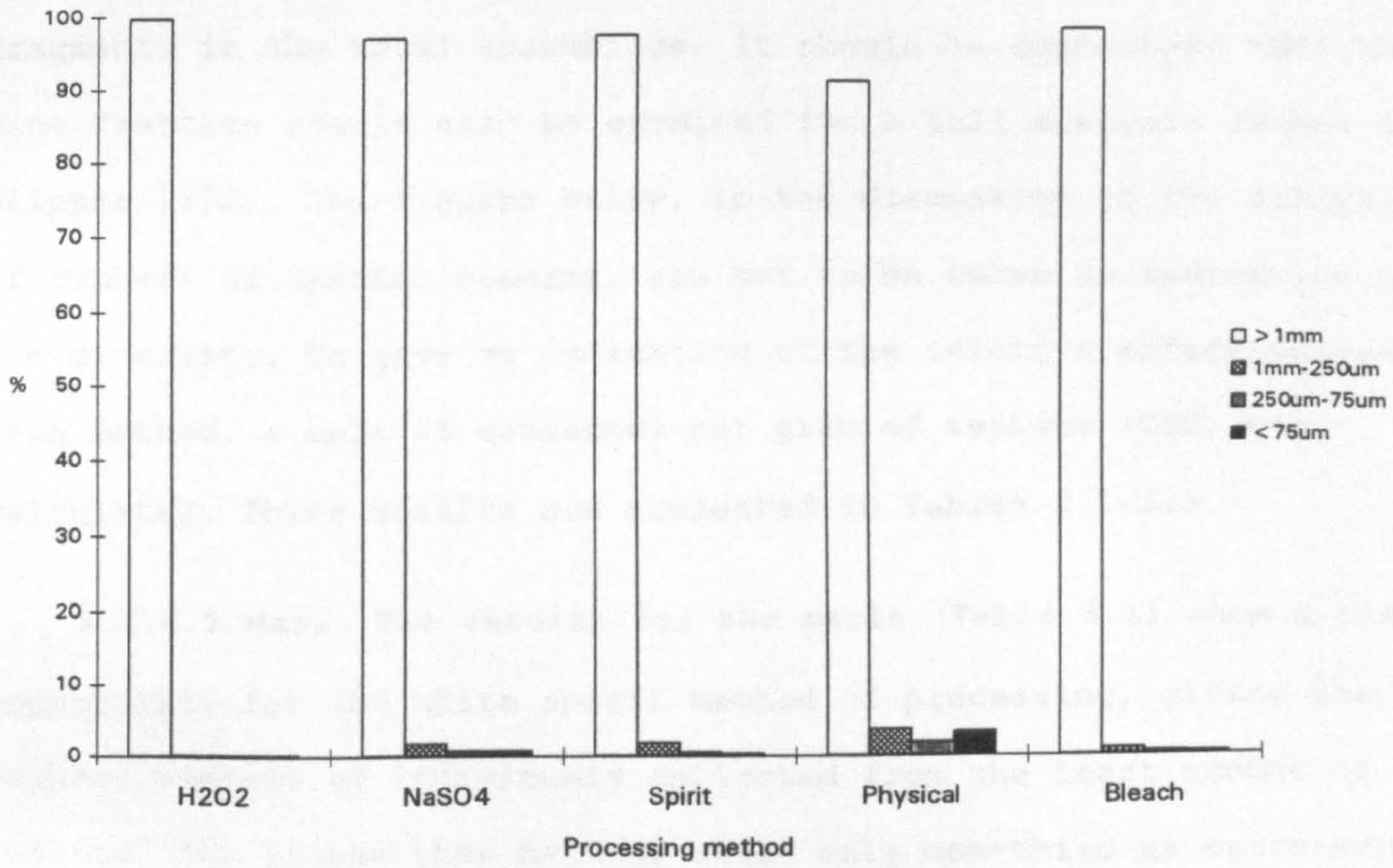
Text-fig. 3.6 Grain size analysis for hardground sample LGSD26 showing effectiveness of processing methods.

The chalk responded with the most variety to the five processing techniques, Text-fig. 3.7. The bleach method, left nearly all the sample in the coarse fraction, with very little resultant residue; this is the least efficient method for chalks. Both the white spirit and hydrogen peroxide methods left a large proportion unprocessed, showing bimodal distributions, with the lesser mode in the fine fraction; hydrogen peroxide was marginally more efficient than white spirit, but both are inefficient for processing chalks. The physical and freeze-thaw methods both processed the chalk quite efficiently, the physical method gave a bimodal distribution and is therefore not as suitable as the freeze-thaw technique which gave a good unimodal distribution.



Text-fig. 3.7 Grain size analysis for chalk sample AKSD54 showing effectiveness of processing methods.

The chalk rock samples were almost unaffected by all the methods attempted here (Text-fig. 3.8). The physical breakdown technique was the only one to produce any residue at all. Since it could not be processed it took no further part in the quantitative study of the assemblages obtained from the samples.



Text-fig. 3.8 Grain size analysis for Chalk Rock sample showing effectiveness of processing methods.

In terms of simply breaking down types of chalks it has been shown that the use of white spirit is recommended for marls and marly chalks, and the freeze-thaw method for white chalk and hardgrounds. The physical method gave a good result for hardgrounds and chalks, but in both cases the freeze-thaw method was superior. Hydrogen peroxide was able to process marls well, but was surpassed by the ability of the white spirit method. Bleach, as an alternative method to hydrogen peroxide, is in all cases here inferior in its ability to process chalk facies rock types.

3.2.6 Quantitative Study of the Assemblages

In order to determine if any of the methods were more selective than others for the recovery of ostracods, the 250μm fractions from each of the five techniques were split to give approximately 1 gram of residue, where possible. This was picked in its entirety, including fragments to show the destructiveness of each technique. A destructiveness index was created, which is the percentage of fragments in the total assemblage. It should be emphasised that the fine fraction should also be examined for a full analysis (Horne & Slipper 1992). The figures below, in the discussion of the analysis of numbers of species present, are not to be taken as indicative of the diversity. To give an indication of the relative effectiveness of each method, a unit of ostracods per gram of residue (OPG) was calculated. These results are presented in Tables 3.1-3.3.

3.2.6.1 Marl. The results for the marls (Table 3.1) show a clear superiority for the white spirit method of processing, giving the highest numbers of individuals collected from the least amount of residue. The freeze thaw method, while only one-third as successful as white spirit, still returns a good figure for recovery. Both of the chemical methods are equally poor, while the physical breakdown had very little effect. The best three methods were able to yield the required 300+ specimens, for statistical significance, yet none obtained the full quota of species found to be present by combining the results from all the samples (Table 3.4). This would indicate that 200g is an insufficient sample size to be sure of obtaining the full fauna.

The physical method is the most destructive, bleach and freeze-thaw are marginally better, while white spirit and hydrogen peroxide gave the least number of fragments in the total assemblage.

Species found	**H_2O_2**	**Na_2SO_4**	**Spirit**	**Phys.**	**Bleach**
Cytherella ovata	177	161	517	28	133
Cytherella concava	11		2		
Cytherella contracta	10	6	11		5
Cytherelloidea kayei	1		1		
Pontocyprella robusta	112	105	207	12	67
Pontocyprella harrisiana	3	3	4		3
Bairdoppilata sp.	6	2	5		6
Paracypris sp.	1	1			
Bythoceratina pedatoides	3	5	8		1
Bythoceratina umbonatoides		1			
Isocythereis elongata	4	5	2		1
Imhotepia euglyphaea	4	2	3		
Loxoconcha bluebellensis	1	1			1
Neocythere kayei	8		10		3
Oertliella alata		1			
Phodeucythere cuniformis	3				1
Pterygocythereis sp.			2		1
fragments	48	57	85	10	49
totals	392	350	857	50	271
destructiveness index	12	16	14	20	18
weight of split	2.36	0.85	0.64	1.7	2.33
ostracods per gram	166	412	1339	29	116

Table 3.1 Results of quantitative study of five different processing techniques on the sample of Plenus Marl bed 1, marl rock type.

3.2.6.2 Chalk. The results obtained from the chalk (Table 3.2) show the freeze thaw method to give the best recovery, closely followed by the bleach and spirit processes. The physical method returned average yields, but the hydrogen peroxide was very poor indeed. None of the methods show the full fauna, here shown as 19 species, the best being freeze-thaw with 12 species. The totals recovered are very much lower than those of the marl, none reached the required 300. It is thought that the size of the splits has limited the sample too much. If this exercise were to be repeated a larger split size should be chosen to give a more representative sample. (Later work on chalks has shown that a split size of 9.7g yielded 270 ostracods at this level. The fauna recovered numbered 32 species).

The bleach and physical methods are both equally destructive, hydrogen peroxide and freeze-thaw are moderately destructive, white spirit is the least destructive method for chalks.

Species found	**H_2O_2**	**Na_2SO_4**	**Spirit**	**Phys.**	**Bleach**
Cytherella ovata	1	8	12	10	5
Cytherella concava	1	7	1		1
Cytherella contracta		1			
Cytherelloidea granulosa		2		1	
Cytherelloidea kayei				1	
Bythocypris brownei			1	1	
Bairdoppilata sp.	1	11	6	7	6
Pontocyprella hindei	2				
Pontocyprella harrisiana		6	2		
Bythoceratina sp.		2	1		1
Bythoceratina pedatoides			1		
Bythoceratina umbonatoides			1	1	
Monoceratina cf. *aculeata*			3		
Cythereis cf. *paraglabrella*					1
Curfsina senior		2			
Xestoleberis bidentata		3			
Golcocythere calkeri		1			
Neocythere verbosa		1	2	1	
Pterygocythereis spinosa	1	1		2	
fragments	2	15	4	10	6
totals	8	60	34	34	20
destructiveness index	25	25	11	29	30
weight of split	1.1	2	1.3	1.7	0.8
ostracods per gram	7	30	26	20	25

Table 3.2 Results of quantitative study of five different processing techniques on the sample AKSD54, representing white chalk rock type.

3.2.6.3 Hardground. Results for the hardground (Table 3.3) are generally slightly better than for the chalk. Freeze-thaw and white spirit showing the most efficient recovery. Bleach and H_2O_2 still show quite good figures; again, the physical method is least effective. Totals are low, again being limited by the small split size. The freeze-thaw method gave the best result for number of species recovered, though not a good representation of the total fauna, here seen as 27 species. Later work has yielded 44 species.

The destructiveness of the methods shows that the physical method is least suitable, bleach is marginally better. Hydrogen peroxide is moderately destructive, while freeze-thaw is second best to white spirit, which is the least destructive method for hardgrounds.

Species found	**H_2O_2**	**Na_2SO_4**	**Spirit**	**Phys.**	**Bleach**
Cytherella ovata	6	12	15	10	10
Cytherella concava	2	4	1		
Cytherelloidea			2	1	
Cytherelloidea granulosa	1	2	1		2
Bairdoppilata sp.	17	18	18	8	11
Macrosarisa siliqua		3	1		
Pontocyprella hindei			4	1	
Pontocyprella harrisiana	4	2	2	1	2
Bythoceratina pedatoides		1	1		
Bythoceratina umbonatoides		4		2	1
Monoceratina trentoniensis		1		1	
Amphicytherura aculeata			1		
Imhotepia marssoni	4	2		1	
Planileberis cuneata				2	
Spinoleberis krejcii					1
Parvacythereis subparva		1			
Karsteneis nodifera			1		2
Cythereis longaeva		1		1	1
Cythereis ornatissima		1			
Oertliella reticulata			1		
Xestoleberis ovata		1			1
Xestoleberis bidentata		3			
Asciocythere nana		1			
Pterygocythereis spinosa	1				
Pterygocythereis robusta	2	3	1	4	2
Pterygocythereis sp.			1		
Polycope sp.		1			
fragments	13	17	12	17	15
totals	50	78	62	49	48
destructiveness index	26	22	19	35	31
weight of split	1.2	1.5	1.2	1.8	1
ostracods per gram	42	52	52	27	48

Table 3.3 Results of quantitative study of five different processing techniques on the sample LGSD26, representing the hardground rock type.

	No. of spp.	H_2O_2	Na_2SO_4	Spirit	Phys.	Bleach
Marl	18	**14**	12	12	3	11
Chalk	19	5	**12**	10	8	5
Hardground	27	8	**18**	14	11	10

Table 3.4 Summary results of number of species recovered from each rock type with each processing method; successful results in bold.

3.2.7 Improving the technique?

The marl responded well to the white spirit method in all aspects of the processing, and is not considered further here. However, a further set of tests was run on the chalk and hardground to see if the results could be improved by combining the methods outlined above. It appeared that freeze-thaw was the most successful overall, for both physically disaggregating the rock, and developing a good fauna, so this formed the first stage. The residue thus obtained was sieved and the 250μm fraction split in half, each being processed afresh using H_2O_2 and white spirit. Since the surface area of the sample is increased by the preliminary breakdown in glauber salts, it is likely that chemical corrosion would have a greater effect during the second part of the treatment. Therefore shorter times were used for the post-processing. As before, the residues were split to give approximately one gram, and then picked completely. The results are shown in Table 3.5.

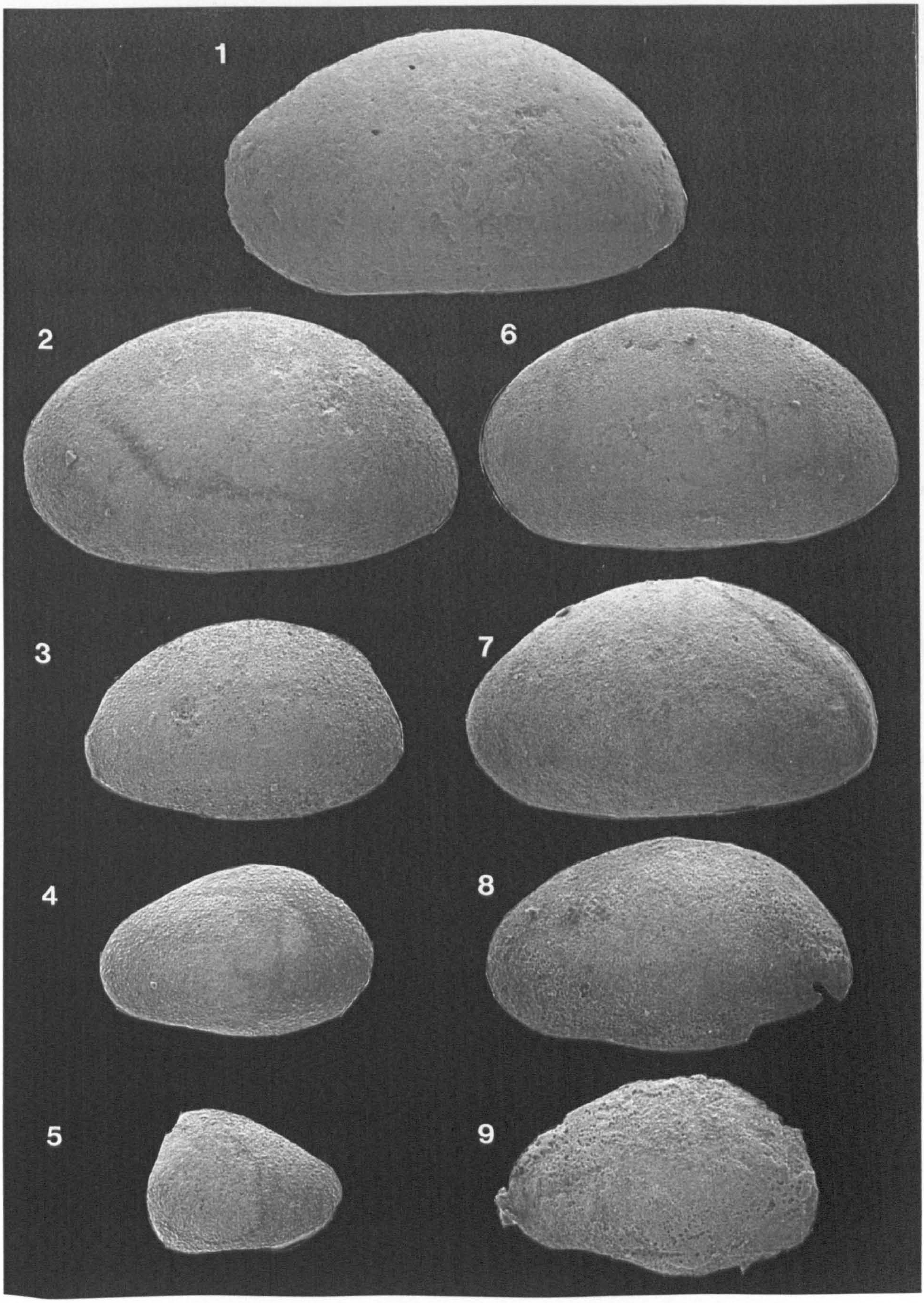
	Chalk		**Hardground**	
	Na_2SO_4 +		**Na_2SO_4 +**	
	H_2O_2	**Spirit**	**H_2O_2**	**Spirit**
Cytherella ovata	2	3	7	6
Cytherella concava	2	3	2	4
Cytherella contracta		2		
Cytherelloidea obliquirugata				3
Cytherelloidea granulosa				3
Bairdoppilata sp.	7	10	15	14
Paracypris sp.		1		
Macrosarisa siliqua				2
Pontocyprella hindei		3		
Bythocypris brownei	1			1
Pontocyprella harrisiana	2	2		3
Bythoceratina pedatoides		2		4
Bythoceratina montuosa			1	
Bythoceratina umbonatoides			4	4
Bythoceratina trentoniensis			1	2
Imhotepia marssoni				1
Planileberis cf. *cuneata*		1		
Curfsina senior			1	
Parvacythereis subparva	1	2		
Cythereis longaeva				2
Cythereis cf. *paraglabrella*	1			
Neocythere verbosa	1			
Oertliella reticulata			1	
Xestoleberis marssoni				1
Pterygocythereis robusta		1	1	4
Polycope sp.			1	
Cardobairdia sp.			1	2
fragments	1	12	12	15
totals	21	42	47	71
weight of split	1	0.9	0.8	0.9
ostracods per gram	21	47	59	79
No. of species	7	12	11	17

Table 3.5 Combined results of Na_2SO_4 freeze-thaw with both H_2O_2 and spirit on both chalk and hardground rock types.

The combined method shows improvements in breakdown and abundance, but the number of species recovered was diminished. The OPG values are better for both variants of the method; indeed, the combination of spirit and Na_2SO_4 has increased the yield over the freeze-thaw alone. The same situation occurs in the results for the hardground. Both values are significantly better than any of the techniques on their own, the greatest recovery, as with the chalk, being obtained by freeze-thaw followed by white spirit. The total numbers in all cases is better, but still not good enough to allow statistical work to be carried out on these assemblages. This may account in part for the low values of species recovered.

3.2.8 Problems with Hydrogen Peroxide

Both of these trials showed that H_2O_2 always yields a smaller assemblage. The very poor results obtained by this technique are worrying. It is a standard technique and has been used for many years. Although processing methods are not always detailed in published works, many ostracod studies in chalk facies have been carried out using hydrogen peroxide (King 1968; Liebau 1977; Horne & Rosenfeld *In* Jarvis *et al.* 1988; Horne *et al.* 1990; Schwarzkopf 1991; Witte *et al.* 1992; Puckett 1996), or combined glauber salt and hydrogen peroxide (Herrig 1966; Clarke 1983). Sohn (*In* Moore, 1962) and Sohn *et al.* (1965) have pointed out that H_2O_2 could be corrosive to some microfossils and so had limited use. An investigation was carried out to study what was happening to the ostracod valves during processing. Individual valves of *Pontocyprella robusta* Weaver, 1982 were selected and cleaned, then immersed in cold H_2O_2 for 1, 2, 3 and 4 hours. A second series of valves of the same species was placed in hot H_2O_2 for 10, 20, 30, and 40 minutes. The results are presented in Text-fig. 3.9.



Text-fig. 3.9 Results of trials of hot and cold hydrogen peroxide on cleaned valves of *Pontocyprella robusta*

The series of photographs of *Pontocyprella robusta* Weaver, 1982 clearly show the effect of both hot and cold hydrogen peroxide. The control specimen (Text-fig. 3.9.1) was developed using freeze thaw processing, and then soaked in water for several hours.

3.2.8.1 Results for Cold Hydrogen Peroxide (Text-fig.3.9.2-5)

- Text-fig. 3.9.2. After 1 hour the outline has been modified slightly, the characteristic curves and angles of the dorsal margin have been lost. The surface texture is unaffected in the central region but towards the edges some pitting is seen.
- Text-fig. 3.9.3. After 2 hours the outline is unrecognisable as *Pontocyprella robusta*, the surface corrosion is affecting all of the valve surface.
- Text-fig. 3.9.4. After 3 hours it is not possible to recognise the genus as much of the peripheral area has been removed.
- Text-fig. 3.9.5. After 4 hours less than half of the original specimen is left.
- After 5 hours the specimen was destroyed.

3.2.8.2 Results for Hot Hydrogen Peroxide (Text-fig. 3.9.6-9)

- Text-fig. 3.9.6. After 10 minutes little change is seen in the outline or the surface of the valve.
- Text-fig. 3.9.7. After 20 minutes the dorsal margin has been altered to a regular curve, particularly anteriorly. Whilst the overall size remains the same, the surface shows much more of the

corrosive effect with small scale pitting covering most of the valve.

- Text-fig. 3.9.8. After 30 minutes the edges are clearly eaten away making the species unrecognisable. Large pitting is seen around the margin.
- Text-fig. 3.9.9. After 40 minutes a very thin deeply pitted remnant of the specimen remains
- After 50 minutes the valve was destroyed.

3.2.8.3 Discussion of hydrogen peroxide tests. These results show that hydrogen peroxide should at no time be used for standard micropalaeontological processing of chalks, as even limited exposure can cause corrosion. In chalks it is possible for finely disseminated pyrite to be present. This can react with hydrogen peroxide to produce sulphuric acid, which would also dissolve any microfossils composed of calcium carbonate. However, the times given here for corrosion and destruction are worst cases since in a normal breakdown procedure the fossils would be protected to some extent by the matrix. The specimens used for these trials were cleaned and as such do not fully represent the real situation. A similar trial was conducted using white spirit in place of H_2O_2 but at no stage was any corrosion observed

3.3 Method

The field sections chosen were similar to those of Horne et *al.* (1990), since accurately drawn lithological logs had been prepared for these sections by Dr. Ian Jarvis. A series of three overlapping sections were used since no single section exposed the whole Turonian. Sampled horizons from Akers Steps and Langdon Stairs match those used in the study of Turonian dinoflagellates by FitzPatrick

(1995). In this work samples are given prefixes ABCMR for Abbots Cliff, AKSD for Akers Steps and LGSD for Langdon Stairs. In the latter two cases the D refers to the sampling horizon used by FitzPatrick (1995) for dinoflagellates. A suffix number is added to each sample, in ascending order to indicate ascending stratigraphical horizon.

Having examined different processing techniques, a standard method had to be chosen to process the samples. Since the Turonian consists predominantly of nodular chalks, the glauber salt - freeze thaw technique was selected for all samples.

3.3.1 Field Sampling

Samples taken in the field consisted of excavated blocks, where possible, of about 1 kg. 250 grams were used for processing and the remainder is stored in the School of Earth and Environmental Sciences, University of Greenwich. Using a hammer and chisel, two vertical channels were cut into the cliff face with a separation of about 20cm. Two horizontal channels were then cut with a similar spacing, to leave a square block of chalk. The upper cut was extended upwards to allow the block to excavated by cutting behind with the chisel. Samples obtained thus were placed in numbered plastic bags, the numbers were marked on the field log and recorded in the field notebook. The hammer and chisel were cleaned of any adherent matrix before further sampling. Samples were collected from bottom to top in any one section to avoid contamination from loose material.

3.3.2 Laboratory Method

All samples underwent the freeze-thaw method of processing. This has been shown to be the most effective method for breaking down chalks (see discussion above). The rock was coarsely crushed to centimetre sized pieces, small grains and rock flour were discarded.

The remainder was put into 250ml plastic beakers and placed in a fan oven to dry at 60°C for 2-3 days. A supersaturated solution of Glauber Salt ($Na_2SO_4.10H_2O$) was prepared; to process 1Kg of chalk requires approximately 800g of sodium sulphate decahydrate in 400ml of water. The heated solution was poured onto the warm chalk in the beakers, covering completely. The immersed chalk was then returned to the oven for 3-4 hours to allow the solution to saturate the sample, during which time it was usually necessary to top up the beakers with heated Glauber Salt solution as it soaks in. After 3-4 hours the liquid was rapidly decanted, to give space for expansion, and the beakers were placed in a freezer for several hours until the samples were frozen, normally overnight. Rapid chilling will ensure high nucleation with small crystal growth required to break the rock apart while leaving the microfossils intact. After removing the samples from the freezer they were topped up with water and heated for 5-10 minutes in a microwave oven. One cycle of freeze-thaw is sufficient to break down most chalks and hardgrounds.

Processed sediment was washed through 75mm, 250mm and 2mm sieves, dried and stored in plastic screw top jars.

3.3.3 Picking

For microfaunal assemblages to be accurately represented by a sub-sample it has been shown that the numbers picked should be above a certain level to achieve statistical significance (Dryden 1931). The limit of 300 is the point above which the accuracy obtained increases at a very slow rate. The probable error in the discovered frequency of an individual will decrease as the frequency in the population increases (Phleger 1960).

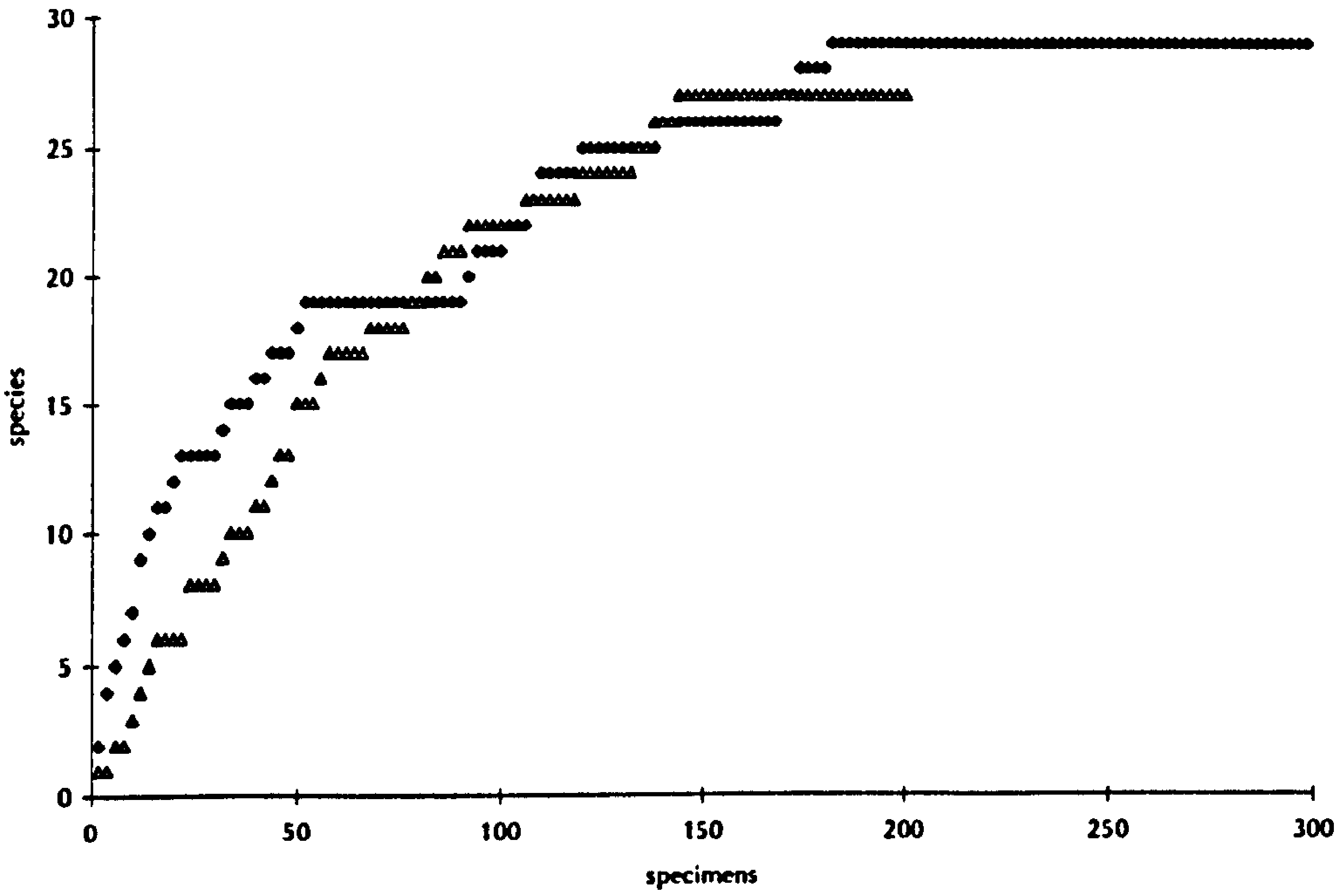
The need for standard counts of 300 has been questioned by Bless (1988) who used only the first 30-50 specimens encountered in the sample in order to obtain only the statistically most abundant taxa.

These data were then used by Bless (1988) to show changes in frequency of ornamented ostracods across the Cretaceous-Tertiary boundary in the Netherlands, and from that to determine water depth; equating ornamented ostracods with nearshore shallow facies. A comparison was made here to examine the validity of that method, the results are shown in Table 3.6 for a sample size of 50 compared with 300.

	300 count		50 count		
Species found in count of 50	**valves**	**%**	**valves**	**%**	**error %**
Cytherella ovata	52	17	4	8	53
Cytherella contracta	18	6	7	14	57
Cytherella sp. *A*	20	7	4	8	7
Cytherelloidea kayei	3	1	2	4	75
Cytherelloidea hindei	1	1	1	2	50
Macrocypris siliqua	12	4	2	4	0
Bairdoppilata sp.	72	24	9	18	25
Pontocyprella harrisiana	4	2	2	4	50
Pontocyprella hindei	15	5	3	6	20
Bythocypris brownei	8	3	2	4	25
Pterygocythereis spinosa	15	5	6	12	58
Neocythere virginea	28	9	4	8	11
Xestoleberis marssoni	10	3	1	2	30
Parvacythereis subparva	6	2	1	2	50
species present	30		14		av=36.4

Table 3.6 Results of trials comparing standard counts of 50 with standard counts of 300, showing relative error for the two methods.

The above Table 3.6 shows that the approach advocated by Bless (1988) in counting the first 30-50 specimens is likely to yield inaccurate results. He states that these figures can be used for a broadbrush quantitative study, and goes on to produce graphs showing changing percentages of ornamented cytheraceans. Unfortunately the variation he measures is in the order of 30%, which is smaller than the error of the measurement as demonstrated above.



Text-fig. 3.10 Results for two samples of chalk showing the increase in diversity with increasing numbers of specimens picked.

In order to determine the number of specimens to be picked to obtain a representative assemblage, trials were carried out recording species found against cumulative individuals picked. This was to examine how the diversity increases with increasing number of specimens picked. Results for two samples of chalks are given in Text-fig. 3.10. Here it is seen that for diversities of approximately 30 species in a sample, that 200 individuals is sufficient to obtain a good representation of the fauna. Less than 200 will result in an underestimation of the diversity, while the effort expended in picking more than 200 is not rewarded in a significant increase in diversity.

Some level of bias in the picking must be present to the detriment of the more ornate species. Smooth forms such as *Cytherella, Bairdoppilata* and *Pontocyprella,* which seem to dominate the assemblages, are much more likely to be cleanly developed from the matrix than are spinose forms such as *Cythereis, Oertliella* and

Bythoceratina. This could lead to smooth forms being picked out preferentially rather than the dirtier, more difficult to see ornate species.

Very early in the work, time became a problem. An average sample with 18 ostracods per gram took 12 hours to pick to a level of 200; for a (relatively) rich sample with 33 OPG, to obtain 300 took 10 hours. It was decided that it was more important to pick adequate numbers of specimens from each sample than to examine large numbers of samples. Accordingly, only every second sample was picked, giving an approximate vertical resolution of 2m. Where extra detail was required, the intervening samples were examined.

The average number of specimens picked over all samples was 199, the maximum and minimum values were 385 and 52 respectively. From Text-fig. 3.10 it can be seen that 199 is sufficient to obtain a representative assemblage.

Picking was done on Nikon stereo-zoom microscopes and the assemblages were mounted on 32 cell slides using a dilute wash of Pritt Stick glue. Both the 250µm and 75µm fractions were examined. The ratio of coarse to fine to be examined was calculated using the ration of mean number of grains on a tray of each fraction. This was achieved by considering the theoretical number of grains of each size, with close packing, in a unit square of 1mm: for 250µm grains, $(1000/250)^2 = 16$, and for 75µm grains $(1000/75)^2 = 177.77$, the ratio is then 16:177, or 1:11. So to obtain the same percentage of specimens in the coarse as the fine by examining the same number grains in each size, one tray of fine material was examined for every eleven of coarse material.

3.3.4 Cleaning

Cleaning specimens encrusted in matrix was carried out using mounted acupuncture needles and sable hair brushes. Individual valves were usually glued down in a spot of 'Pritt Stick', repeatedly wetted and allowed to dry, then, while wet, gently cleaned by sideways movements of the needle. For final cleaning before photography the samples were repeatedly stabbed with the sable hair brush to remove matrix from reticulation meshes. A rinse in alcohol was followed by a rinse in distilled water.

Trials were carried out using ultrasonic tanks to attempt to clean matrix from valves. Sohn (1960) describes a method for ultrasonic cleaning but does not recommend the method for cleaning ostracods since they tend to break. Cottle (1989) found that 1-2 minutes would clean foraminifera very well, however, results obtained here were mostly unsuccessful. A standard 'Engisonic' ultrasonic tank operated for about 2 seconds will destroy most ostracods. A new 'Ney ULTRAsonic', model was tried which had digital control of the waveform and was able to produce ultrasonic action in very short bursts. Even with this set on minimum power it was still able to destroy a valve of a *Cythereis longaeva* in 2-3 seconds. Some valves did survive the treatment, and were thoroughly cleaned; closed carapaces tended survive the process more than loose valves. I suggest that the ability to survive ultrasonication of each individual valve is related to its state of preservation. If any hairline cracks are present, the cavitation effect will take place in the crack and rupture the valve. Hodgekinson (1991) also records that ultrasound is an uncontrolled method which is largely unsuccessful. For general purpose cleaning, the ultrasonic tank is not recommended.

Specimens for SEM examination were mounted on JEOL pin stubs on a substrate of 35mm film emulsion (Whittaker & Hodgekinson 1991) and sputter coated with gold in a Nannotech semprep 2 coating unit. For the internal views, specimens were mounted on double-sided adhesive carbon tabs on standard pin stubs, then coated in gold as before. The photographs were produced by the author on a JEOL JSM 35C scanning electron microscope, using Ilford FP4 120 roll film. The plates were made up using the method of Whittaker & Hodgekinson (1991), but using Pritt Stick glue in place of Cow Gum.

3.3.5 Measurements

Measurements were carried out on a Nikon Stereo-Zoom microscope at 80x magnification using an eyepiece graticule calibrated in steps of 12.5µm. Measurements are reported to the nearest micron; however, the resolution of the graticule is such that the unit of measurement is 12.5µm. The range of measurements in this work is from 165 µm to 1400 µm, which gives 99 unit steps of measurement. An error of the smallest unit then amounts to a potential error of approximately 1% over the whole range. On an individual measurement of the average of approximately 600 µm, or 48 units, the error of ±1 unit, 47.5 to 48.5 units gives 594 to 606 µm. So the maximal error is given by (606-600)/600 * 100 = 1%. All optical measurements are therefore quoted as ±1%.

Measuring from SEM photographs is not recommended since JEOL, the manufacturers, cannot guarantee the scanning electron microscope to give accurate aspect ratios to better than 5%. Distortion may be present in the illustrations up to this level.

In the systematic section measurements are given in the following form: specimen number; male or female; left or right valve; length, height and width, in microns. The measurements include marginal denticles and spines; where only two measurents are given, these indicate length and height. In the text where discussion centres around such measurements, the index of height/length is preferred, since this can more easily be thought of as an index of roundness, where 1 = circular, and 0 = linear. In the accompanying plates, specimens are oriented with their ventral margins on the horizontal axis, the measurement of maximum length is taken parallel to this, while the measurement of maximum height is taken normal to it.

4 TAXONOMY

Introduction

4.1 Systematic Descriptions

Introduction

In this work, 103 species and subspecies in 41 genera have been recovered from the British Turonian, they are described and illustrated below. Nineteen are described as new species and six as new subspecies. One new name is introduced for a secondary junior homonym. Twenty-nine of the species have previously been recorded from Britain, while twenty-nine are referred to species from continental Europe. Eleven species are tentatively referred to known species by the designation cf. where the author believes that there is a possibility that the two may be conspecific but it is not confirmed, or by the designation aff. where the author believes the two species are closely related, but further specimens are required to confirm or deny the relationship. Seven species are left in open nomenclature.

Until the publication of the revised edition of the Treatise on Invertebrate Paleontology (Moore 1961) there is, at present, no single volume with an up-to-date statement of the classification of Ostracoda at the higher taxonomic level. The systematics here is based upon Moore (1961) with certain modifications detailed in the relevant sections.

4.1 Systematic Descriptions

All catalogue numbers are those of the author's collection, prefixed IJS, a two part number follows, the first part refers to the SEM stub, this is separated by a forward slash from the second part which indicates the specimen's unique number on that stub. All illustrated specimens are to be deposited in the Natural History Museum (NHM), the catalogue numbers given there will supersede those given here.

In the synonymy given for each species, Richter symbols have been used; these are non-nomenclatural signs used to make qualifying comments on the citations in the synonymy (Matthews 1973).

If the year is given it italics: the work mentions the species, but has no description or illustration.

* in front of the year: the species can be regarded as valid under Article 11 of the ICZN, earlier mentions of the name are to be regarded as nomina nuda.

? infront of the year: allocation of the reference is subject to doubt.

. in front of the year: I accept responsibility for attaching the reference.

v in front of the year: *vidimus*, I have checked the deposited specimen.

pars in front of year: the reference applies only in part to the species under discussion.

Class OSTRACODA Latreille, 1802

Order MYODOCOPIDA Sars, 1886

Suborder CLADOCOPINA Sars, 1866

Family POLYCOPIDAE Sars, 1866

Genus POLYCOPE Sars, 1866

Type species. By monotypy; *Polycope orbicularis* Sars, 1866, p. 122; from the Recent off Norway.

Diagnosis. Small to moderate in size. Outline subcircular in lateral view, lens shaped in dorsal view. Valves weakly calcified. Hinge simple, usually with a smooth bar in the right valve which fits into a groove in the left.

Polycope lunaplena sp. nov. Pl. 1, fig. 1

Name. Latin; *luna*, meaning moon and *plena*, meaning full; alluding to the similarity in shape of this species to the Earth's satellite.

. 1996 *Polycope* sp. cf. *nuda* Kaye, 1965; Slipper, p. 52, pl. 1, fig. 5.

Holotype. IJS7/9 LV from sample ABCMR1a, Gun Gardens Marl 1, Lower Turonian, *Mytiloides* spp. Zone; from Abbots Cliff path, Dover, Kent.

Material. 61 specimens of adults and juveniles.

Diagnosis. Polycope with reduced ornament at the valve margin, consisting of two weak concentric ribs, and traces of reticulation at the anterodorsal corner.

Measurements.	IJS7/9, LV	434 - 350 -
	IJS20/20, RV	410 - 360 - 140
	IJS20/19, LV	330 - 310 - 100

Description. Valves subcircular; evenly convex ventral margin, slightly angular anterior margin, posterior margin has a weak posterodorsal angle, dorsal margin openly rounded, with a flatter centrodorsal area. Greatest inflation posterodorsally. The surface of the valves is mostly smooth with two concentric marginal ribs which run from the posterodorsal corner round the ventral margin, anterior margin and terminate at the anterodorsal corner. The ribs become more widely separated at the anterior. Beyond the ribs the ventral margin is very thin and fragile, and in most specimens is broken off. Traces of reticulation may be preserved anterodorsally.

Calcified inner lamella narrow. Muscle scars visible on the outside of the valve as three small scars in close triangular group.

Remarks. Two species similar to *P. lunaplena* have been described from the Lower Gault; this species differs from *Polycope nuda* Kaye, 1965, by having a less wrinkled margin (*q.v.* Weaver 1982, pl. 20, fig. 13). *Polycope oweni* Kaye, 1965 has strong concentric ribbing and a pustulose surface. It can be distinguished from the two Cenomanian species described by Weaver (1982) by details of ornament; *Polycope bluebellensis* Weaver, 1982 possesses marginal spines, and *Polycope delicata* Weaver, 1982 has a strong reticulate ornament and an irregular dorsal margin. *Polycope bonnemai* Herrig, 1963, from the Lower Maastrichtian, has ornamentation only at the anterior margin and a more angular outline.

Range. Present in all studied Turonian sections; common at Abbots Cliff, rare at Akers Steps, moderately common at Langdon Stairs. Also found by the author in the Coniacian of Langdon Stairs and the Santonian Chalks from Pinden Quarry, Kent.

Order PLATYCOPIDA Sars, 1866

Suborder PLATYCOPINA Sars, 1866

Family CYTHERELLIDAE Jones, 1849

Genus CYTHERELLA Jones, 1849

Type species. By subsequent designation; Ulrich 1894, p. 684; *Cytherina ovata* Roemer, 1841, p. 104, pl. 16, fig. 21; from the Campanian of Lemförde, West Germany.

Diagnosis. Valves heavily calcified, ovate to subquadrate in lateral view; surface smooth, occasionally with subcentral pit or sulcus. Five to nine elongate muscle scars arranged in two vertical rows. Females larger than males, usually with only one brood chamber in each valve.

Cytherella concava Weaver, 1982 Pl. 1, figs 2, 3

1849 *Cythere (Cytherella) truncata* (Bosquet); Jones, p. 30, pl. 7, figs 25a-c, e, ?fig. 25d.

1870 *Cytherella muensteri* (Roemer); Jones, p. 76.

1890 *Cytherella muensteri* (Roemer); Jones & Hinde, p. 46, pl. 3, figs 63-67 [cop. Jones 1849].

* 1982 *Cytherella concava* Weaver, p. 14, pl. 1, figs 13-17, pl. 2, fig. 22, text-fig. 9.

Holotype. BM OS9351, female right valve, (Weaver 1982, pl. 1, fig. 14). Paratypes: OS9352-60, 9 valves and carapaces; from 13.5m below the Plenus Marls, Upper Cenomanian, Bluebell Hill, Kent.

Material. 665 valves and carapaces of adults and juvenile instars.

Diagnosis. Elongate *Cytherella* with concave ventral margin and concave to convex dorsal margin. Maximum width towards the posterior.

Distinct sexual dimorphism; ventral margin is more concave and dorsal margin is straighter in the males.

Measurements.	IJS15/19, F, car.	635 - 362
	IJS15/20, F, RV	650 - 387
	IJS15/21, F, LV	600 - 312

Description. Carapace elongate ovate with the larger right valve overlapping the left around the entire margin with the exception of the posteroventral corner. Maximum height at two-thirds length, maximum width at four-fifths length. In dorsal view the valve contact is mostly straight with a weak long overhang of the left by the right valve in the anterior half. Inflation is weak such that the valves have straight sides, gently tapering towards the anterior, curving in to the contact weakly at the anterior and more strongly at the posterior; this is enhanced in the females such that a weak concavity exists in front of the expanded posterior. At the anterior extremity is a small peripheral rim. In lateral view the dorsal margin is straight in the left valve and straight to weakly concave in its central part in the right. Anterior margin broadly rounded such that the anterior extremity is above mid-height in the left and at mid-height in the right. The ventral margin is concave in both valves of the male but only in the right of the female; the left valve is straight. Posterior margin is evenly rounded with the extremity below mid-height in the left, the posteroventral margin is weakly truncated in the right valve. Surface of the valves is smooth with only a weak centrodorsal sulcus. The inner edge of the left valve fits into a peripheral groove in the right valve.

Remarks. Distinguished from *Cytherella ovata* (Roemer, 1841) by the straight to concave dorsal margin, the concave ventral margin and the position of maximum width near the posterior end. *Cytherella contracta* Veen, 1932 is more elongate, has a more truncate posterodorsal margin and a more sharply concave dorsal margin in front of mid-length. Left valves are very difficult to distinguish from left valves of *C. contracta* since in both species, in both sexes, the dorsal and ventral margins are concave. In dorsal view the males of both species are very similar.

Range. It occurs from the mid-Cenomanian, to the Plenus Marls of England (Weaver 1982), and has been found by the author throughout the Turonian in the sections studied, also continuing up into the Coniacian, at Langdon Stairs.

Cytherella contracta van Veen, 1932 Pl. 1, figs 4-8

v* 1932 *Cytherella contracta* van Veen, p. 342, pl. 8, figs 1-18, pl. 9, figs 1-17.

1969 *Cytherella contracta contracta* Veen; Gründel, p. 83, pl. 1, figs 8, 9.

1982 *Cytherella* aff. *C. contracta* van Veen, 1932; Weaver, p. 16, pl. 2, figs 9-14.

Syntypes. Specimens on slides 0.15 F_3 and 0.16 F_3, Tray 46, in the Geological Survey of The Netherlands, Haarlem (van Veen, 1932, p. 342, pl. 8, figs 1-18, pl. 9, figs 1-17).

Material. 230 valves and carapaces of adults and juveniles.

Diagnosis. Elongate *Cytherella* with concave dorsal margin in front of mid-length in both valves; truncate posterodorsal margin, accentuated in males.

Measurements.	IJS15/22, F, car.	612 - 312
	IJS15/23, F, RV	719 - 337
	IJS15/24, F, LV	650 - 325
	IJS15/25, M, RV	650 - 312
	IJS15/26, M, LV	612 - 300

Description. Carapace elongate ovate, weakly inflated with straight sides, females with greater posterior inflation, males more elongate with a more truncate posterodorsal margin. Right valve larger than left overlapping the posterior, dorsal and ventral margins, left valve overlapping right the anterior margin. Valve contact along the dorsal margin straight but for a slight flexure in front of mid-length where the right overhangs the left valve. Dorsal margin in both valves convex anteriorly, with a concavity in front of mid-length, more pronounced in the males, and in both sexes in the left valve. Anterior margin broadly rounded with the extremity at mid-height in the left and just above in the right valve. Ventral margin distinctly concave in the centre, convex at the anterior and posterior. The concavity is more pronounced in right valves and in males, and is a little further forward in left valves. Posterior margin is more narrowly rounded than the anterior and is above mid-height in the right valve and at mid-height in the left.

Surface of the valves smooth. A weak median sulcus is developed, and in females the posterior brood pouch causes a slight posterior sulcus. Interior margin of the right valve has a peripheral groove into which fits the left valve edge.

Remarks. Van Veen's (1932) illustrations show that the posterior extremity is closer to the dorsal margin than in specimens from the Cenomanian and in the majority of Turonian specimens.

Range. Reported from the Middle Cenomanian to the Plenus Marls of England (Weaver 1982), the *plenus* Zone of the Germany (Gründel 1969), and found here throughout the studied Turonian sections.

Cytherella ovata (Roemer, 1841) Pl. 2, figs 1, 2

* 1841 *Cytherina ovata* Roemer, p. 104, pl. 16, fig. 21.

1849 *Cythere (Cytherella) ovata* Roemer; Jones, p. 28, pl. 7, figs 24a-g, i, *non* pl. 7, fig. 24h.

1870 *Cytherella ovata* (Roemer); Jones, p. 76.

1971 *Cytherella ovata* (Roemer 1841); Damotte, p. 55, pl. 1, figs 2-7.

1977 *Cytherella* gr. *ovata* (Roemer); Charollais *et al.*, pl. 1, fig. 1.

1982 *Cytherella* ex gr. *ovata* (Roemer, 1840); Weaver, p. 12,
pl. 1, figs 1-5, pl. 2, fig. 20; text-figs 7-8.

Type specimens. Type specimens are lost. Topotypes have been illustrated by Damotte (1971, pl. 1, figs 2, 3); from the Upper Campanian of Lemforde, Germany.

Material. Over 4,500 valves and carapaces.

Diagnosis. Large ovate *Cytherella* with convex dorsal margin, greatest width at two-thirds length; shape variable.

Measurements.	IJS15/16, F, LV	800 - 487
	IJS15/17, F, car.	925 - 600
	IJS15/18, F, RV	850 - 562

Description. Carapace moderately well inflated. Right valve larger than left overlapping most of the margin, less so at the posteroventral and anterodorsal corners. The valve contact is slightly sinuous, the right overhangs the left just in front of mid-length. Maximum height about mid-length in the right valve and behind in the left, maximum width at two-thirds length. In females the posterior has a greater inflation. The dorsal margin of the right valve is usually convex with a distinct angle at maximum height, from here it slopes down gently towards the anterior and more steeply towards the posterior. In the smaller right valve the centrodorsal margin in front of mid-length is longer and flatter. Anterior margin of right valve is openly rounded and passes into the ventral margin without angle; anterior extremity is at mid-height. In the left the anterior extremity is above mid-height, the margin is more narrowly rounded in the dorsal half and openly rounded in the ventral half. Ventral margin of right valve is straight sometimes with a very slight central concavity or rounded and convex; the greatest development of this is usually at, or in front of mid-length. Posterior is narrowly rounded with posterior extremity below mid-height. Surface of the valves is smooth and even without marked sulci.

Adont hinge with the rim of the left valve fitting into a peripheral groove of the right valve.

Remarks. The most commonly encountered Upper Cretaceous ostracod. The shape is variable and may contain discrete species which are difficult to separate. Damotte (1971) undertook a morphometric study of *C. ovata* and concluded that specimens attributed to this species from the Albian to the Campanian of the Paris Basin were conspecific with the topotypes from northern Germany. Therefore the assignation to species of the group of *C. ovata* has been dropped. *Cytherella contracta* can be distinguished by the shape of the dorsal margin which is weakly concave. *Cytherella concava* is more elongate and has a concave ventral margin.

Range. Found throughout the studied Turonian sections. Also reported from the Aptian to the Maastrichtian of northern Europe (Damotte 1971).

Cytherella truncatoides sp. nov. Pl. 2, figs 4, 5, 8;
Pl. 24, fig. 1

Name. After the similarity to *Cytherella truncata* (Bosquet, 1847).

1971 *Cytherella* cf. *ovata* (Roemer); Keen & Siddiqi, p. 62, pl. 1, figs 1, 9.

1982 *Cytherella* cf. *C. truncata* (Bosquet, 1847); Weaver, p. 18, pl. 1, figs 6-12, pl. 2, fig. 21.

non 1990 *Cytherella gaultina* sp. nov.; Wilkinson, p. 254, pl. 1, figs 1, 2.

Material. 25 specimens; 16RV, 8LV, 1car.

Holotype. Female RV IJS15/29, from sample AKSD33, first marl below Glynde Marl 1, Middle Turonian, *T. lata* Zone; from Akers Steps, Dover, Kent.

Diagnosis. Elongate species of *Cytherella* with gently arched dorsal margin, greatest height at two-thirds length. Posteroventral margin truncate such that the valve margin is partially obscured by the weak posteroventral overhang; posterior extremity above mid-height.

Measurements.	IJS15/27, M, RV	637 - 362
	IJS15/28, F, car.	662 - 362
	IJS15/29, F, RV	662 - 387
	IJS15/30, M, LV	650 - 362

Description. Carapace elongate ovate, moderately inflated posteriorly. Right valve larger than left overlapping along the dorsal and ventral margins, left overlaps right at the anterior and the posteroventral margins. Dorsal margin of right valve evenly convex with greatest height slightly behind mid-length, left is more angular and maximum height is further behind. Anterior margin is broadly rounded passing with a slight angle from the dorsal margin and smoothly into the ventral margin. Ventral margin straight with a weak concavity at mid-length. Posterior margin in the right valve is truncated ventrally and angular dorsally at the posterior extremity, left valve posterior is evenly rounded.

Hinge is a marginal groove in the right valve into which the edge of the left valve fits.

Remarks. Wilkinson (1990) incorporated the forms described and illustrated by Weaver (1982) as *Cytherella* cf. *C. truncata* (Bosquet, 1847) into *Cytherella gaultina* Wilkinson, 1990. The specimens recovered here from the British Turonian correspond to those from the Cenomanian (Weaver 1982) and not to those from the Albian (Wilkinson 1990). The author does not agree with the inclusion of the Cenomanian form into the species from the Albian by Wilkinson (1990) on account of differences both in the illustrations and the respective descriptions. Wilkinson (1990) describes the posterior obliquity as being posterodorsal, but the truncation in the younger forms (and *C. truncata*) is posteroventral; the height/length ratio is also greater in *C. gaultina*. Unfortunately Wilkinson does not describe the differences between the left and right valves of *C. gaultina*, which is often necessary since the valves in this group are so asymmetric; it is also not clear whether the holotype of that species is male or female. The interpretation of *C. gaultina* is made more difficult by the inclusion within that species of *Cytherella parallela* (Reuss, 1846) of authors. For example *C.* cf. *parallela* (Reuss) of Damotte (1971, pl. 1, fig. 8) is difficult to interpret since the dorsal view is of a *Cytherella* while the lateral view is clearly a species of *Cytherelloidea* since it possesses a marginal rib and a concave dorsal margin. Also *C. parallela* of Babinot *et al.* (1985) bears little relation to *C. gaultina* since the dorsal margins of both valves of the French form are straight. *C.* cf. *parallela* of Kaye (1963a) is again different, with a straight dorsal margin and a weakly concave ventral margin; the holotype of *C. gaultina* has a distinct angular convexity on the dorsal margin behind mid-length, and a straight ventral margin. Wilkinson (1990) also states that Jones (1849) "confused *C. gaultina* with *C. truncata* (BOSQUET)"; however, his synonymy cites *Cytherella ovata* Roemer of Jones (1849, pl. 7, fig. 24) and not the figures of *C. truncata*.

The author has examined over 150 valves and carapaces of *C. truncata* from the Bosquet collection and can state that in that species the dorsal margin of the right valve has a distinct angle near mid-length, whereas *C. truncatoides* sp. nov. has a more gently arched dorsum, with maximum height further back. As noted by Weaver (1982) the posteroventral margin is more truncate, such that it appears blunt and almost straight. The ventral margin of the right valve has a greater convexity. The left valves of *C. truncata* are longer, have a broader anterior, such that the dorsal margin does not slope down so much towards the posterior, has a more truncate posterior and a more bluntly rounded anterior margin, noticed more at the anteroventral corner which is weak in *C. truncatoides* and well developed in *C. truncata*. Carapaces of *C. truncata* show the right valve overlapping the left round the entire margin.

The material from the British Turonian is smaller than that of the Cenomanian, and smaller than the Maastrichtian *C. truncata*.

Range. Recovered from the Cenomanian of England (Weaver 1982) and Ireland (Keen & Siddiqui 1971). Found by the author to be present sparsely throughout the studied Turonian sections, from the base of the stage to the base of the overlying Coniacian; more common above the Kingston Nodular Chalks, Upper Turonian.

Cytherella vulna sp. nov. Pl. 2, figs 5-7; Pl. 24, fig. 2

Name. Latin; *vulnus*, meaning wound or hole; after the deep central sulcation.

1982 *Cytherelloidea* n. sp. aff. *Cytherelloidea foveata* (Veen, 1932); Clarke, p. 48, pl. 2, figs 1, 2.

Holotype. Female RV, IJS15/13 from sample LGSD10, first weak marl below Caburn Marl, Upper Turonian, *T. lata* Zone; from Langdon Stairs, Dover, Kent.

Material. 26 specimens; 9LV, 17RV adult males, females and juvenile instars.

Diagnosis. Elongate *Cytherella* with concave dorsal and ventral margins; deep pit in central sulcus; maximum height at anterior; very narrow peripheral flange on anterior margin of left valve.

Measurements.	IJS15/12, M, RV	612 - 337
	IJS15/13, F, RV	644 - 362

IJS15/14, F, LV	625 - 325
IJS15/15, M, LV	612 - 312

Description. Carapace elongate, subrectangular; dorsal and ventral margins subparallel; maximum height at one-fifth length just behind anterior margin, anterior extremity above mid-height. Right valves with maximum inflation near mid-length, and close to the posterior in left valves.

Dorsal margin has a concavity in front of mid-length, to the anterior it is rounded and posteriorly it is gently convex; in right valve the concavity is closer to mid-length. Posterodorsal margin rounded in females, truncate in males; posterior extremity above mid-height; posterior margin bluntly rounded. Ventral margin concave centrally, some left valves have a weaker concavity.

Valve surface smooth, strong posterior inflation often creating a weak vertical posterior sulcus in front of the inflation. Strong vertical dorsomedian sulcus with deep muscle pit in the centre of the valve. Anterolateral surface tapers to the anterior margin, where, in the left valve is a narrow peripheral flange. Internally as for the genus.

Remarks. Differs from *Cytherella eosulcata* Colin, 1974 from the Upper Turonian of the Dordogne, by being less ovate in the right valve, having a greater concavity in the left valve and being more elongate; the sulcus in that species is more longitudinal.

Similar to *Cytherella foveata* Veen, 1932, but is more rounded posteroventrally, has a larger median sulcus, and has a more concave dorsal margin. *Cytherella contracta* Veen, 1932 does not have the central sulcation. *Cytherella sulcata* Veen, 1932 differs by having a convex dorsal margin in the right valve and a straight dorsal margin in the left.

Clarke (1982) placed this in *Cytherelloidea,* suggesting that it may be transitional to *Cytherella,* on account of the muscle scar pit and the ventrocentral swelling. These features alone are not sufficient to place it in *Cytherelloidea*. Clarke (1982, p. 39) states that *Cytherelloidea* is distinguished from *Cytherella* by the strongly developed sculpture which is absent in *Cytherella*. This species possesses no surface sculpture of the type found in *Cytherelloidea*, and so remains in *Cytherella*.

Range. First appearance 3m above New Pit Marl 2 on Akers Steps, *T. lata* Zone, Middle Turonian, it occurs sparsely throughout the overlying Turonian, and has also been recovered from the Coniacian at Langdon Stairs.

Cytherella weaveri sp. nov. Pl. 3, figs 1-3; Pl. 24, fig. 3

Name: after Dr. P.P.E. Weaver, in recognition of his work on British Cenomanian ostracods.

Holotype. Female RV, IJS15/11, sample LGSD11, Caburn Marl, Upper Turonian, *T. lata* Zone; from Langdon Stairs, Dover, Kent.

Material. 10 specimens; LGSD7, 5RV; LGSD9, 1LV; LGSD13, 1LV, 1RV; LGSD21, 1RV; LGSD23 1RV.

Diagnosis. A species of *Cytherella* with a weak posteromarginal rib; concave ventral margin in the right valve, and straight ventral margin in the left valve.

Measurements.		
	IJS15/9, M, RV	644 - 344
	IJS15/10, F, LV	650 - 325
	IJS15/11, F, RV	637 - 350

Description. Carapace elongate ovate, smaller left valve has a lower height/length ratio. Maximum width in front of posterior sulcus at about three quarters length, lateral sides are straight and taper towards the anterior before curving in to the margin. Dorsal margin in adult right valves straight with a weak anterior angle which leads into the rounded anterior margin, and a weakly truncate posterodorsal margin; left valves are concave in front of mid-length, convex at the anterior and behind mid-length. Adult males and juveniles have concave dorsal margins in both valves in front of mid-length, with an evenly rounded anterodorsal margin and a very gently arched long posterodorsal margin. Posterior margin is truncate in the right valves and bluntly rounded in the left. Concavity in the ventral margin of the right valve at mid-length is more clearly developed in males; left valve venter is straight. Surface of the valves is smooth but possesses a thin posterior marginal rib, in front of which is a weak sulcus.

The hinge consists of a peripheral groove in the right valve into which fits the edge of the left valve. Along the posterodorsal margin of the left valve is a thickening of the edge such that it deviates from the sagittal plane. This fits into a deepened groove on the posterodorsal margin of the right valve.

Remarks. The possession of the weak posterior rib is not in the author's opinion significant enough to place it in *Cytherelloidea* since all other features of shape and ornament concur with *Cytherella*.

Very similar in outline to *Cytherella contracta* Veen, 1932, but that species lacks the posterior marginal rib.

Range. First appearance 3m below Caburn Marl, *T*. lata Zone, Upper Turonian, it occurs rarely up to the Kingston Nodular chalks, *S. plana* Zone, Upper Turonian.

Cytherella sp. A Pl. 3, figs 4, 7

Material. 2 specimens; LGSD13, 1LV, 1RV.

Measurements. IJS15/7, RV 587 - 312
IJS15/8, LV 522 - 275

Description. Carapace elongate ovate weakly inflated, right valve larger than left; maximum height towards the anterior, maximum width at mid-length in the left valve and just behind in the right. Dorsal margin gently convex from mid-length to the posterior extremity, with a concavity at one-third length in the left valve, slightly further behind in the right; dorsal margin convex at the anterior where it turns into the anterior margin with a slight angle. Anterior margin broadly rounded in the right valve, more narrow in the left; a peripheral rim runs round the anterior margin of the left valve. Ventral margin has a weak concavity at mid-length. Posterior margin is truncate posteroventrally. Surface of the valves in the posterior one-third has a dense punctation, remainder of the valve surface is smooth. Below the dorsal margin of the right valve is a weak longitudinal compressed area.

Remarks. The unique features of this *Cytherella* are the posterior punctation and the dorsal compression of the right valve which no other Turonian platycopids possess. The delicate ornament is only noticed on specimens stained with food colouring. It is not known whether the left and right valves recovered here are male or female, or even adults. The weak inflation suggests that these may be late juveniles stages of which I do not have adult representatives. Lack of further specimens prevents a full description and leaves this species in open nomenclature.

Range. Only recovered from 2m above Caburn Marl, near the top of the *T. lata* Zone, Upper Turonian.

Genus CYTHERELLOIDEA Alexander, 1929

Type species. By original designation; *Cythere (Cytherella) williamsoniana* Jones, 1849, p. 31, pl. 7, figs 26a-i; from the Cretaceous England. See remarks.

Diagnosis. Valves heavily calcified, surface always with sculpture which may consist of marginal and longitudinal ribs, tubercles, and reticulation. Clear sexual dimorphism, females have two posterior internal brood chambers in each valve.

Remarks. Kaye (1964a) considered that *C. williamsoniana* Jones, the type species of the genus, is a *nomen dubium* since the lectotype proposed by Howe and Laurencich (1958) refers to a single figure without specimen. Kaye (1964a) suggested that it is necessary to seek ICZN ratification for an alternative type species for *Cytherelloidea*. However, ICZN Article 74c states that "the fact that the specimen cannot be traced does not of itself invalidate the designation". Therefore the lectotype designation by Howe & Laurencich (1958) should be considered valid.

Cytherelloidea granulosa granulosa (Jones, 1849) Pl. 3, figs 5, 6, 8;
Pl. 4, fig. 1

* 1849 *Cythere (Cytherella) williamsoniana* var. *granulosa* Jones, p. 31, pl. 7, fig 26i.

1880 *Cytherella williamsoniana bosqueti* Marsson, p. 33, pl. 2, figs 8d, e [*vide* Kaye 1964a].

1890 *Cytherella williamsoniana* var. *granulosa* Jones; Jones & Hinde, p. 49, pl. 3, figs 68, 69, 72.

non 1929 Cytherelloidea granulosa (Jones); Alexander, p. 57, pl. 2, fig. 7

1940 *Cytherelloidea williamsoniana* (Jones); Bonnema, p. 95, pl. 1, figs 44-47.

1964a *Cytherelloidea granulosa* (Jones); Kaye, p. 71, pl. 9, figs 24-26.

1966 *Cytherelloidea granulosa* (Jones, 1849); Herrig, p. 750, pl. 6, figs 7-9, pl. 7, figs 2-9.

1978 *Cytherelloidea granulosa* (Jones, 1849); Neale, p. 358, pl. 13, figs 1, 2.

1982 *Cytherelloidea granulosa* (Jones, 1849); Clarke, p. 39, pl. 1, figs 6, 7.

non 1990 *Cytherelloidea granulosa* (Jones, 1849); Horne *et al.*; p. 127, pl. 2, fig. 2 [= *C. granulosa parca* ssp. nov.]

Lectotype. BM In. 51609, female right valve, figured Kaye 1964a, pl. 9, fig. 25; from the Chalk of Norwich.

Material. 25 specimens; 13LV, 12RV.

Diagnosis. Large *Cytherelloidea* with lateral surface densely ornamented with small rounded tubercles. Strong anterior marginal rib, short separate dorsal and ventral ribs present, median rib absent.

Measurements.	IJS15/1, F, LV	712 - 387
	IJS15/2, F, LV	725 - 412
	IJS15/3, F, RV	737 - 437
	IJS15/4, F, RV	762 - 456

Description. Carapace laterally compressed, right valve larger than right, distinct sexual dimorphism. Maximum width at the posterior swellings in females, and at the ventrolateral rib in males. Dorsal margins gently slope down towards the posterior; sinuous in left valves, with a weak convexity at mid-length, a concavity in front of that, and then becoming convex again at the anterior margin, posterodorsal margin hidden by posterodorsal swelling; dorsal margin straighter in right valves, females have a weak convexity behind mid-length, and a concavity behind the anterior margin, where in the males it is weakly concave behind mid-length and straight up to the anterior margin. Anterior margin evenly rounded. Ventral margin weakly concave to straight in females, strongly concave at mid-length in males. Posterior margin bluntly rounded with approximately twelve peripheral denticles.

Anterior marginal rib is high and narrow, set back a short distance from the anterior margin. It runs from the below the concavity on the anterodorsal margin, round to the ventral margin, and is continuous with the posterior marginal rib in the males, in females the rib swells to become the posterior brood pouches. The posterior marginal rib connects the swellings and reappears in front of the dorsal swelling as a short posterodorsal rib, where it fades into the dorsolateral surface. In females the posterior brood pouches are greatly swollen, in males the ventral pouch is reduced to a thin rib, while the dorsal is a little better developed. A short centrodorsal rib runs obliquely downwards, from a little above, and in front of the termination of the posterodorsal rib, to fade into the dorsolateral surface below and behind the dorsal termination of the anterior marginal rib. A short arcuate rib is situated centrally in the ventrolateral field.

The lateral surface of the valves is covered in a dense array of small conical tubercles with sharp pointed crests. On the posterior swellings is a fine reticulation. In the centre of the lateral surface, a little above mid-height is a deep muscle pit, below this the valves are a little inflated.

Internally the two brood pouches in females are hollow. The hinge is a peripheral groove in the right valve. which accommodates the edge of the left valve.

Remarks. Greater compression of the valves, greater density of the tubercles and a sharp edged anterior marginal rib distinguish this from *C. granulosa parca* ssp. nov.

The evolution of the nominate subspecies from *C. granulosa parca* ssp. nov. in the early Upper Turonian is rapid. In the Bridgewick hardgrounds, the juvenile stages of both subspecies only occur together in one sample; below this only *C. g. parca* is found, and above only *C. g. granulosa*.

Range. First appearance in the hardground above Bridgewick Marl 1, *S. plana* Zone, Upper Turonian, where it replaces *C. granulosa parca* ssp. nov. It is found continuously up into the Campanian.

Cytherelloidea granulosa parca ssp. nov. Pl. 4, figs 2, 3;
Pl. 24, fig. 4

Name. Latin; *parcus*, meaning scanty; after the reduced density of tubercles compared to the nominate subspecies.

1990 *Cytherelloidea granulosa* (Jones, 1849); Horne *et al*., p. 127, pl. 2, fig. 2.

Holotype. Female RV, IJS15/5, sample AKSD54, Flint level below Southerham Marl 1, *T. lata* Zone, Upper Turonian, Akers Steps, Dover, Kent.

Material. 72 specimens; 32LV, 39RV, 1car.

Diagnosis. Inflated *Cytherelloidea granulosa* with lateral surface sparsely ornamented with small rounded tubercles. All ribs greatly inflated with a rounded profile; a vertical rib connects the two posterior brood pouches.

Measurements.	IJS15/5, F, RV,	775 - 481
	IJS15/6, F, LV,	750 - 412

Description. Carapace moderately inflated, elongate ovate. maximum width equal at the posterior swelling and at the ventrolateral rib. Dorsal margin of right valve gently arched, higher than *C. g. granulosa* particularly at the posterodorsal corner where a small shelf is left between the posterodorsal swelling and the dorsal margin. Left valve dorsal margin more sinuous than the nominate subspecies with a greater degree of convexity at mid-length. Anterior margins evenly rounded; posterior margin of right valve evenly rounded, more blunt in left without any peripheral spines in either valve. Ventral margin concave just behind mid-length in the right and straight in the left.

The gross ornament is positioned as in the nominate subspecies, except for the ventral edge of the anterior marginal rib which does not flow into the ventral margin, but fades into lateral surface. The posterior rib is also reduced to a simple connection between the two brood pouches, the ventral connection and the dorsal elongation are both absent. The dorsal rib is reduced to a rounded elongate node, while the ventrolateral rib does not have such an arcuate shape but is straighter.

The surface ornament consists of rounded tubercles approximately twenty per valve in number, they have rounded crests. There is no reticulate ornament on the posterior swellings.

Remarks. Only females and juveniles of this subspecies have been identified so far from the Middle Turonian. It can be distinguished from the nominate subspecies by its greater inflation, the less dense tuberculation of the lateral surface the absence of the ventral marginal rib connecting the anterior and posterior ribs, the absence of the elongation of the posterodorsal rib and the different shape of the tubercles. These features, though not of specific significance, together with the separate stratigraphical ranges of the two forms allows them to be separated as subspecies.

Range. First appearance 4m below Glynde Marl 1, *T. lata* Zone, Middle Turonian, found continuously through the Middle Turonian. It is replaced by the nominate subspecies in the hardground above Bridgewick Marl 1, *S. plana* Zone, Upper Turonian at Langdon Stairs.

Cytherelloidea hindei Kaye, 1964a Pl. 4, figs 4-8

* 1964a *Cytherelloidea hindei* sp. nov.; Kaye, p. 72, pl. 9, figs 4, 8, 11.

1965 *Cytherelloidea mariei* n.sp.; Damotte, p. 236, pl. 1, figs 7a-d.

1971 *Cytherelloidea hindei* Kaye, 1964; Damotte, p. 57, pl. 1, figs 13a, b.

1978 *Cytherelloidea hindei* Kaye, 1964; Neale, p. 358, pl. 13, fig. 5.

. 1982 *Cytherelloidea hindei* Kaye, 1964; Weaver, p. 22, pl. 3, figs 13-16.

pars. 1982 *Cytherelloidea cabriensis* n. sp.; Colin, Lamolda & Rodrigues Lázaro, p. 199, pl. 1, figs 3,-6, *non* figs 7, 8.

. 1982 *Cytherelloidea hindei* Kaye, 1964; Clarke, p. 49, pl. 2, fig. 3.

. 1988 *Cytherelloidea hindei* Kaye, 1964; Jarvis *et al*. p. 34, fig. 15f.

. 1988 *Cytherella* sp. cf. *C. chathamensis* Weaver, 1982; Jarvis *et al*. p. 34, fig. 15b.

. 1990 *Cytherelloidea hindei* Kaye, 1964; Horne *at al*., p. 127, pl. 2, fig. 2.

. 1996 *Platella* sp.; Slipper, p. 52, pl. 1, fig 1.

Holotype. BM Io1288, right valve, figured Kaye, 1964a, pl. 9, figs 4, 11; from the Upper Chalk, Norwich. Paratypes, BM Io1289-92, valves; from the same horizon and locality.

Material. 166 specimens; 78 adult and A-1; 29LV, 48RV, 1car., 88 pre A-1; 37LV, 48RV, 3car.

Diagnosis. Cytherelloidea with a continuous dorsal, anterior, ventral, posterior and posterodorsal marginal rib. Separate, dorsally concave, arcuate median rib. Lateral surface smooth.

Measurements.	IJS19/32, F, LV	640 - 340 - 130
	IJS19/33, F, RV	640 - 370 - 150
	IJS19/34, M, RV	630 - 360 - 120
	IJS19/35, M, LV	600 - 320 - 130

Description. Carapace elongate, subrectangular, right valve larger than left overlapping around the entire margin. Maximum width at the posterior swellings, maximum height at one-fifth length. Distinct sexual dimorphism; males have a smaller height/length ratio and less swelling of the dorsal and ventral posterior nodes. Dorsal margin of right valve straight to very weakly convex posterodorsally with a concavity in front of mid-length, more pronounced in males, and a convex anterodorsally merging with the anterior margin. Left valve dorsal margin more sinuous than the right. Posterodorsal margin straight and oblique, hidden partially in left valves by the posterodorsal swelling, it rises gradually from the posterior to a convexity just behind mid-length, this gives way to a concavity in front of mid-length, more pronounced in males. Anterior margin is evenly rounded in right valves, more blunt in the left. Ventral margin is concave just behind mid-length, the concavity is greater in males. Posterior margin is bluntly rounded, slightly truncated dorsally in males.

Anterior marginal rib begins below the dorsal concavity and follows the course of the margin, it is continuous with the ventral marginal rib which is straight and connects with the ventral posterior swelling. This swelling is much reduced in males, and developed into a brood pouch in females. A vertical posterior rib connects the two posterior swellings. The dorsal of these is better developed in males than in the ventral, but is more triangular than that in the females, which tends to be more rounded. A short posterodorsal rib extends forward from the posterodorsal swelling. A weak irregular dorsocentral rib may be connected by a thin rib to the antero- and posterodorsal ribs. Above mid-height centrally is a deep muscle pit, below that is a thin, dorsally concave, arcuate median rib.

Juveniles have a similar outline to the adults, but lack all marginal ribs. The posterodorsal margin is truncate; dorsal margin is concave anterocentrally; the ventral margin is concave at mid-length. A weak flange is present around the anterior margin in the left valve. The muscle pit is very well developed above mid height at mid-length. Over the lateral surface are small nodes, which become more strongly developed at the posterior, and have the weakest expression in the anteroventral field. In the same areas of the lateral surface as the nodes is a feint polygonal reticulation. Calcified inner lamella is poorly developed.

The hinge is a peripheral groove in the right valve, into which the edge of the left valve fits. This groove is well marked along the dorsal margin where the ventral ridge is strong.

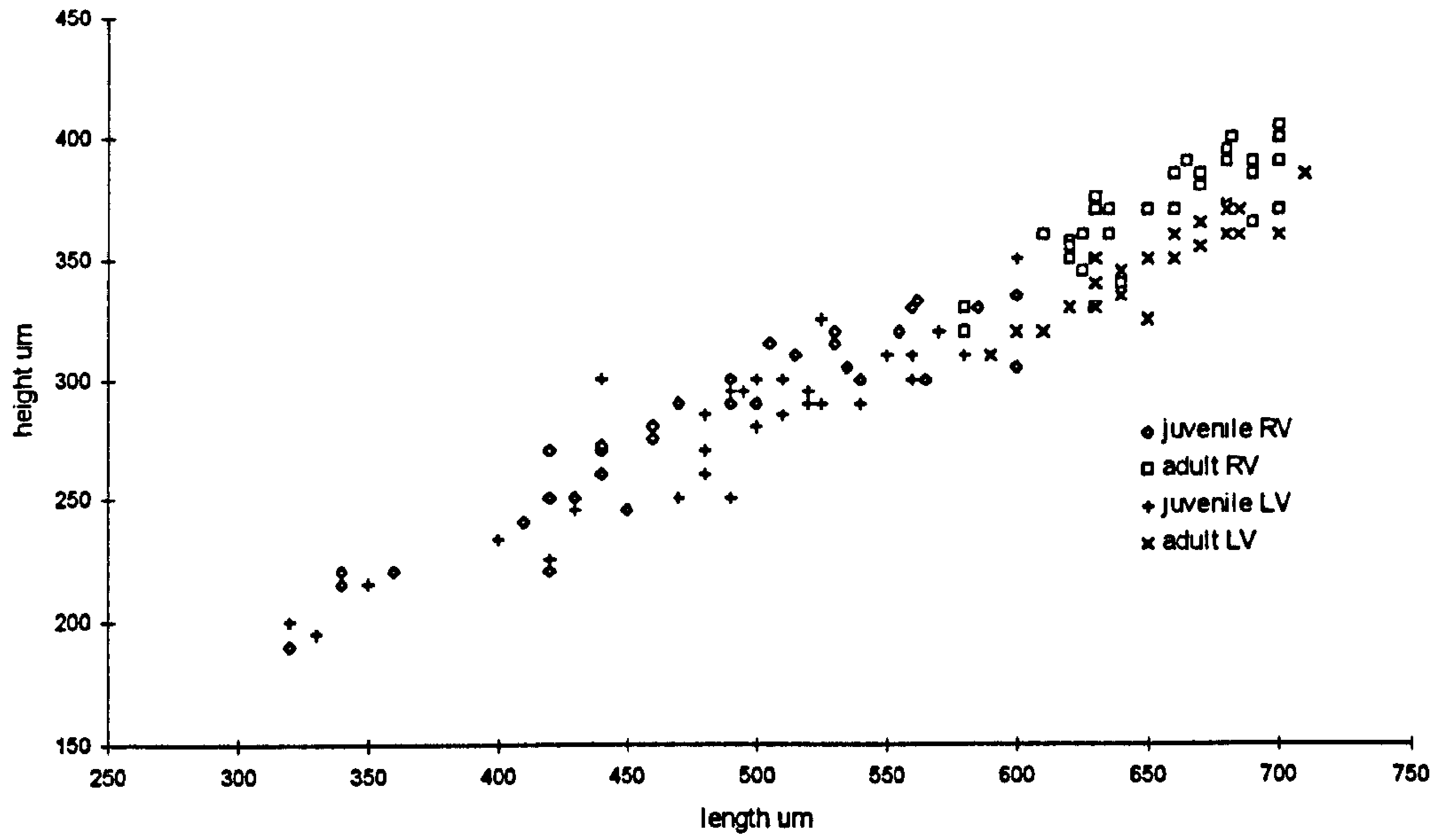
Remarks. Easily recognised and ubiquitous component of the Upper Cretaceous Chalk. *Cytherelloidea stricta* (Jones & Hinde, 1890) is similar but that has an elongated posterodorsal rib which reaches forward and curves down above the muscle pit, terminating below the dorsal extremity of the anterior marginal rib. The median rib is also reduced and the ventral rib is situated low on the lateral surface, above the ventral marginal rib.

Cytherelloidea levigata hemmoori Clarke, 1982 is very similar and differs only by the separation of the dorsal and anterior marginal ribs. This would perhaps be better considered as a subspecies of *C. hindei* since it has more features in common than with *C. levigata*.

The specimens illustrated from the Cenomanian and Turonian of Northern Spain by Colin *et al.* (1982) as *Cytherelloidea cabriensis* fall into two species. Those from the Turonian are conspecific with *C. hindei*, while those from the Cenomanian are more closely allied to *Cytherelloidea kayei* Weaver, 1982; the ventral rib of the Cenomanian specimens is not continuous with the anterior marginal rib. However, the connection of the ventral rib with the posteroventral swelling argues against that assignment.

The juveniles of this species have not previously been identified. In all other assemblages of species of *Cytherelloidea*, the juvenile stages are present and obvious in that they retain the main peripheral ribbing, which allows the assignment of juveniles to the correct species. In *C. hindei* however, no such individuals have ever been found. The closely related *Cytherelloidea levigata* Herrig, 1963, has a similar arrangement of adult ribs, but less well developed. In that species, the A-1 and younger juveniles have an ornament of small posterolateral tubercles (Herrig 1966) and weak polygonal reticulation, but retain a weak ventrolateral rib. The specimens which Slipper (1996) illustrated as *Platella* sp. are similar to the juveniles of *C. levigata* and belong to an assemblage which through morphometric analysis have now been identified as being the juvenile stages of *C. hindei* (Text-fig. 4.1). It is interesting to note that in the collections of Dr. D.J. Horne are Cenomanian specimens of *C. hindei,* from the early part of its range at Dover, where the adults have a tuberculate lateral surface similar to the posterolateral ornament of the juveniles. This is lost in the stratigraphically younger specimens.

Range. Recorded from the Middle Cenomanian (Weaver 1982), it is continuous through the Turonian, and has been found in the Coniacian and Santonian by the author. Reported from the Santonian and Campanian (Neale 1978).



Text-fig 4.1 Length/height plot of valves of *Cytherelloidea hindei*; assemblages from 24 samples through the Turonian at Dover, Kent.

Cytherelloidea kayei Weaver, 1982 Pl. 5, figs 1-3

pars. 1966 *Cytherelloidea obliquirugata* (Jones & Hinde, 1890); Herrig, p. 749, pl. 8, figs 1, 2, 4, 5, *non* fig. 3.

* 1982 *Cytherelloidea kayei* sp. nov.; Weaver, p. 22, pl. 3, figs 4-9.

. 1982 *Cytherelloidea obliquirugata* (Jones & Hinde, 1890); Clarke, p. 48, pl. 2, fig. 5.

. 1988 *Cytherelloidea kayei* Weaver, 1982; Jarvis *et al*. p. 34, fig. 15h.

. 1988 *Cytherelloidea kayei* Weaver, 1982; Wilkinson, p. 1236, pl. 1, fig. 9.

. 1992 *Cytherelloidea kayei* Weaver, 1982; Witte *et al*., p. 47, pl. 1, fig. 11.

. 1995 *Cytherelloidea kayei* Weaver; Horne, *et al*., p. 45, pl. 22, 46, figs 1-6, pl. 22, 48, figs 1-6, pl. 22, 50, figs 1-5, pl. 22, 52, figs 1-5.

Type specimens. Holotype, BM OS9464, female right valve, figured Weaver, 1982, pl. 3, fig. 4; from the Upper Cenomanian of Bluebell Hill, Kent. Paratypes, BM OS9466-79, valves and carapaces; from the same locality and horizon. Paratype male carapace, BM OS4965; from the Middle Cenomanian of the same locality.

Material. 92 specimens; 30LV, 62RV.

Diagnosis. Small *Cytherelloidea* with dorsally concave, arcuate ventrolateral and median ribs, the latter is weaker; anterior marginal rib strong; dorsal rib very short, with a shallow muscle pit below.

Measurements.	IJS19/29, F, RV	600 - 330 - 140
	IJS19/30, F, LV	550 - 345 - 130
	IJS19/31, M, RV	560 - 330 - 100

Description. Carapace elongate, subrectangular, maximum height at one-fifth length, maximum width at posterior swellings. Dorsal margin of right valve straight centrally with a weak upturn at the posterior in females and a stronger curve up to the anterior margin. Dorsal margin of left valve more sinuous than right; the posterodorsal margin is obscured by the large swelling; centrally, it is gently arched; a concavity in front of mid-length gives way to the rounded convex anterodorsal margin. Anterior margin is evenly rounded in right valve, more blunt in left. Ventral margin nearly straight in right valves, gently concave in left valves; this is accentuated in males. Posterior margin is very bluntly rounded, almost straight in right valves.

Anterior marginal rib strongly developed, with a rounded profile. It is set back a short distance from the anterior margin which leaves a small anterior flange. The anterior rib, at its extremities is separate from the ventral and dorsal ribs. Behind the marginal rib are short riblets arranged radially in the anterolateral surface. The dorsal rib is reduced to a short central node between the dorsal margin and the shallow muscle pit. The weak median rib is generally slightly thickened at each end, but not connected to any other ribs. Below the median rib is a stronger, shorter, separate ventrolateral rib. Both lateral ribs are dorsally concave, the ventral slightly more than the median. At the posterior in males is a curved marginal rib which bends sharply, towards the muscle pit, at its dorsal end and fades into the lateral surface. In females this rib is swollen dorsally and ventrally into two large brood pouches, the posterior rib connects the two. In some specimens a weak reticulate ornament is seen on the lateral surface.

Remarks. Weaver (1982) states that, for the Cenomanian specimens, the median rib is obscure or absent. In the Turonian, however the median rib is usually clearly developed, only at two levels is it at all reduced. Below the Southerham Marls after an absence from the section *C. kayei* briefly returns, much increased in size and with a feint median rib, above this level normal size specimens are again found. Also in the Kingston Nodular Chalks, the median rib is reduced and, in one specimen, absent. Horne *et al.* (1995) demonstrate the variability in the development of the median rib from the Cenomanian to the Coniacian, showing how the rib becomes weaker centrally and develops two terminal nodes. This feature is transitional to *Cytherelloidea binoda* Clarke, 1982, in which the median rib is replaced by two nodes. That species differs by being larger, and having a continuous posterodorsal and centrodorsal rib.

Males are rare, only two in ninety-two were positively identified as male right valves. No carapaces were recovered.

Range. Recovered throughout the Turonian, this species ranges from the Albian (Wilkinson 1990) to the Coniacian (Horne *et al.* 1995). This has also been recovered by the author from the Chalk in Pinden Quarry, Kent which is believed to be Santonian (C.J.Wood pers. comm.).

Cytherelloidea obliquirugata (Jones and Hinde, 1890) Pl. 5, figs 4-6

* 1890 *Cytherella obliquirugata* sp. nov.; Jones and Hinde, p. 50, pl. 3, fig. 73.

pars. 1964a *Cytherelloidea oblinquirugata* (Jones & Hinde); [*sic*] Kaye, p. 73, pl. 9, figs 12, 13, *non* fig. 14 [= *C. binoda* Clarke, 1982].

non . 1966 *Cytherelloidea obliquirugata* (Jones & Hinde, 1890); Herrig, p. 749, pl. 8, figs 1-5 [figs 2, 4, = *C. kayei* Weaver]

. 1966 *Cytherelloidea auricularis* (Bosquet, 1847); Herrig, p. 748, pl. 6, figs 1-6.

. 1978 *Cytherelloidea oblinquirugata* (Jones & Hinde, 1890); [*sic*] Neale, p. 358, pl. 13, figs 3, 4.

. 1982 *Cytherelloidea auricularis* (Bosquet, 1847); Clarke, p. 43, pl. 1, figs 8, 9.

Type specimens. No type material designated. The illustrated specimen of Jones & Hinde (1890) is a juvenile left valve from the Chalk of Winchester.

Material. 115 specimens; 1car., 51LV, 63RV of adults and juveniles.

Diagnosis. Small *Cytherelloidea* with dorsal and ventral ribs connected to respective posterior swellings; median rib runs obliquely from near posterodorsal swelling, beneath muscle pit, to the anterolateral field; secondary median rib directly in front of muscle pit runs subparallel to primary rib.

Measurements.	IJS19/26, F, RV	590 - 325 - 140
	IJS19/27, F, LV	570 - 315 - 130
	IJS19/28, M, RV	590 - 325 - 110

Description. Carapace subrectangular, adults strongly dimorphic. Right valve position of maximum height at one-fifth length. Dorsal margin very weakly arched to sinuous, slightly angular in males. Anterior margin evenly rounded. Posterior margin bluntly rounded, truncate posteroventrally, often obscured by posterior marginal rib in males or brood pouches in females. Ventral margin weakly concave in females, strongly concave in males. Left valve has a more angular dorsal margin, with maximum height at three-fifths length.

Marginal ribs strongly developed; anterior marginal rib arises from the below the dorsal margin at one quarter length, runs concentrically with the anterior margin and merges with the ventral margin rib, which is thinner and lower. At the posterior the ventral rib curves upwards to join the lower of the two brood pouches in females, in males this becomes a diagonally sloping posterior marginal rib. This is seen in females between the two brood pouches. Below the posterodorsal corner the rib then bends acutely and runs towards the upper edge of the muscle pit. In females the upper brood pouch is developed at the posterior end of this posterodorsal rib, in males the rib is generally more weakly developed and carries a node. In front of the muscle pit, the dorsal rib then deviates and bends downwards to fade into the dorsal part of the anterolateral surface. A strong ventrolateral rib is weakly connected to the lower of the two brood pouches in females, from where it curves downward to mid-length, then weakly up to form a weak bow, it ends in the ventral part of the anterolateral surface. A weak, sinuous diagonal rib, sometimes bearing small tubercles, arises from below and in front of the upper brood pouch, or posterodorsal node, according to sex. This runs subparallel to the ventrolateral rib, below the muscle pit, and carries on beyond the point where the latter rib fades, and curves down to end in front of the anterior termination of the ventrolateral rib. A small anteromedian rib emerges from the anteroventral corner of the muscle pit to run subparallel with the anterior section of the sinuous diagonal rib, this terminates in the centre of the anterolateral field. The surface of the valves may carry small tubercles.

In juvenile specimens, the truncated posteroventral aspect of the male is emphasised and the diagonal rib is strongly developed, often connecting with the posterodorsal node forming an acute angle with the dorsal marginal rib.

Remarks. The original illustration of Jones & Hinde (1890) is of a juvenile left valve. The locality given for the species, but not necessarily for the illustrated specimen, is Winchester. Kaye (1964a) illustrates a juvenile left valve from Norwich, so this is unlikely to be the original specimen. The specimen stated by Kaye (1964a, pl. 9, fig. 12) as being a juvenile is, in the author's opinion, a left lateral view of a male. His interpretation of the adult of this species (*op. cit.,* fig. 14), in the author's opinion, is of a larger species *C. binoda* Clarke, 1983. Neale's illustration (1978, pl. 13, fig. 4) is not of a female right valve, but a juvenile right valve, as is it too small for an adult specimen, and does not display the enlarged brood pouches at the posterodorsal and posteroventral corners.

The opinion of King [1968] that *C. auricularis* (Bosquet, 1847) is the correct name for this species is now not supported. Comparison with material from the Bosquet collection shows this species to be distinct from *C. auricularis* (Bosquet, 1847). Juvenile *C. obliquirugata* resemble in outline *C. auricularis* in the adult stage, but the latter has greater convexity and concavity in the dorsal and ventral margins respectively. In addition the ribs are more rounded and raised, and the posterior extremity is more drawn out.

Range. First appearance at the Round Down Marl, Middle Turonian, *T. lata* Zone; found throughout the remaining Turonian. Present in the overlying Coniacian, Santonian and Campanian chalks of England (Neale 1978) and the Campanian chalks of northern Germany (Herrig 1966; Clarke 1983).

Order PODOCOPIDA Müller, 1894

Suborder PODOCOPINA Sars, 1866

Superfamily SIGILLIACEA Mandelstam, 1960

Family SAIPANETTIDAE McKenzie, 1968

Genus CARDOBAIRDIA Bold, 1960

Type species. By original designation; *Cardobairdia ovata* Bold, 1960, p. 155, pl. 2, figs 2a-c; from the Middle Eocene of Trinidad.

Diagnosis. Shape ovate, valves usually heavily calcified. Left valve much larger than right, overlaps around the entire margin, particularly dorsally and ventrally. Hinge consists of crenulate terminal teeth in right valve separated by a weak median groove.

Remarks. This genus has previously been placed within the superfamily Bairdiacea (Herrig 1966; Weaver 1982) and the Healdiacea Harlton, 1933 (Nuyts 1990b). Nuyts (1990b) placed *Cardobairdia* in suborder Metacopa Sylvester-Bradley, 1967, presumably following Mckenzie (1967), van den Bold (1968) and Szczechura & Blaszyk (1968). However, van den Bold (1974) showed how the structure of the marginal area in *Cardobairdia* places it within the Podocopina. Van den Bold (1974) placed *Cardobairdia* in the Family Saipanettidae of uncertain superfamily. Maddocks (1982) discussed the relationships of *Saipanetta*; which was considered to belong to the Sigilliacea. The interpretation of the Saipanettidae according to Maddocks (1982) is followed here.

Cardobairdia longitecta sp. nov. Pl. 5, figs 7, 8, Pl. 6, figs 1, 2; Pl. 24, figs 5, 6

Name. Latin; *longus*, meaning long and *tectum*, meaning roof; alluding to the elongated centrodorsal margin.

Holotype. Female LV, IJS20/1, sample AKSD19, 3.8m below New Pit Marl 1, Middle Turonian, *T. lata* Zone; from Akers Steps, Dover, Kent.

Material. 28 specimens of adults and juveniles; 14LV, 10RV, 4car.

Diagnosis. *Cardobairdia* with a small posterior terminal spine at the ventral margin of the right valve. Maximum width at mid-length. Dorsal valve contact straight in posterior two-thirds, deviated to the right in front. Narrowly rounded posterior margin. Long straight centrodorsal margin in the right valve.

Measurements.		
	IJS20/1, F, LV	460 - 280 - 180
	IJS20/2, F, RV	445 - 250 - 135
	IJS20/3, M, LV	510 - 300 - 190
	IJS20/4, M, RV	500 - 245 - 140

Description. Carapace very asymmetric, larger left valve completely overlaps right except at the posteroventral margin; maximum height at, or just in front of mid-length; maximum width at mid-length. Outline of left valve ovate to rhomboid, right valve is subtriangular. Dorsal margin of left valve gently rounded, with a flatter posterodorsal section. Anterior margin rounded, anterior extremity below mid-height. Ventral margin convex, curving up to narrow bluntly rounded posterior margin. Right valve dorsal margin has a gently sloping anterodorsal section, an angular point of maximum height, a long centrodorsal section which slopes more steeply, an angular posterodorsal corner behind which is the very steep posterodorsal margin which terminates in a spine. Ventral margin is sinuous, straight in front of mid-length, and has a central concavity, behind which is a weak convex section that turns upwards towards the posterior spine. Anterior margin is rounded with extremity below mid-height.

In dorsal view valve contact irregular; straight and even in the posterior two-thirds, and strongly deviated towards the right anteriorly. Left valve very well inflated, right valve moderately so. In ventral view left valve strongly overlaps right centrally. Surface of valves devoid of ornament.

Calcified inner lamella narrow. Hinge of right valve has elongate crenulate terminal elements.

Remarks. *Cardobairdia cenomanensis* Nuyts, 1990b does not possess a posterior terminal spine in the right valve, has a smaller height relative to length in the left valve, a greater inflation in the right valve and a steeper posterodorsal margin in the left valve. *Cardobairdia triebeli* Nuyts, 1990b from the Campanian and Maastrichtian of Germany and Belgium is smaller, has a more convex ventral margin, and a more prominent posterodorsal angle in the right valve, while the left valve has a much broader posterior margin with a very slight incline on the posterodorsal margin. *Cardobairdia rectimarginata* Nuyts, 1990b from the Lower Campanian of Belgium is more elongate with subparallel dorsal and ventral margins.

Nuyts (1990b) demonstrated that *Krausella minuta* Triebel as first mentioned by van Veen (1936b) is a *nomen nudum* since Triebel did not publish the taxon *Krausella minuta*. The Middle Turonian to Santonian specimens from the Netherlands illustrated by Bonnema (1940) as *Krausella minuta* were included by Nuyts (1990b) in *Cardobairdia triebeli*, though, in the author's opinion, Bonnema's illustrations appear to be more elongate than Nuyts' specimens, and have the position of maximum height too far in front of mid-length for inclusion within C. *triebeli*. A consequence of the work of Nuyts (1990b) is that the specimens of *K. minuta sensu* van Veen (1936b) are left without a valid name, since they were only excluded in the synonymies, and not given a *nomen novum*.

Krausella minuta sensu van Veen (1936b) differs from *C. longitecta* sp. nov. by the right valve being higher anteriorly and not having a posterior spine, while the left valve has the slope of the posterodorsal margin similar to *C. triebeli*; the position of maximum inflation is behind mid-length, and the valve contact on the dorsal margin deviates slightly to the left centrally.

Range. From 1m above the *Filograna avita* bed, Lower Turonian *Mytiloides* spp. Zone at Abbots Cliff, present sparsely throught the overlying Turonian and found by the author in the Coniacian at Langdon Stairs.

Superfamily BAIRDIACEA Sars, 1888

Family BAIRDIIDAE Sars, 1888

Subfamily BAIRDIINAE Sars, 1888

Genus BAIRDOPPILATA Coryell, Sample & Jennings, 1935

Type species. By original designation; *Bairdoppilata martyni* Coryell, Sample & Jennings, 1935, p. 3, figs 1, 2; from the Miocene of Mississippi, USA.

Diagnosis. Outline ovate to subtrapezoidal, dorsal margin strongly arched in larger left valve. Valve surface smooth or finely punctate. Auxiliary dentition at anterior and posterior ends; 4-6 smooth or frilled denticles in right valve articulate with sockets beneath the left valve overlap. Hinge bar smooth. Muscle scars consist of 8-10 oblong scars arranged in three curved rows, which form a loose spiral.

Remarks. This genus is one of the more difficult in which to make the correct specific assignations, since many species may be present in any one sample, but often some are represented only by juvenile stages. Where no carapaces are found it can be problematic to identify the correct left and right valves for rare species, or where many juveniles are present, it can also be difficult to assign them to the correct species. In this study over 2,700 bairdiacean specimens were recovered, but just under 1000 were identifiable to species level. The subtle differences in outline require that specimens be complete; however, very often the posterodorsal margin of bairdiaceans is broken, which makes identification uncertain.

Bairdoppilata cuvillieri omnipraesens (Pokorný, 1980)

Pl. 6, figs 2, 3

1846 *Cytherina subdeltoidea* v. Münster; Reuss, p. 16, pl. 5, fig. 38.

1874 *Bairdia subdeltoidea* v. M. sp.; Reuss, p. 140, pl. II, 26, figs 5a-c [?mirror image drawings].

1889 *Bairdia subdeltoidea*, v. Münst.; Fric, p. 94, fig. 112 [drawing is a mirror image].

1932 *Nesidea subdeltoidea* (Münst.).; Šulc, p. 4, 7.

pars .1940 *Bairdia septentrionalis* nov. spec.; Bonnema, p. 108, pl. 2, figs 58, 59, *non* pl. 2, figs. 55-57, 60, 64, pl. 3, figs 1-8.

* 1980 *Bairdia cuvillieri* Damotte, 1971 *omnipraesens* subsp. nov.; Pokorný, p. 321, text-figs 2-8, pl. 1, figs 1-9, pl. 2, figs 1-3, pl. 4, fig. 2.

1980a *Bairdoppilata cuvillieri omnipraesens* Pokorný, 1978; Pokorný, p. 359.

. 1988 *Bairdoppilata* sp. A; Jarvis *et al.*, p. 34, fig. 16(b).

. 1990 *Bairdoppilata* sp. A (*sensu* Jarvis *et al.*, 1988); Horne *et al.*, p. 127, pl. 2, fig. 6.

Holotype. Carapace of a supposed female, no. PFUK 0-562; from the Upper Turonian of Vinice Hill, NE of Kolin, Czech Republic.

Material. 190 specimens of males, females and juvenile stages, mostly valves, some carapaces.

Diagnosis. Bairdoppilata with weak caudal process in the right valve and very weak in the left valve. Centrodorsal margin high and angular in the left valve, straight and convergent with the ventral margin in the right valve. Posterior extremity closer to the ventral margin than the anterior extremity. Ventral margin straight in left, centrally concave in the right.

Measurements.	IJS20/5, LV	960 - 670 - 285
	IJS20/6, RV	900 - 550 - 260

Description. Carapace large, subtriangular, left valve larger than right overlapping around the entire margin with the exception of the posterior tip of the caudal process, where the right valve projects further than the left. In dorsal view the carapace is lenticular, the inflation of the left valve is smooth and rounded, while that of the right is more angular, though still smooth; at the posterior the caudal process is slightly pinched and truncated in the left. There is also a slight constriction at the anterior which is more pronounced in the left valve. Valve overlap uneven, the left overlaps the right more strongly along the posterodorsal and anterodorsal margins, less so centrodorsally.

Left valve has a high dorsal margin with the maximum height at about mid-length, where it curves sharply but evenly into the antero- and posterodorsal margins. Both dorsal margins have the same slope down towards the ventral margin, at the posterior the differentiation of the caudal process is very weak, the extremity lies below the anterior extremity. The posterodorsal margin is weakly convex. Ventral margin is evenly convex, less convex in males. The anterior margin is narrowly rounded.

Right valve is subhexagonal; the anterodorsal, centrodorsal and posterodorsal margins are straight, posteriorly there is a concavity in front of the caudal process. The anteroventral and posteroventral margins are convexly curved, the centroventral margin is sinuous with a central concavity between two projecting sections, the anterior having the more angular profile.

Internally, the bairdoppilatan auxiliary dentition is seen on the right valve as a row of denticles at the ventral ends of each of the distal dorsal margins. The inner lamella is well developed.

Remarks. Pokorný's original diagnosis only differentiated *B. cuvillieri omnipraesens* from the nominate subspecies, the diagnosis is here expanded to encompass features which allow a more precise definition. *Bairdoppilata cuvillieri cuvillieri* (Damotte, 1971) from the Coniacian and santonian of the Paris Basin, has a centrodorsal margin of the right valve that is less convergent with the ventral margin and a weaker caudal process in both valves.

Bairdoppilata kunradensis (Veen, 1934) is similar in the left valve, but the caudal process is not developed, and the anterior extremity is lower. The right valve is more elongate with a greater slope on the centrodorsal margin. *Bairdoppilata trigona* (Veen, 1934) has a higher posterior extremity, and no caudal process in the left valve. *Bairdoppilata acuticauda* (Veen, 1934) has the posterior extremity very near the ventral margin, and the right valve has a more rounded profile. *Bairdoppilata cretacea* (Veen, 1934) is very similar in outline, but has the point of maximum height behind mid-length.

Range. This species is found commonly throughout the Turonian of the sections studied, with the exception of the clean white chalks between the New Pit Marls and the mid-Turonian $\delta^{13}C$ excursion of Gale (1996, text-fig. 8). Recorded from the Lower Turonian to the Lower Coniacian of the Bohemian Basin (Reuss 1846, 1874; Fric, 1889; Šulc 1932; Pokorný 1980). The nominate species first appears in the Coniacian of the Paris Basin (Damotte 1971a).

Bairdoppilata turonica sp. nov. Pl. 6, figs 5, 6; Pl. 24, fig. 7

Name. After the Turonian Stage of the Late Cretaceous in which this species is common.

Holotype. LV IJS20/7, sample AKSD43, marl seam 1.6m below Lydden Spout Flint, Middle Turonian, *T. lata* Zone; from Akers Steps, Dover, Kent.

Material. 367 specimens of adult males, females and juvenile stages.

Diagnosis. Equant *Bairdoppilata* with maximum height at mid-length in left valve, in front of mid-length in the right valve. Small but distinct caudal process, the extremity of which is at, or just below the level of the anterior extremity. Weak concavity in the centre of the ventral margin in the left, further forward in the right.

Measurements.		
	IJS20/7, LV	1030 - 700 - 280
	IJS20/8, RV	1010 - 600 - 180

Description. Dorsal margin high and sharply rounded at its apex. Anterodorsal and posterodorsal margins descend with equal slope towards the ventral margin. Distinct, caudal process in both valves the extremity of which is at, or just below the level of the anterior extremity. Ventral margin sinuous in both valves; the left has a weak concavity centrally, and curves up to the anterior and posterior, the right valve has its concavity below the dorsal anterior cardinal angle, the anteroventral projection in front of the concavity is more prominent than that behind. In the right valve the centrodorsal margin is straight and slopes slightly down towards the posterior.

Males are much more elongate with a prolonged caudal process in the left valve. Bairdoppilatan auxiliary dentition visible on the inner margin of the right valves.

Remarks. Similar to *B. cuvillieri omnipraesens*, with which it occurs, but differs by having a more prominent caudal process and a greater height/length ratio. *Bairdoppilata septentrionalis* (Bonnema, 1940) is similar, but that has a well developed caudal process in both valves, and the centrodorsal margin of the right valve and the upper surface of the caudal process are both parallel with the baseline. *Bairdoppilata pseudoseptentrionalis* Mertens, 1956 has a more rounded dorsal margin, and a convex upper part of the posterodorsal margin.

Bairdoppilata sp. *sensu* Gründel (1974), from the Santonian, has a slightly concave anterodorsal margin and less well developed caudal process.

Range. First appears 1m above the *Filograna avita* bed, *Mytoiloides* spp. Zone, lower Turonian, at Abbots Cliff, and is present throughout the remaining chalks of the sections studied.

Bairdoppilata septentrionalis (Bonnema, 1940) Pl. 6, figs 7, 8

pars *1940 *Bairdia septentrionalis* nov. spec.; Bonnema, p. 108, pl. 2, figs 55-57, 60, 64, *non* pl. 2, figs 58, 59, pl. 3, figs 1-8.

non 1966 *Bairdoppilata septentrionalis* (Bonnema, 1940); Herrig, p. 771, pl. 12, figs 1a, b, 2a, b, ?8.

1977 *Bairdoppilata septentrionalis* (Bonnema, 1940); Pokorný, p. 238, pl. 1, figs 1, 2, pl. 2, figs 1, 2, pl. 3, figs 1, 2, pl. 4, figs 1-3.

non 1980a *Bairdoppilata septentrionalis* (Bonnema, 1940); Pokorný, p. 359, fig. 14.

Material. 21 specimens, LGSD11, 7LV, 7RV; LGSD18 1LV; LGSD21, 2LV, 2RV; LGSD23, 1RV; LGSD24, 1RV.

Lectotype. Designated by Pokorný (1977, pl. 1, fig. 1), a female carapace on slide no. 2126; from the Upper Cretaceous of borehole NN-IV de Krim, the Netherlands. Deposited in the Geological Survey of The Netherlands, Haarlem.

Diagnosis. Distinct caudal process in both valves. Centrodorsal margin and dorsal margin of caudal process in the right valve subparallel with the horizontal plane. Left valve with straight anterodorsal margin.

Measurements.	IJS20/9, LV	1104 - 740 - 300
	IJS20/10, RV	1060 - 640 - 300

Description. Valves large ovate to triangular. Greatest height at mid-length in left valves and at the anterior cardinal angle in right valves.

Left valve outline consists of a high, smoothly arched dorsal margin, with straight antero- and posterodorsal sections. The anterior extremity is just below mid-height. The ventral margin is evenly curved from the anterior to the posterior extremities with only a slight flattening centrally. Posterior extremity at, or just above mid-height; distinct bluntly rounded caudal process with a small concavity at the junction with the posterodorsal margin. In dorsal view, the maximum inflation is in front of mid-length and distinct compression is seen at the anterior and posterior extremities.

Right valve has an angular subhexagonal outline. Dorsal margin composed of four segments. A long straight anterodorsal margin slopes up at about 40° to the horizontal from the anterior extremity above mid-height, and passes into a short, straight centrodorsal margin which is nearly horizontal, slightly higher at the anterior end; this becomes more pronounced in the juvenile stages.

The posterodorsal margin is straight, intermediate in length between the latter two segments and slopes at a greater angle than the anterior segment. A small concavity at the ventral end of the posterodorsal margin marks the dorsal border of the caudal process. Depending on the preservation this dorsal border can appear straight or slightly sloping. In well preserved specimens a weak flange is present at the valve contact which draws the eye away from the horizontal nature of the dorsal border to the caudal process, in most specimens this is broken off.

Caudal process very well developed with a short blunt termination just below mid-height. The ventral margin is composed of three distinct segments. The posteroventral margin is short, straight and descends to the posteroventral angle at about 45° to the horizontal. The centroventral margin is sinuous, with a concavity in front of mid-length and a prominent anteroventral process. The anteroventral margin is bipartite, the more ventral section is concave, while the dorsal section is convex, with a weak frill preserved in rare specimens.

In dorsal view the maximum inflation is at mid-length. The inflation is not even, but appears as a series of straight sections. The anterior is compressed, the valve increases rapidly in width up to about one-fifth length, then increases gradually to maximum inflation, from where it decreases in width gradually to four-fifths length, where the strong posterior compression begins.

The calcified inner lamella is well developed at the anterior and posteroventral margins. Bairdoppilatan auxiliary dentition is present at the ventral ends of the antero- and posterodorsal hinge lines. Wide flanges are present beyond the line of valve contact along the antero- and posteroventral margins of the right valve.

Remarks. *Bairdoppilata pseudoseptentrionalis* Mertens, 1956 (*non B. pseudoseptentrionalis* Mertens, 1956 *sensu* Weaver 1982, p. 24, pl. 4, figs 1-3) also has a distinct caudal process in both valves, but is distinguished by its convex posterodorsal margin. Weaver's specimens assigned to that species are more elongate, do not possess a distinct caudal process in the left valve, and have the posterior extremity well below mid-height. These should be considered as a distinct species.

Range. This species first appears very abundantly at the Caburn Marl, it then occurs rarely through the Upper Turonian of southern England. According to the age determinations (Pokorný 1977, p. 242) this species was found from the Lower Turonian to the Lower Santonian of NN-IV de Krim, Netherlands. Its first appearance in the Coniacian in Bohemia (Pokorný 1980a) is uncertain as the illustrations (Pokorný 1980a, fig. 14) appear not to be conspecific with *B. septentrionalis*.

Bairdoppilata sp. 1 Pl. 7, figs 1, 2

Material. 51 specimens; 42LV, 9RV.

Measurements.	IJS20/11, LV	910 - 610 - 260
	IJS20/12, RV	960 - 500 - 230

Description. Dorsal margin of left valve is evenly curved in a low arch from the anterodorsal angle to the posterodorsal concavity. Maximum height at mid-length. Anterior margin openly rounded, the extremity is at or just below mid-height, it merges, without angle into the weakly convex ventral margin. A weak caudal process is developed at the posterior which terminates below mid-height. In dorsal view the inflation is evenly curved, at a maximum behind mid-length, the valves become compressed unevenly toward the distal extremities; the valve slopes evenly to the posterior, but towards the anterior it passes through a 'step down' to the valve margin.

Outline of right valve is angular hexagonal. A long centrodorsal margin very weakly convex, slopes slightly down towards the posterior. Antero- and posterodorsal margins slope equally down towards the baseline; the former is straight, whilst the latter is straight to very weakly convex. Anterior extremity narrowly rounded, below mid-height. The caudal process is elongate and terminates below-height. Ventral margin sinuous; the central section is concave, more so to the anterior; anterior and posterior ventral angles are pronounced.

Calcified inner lamella narrow to moderate width, bairdoppilatan auxiliary dentition not seen.

Remarks. The internal features strongly suggest that these specimens represent a species of which no adults have yet been found, and is therefore left in open nomenclature. It is quite distinctive in its low arched dorsal margin of the left valve. No other *Bairdoppilata* from the Chalk facies of Europe resembles the outline of this species.

Range. First appears gradually towards the end of the deposition of the nodular chalks of the Lower Turonian, becomes established in the Middle and Upper Turonian.

Bairdoppilata cf. **B. limburgensis** (van Veen, 1934) Pl. 7, figs 3, 4

cf. 1934 *Bairdia limburgensis* nov. spec.; van Veen, p. 115, pl. 6, figs 10-18.

Material. 19 specimens; 14LV, ?5RV.

Measurements. IJS20/13, LV 975 - 645 - 325

IJS20/14, RV 890 - 550 - 190

Description. Few specimens and no carapaces have been recovered, therefore it is not possible to unequivocally allocate right valves to the left valves, so only the left valve will be described here.

Left valve dorsal margin moderately high arch with maximum height at mid-length. Anterodorsal margin straight, posterodorsal margin strongly convex. Anterior margin narrowly rounded, merging into convex ventral margin. Narrow caudal process distinct, just below mid-height, with a weak concavity ventrally and a stronger concavity dorsally. Valve inflation is even with maximum just behind mid-length.

Calcified inner lamella wide posteroventrally and at anterior. Dorsal hinge bar is short. Auxiliary bairdoppilatan dentition not observed.

Remarks. The shape of the left valve strongly resembles *Bairdoppilata limburgensis* (van Veen, 1934) from the Maastrichtian of south Limburg, but without right valves the identification is only tentative. *Bairdoppilata pseudoseptentrionalis* Mertens, 1956 from the Upper Albian and Cenomanian of north-west Germany also has a convex posterodorsal margin in the left valve, but that species is distinguished by the caudal process at mid-height without a ventral concavity, and a straighter ventral margin. *Bairdoppilata southerhamensis* Weaver, 1982 from the Cenomanian of southern Britain is very similar but has a more elongated caudal process, an anteroventral angle and a less convex posterodorsal margin in the left valve.

Range. First appears 2m below the Southerham Marls, Upper Turonian, *T. lata* Zone, and occurs rarely throughout the remaining Turonian.

Genus NEONESIDEA Maddocks, 1969

Type species. By original designation; *Triebelina schulzi* Hartmann, 1964, p. 44, pls. 4, 5, figs 14-22.

Diagnosis. Carapace elongate to subtriangular, thinly calcified. Surface generally smooth or with fine punctae. Marginal denticulation may be present. Hinge bar may be finely serrate, auxiliary bairdoppilatan dentition is absent. Muscle scars consist of four zigzag rows of two elongate or wedge-shaped scars; three rows are horizontal, one is an inserted wedge.

Subgenus MADDOCKSIA Pokorný, 1980a

Type species. By original designation; *Nesidea vinicensis*, Šulc, 1932, p. 5, fig. 1; from the Upper Turonian of the Czech Republic.

Diagnosis. Anteroventral and posteroventral margins of both valves denticulate, more numerous in the right valve.

Remarks. Erected to encompass those species which Maddocks (1969) suggested may represent a new taxon in either *Neonesidea* or *Paranesidea*. Ranges from the Upper Cretaceous to the Recent.

Neonesidea (Maddocksia) denticulata (Marsson, 1880) Pl. 7, figs 5, 6

* 1880 *Bairdia subdeltoidea* (Münster), var *denticulata* n. var.; Marsson, p. 35, pl. 2, figs 9a, b.

pars 1966 *Bairdia denticulata* Marsson, 1880; Herrig, p. 759, pl. 9, figs 1-10, pl. 43, figs 7, 8, pl. 44, fig. 10, *non* pl. 10, figs 1, 3 [= *N. (M.) dentifera* (Veen)], pl. 10, fig 2 [= *N. (M.) vinicensis* (Šulc)].

Type specimens. Lectotype, designated Herrig (1966), 1 female right valve, catalogue no. II/1 in the Marsson collection, Zentrales Geologisches Institut, Berlin. Paralectotypes: 2 female carapaces, 8, female RV, 2 male RV, 2juv RV, cat. nos. II/2-14.

Material. 102 specimens; 67LV, 35RV, 1car.

Diagnosis. High arched dorsal margin with near symmetrical sloping of the anterodorsal and posterodorsal margins towards the baseline. Convex ventral margin in left valve. Straight posterodorsal margin, straight to concave anterodorsal margin. Height/length ratios of near 0.65 for right valves, 0.72 for left valves.

Measurements.	IJS20/17, LV	910 - 560 - 250
	IJS20/18, RV	820 - 600 - 260

Description. Left valve has a high arched dorsal margin, the posterodorsal margin is convex in its upper part and straight below which descends at an angle of 48° The anterodorsal margin is straight and makes an angle of 38° The anterior extremity lies below mid-height, but above the posterior extremity, the anterior margin is openly rounded. Ventral margin straight with a weak concavity at mid-length. Caudal process blunt at one-third height. Valve is strongly inflated medially with stronger compression at the posterior than at the anterior. Calcified inner lamella broad at anterior and anteroventral margins. Marginal denticles more prominent posteroventrally. Juvenile left valves are of similar shape but tend to have a concave anterodorsal margin, and an angular, rather than smoothly convex posterodorsal margin. The marginal denticles are seen much more clearly in the juveniles. They occur from the anterior extremity, to about halfway round the anteroventral margin, and along the posteroventral margin, below the caudal process.

Right valve with asymmetric hexagonal shape. Centrodorsal margin 35% length of valve, sloping down weakly towards the posterior. Straight anterodorsal margin slopes at 40° down to anterior extremity below mid-height, straight posterodorsal margin slopes at 45° down to a weak concavity above the caudal process. The evenly curved posteroventral margin bears approximately fourteen denticles. Ventral margin sinuous with strong concavity in front of mid-length. Anteroventral margin evenly curved bears approximately twelve denticles.

Calcified inner lamella broad posteroventrally and anteriorly, with vestibules.

Remarks. Herrig (1966) included *Bairdia aculeata* Bonnema [= *N. (M.) vinicensis* Šulc], and *N. (M.) dentifera* (Veen) within this species, describing them as "negative variants" of *Bairdia denticulata*. Length height measurements and observation of differences in outline allow these to be distinguished as separate species. *N. (M.) dentifera* is more elongate than *N. (M.) denticulata* and has a distinct convexity in the posterodorsal margin in both valves. *N. (M.) vinicensis* is also more elongate, with asymmetrically sloping distal dorsal margins, the caudal process is also better developed.

Range. Rare in the Lower Turonian, more common in the lower part of the Middle Turonian and the upper part of the Upper Turonian, rare between the Southerham Marls and the Kingston Nodular Chalks. Reported from the Campanian and Maastrichtian of Germany (Marsson 1880; Herrig 1966)

Neonesidea (Maddocksia) vinicensis (Šulc, 1932) Pl. 7, figs 7, 8

* 1932 *Nesidea vinicensis* n. sp.; Šulc, p. 5, 8, fig. 1.

1940 *Bairdia aculeata* nov. spec.; Bonnema, p. 108, pl. 3, figs 9-14.

pars 1966 *Bairdia denticulata* Marsson, 1880; Herrig, p. 759, pl. 10, fig. 2, *non* pl. 10, figs 1, 3 [= *N. (M.) dentifera* (Veen)], pl. 9, figs 1-10 [= *N. (M.) denticulata*].

1980a *Neonesidea (Maddocksia) vinicensis* (Šulc, 1932); Pokorný, p. 55, fig. 1, pl. 1, figs 1, 2.

Neotype. Selected Pokorný (1980a, pl. 1, fig. 1), a carapace no. PFUK 0-604; from Vinice Hill, near Kolín, Czech Republic. Housed in the Dept. of Palaeontology, Charles University, Prague.

Material. 147 specimens; 76LV, 67RV, 4car.

Diagnosis. Straight posterodorsal margin in both valves, with a weak concavity near the caudal process. Sinuous ventral margin in right valve, convex in left. Height/length ratio near to 0.54 in right valves, 0.58 in left valves.

Measurements.	IJS20/15, RV	870 - 490 - 210
	IJS20/16, LV	830 - 510 - 240

Description. Carapace elongate, subhexagonal. Right valve has greatest height in front of mid-length. All three sections of the dorsal margin are straight. Centrodorsal margin slopes down at about

12° and makes up 31% of the valve length. Posterodorsal margin slopes more steeply than anterodorsal. Caudal process is acute at one-third height. The posteroventral margin carries 14-15 small denticles which are very well developed in juvenile stages. Ventral margin is concave centrally and has a distinct anteroventral process. Anteroventral margin is evenly rounded and carries 10-12 denticles.

Left valve has greatest height in front of mid-length, dorsum is gently arched, merging into a straight anterodorsal margin, and a posterodorsal margin which has a weak convex angle in its upper part and a weak concavity above the caudal process. Anterior margin narrowly rounded at mid-height, more openly rounded as it merges into the anteroventral margin. Anteroventral denticles not well preserved, but appear to be fewer in number than on the right valve. Ventral margin convex anteriorly, straight behind. Short posteroventral margin beneath caudal process carries six denticles, which are more stout than those in the right valve.

Carapace in dorsal view shows uneven inflation; the left valve has a full even inflation while the right is more compressed, with a distinct angle at maximum inflation about mid-length. Calcified inner lamella broad at anterior with vestibule. Other internal features not seen.

Remarks. Although it was not included in his synonymy list, Pokorný (1980a) considered *N. (M.) aculeata* (Bonnema, 1940) to be conspecific with *N. (M.) vinicensis*, based on height/length ratios. Pokorný then suggested that due to differences in the curvature of the centrodorsal and centroventral margin, there may be a separation at subspecific level. The present author believes these features are within allowable intraspecific variation and therefore considers *N. (M.) aculeata* (Bonnema, 1940) to be a junior synonym.

Neonesidea (M.) vinicensis is more elongate than *N. (M.) denticulata* and does not have the concave anterodorsal margin. Herrig

(1966) included some elongate specimens within *Bairdia denticulata* referring them to juvenile stage 8, but comparison with his figures of instar 8 (Herrig 1966, pl. 10, figs 4, 5) shows the height/length ratio to be in accord with *N. (M.) vinicensis*.

Range. First occurs in at Sample ABCMR1 at the base of the Turonian at Abbots Cliff, found throughout the overlying Turonian of the sections studied. Also occurs in the Turonian to Santonian of Bohemia and The Netherlands (Pokorný 1980a), and the Campanian of northern Germany (Herrig 1966).

Subfamily BYTHOCYPRIDINAE Maddocks, 1969

Diagnosis. Carapace thin, reniform shape, smooth; hinge weak; adductor scars arranged in an anterior row of three horizontal scars and one posteroventral scar, scars may be divided but not separated.

Genus BYTHOCYPRIS Brady, 1880

Type species. By original designation; *Bythocypris reniformis* Brady, 1880, p. 46, pl. 5, figs 1a-l; from north of St. Thomas Island, in the Caribbean, at 390 fathoms.

Diagnosis. Carapace smooth, outline oblong to subreniform. Left valve larger than right. Hinge adont. Muscle scars in an anterior row of three horizontal scars, plus one posteroventral scar, all may be divided but not separated.

Bythocypris brownei Jones & Hinde, 1890 Pl. 8, figs 1, 2

* 1890 *Bythocypris brownei* Jones & Hinde; p. 13, pl. 3, figs 38-39, ?42-43.

1996 *Bythocypris brownei* Jones & Hinde, 1890; Slipper, p. 52, pl. 1, fig. 2.

Type specimens. Jones & Hinde's original specimen is located in the NHM under IO 358, and should be designated as a lectotype; from the Chalk Rock (Upper Turonian) of Dunstable.

Material. 58 valves and carapaces, many are crushed; 17LV, 27RV, 14 car.

Diagnosis. Strongly concave ventral margin in the centre of the valves. Right valve with dorsal angle in front of mid-length, left at one-third length. Strong posterodorsal cardinal angle, which enlarges that part of the valve.

Measurements.	IJS7/4, LV	750 - 425
	IJS7/5, RV	750 - 400

Description. Outline reniform, valves strongly compressed. Dorsal margin in right valve has maximum height in front of mid-length at a distinct angle. The straight anterodorsal margin slopes down to the anterior cardinal angle, the longer posterodorsal margin slopes down equally to the posterior cardinal angle. The posterior margin bends downward from the angle to the maximum extremity at two-fifths height. Posterior margin narrowly rounded. Ventral margin strongly concave centrally. Anterior margin almost semi-circular, extremity just below mid-height.

The larger left valve has a long straight dorsal margin, maximum height at one-third length at the anterior cardinal angle. The posterodorsal margin curves down as in the right valve. Ventral margin is concave centrally, but not as strongly as in the right valve. Juvenile stages are generally more equant, left valves are more rounded dorsally, right valves have similar shape to adults.

Calcified inner lamella broad at anterior and posterior with vestibules, the anterior vestibule is narrow dorsally and ventrally but is wider at the anteroventral corner. Muscle scars not seen.

Hinge in left valve is a narrow groove at the valve margin, which is folded down below the dorsal margin particularly at the posterior.

Remarks. Distinguished from *Bythocypris* sp. B by the greater development of the posterodorsal margin, particularly in the right valve; futhermore, its ventral concavity is positioned closer to the centre of the valve. *Bythocypris* sp. A *sensu* Weaver (1982) from the Upper Cenomanian is similar but is more elongate, has a straighter ventral margin in the left valve and a less concave ventral margin in the right valve; the posterior termination in the Cenomanian species is more acute. *Bythocypris chapmani* Neale, 1975 from the Santonian of western Australia can be distinguished by its concave anterodorsal margin in the right valve.

Range. Found rarely throughout the Turonian, from the base of the stage at Abbots Cliff, to the base of the overlying Coniacian at Langdon Stairs. However, it occurs in great abundance in one sample AKSD17 1m above Round Down Marl, Middle Turonian.

Bythocypris sp. B Pl. 8, fig. 3

Material. 10 specimens; 2LV, 6RV, 2 car.

Measurements. IJS19/25, RV 1050 - 520 - 220

Description. Elongate bairdiid shape. Dorsal margin of right valve has maximum height at a distinct angle just in front of mid-length. Straight antero-, centro- and posterodorsal margins. Anterior margin openly rounded, extremity at one-third height. Posterior margin very narrowly rounded, extremity on a level with anterior. Ventral margin sinuous, with a strong concavity beneath the point of maximum height.

Left valve only known from a juvenile stage; dorsal margin has point at maximum height in front of mid-length, anterodorsal margin straight, but the posterodorsal margin curves down to the posterior extremity. Ventral margin is straighter than in the right valve.

Calcified inner lamella broad at the anterior and posterior with vestibules. The fused area is broader at the anterior. About ten straight marginal pore canals at the anterior, about seven shorter, straight marginal pore canals at the posterior

Remarks. The Cenomanian *Bythocypris* sp. A *sensu* Weaver (1982) is very similar but has an elongate centrodorsal margin in the right valve, placing the point of maximum height at one-third length. The caudal process in *B.* sp. B herein is more elongate in the right valve; the left valve is also slimmer with a less pronounced posterodorsal margin. *Bythocypris chapmani* Neale, 1975 from the Santonian of Western Australia can be distinguished by its concave anterodorsal margin in the right valve.

The outline of *Bythocypris* sp. B is very similar to the Recent species *Bythocypris elongata* Brady, 1880, as figured by Maddocks (1969), but the ventral margin is slightly more concave, and the dorsal margin has a distinct angle in front of mid-length

Range. Restricted to the Upper Turonian, *S. plana* Zone, its first appearance is just below the Bridgewick Hardgrounds.

Genus PONTOCYPRELLA Mandelstam in Ljubimova, 1955

Type species. By original designation; *Cythere (Bairdia) harrisiana* Jones, 1849, p. 25, pl. 6, figs 17a-f; from the Cretaceous of Britain.

Diagnosis. Elongate reniform with arched dorsal margin and straight to weakly concave ventral margin. Left valve larger than right. Hinge adont, dorsal margin of right valve locates in a groove in left valve dorsal margin. Bythocypridine muscle scar pattern.

Remarks. The genus *Pontocyprella* was originally described and illustrated by Ljubimova (1955) who stated the author as Mandelstam. However, Mandelstam's (1956) description appeared after Ljubimova (1955); the type species she selected was *Bairdia harissiana* [*sic*] Jones. Originally placed in the subfamily Pontocypridinae on account of its similarity in form to *Pontocypris*, *Pontocyprella* has been assigned variously to: the Bairdiidae (Kaye 1965a; Van Morkhoven 1963; Babinot 1973), the Paracypridinae (Swain 1961, 1978; Dingle 1981) and the Pontocyprididae (Colin *et al*. 1982; Weaver 1982; Majoran 1989). Neale (1962) placed *Pontocyprella* within the Cyprididae, Pontocypridinae, on account of the muscle scar pattern being more allied to the Cyprididae rather than the Bairdiidae. Weaver (1982) places *Pontocyprella* in the Pontocyprididae, yet questions Hartmann & Puri (1974) who group *Pontocyprella* with *Argilloecia*, which itself belongs to the Pontocyprididae. As noted by Weaver (1982), the muscle scar pattern has not been observed in the type species, but the author's own observations on the closely related *Pontocyprella robusta* Weaver, 1982, from the Cenomanian Plenus Marls, agree with the muscle scar pattern as described by Weaver (1982) for *P. robusta* and *Pontocyprella hindei* Weaver, 1982, the illustrations given by Kaye (1965a) for *Pontocyprella semiquadrata* and the photographs and diagram by Dingle (1985) of *Pontocyprella nibelaensis* Dingle, 1985: an anterior row of three elongated scars, plus one behind and slightly below the central scar. This is the bythocypridine muscle scar pattern as illustrated by Maddocks (1969). Taken together with the valve overlap, the hinge type and the general valve shape, especially comparing *Bythocypris prolata* Maddocks, 1969 with *Pontocyprella harrisiana* (Jones, 1849) and *Bythocypris reniformis* Brady, 1880 with *Pontocyprella robusta* Weaver, 1982, it would appear that *Pontocyprella* is more closely related to *Bythocypris*, than to *Pontocypris*, and is here regarded as belonging in the Bairdiidae, Bythocypridinae.

Pontocyprella harrisiana (Jones, 1849) Pl. 8, figs 4, 5

* 1849 *Cythere (Bairdia) Harrisiana nobis*; Jones p. 25, pl. 6, figs 17a-f.

non 1854 *Cytheridea Harrisiana* Bosquet, 1853; Bosquet, p. 63, pl. 5, figs 5a-d [= *Bythocypris veeni* Howe & Laurencich, 1958].

1870 *Bairdia Harrisiana* (Jones); Jones, p. 75, 77.

non 1874 *Bairdia Harrisiana* Jones; Reuss, p. 141, pl. II. 26, figs 6a-c, 7.

1890 *Bairdia Harrisiana* Jones; Jones & Hinde, p. 8, pl. 2, figs 52-55 [cop. Jones (1849), introduced errors].

?1929 *Bairdia harrisiana* Jones; Alexander, p. 60, pl. 2, figs 18, 19 [anteroventral margin too truncate].

1955 *Pontocyprella harrisiana*; Ljubimova, p. 30, fig. 3 [cop. Mandelstam].

1962 *Pontocyprella harrisiana* (Jones); Neale, p. 431, pl. 6, figs 12a, b, 13a, b.

non 1965 *Pontocyprella harrisiana* (Jones, 1849); Kaye, p. 73, 74, pl. 5, figs 3, 4.

1982 *Pontocyprella harrisiana* (Jones, 1849); Weaver, p. 29, pl. 4, figs 17-20.

Lectotype. Selected Weaver, 1982, p. 29, pl. 4, fig. 20; NHM In51624, a right valve; figured Jones, 1849, pl. 6, fig. 17d; from the chalk detritus at Charing.

Material. 132 specimens; 52LV. 78RV, 2car.

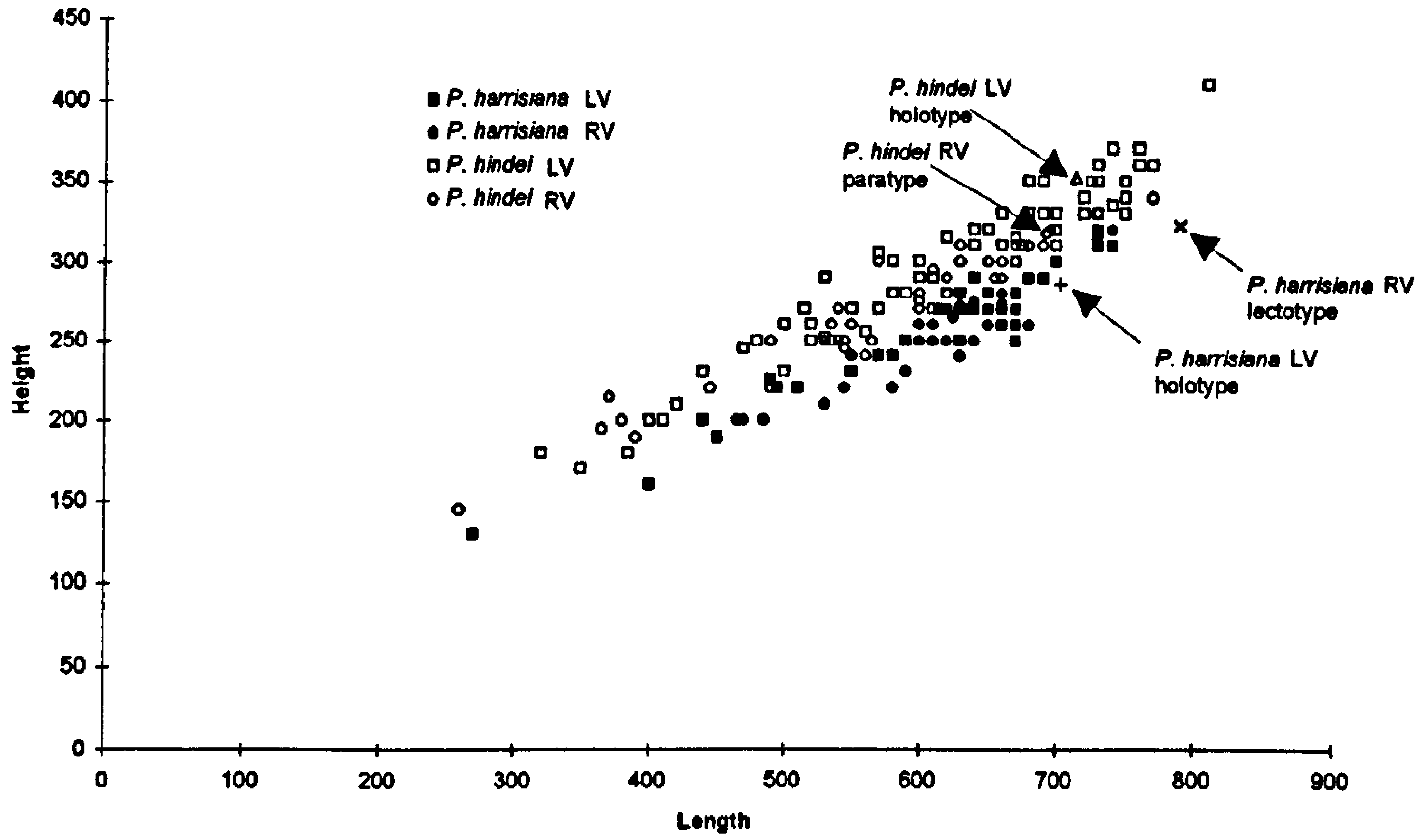
Diagnosis. Very elongate species of *Pontocyprella* with anterior extremity above mid-height; posterior end drawn out and bluntly pointed.

Measurements.	IJS7/2, LV	643 - 318
	IJS7/3, RV	643 - 293

Description. Carapace elongate, dorsal margin of left valve gently arched, right valve has a weak angle at mid-length. Anterior margin truncate anteroventrally, posterior margin narrowly rounded. Ventral margin is straight or has a weak concavity in the left valve, which is more pronounced in the right valve. The ventral margin rises up just in front of the posterior.

Remarks. Similar in outline to *Pontocyprella hindei* Weaver, 1982 but is much more elongate (Text-fig. 4.2). In *P. hindei* left valves the H/L of the holotype is 0.49 and the average of 68 measurements in the Turonian gives 0.48; similarly for right valves the paratype is 0.46, while 51 measurements give 0.47. In *P. harrisiana* the equivalent data are: LV Turonian = 0.42, n=34. RV lectotype = 0.41, RV Turonian = 0.42, n=43.

Range. Although found in the underlying Cenomanian (Weaver 1982), this species is rare in the Lower Turonian, but becomes more common in the Middle and Upper Turonian. The youngest specimens were recovered from the lowest of the Kingston Nodular Chalks at Langdon Stairs.



Text-fig. 4.2 Length/height plot for valves of *P. harrisiana* and *P. hindei*, including the type specimens; assemblages from 24 samples through the Turonian at Dover, Kent.

Pontocyprella hindei Weaver, 1982 Pl. 8, figs 6, 7

1966 *Pontocyprella rara* Kaye; Gründel, p. 16, pl. 2, figs 5, 6, pl. 9, fig. 1.

* 1982 *Pontocyprella hindei* Weaver, p. 30, pl. 4, figs 15, 16.

1996 *Pontocyprella hindei* Weaver, 1982; Slipper, p. 52. pl. 2, fig. 4.

Type specimens. Holotype. BM OS9504, left valve (Weaver, 1982, pl. 4, fig. 15). Paratypes: BM OS9506-14, 9 valves; from 13.5m below the Plenus Marls, Upper Cenomaian, Bluebell Hill, Kent.

Material. 293 specimens; 157LV, 123RV, 13car.

Diagnosis. Evenly convex dorsal margin and straight ventral margin in the right valve. Posterior bluntly rounded, anterior end obliquely rounded above mid-height in the right valve, at mid-height in the left valve.

Measurements. IJS19/24, RV 690 - 320 - 130

IJS19/23, LV 690 - 335 - 160

Description. Carapace compressed, elongate ovate with larger left valve overlapping right around the margin except for the posterior extremity. Greatest height at mid-length. Weak inflation is at a maximum behind mid-length. Dorsal margin of left valve evenly arched, of right with a distinct central angle, convex behind, and straight to concave in front. Anterior margin truncate anteroventrally. Ventral margin straight to weakly concave in the left and more strongly concave in front of mid-length in the right. Posterior narrowly rounded, below mid-height. Males are more elongate, and have a sharper termination to the posterior extremity.

Calcified inner lamella very broad at anterior runs parallel with anterior margin, wide vestibule, moderate fused margin, narrower at the posterior with small vestibule. Even the best preserved specimens have suffered too much recrystallisation to allow for the observation of muscle scars. Hinge consists of a very narrow groove on the dorsal edge of the right valve and a wider groove which runs along posterodorsal edge in the left valve.

Remarks. The specimen illustrated by Slipper (1996) is of a male right valve with a greater elongation and sharper posterior termination. *Pontocyprella* sp. *sensu* Colin *et al.* (1982), from the Upper Cenomanian of northern Spain, has a more truncate posterodorsal margin. *Pontocyprella* sp. *sensu* Babinot (1973), from the Turonian of southern France, is more elongate.

Range. Found throughout the Turonian in all sections studied. Reported from the Cenomanian of southern England (Weaver 1982) and the Albian and Cenomanian of Germany (Gründel 1966).

Pontocyprella robusta cometa ssp. nov. Pl. 8, figs 8, 9;
Pl. 24, fig. 8

Name. After the comet Hale-Bopp, in the sky at the time of writing.

Holotype. LV IJS19/19, sample LGSD28, beneath Navigation Hardground 3, Upper Turonian, *S. plana* Zone; from Langdon Stairs, Dove, Kent.

Material. 24 specimens; 11LV, 8RV, 5 car.

Diagnosis. A large *Pontocyprella* with high arched dorsal margin. Left valve with weak dorsal cardinal angles and weakly concave ventral margin; posterodorsal margin of right valve truncate.

Measurements.	IJS19/19, LV	740 - 400 - 200
	IJS19/20, RV	720 - 310 - 150

Description. Carapace large and well calcified, left valve larger than right, greatest height at mid-length, maximum width at or just behind mid-length. Dorsal margin of left valve tripartite; anterior segment short, straight, bends at two-sevenths length to gently arched central segment, bends at two-thirds length to more strongly curved long posterior segment which is continuous to the posterior extremity at one-sixth height. Posterior margin is acutely rounded. Dorsal margin of right valve has a long straight anterodorsal segment angled down from the point of maximum height to the anterior cardinal angle. The posterodorsal margin has a weak angle at six-sevenths length, behind which it is somewhat truncate. Ventral margin of right valve strongly concave in front of centre, left valve only very weakly so.

Calcified inner lamella broad, particularly at the anterior, no vestibules seen.

Remarks. Very similar in outline to *Pontocyprella robusta robusta* Weaver, 1982, but stratigraphically separated by nearly the whole of the Turonian Stage. *Pontocyprella robusta cometa* ssp. nov. has a more sharply angled posterior extremity in the left valve, and it lacks the weak concavity in the anterodorsal margin of the right valve. The left valve of *P. robusta cometa* is lower and more angulated, whereas *P. robusta robusta* is very smoothly arched. The ventral margin of *P. robusta cometa* is weakly concave whereas in the nominate subspecies it is straight. The latter also is slightly higher in relation to its length in the left valve; H/L LV = 0.58, *P. robusta cometa* LV = 0.54.

Range. First appearance at the end of the Upper Turonian, 1m below Navigation Hardground 1, *S. plana* Zone. This species has been found by the author in the Coniacian at Langdon Stairs and the Santonian from Pinden Quarry, Kent.

Pontocyprella? bosquetiana (Jones, 1849) Pl. 8, fig. 10, Pl. 9, fig. 1

* 1849 *Cythere (Cytherella) (?) bosquetiana, nobis*; Jones, p. 33, pl. 6, figs 23a-c.

1870 *Cythere bosquetiana* (Jones); Jones, p. 76, 77.

1890 *Cythere ? bosquetiana* (Jones); Jones & Hinde, p. 15, pl. 2, figs 35-37.

1982 *Pontocyprella ? bosquetiana* (Jones, 1849); Weaver, p. 31, pl. 5, figs 3-5.

Holotype. BM In 51594 carapace; figured Jones, 1849, pl. 6, figs 23a-c; from the chalk detritus at Charing.

Material. 6 specimens; 4LV, 2RV.

Diagnosis. Small subquadrate outline with broadly rounded anterior and posterior extremities.

Measurements.	IJS19/18, RV	635 - 300
	IJS19/17, LV	670 - 340

Description. Carapace elongate, subrectangular. Left valve larger than right, strongly compressed with maximum width just behind mid-length, maximum height at mid-length. Dorsal margin is gently arched with a weak central angle. The anterior cardinal angle is well marked, but rounded. The anterior margin is truncate, angled dorsally, but rounded anteroventrally. Ventral margin weakly concave, indentation is greater in the right valve at mid-length. The posterior margin is bluntly rounded with the extremity at or just below mid-height, slightly truncate posteroventrally and more rounded posterodorsally.

Wide calcified inner lamella at anterior is broadest anteroventrally without vestibule. Hinge is adont. Muscle scars not observed.

Remarks. The generic assignment is provisional until more details on the internal features can be ascertained. There is the possibility that it may prove to belong to *Anchistrocheles*, based upon the strong compression, the valve outline and the broad fused area of the calcified inner lamella.

The Upper Hauterivian *Pontocyprella mandelstami* Kaye, 1965 has a more pointed posterior, and rounded dorsal margin. There are similarities with *Pontocyprella semiquadrata* Kaye, 1965a from the Albian, but that species is less elongate.

Range. Reported from the Lower to the Upper Cenomanian of southern England (Weaver 1982). It is first recorded here at the base of the Middle Turonian at Abbots Cliff; its last occurrence is 2m above New Pit Marl 2, Middle Turonian.

Superfamily CYPRIDACEA Baird, 1845

Diagnosis. (After Athersuch *et al.* 1989) Carapace usually thin shelled, smooth or faintly sculpted, rarely noded or sulcate; variable in shape and size; overlap variable. Hinge simple, adont or merodont. Inner lamella always well-developed with deep vestibules. Muscle-scars variably arranged in a cluster, rarely in vertical rows.

Family CYPRIDIDAE Baird, 1845

Subfamily PARACYPRIDINAE Sars, 1923

Diagnosis. Laterally compressed carapace with length more than twice the height. Strongly calcified, surface smooth or weakly ornamented. Greatest height in front of mid-length. Left valve larger than right. Many marginal pore-canals, usually long and branched.

Remarks. The subfamily Paracypridinae has been placed in the families Cyprididae (van Morkhoven 1963; Kaye 1965a; Damotte 1971a; Maddocks 1990, 1992) and Candonidae (Athersuch *et al.* 1989). It has also been elevated to family level (Swain 1961; Weaver 1982; Dingle 1981, 1985; Witte *et al.* 1992; Wakefield 1994). The assignment to Candonidae is dependent on the similarity of the muscle-scar field of the two groups (Athersuch *et al.* 1989), and while there are similarities, the two are distinct (Maddocks 1992).

There is some confusion as to the description of the muscle-scar pattern for Paracypridinae (van Morkhoven 1963, p. 6) where the pattern is compared to the Candoninae "anterior row of three and a posterior row of two", and that of *Paracypris* (van Morkhoven 1963, p. 80), where the pattern is contrasted with that of the Candoninae, "but with two scars in the anterior, and three in the posterior row". This appears to be a result of the inverted orientation of the redrawn illustration of *Paracypris* from Sars (1923; see van Morkhoven 1963, p. 80, fig. 111). The similarity in the muscle-scar pattern to that of the Candonidae is not thought to be sufficient justification for the Paracypridinae to be included in that family. The upper scar in the Candonidae is not as elongate as that in the Paracypridinae, and in this respect more similarity is seen with the Cypridinae (Maddocks 1990, p. 13, fig. 1). The same general pattern of one scar above, three anterior and two posterior can also be seen in other subfamilies of the Cyprididae: namely the Scottinae, Cyproidinae, Eucypridinae, Herpetocypridinae and Dolerocypridinae (Henderson, 1990).

Maddocks (1992) in her review of the subfamily Paracypridinae has used soft parts to place Recent species into three informal tribes, the Paracypridini, Renaudcypridini and Thalassocypridini; with so few features available in the fossil material, it is unwise to use these divisions here. Taking into account other factors such as the overall shape with the greatest height towards the anterior and the differences in the marginal areas, particularly the branched nature of the marginal pore canals, the author prefers to retain the Paracypridinae at subfamily level. Athersuch *et al.* (1989, p. 62) state the overlap incorrectly as right valve larger than left.

Genus PARACYPRIS Sars, 1866

Type species. By original designation; *Paracypris polita* Sars, 1866, p. 12; from the Recent of Norway.

Diagnosis. Carapace elongate, subtriangular, tapering posteriorly. Left valve larger than right. Ventral margin concave. Maximum width and height in front of middle. Wide calcified inner lamella with broad zone of concrescence crossed by branching marginal pore canals, deep anterior and posterior vestibules. Hinge adont, the dorsal margin of the right valve locates in a groove in the left valve dorsal margin. Adductor muscle scars in an anterior curved row of three, two posterior and one larger cap scar. Two mandibular scars and one small frontal scar (Maddocks 1988).

Paracypris siliqua Jones & Hinde, 1890 Pl. 9, fig. 2

1875 Paracypris gracilis; Jones, pp. 79, 81.

* 1890 *Paracypris siliqua* sp. nov.; Jones & Hinde, p. 2, pl. 2, figs 48, 49, 51, pl. 3, figs 33, 34.

pars .1940 *Paracypris jonesi* nov. spec.; Bonnema, p. 115, pl. 3, fig. 26, *non* pl. 3, figs 24, 25, 27.

1961 *Paracypris siliqua* Jones & Hinde, 1890; Neale, p. 194, pl. 7, figs 1a, b, 2a, b (q.v. for full synonymy).

1996 *Paracypris* sp. A; Slipper, p. 52, pl. 1, fig. 3.

Type specimens. Two syntypes; right valves from Horstead, Norfolk NHM In 19297-304a, b.; illustrated by Neale (1961, pl. 7, figs 1a, b, 2a, b).

Material. 65 specimens; 29LV, 35RV, 1juv. car.

Diagnosis. Marked concavity in the centre of the ventral margin, slight upturn at the posteroventral margin. Dorsal margin of right valve in three sections with maximum height at anterodorsal cardinal angle at 30% of length, left dorsal margin evenly curved.

Measurements. IJS19/16, LV 730 - 310 - 130

Description. Carapace elongate, tapering posteriorly. Anterior margin rounded with the anterior extremity at mid-height. Dorsal margin in the left valve is evenly convex, while the right valve dorsal margin has three segments; the anterodorsal margin is short and straight to weakly concave with distinct angles at both ends, the anterodorsal cardinal angle is at maximum height at 30% of the length; the long centrodorsal margin is straight to weakly convex, it bends into the posterodorsal margin which is mostly straight, but with a weak concavity towards the posterior. Posterior extremity at one-fifth height, the taper is shortened at the tip. There is a strong ventral concavity in the centre of the ventral margin in both valves, but is better developed in the right valve. In dorsal view the valves have a weak inflation which is evenly curved from anterior to posterior, the maximum width is in front of mid-length.

Calcified inner lamella broad at anterior and posterior. Anterior vestibule very broad at anterior, fused zone broad anteroventrally. Hinge structures absent.

Remarks. Neale (1961) gives a synonymy of this species and discusses it fully. *Paracypris acuta* (Cornuel, 1848) from the Hauterivian is shorter, has the posterodorsal angle in the left valve further back, and lacks the concavity in the right valve. The Albian *Paracypris wrothamensis* Kaye, 1965a is more elongate, has a less concave ventral margin and has a much sharper posterior termination. The Cenomanian form *Paracypris* aff. *wrothamensis* Kaye, 1965a *sensu* Weaver (1982) is more elongate than the these Turonian specimens and also has a sharper posterior termination. Weaver (1982) notes that the ventral concavity is marked in the right valve in the Cenomanian forms; this is more so in *Paracypris* sp. A. There appears to be a gradation of morphological change from the Albian to the Turonian forms; reduction in elongation and degree of acuity of the posterior termination, an increase in the degree of concavity in the ventral margin. *Paracypris gracilis* Bosquet, 1854 from the Maastrichtian of Limburg is much more slender and elongate. *Paracypris jonesi* Bonnema, 1940 has a more rounded anterior margin and lacks the angled anterodorsal cardinal angle. *Paracypris depressa* Bonnema, 1940 differs by being larger, having the maximum height further back, a greater height relative to length, and by lacking the ventral concavity.

Range. *Paracypris siliqua* first appears near the *Roveacrinus communis* bed 2, above the Lulworth Marl, Lower-Middle Turonian boundary at Abbots Cliff, Dover, and occurs throughout the sections studied. First described from the Campanian of Ireland; also found in the Campanian of Norfolk (Jones & Hinde 1890).

Paracypris cf. **P. depressa** Bonnema, 1940 pl. 9, figs 3, 4

cf. 1940 *Paracypris depressa;* Bonnema p. 115, pl. 3, figs 30, 31.

Material. 11 specimens; 7LV, 4RV.

Measurements. IJS19/14, LV 915 - 390 - 130
IJS19/15, RV 880 - 380 - 170

Description. Carapace elongate, with maximum height at two-fifths length. Dorsal margin has three distinct sections in both valves; anterodorsal margin straight to weakly convex merges into rounded anterior margin, centrodorsal margin slopes gently down towards the posterior, posterodorsal margin slopes more steeply and has a weak concavity above the posterior termination. Acute posterior extremity nearer the ventral margin in the right valve. Ventral margin sinuous, weak concavity in the left valve, better developed in the right, both are behind mid-length; ventral margin turns upwards towards the posterior extremity. In dorsal view the valves are moderately inflated with a weak angulation at the position of maximum width just in front of mid-length.

Calcified inner lamella very broad at anterior and posterior with wide vestibules and narrow fused zone.

Remarks. Bonnema (1940) only recovered three left valves of *Paracypris depressa*, he gave no description and only an illustration of a left valve and dorsal view of the same. He contrasted it with *Paracypris limburgensis* Veen, 1934, which has a more angled dorsal margin. *Paracypris depressa* is also similar to *Paracypris umzabaensis* Dingle, 1969, from the Santonian to Maastrichtian of South Africa, but that also has an angled dorsal margin. *Paracypris siliqua* is distinguished by its smaller height/length ratio and greater ventral concavity.

Range. First appearance at lowest of the New Pit Marls, Middle Turonian, *T. lata* Zone, where the sedimentation changes from nodular chalks to white chalks with marls, sporadic occurrence throughout the remaining Turonian.

Family MACROCYPRIDIDAE Müller, 1912

Diagnosis. (After Maddocks 1990). A cypridacean family with relatively large, elongate, smooth carapace; right valve larger than left, overlapping anterodorsally, posterodorsally, and ventrally. The hinge is the unique macrocypridid type with five elements which merge into one another; in the right valve are anterior and posterior crenulate platform-grooves, two shorter, thinner, sharp-edged crenulate, arcuate to discoidal, anteromedian and posteromedian teeth, between which is a fairly smooth median bar, the left valve has a complementary set of elements. Adductor muscle scars form the unique macrocypridid pattern of an upper group of three scars in an arcuate row, separated by a diagonal space from a lower group of about nine scars in a diagonally elongated oval. Anterior and posterior vestibules deep, juveniles have a well calcified inner lamella.

Remarks. Maddocks (1990) erected four new genera within the Macrocyprididae in order to rationalise the indiscriminate usage of *Macrocypris* Brady, 1868a. *Macrocypris* is confined to the Holocene, whilst those genera with fossil representatives include *Macromckensia* Maddocks, 1990, *Macropyxis* Maddocks, 1990, *Macrocyprissa* Triebel, 1960, *Macrosarisa* Maddocks, 1990 and *Macrocyprina* Sars, 1923.

Genus MACROSARISA Maddocks, 1990

Type species. By original designation; *Macrosarisa bensoni* Maddocks, 1990, p. 88, figs 12.9, 13.9, 28.31,32, 47.5, 73.9, pls 28.13,14, 29.12-14, 60.8, 61.8, 69.10, 70.5, 71.1,2,4, 73.1,16, 84.3, 91.3,4, 104.6,7; from Atlantis *II* cruise 31 station 159, 7°58.0'°°S, 34°22.0'W, depth 834-939m.

Diagnosis. (After Maddocks 1990) Carapace elongate, with gently arched to angulate dorsal margin; ventral margin concave, straight, or sinuous; anterior margin unevenly rounded to broadly truncate; posterior end acutely tapered to narrowly truncate, often with a slight posterodorsal concavity and a flared, flange-like posterior margin; distinct anteroventral dentiform corner on both valves; medially swollen in dorsal view, with abruptly compressed, flattened or tapering anterior and posterior ends; conspicuous stragulum and very sinuous dorsal line of valve contact; vestibules deep and open; zone of concrescence may be narrow, with short, straight radial pore canals, to fairly broad, with numerous, fairly straight, nearly parallel radial pore canals and occasionally false radial pore canals.

Remarks. Possession of the anterior dentiform corner distinguishes this genus from *Macromckensia*, futhermore, the latter has a truncate or rounded posterior margin, and less tapered distal extremities in dorsal view.

Macrosarisa siliqua (Jones, 1849) Pl. 9, figs 5, 6

* 1849 *Cythere (Bairdia) siliqua* Jones, p. 25, pl. 5, figs 16a-d.

1870 *Macrocypris siliqua* (Jones); Jones, p. 75, 77.

1890 *Macrocypris siliqua* (Jones); Jones & Hinde, p. 9, pl. 2, figs 38-41 [cop. Jones 1849]

non 1934 *Macrocypris siliqua* nov. spec.; Veen, p. 88, pl. 1, figs 1-9 [= *M. limburgensis* Veen, 1936].

1964a *Macrocypris siliqua* (Jones); Kaye, p. 43, pl. 4, figs 11-15, 18.

1982 *Macrocypris siliqua* (Jones); Weaver, p. 28, pl. 4, figs 9, 10.

1988 *Macrocypris siliqua* (Jones); Wilkinson, pl. 3, fig. 5.

. 1990 *Macrosarisa siliqua* (Jones); Maddocks, p. 92, pls 32.5-8, 33.5-8, 72.9.

. 1992 *Macrocypris siliqua* (Jones); Witte *et al.*, p. 50, pl. 2, fig. 11.

. 1996 *Macrocypris siliqua* (Jones, 1849); Slipper, p. 52, pl. 1, fig. 6.

Type material. Lectotype, selected by Kaye 1964a, p. 44, pl. 4, fig. 15; BM In.51617, carapace; figured Jones 1849, pl. 5, fig. 16a; Maddocks 1990, pl. 32, fig. 6, pl. 33, figs 7, 8, from the 'chalk detritus' at Charing, Kent. Paralectotypes, selected by Kaye (1964a, p. 44); BM In51619, BM In51620, fragmentary right valves; figured Jones (1849), pl. 5, figs 16c, d; Maddocks 1990, pl. 32, figs 7, 8, from the Chalk at Gravesend.

Material. 264 specimens; 131LV, 129RV, 4car, mostly fragments.

Diagnosis. Maximum height at mid-length, centrodorsal margin of left valve straight, dorsal margin of right arched with a central angle. Anterior margin bluntly rounded with an anteroventral dentiform corner. Posterior drawn out into a slender point at venter. Ventral margin sinuous with anterior and posterior concavities.

Measurements.	IJS19/13, LV	1187 - 375 - 162
	IJS7/6, RV	1093 - 375

Description. Carapace large, very elongate. moderately well inflated at mid-length in right valve, and just in front in the left valve. Right valve overlaps left around the margin except at the anterior and posterior extremities. Left valve dorsal margin tripartite; anterodorsal margin weakly sinuous with concavities above the anterior angle and below the anterodorsal angle, weakly convex between; centrodorsal margin straight and horizontal, marked posterodorsal angle; posterodorsal margin straight, sloping towards the baseline more strongly than anterodorsal margin, slight concavity above the posterior extremity. Anterior margin bluntly rounded, extremity at one quarter height, anteroventral corner is angular and dentiform. Posterior margin elongate, tapering to a point at the ventral margin. Ventral margin sinuous; distinct concavities behind anterior, and in front of posterior extremities and also just in front of mid-length; weakly convex at one quarter length, broadly convex in the posterior half.

Right valve outline less complex than left. Dorsal margin is evenly arched with an angle at mid-length at the point of maximum height, centrodorsal and anterodorsal margins slope equally away down towards the base line. A posterodorsal angle marks the transition to the straight posterodorsal angle, while the anterodorsal margin merges into the bluntly rounded anterior margin. Angular anteroventral corner is dentiform. Posterior margin tapers to a point, in all specimens this posterior extremity is truncated, which may be function of preservation.

Calcified inner lamella broad at the anterior and posterior.

Remarks. The position of maximum height at mid-length distinguishes this species from *Macrosarisa wrighti* (Jones & Hinde), at two-thirds length, and *Macrosarisa simplex* (Chapman, 1898), at one-third length. It is more elongate than the Cenomanian *Macrosarisa muensteriana* (Jones & Hinde, 1890) and less elongate than the Albian *Macrosarisa exquisita* (Kaye, 1964a) and *Macrosarisa graysonensis* (Alexander, 1929) from the Cretaceous of Texas. *Macrocypris limburgensis* Veen, 1936 from the Maastrichtian of south Limburg is very similar but has a more rounded anterior and a straighter ventral margin.

Range. Common throughout the Turonian in the sections studied. Reported from the Albian and Cenomanian of England (Weaver 1982; Wilkinson 1988), the Lower Cenomanian of The Netherlands (Witte *et al.* 1992), and as high as the Campanian *B. mucronata* Zone of Londonderry (Jones & Hinde 1890; Kaye 1964a).

Macrosarisa wrightii (Jones & Hinde, 1890) Pl. 9, fig. 8

1875 Macrocypris siliqua; Jones, p. 81, 92.

* 1890 Macrocypris Wrightii sp. nov.; Jones & Hinde, p. 10, pl. 2, figs 43, 44.

1964a Macrocypris wrighti Jones & Hinde; Kaye, p. 44, pl. 4, fig. 13.

1990 Macrosarisa wrightii (Jones & Hinde, 1890); Maddocks, p. 94, pl. 32, fig. 15, pl. 33, fig. 16.

Type specimens. Lectotype, designated by Kaye (1964a) LV, Io.1595. Paralectotype, RV, broken, I.2473; from the Upper Chalk of Magee, Antrim, N. Ireland.

Material. 31 specimens; 25LV, 5RV, 1car, mostly juvenile fragments.

Diagnosis. Elongate *Macrosarisa* with greatest height behind mid-length. Anterior one-third narrow. Ventral margin of left valve with a single concavity at one-third length, convex behind. Anterior and posterior dentiform corners.

Measurements. IJS19/12, LV 1125 - 387 - 156

Description. Carapace very elongate, greatest height behind mid-length. Left valve anterodorsal margin long and straight, reaching an angle at, or just behind mid-length; centrodorsal margin short and straight, slopes gently down to the posterodorsal angle; posterior margin tapers to a point. Posterior extremity has a dentiform corner. Anterior margin evenly rounded.

Right valve dorsal margin is angular with a strongly concave long anterodorsal margin, the foremost section is straight, the hindmost is weakly convex. Maximum height at an angle just behind mid-length. Short, gently sloping centrodorsal margin, sharp posterodorsal angle.

Posterior extremity tapers to a point at the ventral margin with a distinct dentiform corner. Anterior margin evenly rounded with a distinct anteroventral dentiform corner, Anteroventral margin straight, concave at one-third length, convex behind.

Internal details not seen.

Remarks. Maddocks (1990) provides good illustrations of the type material, her assignment of *M. wrightii* to the genus *Macrosarisa* was uncertain, since no dentiform corners were observed in the type material. Their observation here allows this species to be referred to *Macrosarisa*. Distinguished from *M. siliqua* by the lack of ventral concavities at anterior and posterior in the left valve, the position of greatest height, a more evenly rounded anterior margin, longer anterodorsal margin and the angular nature of the dorsal margin in the right valve.

Range. First appearance 4m below New Pit Marl 1, *T. lata* Zone, Middle Turonian at Akers Steps; it occurs rarely throughout the overlying Turonian in the sections studied. Also recorded from the Campanian *B. mucronata* Zone of Northern Ireland (Jones & Hinde 1890; Kaye 1964a).

Superfamily CYTHERACEA Baird, 1850

Family BRACHYCYTHERIDAE Puri, 1954

Diagnosis. Large ventrally inflated carapace with ventrolateral ridge or ala; anterior broadly rounded, posterior narrower; subcircular to subtriangular in anterior view; eye tubercle present; surface smooth to reticulate; hinge amphidont with or without accommodation groove; adductor muscle scars in a vertical row of four; broad marginal areas without vestibules; marginal pore canals bulbous in the mid-section.

Remarks. Three genera and one subgenus of this family are represented in the Turonian. *Brachycythere* Alexander, 1933 lacks any marginal ribbing and possesses a ventrolateral ridge rather than an ala. The remaining genera possess distinct alae; *Pterygocythere* Hill, 1955 is distinguished from *Pterygocythereis* Blake, 1933 by more weakly developed marginal ribs, reduced ornament of spines, greater convexity in the left valve, with a large accommodation groove. *Pterygocythereis* (*Pterygocythereis*) is distinct from *Pterygocythereis* (*Diogmopteron*) Hill, 1955 by virtue of the small accommodation groove, valve overlap and stratigraphical range (see remarks for the latter subgenus).

Genus BRACHYCYTHERE Alexander, 1933

Type species. By original designation; *Cythere sphenoides* Reuss, 1854 (*sensu* Alexander 1933), p. 141, pl. 27, figs 2a-c; from the Cretaceous of Gosau.

Diagnosis. Lateral outline ovate to oblong with arched dorsal margin, maximum height in front of mid-length. Extremities compressed, central part of valves inflated and convex. Anterior and posterior margins may be dentate but not spinose. Left valve larger than right. Surface smooth, occasionally with punctae, reticulation, tubercles or ridges. Ventrolateral edge not extended into a distinct ala, but is developed as a carina. Hinge in the right valve has a strong knob-like anterior tooth, postjacent socket, thin median groove and an elongate crenulate posterior tooth; the dorsal edge of the right valve forms a bar over the median element. The left valve has an accommodation groove above the median elements.

Remarks. The specimens of *Brachycythere sphenoides* selected by Alexander, from the Brownstone Marl (Lower Campanian) of Texas, on which he based the genus *Brachycythere* appear not to be conspecific with *Brachycythere sphenoides* (Reuss, 1854). The latter is smaller (Hazel & Paulson 1964), has a compressed dorsal region, whereas

Alexander's material has an evenly curved inflation in anterior view. The ventrolateral carina in Alexander's own material is shorter, without a distinct posterior termination; this species requires a new name. However, *B. sphenoides* is clearly congeneric with Alexander's material.

Brachycythere cf. **B. sphenoides** (Reuss, 1854) Pl. 9, figs 7, 9

? 1854 *Cythere sphenoides;* Reuss, p. 141, pl. 27, figs 2a-c.
? 1874 *Cythere sphenoides* Rss; Reuss, p. 147, pl. 2. 27, figs 7a, b.
1890 *Cytheropteron sphenoides* (Reuss); Jones & Hinde, p. 33, pl. 1, figs 18-20.
non 1929 *Cythere sphenoides* Reuss; Alexander, p. 81, pl. 7, fig. 14.
non 1933 *Brachycythere sphenoides* (Reuss); Alexander, p. 205, pl. 25, figs 3a-c, 14a, b, pl. 26, figs 7a, b, pl. 27, fig. 19.
non 1958 *Brachycythere sphenoides* (Reuss); Howe & Laurencich, p. 91 [Alexander's material].
1964a *Brachycythere* cf. *sphenoides* (Reuss); Kaye, p. 50, pl. 2, fig. 5.

Material. 6 specimens; LGSD24, 2LV, 1RV (juv.); LGSD26, 2RV, (juv.); LGSD26a, 1LV (juv. frag.)

Measurements. IJS14/14, LV frag. - - 500 - -
IJS20/26, RV juv. 637 - 393 - 231

Description. Valve outline subtriangular. Anterior margin evenly rounded with three weak spines above the anteroventral corner; the right valve of the juvenile has the remains of a marginal frill. Dorsal margin slopes down towards the posterior, it is straight with a slight convexity at mid-length. Maximum height immediately behind eye tubercle, in the right valve is a slight hinge ear, while the left is evenly rounded. Posterior margin of the right valve has a short caudal process below mid-height; the dorsal border is straight to weakly concave, the ventral border is rounded with marginal spines. Ventral margin straight, obscured centrally by ventral tumidity.

A weak marginal rib is developed around the caudal process. The principal ventrolateral rib arises in the lower anterolateral field, is evenly curved and terminates in a small backward and outwardly directed spine. The valves are strongly inflated, particularly medially. In dorsal view the alae are curved in an even bow. The lateral and basal surfaces are smooth.

Hinge poorly preserved in the adult left valve; a median bar has an anteromedian tooth, socket covered by matrix. Above the median bar is a large accommodation groove. The hinge in the juvenile valves is merodont.

Remarks. This species resembles *Pterygocythere laticristata* (Bosquet, 1854) but is not so strongly inflated and the ala is not developed, hence the generic assignation to *Brachycythere*. The outline and ala of the left valve are similar to *Pterygocythere hilli* Keij, 1957 *sensu* Clarke (1983, pl. 7, fig. 13, *non* fig. 14). Clarke (1983) states that the inner marginal zone is weak, but also notes that in the juvenile stages the structural elements of the hinge are more weakly developed, and not, as in this case distinctly merodont. *Brachycythere sphenoides* (Reuss) *sensu* Alexander (1933) has a finely denticulate anterior margin.

Range. First appearance at the topmost Kingston nodular chalk, Upper Turonian, *S. plana* Zone, and ranges up into the Coniacian at Langdon Stairs.

Genus PTERYGOCYTHERE Hill, 1955

Type species. By original designation; *Cypridina alata* Bosquet, 1847, p. 369, pl. 4, figs 1a-d; from the Maastrichtian of Holland.

Diagnosis. Large alate brachycytherid with elongate ovate shape. Left valve larger than right with an arched dorsal margin in the left valve. Ornament of spines restricted to anterior and posterior margins. Marginal ribs usually weakly developed. Weak eye tubercle. Hinge of left valve with conspicuous accommodation groove above the strong posteromedian bar; above the groove is a thickened dorsal hinge bar at the margin. Crenulate elongate posterior tooth in right valve.

Remarks. The genus *Pterygocythere* was erected by Hill (1955), to differentiate winged forms of *Brachycythere* with the hingement of that genus; it also accounted for some forms previously placed in *Alatacythere*. *Pterygocythere* has been ranked as a subgenus of *Pterygocythereis* (Morkhoven 1963; Damotte 1971; Weaver 1982). The latter author based this upon the small difference in shape of the posterior tooth, but did not consider the presence of the large accommodation groove in the left valve, the different valve overlap, shape of the dorsal margin, reduced eye tubercle and weaker ornamentation in *Pterygocythere*. The present author believes these to be sufficiently distinct to allow generic separation.

Pterygocythere pulvinata Damotte, 1962 Pl. 9, fig. 10

Pl. 10, fig. 1

* 1962 *Pterygocythere pulvinata* n. sp.; Damotte, p. 200, pl. 1, figs 4a-e, pl. 3, figs 8a, b.

1971 *Pterygocythereis (Pterygocythere) pulvinata* Damotte 1962; Damotte, p. 91, pl. 6, figs 2a, b.

1985 *Pterygocythere pulvinata* Damotte, 1962; Babinot *et al*., p. 230, pl. 58, figs 8, 9.

Holotype. A carapace; Damotte 1962, pl. 2, figs 4a-c; from the Lower Turonian of Sainte-Maure-de-Touraine.

Material. 19 specimens; LGSD8, 2LV (1 fragment); LGSD9, 3RV (1 juv), 2LV (juv); LGSD10, 1 LV (fragment); LGSD15, 4LV, 6RV (juveniles); LGSD21, 1RV (fragment).

Diagnosis. A strongly inflated species of *Pterygocythere* with elongated carapace, strongly alate, dorsal margin straight, ventral margin obscured by the alae which has two posterior spines, anterior margin of the right valve with two or three spines in the lower part, posterior margin has a sharp angle below mid-height. Eye tubercle present. Surface of the valves smooth.

Measurements. IJS14/11, LV 900 - 512

Description. Left valve outline subtriangular, strongly alate in dorsal view with maximum inflation behind mid-length. Maximum height is at the hinge ear, above the eye tubercle. From the rounded hinge ear the dorsal margin slopes down in a straight line to the indistinct posterior cardinal angle. The posterior margin has a sharp caudal process below mid-height, which has two or three spines on the ventral border. The straight ventral margin is overhung by the ala. The anterior margin is broadly rounded dorsally and more tightly rounded ventrally, the remains of spines are present on the anteroventral corner.

Marginal ribs are weakly developed. The dorsal rib begins in front of an inflated part of carapace which reaches the dorsal margin behind mid-length, it follows the dorsal margin before deviating downwards behind the eye tubercle. The rib passes over the eye tubercle and flows into the anterior marginal rib, which again is continuous with the anterior border of the ala. A broad frill-like flange marks the edge of the ala, this becomes wider towards the posterior. The lateral edge is straight in the anterior half, then convexly curved behind. The ala is terminated with a small spine directed out and backwards. Poor preservation prevented the observation of the nature of the posterior border of the ala. The surface of the valve is completely smooth.

On the basal surface a prominent rib begins on the lateral side of the anterior marginal rib, curves outwards and runs longitudinally, it bends in towards the valve margin at about mid-length, then follows the margin to the posterior border.

The hinge of the left valve consists of an anterior socket, a small anteromedian tooth, posteromedian bar and posterior socket. Above the median elements is a broad accommodation groove. The posterior tooth of the right valve is coarsely crenulate. Other internal details not seen.

Sexual dimorphism distinct, the dorsal margin of the males slopes evenly from anterior to posterior without the distinct posterodorsal cardinal angle of the female.

Remarks. In her original diagnosis of *P. pulvinata*, Damotte (1962) stated that the sharp angle at the posterior margin was "á mi-hauteur des valves". I believe that this should be adjusted to below mid-height of the valves, since originally, her specimen was oriented with the hinge line horizontal. If the valve is oriented in a more natural position with the basal surface horizontal, the dorsal margin slopes down towards the posterior and terminates below mid-height.

Range. A restricted range in the British Turonian, from 2.5m below Caburn Marl, *T. lata* Zone, Upper Turonian, to the lowest of the Kingston Nodular Chalks, *S. plana* Zone, Upper Turonian. Reported from the Lower Turonian of Tourain by Damotte (1962) but later found to be present through all the Turonian of Tourain (Babinot *et al.* 1985).

Pterygocythere sp. A Pl. 10, fig. 2

Material. 2 valves; 1RV fragment LGSD23, 1LV LGSD26a.

Measurements. IJS14/12, LV 875 - 419

Description. Outline subovate, anterior margin evenly rounded with five or six marginal tubercles. Dorsal margin of left valve complex, convex rounded above the eye tubercle, convex rounded at mid-length, between is a depression above the post ocular pit. Posterodorsal margin straight to weakly convex from mid-length to posterior extremity at the posterodorsal cardinal angle. There is no single point of maximum height in the left valve; right valve dorsal margin straight behind raised eye tubercle which is the position of maximum height. Posterior margin of left valve straight above and rounded below carrying six stubby tubercles. Ventral margin obscured by overhang of ala.

Marginal ribs weakly developed. Dorsal rib is set below the dorsal margin, it passes through the eye tubercle, and continues round the anterior margin becoming stronger at mid-height; anterior marginal rib continuous with the anterior border of the ala which has a strong curvature. At the junction of the anterolateral border of the ala and the body is row of nine or ten weak pits. In the middle of the posterior border of the ala is a single broad clavate spine which is oriented at an angle of about 60° to the saggital plane. Behind and slightly below the eye tubercle is a broad shallow depression with a smaller deeper depression between the eye and the postjacent thickening of the dorsal marginal rib. The remainder of the valve surface is smooth. Basal surface smooth with a broad groove at the position of the junction of the ala with the body.

Internal details are imperfectly preserved. Hinge is amphidont with a very broad accommodation groove above the posteromedian bar in the left valve.

Remarks. Only two individuals have been recovered, the identification of the right valve fragment as conspecific with the complete left valve is based on the similarity in shape and orientation of the spine on the posterior border of the alae, which is unlike any other present in the Turonian within this family.

There is a resemblance to *Pterygocythereis hibernica* (Jones & Hinde, 1890) as illustrated by Neale (1978, pl. 15, figs 15-17), but that species has a simple vaulted dorsal margin in the left valve and a weakly convex dorsum in the right where the eye tubercle is inconspicuous. That species may be descended from *Pterygocythere* sp. A.

Range. First appearance at the top of the Bridgewick Hardgrounds, *S. plana* Zone, Upper Turonian, ranges up into the Coniacian at Langdon Stairs.

Genus PTERYGOCYTHEREIS Blake, 1933

(syn. ALATACYTHERE Murray and Hussey, 1942)

Type species. By original designation; *Cythereis jonesii* Baird, 1850, p. 175, pl. 20, fig. 1; from the Recent of the North Atlantic.

Diagnosis. Outline subrectangular, large alar projections give an arrow-head shape in dorsal view. Dorsal margins nearly straight. Conspicuous eye tubercle. Ornamentation may be present on the margins as spines or frills. The hinge is holamphidont; the right valve has a stepped anterior tooth, postjacent anteromedian rounded socket, a long thin posteromedian groove with a dorsal bar above, and a weaker ventral bar below. The posterior tooth is crenulate in primitive species and becomes smooth during phylogeny. The left valve hinge has complementary elements. An accommodation groove may be present in either valve.

Remarks. The genus *Alatacythere* Murray & Hussey, 1942 was shown by Hill (1955) to be insupportable since it encompassed species with varying hinge types, which could be better placed in the genera *Pterygocythere* or *Pterygocythereis*. The type species of *Alatacythere* accorded with the hinge of *Pterygocythereis*, and was considered as a junior synonym by Hill (1955).

Subgenus DIOGMOPTERON Hill, 1955

Type species. By original designation; *Brachycythere luenenensis* Triebel, 1941, p. 383, pl. 8, figs 77-80; from the Lower Senonian of Germany.

Diagnosis. Right valve overlaps left at mid-length, left valve overlaps right at anterior and posterior cardinal angles. Dorsal margin of left valve straight, right valve weakly to strongly arched. Hinge of right valve has an accommodation groove above the upper bar, and a dorsal bar above that.

Remarks. The genus *Diogmopteron* Hill, 1955 has been dismissed as a synonym of *Pterygocythereis* Blake, 1933 (Morkhoven 1963; Weaver 1982) on account of the position of the accommodation groove in either the left or the right as being insufficient to warrant generic or subgeneric status. Conversely it has been considered as a distinct genus since the hingement is unique within the Brachycytheridae (Hill 1955; Sylvester-Bradley & Kesling *in* Moore 1961; Herrig 1966; Clarke 1983). The present author considers that *Diogmopteron* should be retained at subgeneric level for the following reasons. In addition to the presence of three hinge bars and two grooves in the right valve, *Diogmopteron* also displays a complex pattern of valve overlap which is distinct from that in *Pterygocythereis*; this also affects the shape of the dorsal margin in the right valve. In the author's Turonian material species fall into either *Pterygocythere* or *Pterygocythereis* (*Diogmopteron*), no representatives of *Pterygocythereis* (*Pterygocythereis)* are found. This is also true of the Late Cretaceous German material of Clarke (1983) (*Pterygocythereis phylloptera* should probably be placed in the subgenus *Diogmopteron* q.v. Herrig 1966, p. 834, fig. 79c for detail of hinge). Weaver (1982) has a different concept of these genera and subgenera, but his Cenomanian species fall into the same taxa according to the classification proposed here. *Pterygocythereis*

(Diogmopteron) appears to be confined to the Upper Cretaceous, while *Pterygocythereis (Pterygocythereis)* is found from the Upper Cretaceous to the Recent.

Pterygocythereis (Diogmopteron) carolinae sp. nov. Pl. 10, figs 3, 4; Pl. 25, fig. 1

Name: After the Christian name of Caroline Frost.

Holotype. LV IJS14/10, from sample LGSD9, second flint band below Caburn Marl, Upper Turonian, *T. lata* Zone; from Langdon Stairs, Dover, Kent.

Material. 9 specimens; LGSD3, 1 LV; AKS3/10, 1LV (frag.); LGSD6, 2RV; LGSD7, 1RV; LGSD9, 1RV, 2LV; LGSD12, 1LV (frag.).

Diagnosis. *Pterygocythereis* with three centrodorsal tubercles, two ventrolateral tubercles and single prominent curved longitudinal ornament on the basal surface. Strong eye tubercle.

Measurements.	IJS14/9, RV	650 - 362
	IJS14/10, LV	725 - 419

Description. Carapace subquadrate, moderately inflated, alate in dorsal view. Right valve dorsal margin straight, interrupted anteriorly by a prominent, spherical, glassy eye tubercle, and posterocentrally by a projecting backwardly curved blade-like spine. The left valve dorsal margin differs by possessing a small process at the posterodorsal cardinal angle and a hinge ear, under which the eye tubercle sits. In both valves the position of maximum height is at the eye tubercle. Right valve anterior margin evenly rounded with five or six blunt spines in the ventral half. The left valve anterior margin is evenly curved in the dorsal one-third, almost straight medially and sharply curved ventrally, it has two rows of spines; one at the valve edge which continues to the ventral margin, and a second at the outer edge of the marginal rib. The almost horizontal aspect of the alae allow the ventral margin to be seen to be sinuous, strongly concave in front of centre, weakly concave in the posterior quarter and convex elsewhere. The posterior margin in both valves has a blunt caudal process, weakly concave above and rounded below, carrying five clavate or blunt spines.

The marginal ribs are well developed except at the dorsal margin, posterocentrally, behind the curved spine. At this point the rib is reduced and the inflation of the valve meets the dorsal margin. The dorsal rib is interrupted at the eye tubercle and continues round the anterior margin to flow into the lateral edge of the ala. The front edge has a wide frill-like shelf, at the junction of this and the lateral surface of the valve are a series of depressions. In dorsal view, the anterior borders of the alae appear straight, to very weakly convex, with a slight indentation before the terminal spine which is directed backwards at an angle of 120°. The posterior margins of the alae each bear a keel-like spine at the junction of the frill and the valve surface and a second lower spine closer to the midline.

The smooth basal surface is convex proximally and concave distally with five depressions and weak ribs beneath the frill. A prominent longitudinal rib runs down the centre of the convex part of the basal surface, originating on the distal side of the continuation of the anterior margin, where it terminates on the ventral margin, then curving outwards to follow a line which divides the ventral surface in two, it then curves back at about mid-length and continues a short distance longitudinally before fading into the ventrolateral surface. A thicker rib extends forward from the outer keel-like spine, this initially curves outwards to cross the terminal spine at right angles, then curves forward to follow the edge of the alae.

Ornamentation consists of a prominent dorsal spine just behind mid-length described above, and several small tubercles which have a constant position from one specimen to another. There are three dorsal and two ventral tubercles, the three dorsal form an oblique line in front of the main dorsal spine, each is successively lower than the previous, the second is at mid-length, the third is in front of posterior edge of the eye tubercle. The ventral tubercles straddle either side of the spiny termination of the alae on the lateral surface of the valve, the hindmost is a little higher.

The hinge of the right valve consist of a high anterior tooth, and postjacent socket, the posteromedian groove has a bar above, and a very thin accommodation groove above that. Posterior tooth is crenulate and higher posteriorly. Left valve hinge details unclear, muscle scars not seen. Marginal pore canals more numerous at the posterior margin.

Remarks. Six similar spinose *Pterygocythereis* species have been described by Pokorný (1987). *Pterygocythereis annae* Pokorný, 1967c, from the Middle and Upper Turonian of Bohemia, has more tubercles on the lateral surface. That species also has a basal rib which bifurcates towards the posterior. *Pterygocythereis caroli* Pokorný, 1967c, from the Middle Turonian of Bohemia, has a greater number of spines in the median part of the lateral surface. In the Bohemian Middle and Upper Turonian *Pterygocythereis agarensis* Pokorný, 1987, the ventrolateral spine is broken up into a spiny frill. *Pterygocythereis armata* Pokorný, 1987 and *Pterygocythereis mira* Pokorný, 1987, both from the Bohemian Coniacian and Santonian, have a complex arrangement of spines on their lateral surfaces which are distinct from the simple pattern in *P. carolinae*.

Range. A short ranging species with its first appearance just below the Upper Southerham Marl, Upper Turonian, *T. lata* Zone, to the large flint 1.5m below Caburn Marl, Upper Turonian, *T. lata* Zone.

Pterygocythereis (Diogmopteron) diversum (Clarke, 1983) Pl. 10, figs 5, 6

* 1983 *Diogmopteron diversum* n. sp. Clarke, p. 113, pl. 8, figs 5-7.

Type specimens. Holotype, a right valve, SGPIH 2610, in the Geological Institute and Museum, Hamburg; from the Upper Santonian at Lägerdorf, northern Germany.

Material. 36 valves; 19RV (8 juv), 17LV (4 juv).

Diagnosis. A large, smooth species of *Pterygocythereis* with wide, curved alar extensions, ending in a sharp point. Weakly developed marginal ribs. The dorsal margin of the left valve is concave to straight while the right is strongly convex.

Measurements. IJS14/1, LV 762 - 412

Description. Left valve outline subquadrate, maximum height at the anterior hinge ear. Anterior margin slopes steeply above mid-height, broadly rounded below; ventral half bears two rows of spines, the inner row, at the valve edge continues into the ventral margin, the outer row terminates where the ventrolateral edge departs from the anterior margin. Ventral margin obscured by the considerable overhang of the ala. Posterior margin bluntly rounded with a row of marginal spines. The dorsal part of the posterior margin is straight and slopes up gently to the posterior cardinal angle. The central section of the dorsal margin is straight, which slopes up slightly to the anterior, behind the anterior cardinal angle is a concave section. The right valve differs in many respects; the anterior margin is evenly rounded, without the inner row of spines, but carrying five or six peripheral spines. The dorsal margin is strongly convex, such that the point of maximum height is at mid-length of the valve. Anterior to this point the dorsal margin descends to the anterior cardinal angle with a slight flexure above the weak eye tubercle. The posterior section is weakly convex in its anterior half, and straight thereafter.

The peripheral ribs are very weak, particularly in the anterodorsal part of the valves. The dorsal rib becomes a little stronger towards the posterior and is continuous around the posterior margin. The anterior marginal rib becomes stronger ventrally where it flows into the broad shelf of the anterior edge of the alae. The greatest inflation of the carapace is behind mid-length. On the posterior border of alae are two keel-like spines, with a smaller spines between.

The basal surface is smooth and convex proximally, and concave with a series of depressions distally.

The hinge of the right valve consists of a high smooth anterior tooth, postjacent round smooth anteromedian socket, a weak posteromedian groove, with thin bars above and below; above which is a large accommodation groove, and above that is a thick section of the dorsal margin. The posterior tooth is higher anteriorly, and weakly crenulate. The hinge of the left valve, has complementary elements; above the bar is a long groove which continues to the hinge ear. Marked selvage in both valves.

Remarks. This species is very similar to *Pterygocythereis alatoides* (Bonnema, 1940), but that species has strong spination around the anterior and posterior margins.

Range. First appearance at AKSD45, 1.2m above Lydden Spout Flint, *T. lata* Zone, Middle Turonian, it occurs throughout the remainder of the Turonian, Coniacian and is present in the Santonian. First described from the Middle Coniacian to Upper Campanian of northern Germany.

Pterygocythereis (Diogmopteron) robusta (Jones & Hinde, 1890) Pl. 10, fig. 7

1849 *Cythereis alata* Bosquet; Jones, p. 21, pl. 5, figs 14a-d.

* 1890 *Cytheropteron alatum* (Bosquet) var. *robusta* nov.; Jones & Hinde, p. 35, pl. 2, figs 24-27 [redrawn from Jones, 1849].

pars 1964a *Alatacythere robusta* (Jones & Hinde); Kaye, p. 51, pl. 2, figs 8-11, 15, *non* figs 7, 12-14, 16, 18 [figs 14, 16 = *Pterygocythere hibernicum* (Jones & Hinde); fig. 7 = *Pterygocythereis diversum* (Clarke)].

non 1965a *Alatacythere robusta robusta* (Jones & Hinde); Kaye, p. 240, pl. 10, figs 9, 10.

1966 *Diogmopteron alatoides* (Bonnema, 1940); Herrig, p. 832, pl. 24, figs 5a-c, 6a, b, pl. 25, figs 2a, b.

1978 *Alatacythere robusta* (Jones & Hinde); Neale, p. 362, pl. 15, figs 11-14.

1983 *Diogmopteron alatoides* (Bonnema, 1941); Clarke, p. 112, pl. 8, figs 1-4.

Type specimens. No type material designated. The original illustrations (Jones 1849) was of material from the Chalk of Norwich, probably Campanian, *B. muconata* Zone.

Material. 33 specimens; 17LV, 16RV, 1car.

Diagnosis. Subquadrate *Pterygocythereis* with inflated carapace in the mid-dorsal region, strong eye tubercle, straight to weakly concave dorsal margin of left valve, straight to weakly convex dorsal margin of right valve. Ventrolateral alae without significant curvature.

Measurements. IJS14/7, LV 637 - 343

IJS14/8, RV 662 - 362

Description. Carapace moderately well inflated, strongly alate in dorsal view. Right valve overlaps left in mid-dorsal region. Anterior margin evenly rounded, anterodorsal corner of left valve possesses a hinge ear, beneath which is the strong eye tubercle. Right valve has eye tubercle projecting slightly above the dorsal margin. Right valve dorsal margin straight to weakly convex, left valve dorsal margin straight to weakly concave. The position of maximum height in the right valve is immediately behind the eye tubercle, where a slight swelling of the dorsal margin corresponds to the position of the anteromedian socket of the hinge. The posterodorsal cardinal angle of the left valve is raised and distinct, while in the right valve it is smooth and inconspicuous. Posterior drawn out into a short caudal process, the dorsal side of which is concave in the left valve and straight in the right valve. Anterior margin bears two rows of spines, an inner row which is continuous with the ventral margin, and an outer, bearing stout spines on the periphery of the anterior marginal rib. The ventral margin is obscured by the overhang of the alae.

The marginal ribs are generally well developed, with the exception of mid-dorsal region where the inflation of the valve often reaches the dorsal margin. The anterior marginal ribs are continuous with the front edges of the lateral alae, the curvature of which is slight, and which terminates in an outwardly directed spine. The posterior border of the ventrolateral alae each carry two keel-like spines between which is a small tubercle.

The basal surface is smooth and convex proximally, and concave distally where a series of depressions run along parallel to the lateral edge of the ala.

Calcified inner lamella moderate, without vestibules. Hinge of right valve with high crenulate anterior tooth with postjacent socket which opens out into a thin groove. A thin bar underlies the groove, and a thicker bar extends above. Above this is a narrow accommodation groove. The posterior terminal tooth is crenulate and appears highest centrally. The left valve elements are complementary, the anteromedian tooth is flat topped and weakly crenulate.

Remarks. *Pterygocythereis alatoides* (Bonnema, 1940) has a narrower posterior extremity and maximum height in the right valve at mid-length. *Pterygocythereis diminuta* Weaver, 1982 is slightly smaller with a more concave posterodorsal margin which is more drawn out. The form figured by Kaye (1965a) has a low elongated dorsal rib and may belong to a new species; this Cenomanian form has been identified as *Pterygocythereis (Pterygocythere)* cf. *P. (P.) robusta* (Jones & Hinde, 1890) by Weaver (1982) and Jarvis *et al.* (1988). *Pterygocythereis robusta langei* (Kaye, 1965a) is more closely allied with *P. spinosa* (Reuss, 1846) and is probably its direct ancestor.

Range. First appearance at AKSD29, 3m above New Pit Marl 2, *T. lata* Zone, Middle Turonian. Present throughout the remaining Turonian. Reported up to Maastrichtian of England [King 1968].

Pterygocythereis (?D.) sp. aff. **P. serrata** (Bonnema, 1940) (not figured)

aff. 1940 *Archicythereis serrata* n. sp.; Bonnema, p. 130, pl. 4, fig 12-15.

1955 *Pterygocythereis serrata* (Bonnema); Hill, p. 818, pl. 100, figs 2a-h.

Material. 3 specimens; LGSD5, 1RV fragment; LGSD26 1RV fragment; LGSD28, 1RV juvenile.

Measurements. IJS14/13, RV frag. height = 425

Description. Poor preservation does not permit a full description, only right valves have been recovered, and the only complete valve is of a juvenile stage.

The periphery of the anterior margin has a thin frill like flange, only remnants of which can be seen in the authors material. The dorsal margin is interrupted by three or four blade-like spines which are arranged alternately along the dorsal margin. The first blade is a continuation of the anterior marginal frill, and as such is probably not a true dorsal blade; the juvenile specimen shows only three dorsal spines. The second begins outside the first and continues the line of the frill. A short gap separates the third blade which is situated near the valve margin, the tip of this blade is curved outwards. The fourth blade occurs posterodorsally below and lateral to the third. The anterior margin possesses a thin rib which continues to the ventral margin, not connected to the ventrolateral alae. The ala arises in the ventral part of the anterolateral field, that which is preserved is very thin. Apart from the thin anterior rib the surface of the valve is smooth, there is no eye tubercle. Internal details not seen.

Remarks. Very similar to *Pterygocythereis serrata* (Bonnema, 1940), but can be distinguished by the shape of the blades, which in the latter are sharp and triangular. Better preserved material may confirm or deny this identification. *Pterygocythereis (Alatacythere) cirrusa* Deroo, 1966 possesses a row of dorsal spines, but this species can be distinguished by the presence of a subcentral tubercle.

Range. Rare in the Turonian, from 1m above Southerham Marl 2, *T. lata* Zone, Upper Turonian; further specimens have been recovered from the overlying Coniacian at Langdon Stairs.

Pterygocythereis (Diogmopteron) spinosa (Reuss, 1846) Pl. 10, fig. 8

Pl. 11, fig. 1

* 1846 *Cytherina spinosa* Reuss, p. 105, pl. 24, figs 21a, b.

1940 *Cythereis (Pterygocythereis) aserrulatoides* n. sp.; Bonnema, p. 130, pl. 4, figs 33-36.

1967c *Pterygocythereis spinosa* (Reuss, 1846); Pokorný, p.305, pl. 4, figs 1, 2.

1970 *Alatacythere (Diogmopteron) spinosa* (Reuss 1846); Gründel, p. 45, pl. 11, figs 17, 18.

1983 *Diogmopteron spinosa* (Reuss, 1846); Clarke, p. 115, pl. 8, figs 12-16.

Holotype. No type material designated. The original specimens collected by Reuss came from the Turonian at Luzice, Czech Republic.

Material. 150 valves of adults and juveniles.

Diagnosis. A species of *Pterygocythereis* with a single blade like spine arising just below the dorsal margin, just behind mid-length and directed posteriorly; prominent posterodorsal cardinal angle in the left valve, often with a small spine on the raised process, absent in the right valve; remainder of lateral surface smooth.

Measurements.	IJS19/10, LV	812 - 400 - 343
	IJS19/11, RV	800 - 375 - 350

Description. Carapace subrectangular, tapering towards posterior in lateral view, moderately inflated arrowhead shape in dorsal view. Left valve larger than right, overlapping at the anterodorsal corner in front of the eye tubercle, at the posterior cardinal angle and ventrally in front of the oral concavity. Dorsal margin of right valve straight, left valve rounded above eye tubercle, straight in the centre and raised up to a point at the posterior cardinal angle; in well preserved specimens this has a small spine on its crest. Anterior margin evenly rounded in both valves. The right valve has six or seven spines in the lower half, while the left valve may have up to twelve clavate spines, often recurved downwards, starting above mid height and continuing round the margin to the ventral overlap in front of the oral concavity; a second row of smaller spines occur absagittaly. The ventral margin is straight posteriorly with a considerable concavity in front of centre, most of the ventral margin overhung by the large alae. The posterior margin is rounded ventrally and straight dorsally, with six spines on the ventral section, and occasionally on the dorsal section; the spines are sometimes clavate, and usually recurved upwards.

The anterior marginal rib is continuous with both the thin dorsal rib and the lateral edge of the alae. There are several small pits and ridges where this rib joins the lateral surface. The eye tubercle interrupts the rib in the dorsal section and sits below the dorsal margin in the left valve where a small hinge ear is developed at the point of maximum height, this is not present in the right valve and the eye tubercle there is at the dorsal margin. The large alae have a slightly sinuous anterior margin which is straight in front, then flares out in the central section, pinches back inwards near the tip which is turned out again. The posterior edges of the alae each have two keel-like spines directed downwards, there are three smaller spines above and between these. A prominent dorsal spine arises from the lateral surface below the dorsal margin behind mid-length, to project above the dorsal margin; it has a fairly broad base and the top is directed backwards. The lateral surface of the valve is totally smooth.

Basal surface on the right valve has an evenly sinuous marginal rib which is connected to an absagittal rib by the short straight riblets. This second rib curves evenly following the outer margin, then bends in at the posterior border of the ventrolateral surface to connect with the distal keel. A third much narrower rib arises at the anterior margin, running longitudinally, it curves outwards slightly, then fades into the basal surface.

Inner lamella very narrow with no vestibules. Hinge of right valve has a small rounded anterior tooth and a slightly elongated socket. Behind the socket is a narrow groove with thin bars above and below, above the upper bar is a narrow accommodation groove. The posterior tooth is crenulate and higher posteriorly.

Remarks. Reuss' description of his material states that there are two to three small spines projecting from the upper margin. His illustration is unclear and the number of spines cannot be resolved. Pokorný (1967c) illustrated a specimen from Reuss' collection and showed it to posses a single spine at the dorsal margin.

Range. First appearance 4m below New Pit Marl 1, in the Middle Turonian *T. lata* Zone. Present throughout the overlying Turonian and Coniacian. Reported from the Turonian of Bohemia (Pokorný 1967c) and the Coniacian to Campanian of N. Germany (Clarke 1983).

Pterygocythereis (Diogmopteron) sp. A   Pl. 11, figs 2, 3

1988 *Pterygocythere* sp. cf. *P. diminuta* Weaver, 1982; Horne & Rosenfeld *In* Jarvis *et al.* p. 34, fig 16h.

Material. 7 specimens; ABCMR1, 1 carapace; ABCMR3, 2RV; ABCMR4, 1RV, 1LV (frag.); ABCMR5, 1LV (frag.); AKSD16, 1RV (frag.).

Measurements. IJS14/6, RV   700 - 375

Description. Carapace subovate in lateral view, alate in dorsal view. Right valve overlaps left in mid-dorsal region. The right valve has an evenly convexly curved dorsal margin, which has the point of maximum height in front of mid-length at the position of the eye tubercle. The anterior margin is evenly rounded bearing six strong pointed spines on the periphery of the anterior marginal rib. The ventral margin is obscured by the overhang of the ala. A short concave section of the dorsal margin passes into the bluntly rounded caudal process which carries five stout to clavate spines. The left valve outline differs from the right by being more quadrate than ovate, this is brought about by a straight dorsal margin. The posterior cardinal angle is smooth without being raised. The anterior margin bears two rows of spines, one at the valve margin and a second on the marginal rib. Those at the valve margin continue round into the venter.

The posterior and dorsal marginal ribs are weak, the latter passes through the eye tubercle, becomes stronger around the anterior margin and is continuous with the anterior edge of the alae. The posterior border of the alae carry two keel-like spines which are directed down and outwards.

The basal surface is smooth proximally with a weak rib crossed by depressions distally following the outer margin of the alae. The left valve has a weak rib near the valve margin against which the right valve closes. In ventral view the curve of the alae is clearly seen as a straight anterior section, a flexure at about one-third length, and a straight to very weakly convex posterior section.

The calcified inner lamella is of moderate width without vestibules. The hinge of the right valve consists of a smooth high anterior tooth with an ocular depression in front and a rounded socket behind. The socket opens into a groove, bounded above and below by two bars, the upper being the stronger. An accommodation groove sits above the median elements. The trilobate posterior tooth is tilted over towards the valve margin, it is highest medially. Left valve internal feature and muscle scars not seen.

Remarks. Similar to *Pterygocythereis (Pterygocythere) diminuta* Weaver 1982, from the Upper Cenomanian of Dorset, from which it may be derived. *Pterygocythereis (P.) diminuta* can be distinguished by a more convex dorsal margin in the right valve, a slightly concave dorsal margin in the left valve, a weaker eye spot and a longer more drawn out posterior. Horne & Rosenfeld (*In* Jarvis *et al.* 1988) draw a comparison with the form illustrated by Neale (1978) as *Alatacythere robusta* (Jones & Hinde); this however can be distinguished by the prominent posterodorsal cardinal angle, shape of curvature of the alae and a straighter dorsal margin in the right valve.

Range. Only found in the *Mytiloides* spp. Zone, Lower Turonian at Abbots Cliff.

Family BYTHOCYTHERIDAE Sars, 1926

Diagnosis. Variably shaped carapace, usually with a short caudal process, often possessing alar projections and a dorsomedian sulcus. Five muscle-scars arranged in a vertical or arcuate row. Hinge adont, lophodont or merodont with a long median element. Variable marginal zone, usually with vestibules, marginal pore canals simple or branching.

Remarks. Members of this family are ubiquitous throughout the Turonian, represented by 17 species in 4 genera, with the notable exception of the sample from the Caburn Marl LGSD11, where not a single bythocytherid was discovered.

Herrig (1966) undertook a survey of this group using specimens from the Upper Cretaceous from the Isle of Rügen, and determined three form groups according to differences in outline, surface features, sculpture and hinge. One of these was assigned to the genus *Bythoceratina* Hornibrook, 1952, while the other two were tentatively assigned to new subgenera of *Monoceratina* Roth, 1928. Gründel & Kozur (1972), using literature, erected many new genera within the Bythocytheridae; within this scheme they created two new genera for species which were previously placed within one subgenus by Herrig (1966): *Cuneoceratina* Gründel & Kozur, 1972, type species *Cythere pedata* Marsson, 1880 and *Veeniceratina* Gründel & Kozur, 1972, type species *Monoceratina hispida* Veen, 1936. Further analysis by Weaver (1982) showed that *Cuneoceratina* should be considered as a subgenus of *Bythoceratina*, which equates to form group 1 of Herrig (1966). His form group 3 then becomes the nominate subgenus. Form group two, in the author's opinion, has sufficiently distinct hingement to be considered as a separate genus, and is here referred to as *Monoceratina*. An analysis of the hinge characteristics of the genus *Veeniceratina* shows that it is indistinguishable from *Cuneoceratina*. Furthermore, Gründel & Kozur (1972) erected the genus *Veeniceratina* using the illustration of Herrig (1966), which does not correspond to the specimens of van Veen (1936a) (see below under *B. (C.) hispida* for further discussion). It is recommended here that the genus *Veeniceratina* should not be used since the only feature distinguishing this from *Cuneoceratina* is the subparallel dorsal and ventral margin of the former against the wedge shape of the latter. In *Cuneoceratina*, this feature is variable, particularly in *Bythoceratina (Cuneoceratina) pedatoides* Bonnema, 1941.

Genus BYTHOCERATINA Hornibrook, 1952

Type species. By original designation; *Bythoceratina mestayerae* Hornibrook, 1952, p. 62, pl. 16, figs 257-9; from the Recent of New Zealand.

Diagnosis. Carapace outline subrectangular to subtriangular with caudal process terminating above mid-height. Surface usually reticulate but may be noded, pitted or smooth. Long lateral spine arising from a narrow base behind mid-length. Hinge adont to lophodont. Hinge with or without terminal sockets separated by a smooth or crenulate terminal bar.

Remarks. The genus *Bythoceratina* Hornibrook, 1952 was originally distinguished from *Monoceratina* Roth, 1928, by details of hingement, the latter with a more primitive simple groove and hinge bar without terminal teeth, the former with a crenulate median bar and terminal sockets. Weaver (1982) noted that some older species of *Bythoceratina* lacked terminal teeth, but showed an evolutionary lineage to those that possessed terminal teeth; thus he emended the generic diagnosis to include these forms. Since this feature was the prime distinction between the two genera it became necessary to use other characters. Weaver (1982) noted that differences exist in shape between the two genera; in outline *Bythoceratina* is more elongate, generally less well inflated, has a greater degree of ornamentation, and possesses a spine arising from a narrower base.

Weaver (1982, p. 37) states for the genus *Bythoceratina* that the spine arises from a narrow base, and subsequently for the nominate subgenus *Bythoceratina* that it has a fairly broad base. This, I believe, was intended to draw attention to the base of the spine being narrower than that of *Monoceratina*, but when contrasted with *Bythoceratina (Cuneoceratina)*, then the nominate subgenus has a relatively broader base. In *Monoceratina* (Weaver 1982, p.43) the spine is short with a very broad base, and in *Patellacythere* (Weaver 1982, p. 44) it is a lateral broad swelling. In discussion of *Patellacythere parva* Weaver, 1982, it is distinguished from *B. (B.) pseudoutilazea* Weaver by the latter having a ventrolateral swelling; this would therefore assign that species to *Patellacythere*.

Subgenus BYTHOCERATINA Hornibrook, 1952

Diagnosis. Outline subrectangular with a caudal process. Valves moderately inflated with a broad, deep median sulcus, lateral spine usually moderately long with a fairly narrow base in posterior half of valve. Ornamentation of pits, reticulation, or ridges. Hinge of right valve with median groove and usually terminal teeth, left valve median bar may be finely denticulate.

Remarks. Distinguished from *Bythoceratina (Cuneoceratina)* by being less triangular in outline, having a broader base to the lateral spine and by not possessing the thickening at the ends of the median bar in the left valve.

Bythoceratina (Bythoceratina) antetumida nom. nov. Pl. 11, figs 5, 6

Name. Latin; *ante*, in front and *tumida*, swelling; relating to the characteristic anterior marginal inflation.

non 1848 *Cytherina umbonata* Williamson, p. 79, pl. 4, fig. 78.

non v 1849 *Cythere umbonata* (Williamson); Jones, p. 12, pl. 2, figs 3a-g.

1880 *Cythere umbonata* (Williamson); Marsson, p. 45, pl. 3, figs 15a-c.

v 1941 *Monoceratina umbonata* Williamson; Bonnema, p. 24, pl. 6, figs 54-62.

pars 1964a *Monoceratina umbonata* (Williamson); Kaye, p. 56, pl. 4, figs 7, 8, *non* pl. 4, figs 3, 4, 6 [= *Bythoceratina umbonata*].

pars 1964a *Monoceratina umbonatoides* nom. nov. Kaye, p. 57, pl. 4, fig. 2, *non* pl. 4, fig. 5 [= *Bythoceratina umbonatoides* (Kaye)].

non. 1964a *Monoceratina bonnemai* sp. nov. Kaye, p. 52, pl. 3, figs 5, 6.

1964 *Monoceratina umbonata* (Williamson, 1848); Szczechura, p. 391, pl. 5, figs 1-12, pl. 10, figs 9-13, pl. 11, fig. 3.

1966 *Bythoceratina bonnemai* nom. nov.; Deroo, p. 80, pl. 9, figs 104-106.

1966 *Bythoceratina umbonata* (Williamson, 1848); Herrig, p. 930, pl. 36, figs 2-8, pl. 44, figs 1, 2.

. 1974 *Bythoceratina bonnemai* Deroo, 1966; Szczechura, p. 428, pl. 187, figs 16-21

. 1978 *Bythoceratina (Bythoceratina) umbonatoides* (Kaye); Neale, pl. 14, figs 2-6.

non. 1982 *Bythoceratina (Bythoceratina) bonnemai* (Kaye); Weaver, p. 38, pl. 6, fig. 26.

. 1983 *Bythoceratina umbonata umbonata* (Williamson); Clarke, p. 146, pl. 15, figs ?11, 12.

. 1983 *Bythoceratina umbonata multireticulata* n. ssp.; Clarke, p. 147, pl. 15, figs 13-15.

. 1996 *Bythoceratina umbonata multireticulata* Clarke, 1983; Slipper, p. 52, pl. 2, fig. 1.

Lectotype. Here designated, NHM Io1591 (Kaye, 1964a, Pl. 4, fig. 2) RV, Upper Chalk, *coranguinum* Zone, from Sonning, Berkshire.

Material. 112 valves

Diagnosis. Species of *Bythoceratina* with distinctly raised anterior marginal border separated from large swelling in dorsal portion of anterior lateral field by a sulcus which runs from dorsal to ventral margins. Long sharp lateral spine arising from a narrow base. Surface of valves entirely reticulate.

Measurements.	IJS19/6, LV	650 - 300 - 237
	IJS19/7, RV	725 - 337 - 287

Description. Elongate ovate shape, anterior margin evenly rounded in both valves, dorsal and ventral margins subparallel, both slightly sinuous with a constriction on the ventral margin in front of mid-length, and that on the dorsal margin behind mid-length, corresponding to the position of the dorsomedian sulcus. Posterior margin evenly rounded ending in a short caudal process in the right valve at two-thirds valve height, in the left valve just below the dorsal margin. The left valve has a small hinge ear at the anterodorsal corner.

At the anterior margin is a raised ridge which begins just below the dorsal margin and ends above ventral margin, the rear border of which is straight and delimited by a sulcus. The ventral portion of the anterior marginal ridge often has a spine-bearing node. The spines are arranged in two rows, the most peripheral has about seven spines, those in the centre of the row being the longest. The inner row has three or four shorter spines. A large domed swelling occupies most of the dorsal part of the anterolateral field, behind which is the deep median sulcus. The sulcus slopes steeply from the dorsal margin back and down to the anterior edge of the lateral spine. The base of the lateral spine is situated at or just below mid-height from where it extends out and slightly down, in some specimens it is swept back slightly. The posterior lateral field is compressed in the posteroventral section to form a broad shelf. The surface of the valves is covered in a coarse reticulation network which sometimes appears stretched over the anterodorsal swelling where the individual meshes are larger. Three rows of meshes run obliquely from below the lateral spine up towards the centre of the anterior sulcus.

Calcified inner lamella quite narrow, with very narrow crescent shaped anterior vestibule in the anteroventral corner. Hinge is a long thin bar in the left valve, which fits into a groove in the right; terminal sockets are present in the left valve.

Remarks. *Bythoceratina bonnemai* Deroo, 1966 was introduced as a *nomen novum* for *Cythere umbonata* (Williamson, 1848) *sensu* Marsson, 1880, to separate the German and Dutch Maastrichtian forms of Marsson (1880) and Bonnema (1941) from the British Albian-Cenomanian *Cytherina umbonata* Williamson, 1848, which were both placed in *Monoceratina umbonata*. This was not necessary, and should have been given as a new species designation rather than a new name. No type specimen was given. However, *Bythoceratina bonnemai* Deroo, 1966 is a junior secondary homonym of *Bythoceratina (Bythoceratina) bonnemai* (Kaye, 1964) which was originally placed in the genus *Monoceratina* by Kaye (1964a) and later transferred to *Bythoceratina* by Weaver (1982). It is therefore invalid since the two species group names are congeneric, and requires a new name (Art. 60 ICZN), *B. (B.) antetumida* nom. nov. herein.

Range. First appearance at Gun Garden Marl 1, Lower Turonian *Mytiloides* spp. Zone at Abbots Cliff. Present throughout the overlying Turonian of the studied sections, and found in the Coniacian at Langdon Stairs. Widely distributed; found in the Santonian of Berkshire (Kaye 1964a), the Santonian, Campanian and Maastrichtian of northern Germany (Herrig 1966; Clarke 1983), the Upper Campanian of Belgium (Deroo 1966) and the Campanian and Lower Maastrichtian of Poland (Szczecherua 1964).

Bythoceratina (Bythoceratina) sp. aff. **B. (B.) antetumida** Pl. 11, fig. 4

Material. 6 valves; ABCMR1 2RV, ABCMR2 1RV, 1LV broken, ABCMR3 2RV.

Measurements. IJS19/5, RV 522 - 237 - 137

Description. Sinuous subparallel dorsal and ventral margins, evenly rounded anterior margin, posterior caudal process ending below the dorsal margin. Spinose node at the anteroventral corner, no anterior marginal rib. Swelling in the dorsal portion of the anterolateral field. Median sulcus runs from behind the anterodorsal swelling to end above and in front of the lateral spine. Posteroventral shelf developed from compression of the valves. Lateral spine extends from just below the line of mid-height behind the median sulcus. Valve surface entirely covered in reticulation. Small anterior vestibule in the anteroventral section of the calcified inner lamella. Hinge of right valve a long thin bar, left valve hinge not seen.

Remarks. A transitional form between *Bythoceratina (B.) umbonata umbonata* Williamson, 1848 and *Bythoceratina (B.) antetumida*. The anterior margin is flattened and smooth in the Cenomanian *B. (B.) umbonata*, it then develops a spinose node on the anteroventral corner in the Lower Turonian *B. (B.)* sp. aff. *antetumida*. The latter coexists briefly with *B. (B.) antetumida* which then becomes quite numerous throughout the remaining Turonian.

Range. Short ranging, restricted to the Holywell Member of the Lower Turonian, *Mytiloides* spp. Zone, at Abbots Cliff.

Bythoceratina (Bythoceratina) nitidoides (Bonnema, 1941) Pl. 11, fig. 7

* 1941 *Monoceratina nitidoides* nov. spec. Bonnema, p. 41, pl. 7, figs 15-19.

Type specimens. No type material designated; Bonnema's specimens came from Marls in the Late Cretaceous of northeast Holland.

Material. 4 valves; AKSD50 1 right valve, AKSD3/10 1 RV, LGSD19 1 partially broken left valve, LGSD24 1 central fragment of a right valve.

Diagnosis. Lateral spine arising from the posterior edge of a very broad base which is divided in two. In dorsal view, the anterior section of the base, below the median sulcus, is about half the width of the spine; spine and base covered in reticulation, remainder of the valve is smooth. Anterior lateral field weakly divided in two by a horizontal median swelling.

Measurements. IJS12/4, RV height = 250

Description. Dorsal and ventral margins almost straight, slightly sinuous and parallel; dorsal marginal ridge extends from behind the anterodorsal hinge ear, weakly at first, towards the inflation in front of the median sulcus, where it becomes less clear as the dorsal margin flexes upwards, then more strongly developed above median sulcus, running posteriorly in a straight line and ending with slight downturn just below the posterodorsal angle; ventral margin with weak marginal rib flexing upwards just in front of mid-length. Anterior margin possesses a marginal rib and outside of that is a thin flange, often not preserved. Posterior margin drawn out into an acute caudal process which terminates below the dorsal margin. A weak horizontal swelling extends from behind the depression posterior of the anterior marginal rib and raises up to connect with the anterior portion of the base of the ventrolateral extension. The median sulcus is terminated dorsally by the dorsal rib and ventrally by the ventrolateral swelling. The very long lateral spine extends from the posterior edge of the ventrolateral swelling, leaving the anterior part as a lower step; both spine and step are reticulate, the remainder of the valve surface is smooth. In dorsal view the spine is seen to sweep backwards. Internal features obscured by matrix.

Remarks. This species is distinguished from *Monoceratina nitida* Alexander, 1934, by presence of the anteromedian bulge which separates the anterolateral field into dorsal and ventral compressed areas (Bonnema 1941, p. 41).

Range. First appearance in AKSD50, 5m below Southerham Marl 1, *T. lata* Zone, at the Middle/Upper Turonian boundary, thereafter occuring rarely through the overlying Turonian and continuing into the Lower Coniacian (Slipper in press, Appended).

Bythoceratina (Bythoceratina) saxa sp. nov. Pl. 11, fig. 8; Pl. 12, fig. 1; Pl. 25, fig. 8

Name. Latin; *saxum*, meaning boulder; after the characteristic large node, reminiscent of a boulder.

1996 *Monoceratina* sp. A, Slipper, p. 52, pl. 2, fig. 3.

Holotype. RV IJS18/30, from sample AKS3/10, 1m above Southerham Marl 2, Upper Turonian, *T. lata* Zone; from Akers Steps, Dover, Kent.

Material. 10 valves; ABCMR1a 1LV (illus. Slipper, 1996), ABCMR2 1LV, ABCMR3 1RV (broken), AKSD33 1LV (fragment), AKSD48 1LV (juv frag), DOE8A 1LV (juv broken), AKSD54 2RV (fragments), AKS3/10 1RV, LGSD18 1LV.

Diagnosis. Bythoceratina with a large reticulate node in the dorsolateral field which projects above the dorsal margin. Single sharp reticulate spine arises from a wide base.

Measurements.	IJS18/30, RV	525 - 310 - 340
	IJS7/10, LV	h = 245

Description. Weakly calcified *Bythoceratina* with elongate ovate outline; dorsal and ventral margins parallel and straight, small hinge ear at anterior cardinal angle. Anterior margin evenly rounded, posterior margin drawn out into a caudal process at the dorsal margin. Valves moderately well inflated particularly in front of and behind the median sulcus, elsewhere compressed. The weak anterior marginal rib is thickened in its central part which then joins the main inflated anterolateral field. Large hemispherical reticulate node projects from the dorsal half of the anterolateral field which reaches and overlaps the dorsal margin. Behind the node is an indistinct median sulcus which terminates ventrally against the dorsal portion of the ventrolateral swelling. The ventrolateral spine, where preserved, is long and sharp and has a small dihedral angle. The tip of the spine is slightly swept backwards. The spine is ringed with thin circular ribs, which break up at the base of the spine to form thin longitudinal ribs; on the ventral surface three parallel ribs run across the spine base, a fourth adsagittal rib connects with the third at the point where the anterior face of the spine rises from its base, from here it curves away towards the mid-line and bifurcates. The three absagittal ribs curve around the spine base and run obliquely along its anterior surface. A thin dorsal rib runs posteriorly from the anteroventral node beyond the median sulcus. Apart from the ornament detailed above the surface of the valves is smooth. Anterior calcified inner lamella moderately broad. Hinge long, thin median bar in left valve with very small terminal sockets, right valve with a median groove, terminal teeth not observed. Muscle scar details not seen.

Remarks. A single undescribed valve was found in Bonnema's collection, in the Geological Survey of The Netherlands, Haarlem, it is labelled as *Monoceratina* with the number 3.g 0.2334, from NN IV de Krim. This specimen is thought to be the conspecific with the author's material.

The general outline and lack of heavy ornament suggests that this might belong to the genus *Monoceratina*, but the presence of a terminal socket in the left valve indicates that hinge is that of *Bythoceratina*.

Two similar Cenomanian species which have large nodes in the anterolateral field can be distinguished: *Bythoceratina (Bythoceratina) bluebellensis* Weaver, 1982 has in addition an anteroventral node, and *Bythoceratina (Bythoceratina) bonnemai* Kaye, 1964a has two lateral spines.

Range. Restricted to the Turonian; first appearance in the Lower Turonian *Mytiloides* spp. Zone, last occurrence LGSD18 immediately above Bridgewick Marl 1, *S. plana* Zone, Upper Turonian.

Bythoceratina (Bythoceratina) trentoniensis (Bonnema, 1941) Pl. 12, figs 2, 3

v* 1941 *Monoceratina trentoniensis* Bonnema, p. 41, pl. 7, figs 20-22.

1958 *Monoceratina trentoniensis* Bonnema; Howe & Laurencich, p. 422.

. 1983 *Bythoceratina bicostata* n. sp.; Clarke, p.134, pl. 12, figs 15,16.

Lectotype. Designated herein, female left valve, slide O.2350, in the Geological Survey of The Netherlands, Haarlem, figured Bonnema 1941, pl. 7, figs 20, 21; from the borehole NNIV de Krim, Holland.

Material. 4 valves; AKSD48 1RV lost, LGSD26 1LV, LGSD28 1LV broken.

Diagnosis. *Bythoceratina* with a dorsal swelling anterior of the median sulcus, bearing five or six parallel, slightly curved ridges. Two well defined ventral ridges extending forward from the lateral spine below the median sulcus, up to mid-height at the anterior of the dorsal swelling, where they unite; the dorsal ridge is straight, whereas the ventral ridge curves round the meet the dorsal ridge.

Measurements.	IJS12/13, RV	637 - 262
	IJS18/29, LV	540 - 320 - 220

Description. Dorsal and ventral margins straight, but sinuous and subparallel; the dorsal margins are straight except for a raised portion just behind the median sulcus, which is bordered by two slight depressions, and also a depression in front of the caudal process, there is a weak hinge ear at the anterior; the ventral margins are very broadly curved from below the caudal process round to the anterior third of the valve, where there is a constriction, then curving down to flow into the anterior margin. The anterior margins begin at an anterodorsal angle at one-seventh of the valve length and are broadly rounded in the dorsal half, then narrowly rounded in the ventral half. The posterior is drawn out into a caudal process terminating just below the dorsal margin. Behind the broad anterior margin, the anterior lateral field is flattened dorsally and ventrally to leave a raised area which connects with the low anterocentral node; the ventral flattened area is more marked, giving a distinct comma shape. A raised swelling connects the anterocentral node with the dorsal margin, this runs diagonally up and back, and is covered in five or six ridges which run parallel to the small flexure in the dorsal margin. Ventrally from the node are two ridges which connect to the anterior side of the lateral spine; the dorsal of the two is straight and the more ventral curves down and then along to meet the spine. The lateral spine arises from below and slightly behind the median sulcus from a very broad base, it is approximately rectangular in section and is capped by a small tubercle; two very fine ribs run along the posterior border of the lateral spine. The posterior lateral field is compressed in the ventral portion to form a broad shelf, and raised in the dorsal area diagonally from the lateral spine to the caudal process. The surface of the valves is smooth with the exception of the ribs as noted above and also faint ribs at the anterior margin. Normal pores are widely spaced in the anterior half of the valves, along the ventral ribs and around the periphery.

Inner calcified lamella narrow, vestibule not seen. Hinge of left valve is a very long thin median bar which has a flexure in front of mid-length with a very small socket at the anterior, beneath the exterior hinge ear.

Remarks. This species is a member of a group of similar bythocytherids which posses two ribs extending forward from the lateral spine: *Patellacythere pseudosulcata* (Veen, 1936), *Monoceratina jugosa* Alexander, 1934, *Patellacythere* sp. A Weaver, 1982 and *Patellacythere bicostata* Wilkinson, 1988. The latter author included the specimens figured by Weaver (1982) however, Slipper (1996) notes that the two are not conspecific. *Patellacythere* sp. A Weaver, 1982 should probably be accommodated in the genus *Bythoceratina*, and can be distinguished from *B. (B.) trentoniensis* by the absence of the five or six parallel ridges on the swelling in front of the median sulcus. The fragile nature of the valves makes this a very rare species.

Range. First appearance in AKSD48 (specimen lost) 6.5m below Southerham Marl 1, *T. lata* Zone, near the top of the Middle Turonian, it ranges up into the overlying Coniacian (Slipper in press, Appended).

Bythoceratina (Bythoceratina) umbonatoides umbonatoides (Kaye, 1964a)

Pl. 12, figs 4, 5

pars 1890 *Cytheropteron umbonatum* (Williamson), var. *acanthoptera* (Marsson); Jones & Hinde, p. 41, pl. 1, figs 11-13, pl. 4, figs 22-24, *non* figs 25-29 [= *B. (C.) hispida* (Veen)].

v? 1941 *Monoceratina longispina* Bosquet; Bonnema, p. 40, pl. 6, figs 69-76.

*pars** 1964a *Monoceratina umbonatoides* nom. nov. Kaye, p. 57, pl. 4, fig. 5, *non* fig. 2 [= *B. (B.) antetumida* nom. nov.].

1965a *Bythoceratina umbonatoides* (Kaye); Damotte, pl. 6, figs 6-8.

1967a *Bythoceratina umbonatoides umbonatoides* (Kaye, 1964); Herrig, p. 607, pl. 1, figs A1-4, C1-6.

1971 *Bythoceratina umbonatoides umbonatoides* (Kaye 1964); Damotte, p. 98, pl. 6, fig. 10.

non. 1978 *Bythoceratina (Bythoceratina) umbonatoides* (Kaye, 1964c); Neale, p. 360, pl. 14, figs 2-6 [= *B. (B.) antetumida* nom. nov.].

1982 *Bythoceratina (Bythoceratina) umbonatoides umbonatoides* (Kaye, 1964a); Weaver, p. 40, pl. 6, figs 6-9.

1983 *Bythoceratina umbonatoides* (Kaye, 1964); Clarke, p. 149, pl. 15, figs 16-21.

1986 *Bythoceratina umbonatoides* (Kaye 1964); Damotte, p. 38, pl. 3, figs 20, 21.

1988 *Bythoceratina umbonatoides* (Kaye); Jarvis *et al.*, p. 34, fig. 16g.

Lectotype. Designated Kaye, 1964a, p. 57, pl. 4, fig, 5; BM Io1592, left valve; from Upper Chalk of Magee, N. Ireland, Jones' collection.

Material. 85 specimens; 41LV, 44RV, adults and juveniles.

Diagnosis. Species of *Bythoceratina (Bythoceratina)* with reticulate ornament anterior of the median sulcus and a smooth area behind the median sulcus. Anterior extremity compressed, behind which is an inflated anterolateral area. Dorsal rib is thin and continuous without ornament.

Measurements.		
	IJS19/8, LV	625 - 293 - 256
	IJS19/9, RV	643 - 337 - 250

Description. Carapace subrectangular, long margins subparallel. Dorsal margin weakly concave behind mid-length, distally obscured by dorsal ribs. Left valve has a small hinge ear at the anterior cardinal angle and a similar structure at the posterior cardinal angle. Anterior margin broadly rounded in the right valve, more truncate ventrally in the left valve. Ventral margin sinuous with a deep oral concavity. Ventral margin rises up steeply at the posterior towards the caudal process which terminates below the dorsal margin.

Anterior marginal rib confined to a weak swelling at the anteroventral corner, often bearing three small spines. Dorsal rib divided by dorsomedian sulcus; posterior section convex, evenly arched, anterior section horizontal with a curve at the anterior cardinal angle in the right valve.

Valves strongly inflated in the anterior one-third behind a compressed shelf round the anteroventral margin. The inflation is augmented by a swelling above mid-height in front of the median sulcus, and also below the median sulcus where the ventral tumidity obscures the ventral margin. A deep median sulcus runs from the dorsal margin in a sinuous line down, then curving backwards at mid-height, and then curving down and forwards in front of the base of the lateral spine. The posterior lateral field is strongly inflated dorsally, less so than the anterior lateral field, a wide compressed shelf extends from the posteroventral margin. The long and pointed lateral spine extends from the posteroventral field behind and below the ventral end of the median sulcus. In some specimens the spine is angled backwards slightly, in most, however, it extends perpendicular to the sagittal plane.

The ornament on the lateral surfaces is variable, but conforms to the basic plan of a concentric pattern of reticulation or pits in the anterior lateral field, ventrolateral curved ribs contiguous with the anterior concentric pattern, and a smooth posterolateral field. In the Middle Turonian, some specimens have a row of pits beneath the posterodorsal rib. The reticulation is found in some specimens in the posterior lateral field behind the median sulcus, leaving only the more compressed part free of ornament. In juvenile specimens, the ventrolateral ribs are more prominent, with rows of small spines.

The calcified inner lamella is narrow at the anterior but very wide at the posterior without vestibules. The hinge in the left valve is a very long thin bar with small terminal sockets, the right valve has a median groove, but the corresponding teeth are rarely preserved. Muscle scars not seen.

Remarks. Confusion has arisen from Kaye (1964a, pl. 4, figs 2 and 5), since the specimen selected as lectotype (Kaye 1964a, pl. 4, fig.

5), from Jones' collection, is not conspecific with his fig. 2, here assigned to *B. (B.) antetumida* nom. nov., which was from Kaye's collection from Sonning, Berkshire. Neale (1978) selected the latter to represent the species. Bonnema's specimens from Krim IV belong to this species, but his illustrated specimens from Schuinesloot are slightly different in outline. *Bythoceratina (B.) umbonatoides insolata* Herrig, 1967a from the Lower Maastrichtian of the Isle of Rügen, of can be recognised by a more raised anterior marginal rib and a row of pits below the dorsal rib in the posterior half of the valve. Some specimens in the Middle Turonian develop a row of pits below the posterodorsal margin similar to *B. (B.) u. insolata* but these do not have the raised anterior marginal rib.

Range. Present from the Holywell Member of the Lower Turonian, throughout the remaining Turonian of the sections studied. Long ranging and widely distributed from the Cenomanian of southern England (Weaver 1982), the Lower Coniacian of Dover (Slipper in press, Appended), the Santonian and Lower Campanian of northern Germany (Clarke 1983), and the Upper Campanian of the Paris Basin (Damotte 1965a, 1971, 1986).

Bythoceratina (Bythoceratina) sp. aff. **umbonatoides** (Kaye, 1964a)

Pl. 12, fig. 6

1996 *Bythoceratina* sp. aff. *B. umbonatoides*; Slipper, p. 54, pl. 2, fig. 5.

Material. 20 specimens, 14LV, 6RV.

Measurements. IJS7/17, LV 562 - 275

Description. Outline subrectangular to rhomboidal. Dorsal margin sinuous, with a concavity centrally, obscured in the posterior half of the valve by the arched posterodorsal rib. Ventral margin sinuous with central concavity. Anterior margin very broadly rounded, interrupted by nodes at the anterodorsal cardinal angle and the anteroventral angle. Posterior margin drawn out into an oblique caudal process which terminates below the dorsal margin.

Marginal ribs weakly developed, except the posterodorsal rib which is strongly arched above the dorsal margin. The anterior part of anterolateral field is compressed and smooth, with a spinose node at the anteroventral corner and a second node at the anterodorsal corner. The posterior half of the anterolateral field is strongly inflated with a coarse reticulation. A deep, vertical median sulcus divides the valve in two. At the ventral end of the sulcus in the posteroventral field rises a long spine, which has a concentric pattern of ribs and tubercles. While there is some reticulate pattern above and behind the spine base, the rest of the posterolateral field is smooth.

Remarks. While this species is similar to *(B.) umbonatoides* in respect of the reticulate anterior and smooth posterior, it can be distinguished by the presence of nodes at the anterodorsal and anteroventral corners. Slipper (1996) has commented upon the differences between this species and specimens of *B. (B.) umbonatoides*.

Bythoceratina (C.) hispida possesses similar anterior nodes, but lacks the smooth posterolateral field, and has in addition a vertically descending posterodorsal rib.

Bythoceratina (C.) howei also has anterior nodes, but is distinguished by a more reticulate posterolateral field and a strongly truncate posteroventral margin which places it in the subgenus *Cuneoceratina* rather than *Bythoceratina*.

Range. First appearance at Gun Garden Marl 1, Lower Turonian, *Mytiloides* spp. Zone; ranges sporadically up into the high Turonian.

Bythoceratina (Bythoceratina) sp. A Pl. 12, fig. 7

Material. 3 valves; LGSD25 1RV (fragment), LGSD26 2LV (1 fragment).

Measurements. IJS19/4, LV 650 - 281 - 212

Description. Moderately sized elongate *Bythoceratina*. Dorsal and ventral margins nearly straight and parallel, anterior margin is bluntly rounded, almost straight; a distinct hinge ear is present in both valves, ventral margin has a concavity in front of mid-length, a convex section behind this and then a broad curve up to the caudal process, which is below the dorsal margin with a small concave dorsal section. A weak anterior marginal rib is slightly thickened at the dorsal and ventral corners. Behind the rib is a weak furrow, behind which the valve gradually becomes more inflated. A weak median sulcus is present and is slightly deeper in its more ventral section, near to the spine base. The ventrolateral spine has a very large base and projects horizontally out and back. Posterior not seen in the Turonian specimens. Surface of the valves covered in a dense reticulation with small conjunctive and disjunctive tubercles.

Calcified inner lamella is narrow with a small anterior vestibule. The hinge of the left valve has terminal sockets and a long thin bar, the anterior end of which appears to be denticulate.

Remarks. The denticulate nature of the terminal parts of the median bar in the left valve suggest that this species should belong in the subgenus *B. (Cuneoceratina)*, but other features such as the subparallel nature of the dorsal and ventral margins and the very large base to the lateral spine argue for retention in the nominate subgenus.

Range. First appearance 1m below Navigation Hardground 1, *S. plana* Zone, Upper Turonian, in the level of the *Zoophycos* maximum. Also occurs in the Coniacian.

Subgenus CUNEOCERATINA Gründel & Kozur, 1972

(Syn. VEENICERATINA Gründel & Kozur, 1972)

Type species. By original designation; *Cythere pedata* Marsson, 1880, p. 46, pl. 3, fig. 16a; from the Upper Chalk of Rügen, Germany.

Diagnosis. Elongated, triangular carapace; weakly inflated; median sulcus not well developed. Slender lateral spine, arising from narrow base behind mid-length; well developed caudal process; anterior and posterior vestibules; hinge modified lophodont: median bar of hinge in left valve thickening distally where it is weakly denticulate, smooth terminal sockets.

Remarks. *Cuneoceratina* Gründel and Kozur, 1972 was regarded as a subgenus of *Bythoceratina* by Weaver (1982) on account of the similarity in outline and hingement of early forms of *Cuneoceratina* strongly resembling the genus *Bythoceratina*. That use is followed here. *Bythoceratina (Cuneoceratina)* is distinguished from the nominate subgenus by being more elongate and having a wedge shaped outline, having a narrower base to the lateral spine and possessing a distally thickened median bar in the left valve.

The genus *Veeniceratina* Gründel & Kozur, 1972 was erected for species with a ventral margin parallel to the dorsal margin in the anterior and central region, and inflation around the median sulcus. The difference in outline and the difference in degree of inflation between this and *Cuneoceratina* is thought to be insufficient to retain this a separate genus. In the analysis by Herrig (1967) of members of the Bythocytheridae, he included within his form group 1, equivalent to species of *Monoceratina* (sgen. n. ? 1) that were later placed in the two different genera by Gründel & Kozur (1972). The ornament, median sulcus, size of spine base, presence of marginal ribs, presence of vestibules and hingement is the same as that in *Cuneoceratina*. *Veeniceratina* is therefore regarded as a synonym of *Cuneoceratina*.

Bythoceratina (Cuneoceratina) hispida (van Veen, 1936) Pl. 12, fig. 8

pars 1890 *Cytheropteron umbonatum* (Williamson), var. *acanthoptera* (Marsson), (vel *umbonatum-acanthopterum*); Jones & Hinde, p. 41, pl. 4, figs 25, 27, ?26, ?29, *non* pl. 1, figs 11-13, pl. 4, figs 22-24 [= *Bythoceratina (B.) umbonatoides* (Kaye, 1964)].

v* 1936 *Monoceratina hispida* nov. spec., van Veen, p. 42, pl. 2, figs 1-3.

v 1938 *Monoceratina hispida* van Veen; van Veen, p 12, pl. 1, figs 16-19.

1958 *Monoceratina hispida* van Veen; Howe & Laurencich, p. 409.

1964 Monoceratina ?howensis n. sp. Szczechura, p. 386, pl. 9, fig. 3 *non* figs 1, 2 [= *B. (C.) howei* Szczechura, 1964)].

? 1966 *Monoceratina* (sgen. n.? 1) *hispida* Veen; Herrig, p. 899, pl. 38, figs 3-5.

1966 *Bythoceratina hispida* (van Veen); Deroo, p. 80, pl. 9, figs 107-109.

1972 *Veeniceratina hispida* (van Veen 1936); Gründel & Kozur, p. 929, fig. 8a.

? 1983 *Bythoceratina hispida* (Veen, 1936); Clarke, p. 136, pl. 13, figs 4-8.

Holotype. No type designated: Right valve O.1404, in the Geological Survey of The Netherlands, Haarlem figured Veen (1936, pl. 2, figs 1-3) is a candidate for being designated lectotype.

Material. 6 valves; LGSD21 1RV (broken), LGSD26 3RV (1juv) 1LV (broken), LGSD28 1LV.

Diagnosis. Elongate with a short vertical rib or node at the anterodorsal corner, a swelling immediately in front of the median sulcus, and an angular posterodorsal rib.

Measurements. IJS18/28, RV 600 - 310 - 220

Description. Valve outline is elongate wedge shaped; the dorsal margin is slightly concave in its central part, convex behind this, and then concave above the caudal process; the ventral margin similarly is concave centrally, but this is obscured by the overhang of the ventrolateral tumidity. The posterior part of the ventral margin curves up broadly to the caudal process. The posterior extremity is at about two-thirds height. The anterior margin has a node at the anterodorsal corner, and occasionally a smaller node at the anteroventral corner. The valves are moderately well inflated and possess a large swelling in the anterodorsal field. A deep vertical median sulcus is present bordered dorsally by a thin dorsal ridge and ventrally by the ventrolateral swelling. Behind the median sulcus is a long spine with a stout base. A prominent posterodorsal rib runs from the median sulcus parallel to the dorsal margin then turns sharply through about 110^0 where it thickens up and terminates at about mid-height. The surface ornament consists of many low ribs which are concentric about the centre of the valves, each bearing closely spaced tubercles. The ribs bifurcate around the lateral spine and encircle it such that it is covered in rings of tuberculate ribs.

Remarks. In the plate explanations of Jones & Hinde (1890), the figures 25-29 are referred to as the "Narrow form" of *Cytheropteron umbonatum acanthoptera* (Marsson, 1880) without further discussion. These specimens were included by Kaye (1964a) in *Monoceratina umbonatoides* nom. nov. The author's specimens correspond to the narrow form of Jones & Hinde (1890), and it is clearly distinct from the lectotype of *B.* (*B.*) *umbonatoides* selected by Kaye, which does not have the posterodorsal node.

The original specimen of van Veen has a prominent angular posterodorsal ridge and slightly raised anterior margin. The specimens illustrated by Herrig (1966) and by Clarke (1983), however, show some differences from the typical form. The German specimens do not have the posterodorsal ridge developed, but have in addition a distinct node on the anterodorsal part of the anterior margin. The specimens illustrated here seem to be intermediate between these two forms in that they possess both the posterodorsal ridge and the anterodorsal node. There is a possibility that these are subspecies; the Turonian form is ancestral having both sculptural elements, the dorsal ridge and the anterior node, the German Upper Campanian and Maastrichtian subspecies have lost the posterior ridge and retained the anterior node, while the Dutch subspecies have lost the anterior node and retained the posterior ridge. The Polish specimen (Szczechura 1964, pl.9, fig. 3), which was only tentatively assigned to this species, has much in common with the British specimens in having both anterior and posterior nodes.

This species was selected by Gründel & Kozur (1972) as the type species of their new genus *Veeniceratina*, here taken as a synonym of the subgenus *Bythoceratina (Cuneoceratina)* (see remarks for subgenus).

Range. First appearance immediately below the Kingston Nodular Chalks, *S. plana* Zone, Upper Turonian. Present in the Coniacian and Santonian of Kent, and the Campanian and Maastrichtian of Holland and Germany.

Bythoceratina (Cuneoceratina) howei (Szczechura, 1964) Pl. 13, fig. 3

pars. 1964 *Monoceratina howensis* n. sp. Szczechura; p. 385, pl. 3, figs 3a-b, 4, pl. 9, figs 1-2, *non* pl. 9, fig. 3 [= *B. (C.) hispida* (Veen)].

. 1974 *Veeniceratina howensis* (Szczechura); Szczechura, p. 434, pl. 186, figs 1, 2.

pars. 1983 *Bythoceratina howensis* (Szczechura, 1964); Clarke, p. 139, pl. 13, fig. 10, *non* fig. 9.

Holotype. A left valve, O.I/29; from the Lower Maastrichtian of Mielnik, Poland.

Material. 3 specimens; AKSD48 2LV broken; LGSD7 1RV.

Diagnosis. Subtriangular outline, inflated anterior with anterior marginal ridge, divided centrally to leave two nodes, behind which is a furrow. Long sharp spine rises from ventral part of posterolateral field.

Description. Left valve outline wedge shaped; straight to slightly concave dorsal margin, ventral margin straight and horizontal in anterior half then rising up to meet the dorsal margin. The blunt caudal process is compressed and is set a little way beneath the dorsal margin with a small concave section above it, the ventral margin below it is straight. Anterior margin is very broadly rounded, almost straight with a marginal rib which is better developed at the anterodorsal corner. The anterior part of the anterolateral field is compressed, behind this the inflation increases, but does not develop a swelling or a node in the dorsal half; ventrally this passes into the ventrolateral swelling. A short median sulcus exists in front of and above the spine base. The posterior lateral field is moderately inflated, with no ribs or projections. The long thin lateral spine arises from a small base in the ventral half of the posterolateral field. Surface ornament consists of concentric rows of closely spaced tubercles.

Right valve has distinct nodes at anterodorsal and anteroventral corners, strongly truncate posteroventral margin and reticulate surface.

Remarks. The species-group name *Bythoceratina* (*Cuneoceratina*) *howei* (Szczechura, 1964) is a "justified emendation" of *Bythoceratina* (*Cuneoceratina*) *howensis* [under Article 33b (ii) of the International Code of Zoological Nomenclature] to correct the suffix since the trivial name was given in honour of Dr. H. V. Howe.

The specimen figured by Clarke (1983, pl. 13, fig. 9), from the Middle Coniacian, does not have the divided anterior rib nor the pronounced hinge ear of *B.* (*C.*) *howei*, but possesses a large anterodorsal swelling not found in that species. That is closer to the species described here as *Bythoceratina staringi comacula* ssp. nov.

Similar to *B. (B.)* sp. aff. *umbonatoides* in possessing the anterior nodes, but has the typical shape of the subgenus *Cuneoceratina* and a reticulate posterolateral field.

Range. Only discovered in one sample 6m below the Southerham Marls, near the top of the Middle Turonian, *T. lata* Zone, and in one sample 4m above Southerham Marl 2, Upper Turonian, *T. lata* Zone.

Bythoceratina (Cuneoceratina) montuosa montuosa (Jones and Hinde, 1890) Pl. 12, fig. 9

1875 *Cythere (Cythereis) montuosum* Jones, p. 81 [*nomen nudum*]

* 1890 *Cytheropteron cuspidatum* sp. nov., var. *montuosa* nov. (vel *cuspidatum-montuosum*); Jones & Hinde, p. 38, pl. 3, figs 14-16.

non 1934 *Monoceratina montuosa* (Jones); Alexander, p. 62, pl. 8, fig. 5 [= *Monoceratina* (sgen. n. ? 1) *montuosa vetula* Herrig 1967].

pars. 1941 *Monoceratina montuosa* Jones; Bonnema, p. 41, pl. 7, figs 5-7, *non* figs 1-4 [= *Monoceratina* (sgen. n. ? 1) *obvoluta* Herrig 1967] ?figs 8, 9.

1964a *Monoceratina montuosa* (Jones & Hinde); Kaye, p. 53, pl. 3, figs 3a, b.

1964 *Monoceratina montuosa* (Jones, 1875); Szczechura, p. 384, pl. 8, figs 11-14.

1966 *Bythoceratina montuosa* (Jones & Hinde); Deroo, p. 81, pl. 9, figs 119-121.

1967 *Monoceratina* (sgen. n. ? 1) *montuosa montuosa* (Jones & Hinde, 1890); Herrig, p. 201, pl. 1, figs 1-4.

1974 ?*Bythoceratina montuosa montuosa* (Jones et Hinde, 1890); Szczechura, p. 429, pl. 186, figs 7-10.

pars 1983 *Bythoceratina montuosa* (Jones & Hinde, 1809); Clarke, p. 141, pl. 14, fig. 4, *non* pl. 14, fig. 5 [spinose nodes = *B. (C.) montuosa vetula* (Herrig, 1967)].

Lectotype. Designated Kaye, 1964a, p. 53, pl. 3, fig. 3; BM I.2478, right valve; from the Upper Chalk of Magee, Ireland.

Material. 6 valves; AKSD53 1RV, LGSD9 1LV, LGSD23 1LV, LGSD24 1LV, LGSD26 1RV, LGSD28 1LV. Mostly fragments.

Diagnosis. *Bythoceratina* (*Cuneoceratina*) with two lateral spines in each valve, the posterior being the larger. Dorsal margin with four tubercles. Lateral surface smooth or with faint reticulation.

Measurements. IJS18/27, LV 690 - 290 - 175

Description. Outline elongate; dorsal margin straight, interrupted by four tubercles. Ventral margin straight with small concavity in front of centre. Anterior margin descends steeply from anterodorsal corner, almost vertical in its dorsal part, then evenly rounded below mid-height; 5-6 blade like tubercles project beyond the anteroventral margin, the topmost two are very close together, the remainder are evenly spaced. Ventral margin with a slight concavity in front of mid-length, truncated posteriorly, which slopes up to the caudal process bearing twelve marginal denticles. The caudal process is raised above the dorsal margin.

A weak marginal rib runs around the periphery of the valve and is strongest at the anterior where it carries the marginal denticles. At the anterodorsal corner is a rounded tubercle, which could be an eye tubercle, has two spines projecting from its anterior face. Behind the anterior marginal rib is a compressed featureless anterolateral field which at one-third length rises up to the anterior inflation. Dorsally this inflation has projecting from it a large pyramidal node, on either side of the sinuous crest of which are two small tubercles. Just below mid-height on the anterior inflation, situated below the dorsal node is a small laterally directed spine. At the ventral edge of the anterior inflation a curved ventral rib descends, obscuring the concave section of the ventral margin, then rises to connect with the ventral side of the main lateral spine. A second weaker straight rib connects the two lateral spines. Above this connecting rib, extending to the dorsal margin is the median sulcus which is slightly more depressed in its central part. Behind the median sulcus the valve becomes more inflated, but less so than in front. A large lateral spine rises from the ventral portion of this posterior inflation and is directed outwards and slightly backwards. The posterior edge of the lateral spine has two small spines projecting down and backwards. On the dorsal margin above the lateral spine is a small tuberculate node, the smallest of the four on the dorsal margin. A short section of dorsal rib connects this node to the fourth which is also tuberculate on its crest.

The lateral surface of the valves is smooth, except for a trace of reticulation on the posterior face of the posterior inflation.

The calcified inner lamella is narrow with a small vestibule seen at the anterior. An ocular depression is seen at the anterodorsal corner confirming that the external node is an eye tubercle.

Remarks. *Bythoceratina (Cuneoceratina) montuosa vetula* (Herrig, 1967) is smaller and distinguished by having a slight reticulation on the valve surface, the division of the dorsal and anteroventral nodes into small spines, and by having the ventrolateral rib overhanging the ventral margin. Clarke (1983) found both the smooth and reticulate forms in the Upper Campanian and Lower Maastrichtian chalks from Kronsmoor and could find no justification for separating the two as subspecies. She suggested that that they might be ecophenotypes. Only the smooth subspecies has been encountered in the British samples.

Range. From 2m below Southerham Marl 1, *T. lata* Zone, Upper Turonian (AKSD53) to the Santonian. It is also reported from the Campanian and Maastrichtian of Norfolk and Ireland by King [1968].

Bythoceratina (Cuneoceratina) pedatoides (Bonnema, 1941) Pl. 12, fig. 10, Pl. 13, fig, 1

v 1890 *Cytheropteron umbonatum* (Williamson), var. *longispinata*, nov. (vel *umbonatum-longispinatum*); Jones & Hinde, p. 41, pl. 3, figs 11-13, pl. 4, figs 30, 31.

v* 1941 *Monoceratina pedatoides* nov. spec.; Bonnema, p. 29, pl. 6, figs 40-46.

pars v1941 *Monoceratina laevioides* nov. spec.; Bonnema, p. 29, pl. 6, figs 47-50 [juv.], *non* figs 51-53 [= *B. pedata* (Marsson) juv.]

non 1966 *Monoceratina* (sgen. n. ? 1) *pedatoides* Bonnema, 1941[10]; Herrig, p. 906, pl. 39, figs 2-9, pl. 44, fig. 3 [= *B. pedatella* Deroo, 1966].

v 1982 *Bythoceratina* (*Cuneoceratina*) *herrigi* sp. nov.; Weaver, p. 41, pl. 7, figs 1-4.

v 1983 *Bythoceratina pedatoides calcifera* n. ssp.; Clarke, p. 144, pl. 14, figs 14-17.

non v 1983 *Bythoceratina pedatoides pedatoides* (Bonnema, 1941); Clarke, p. 143, pl. 14, figs 12, 13 [= *B. pedatella* Deroo 1966].

v 1988 *Bythoceratina herrigi* Weaver; Jarvis *et al.*, p. 34, fig. 16e.

.1996 *Bythoceratina (Cuneoceratina) pedatoides* (Bonnema, 1941; Slipper, p. 52, pl. 2, figs 4, 6.

Syntypes. Slide O.2341 contains the specimens illustrated by Bonnema (1941), eight further slides, labelled as O.2208-O.2215, contain many more specimens, some have in addition, specimens of *B. howei* Szczechura. All are deposited in the Geological Survey Of The Netherlands, Haarlem; from borehole NNIV de Krim, The Netherlands.

Material. 249 valves of adults and juveniles.

Diagnosis. Large species of *Bythoceratina (Cuneoceratina)* with a horizontal anterodorsal rib connected to a short vertical dorsal anterior marginal rib, which is separated from a spinose enlarged anteroventral rib. Ornament of coarse reticulation.

Measurements.	IJS18/25, LV	890 - 450 - 340
	IJS18/26, RV	820 - 370 - 240

Description. Carapace large, weakly inflated, outline cuneiform to rhomboidal. Dorsal and ventral margins parallel and sinuous. Dorsal margin has an anterior hinge ear in both left and right valves, behind which is a straight very weak marginal rib which extends to mid-length. A stronger dorsal rib emerges behind the median sulcus which is often finely spinose on its dorsum depending on the state of preservation. In dorsal view this rib is set off from the valve margin a short distance, but converges with it posteriorly and ends in a small arch. Anterior margin is bluntly rounded, almost straight above mid-height in mature specimens. Below mid-height it is enlarged and may bear 6-7 spines. The ventral margin has a broad incurvature just in front of mid-length. The posterior margin is drawn out into a sharp caudal process at the dorsal margin in the left valve and just below the dorsal margin in the right valve.

The anterior marginal rib is clearly divided at mid-height, the ventral end of the vertical anterodorsal rib terminates behind the anteroventral rib. Behind both ribs are compressed anterolateral fields between which is a raised ridge which slopes up to meet the main anteromedian swelling. A weak median sulcus extends from the dorsal margin to mid-height. In front is a crescentic muscle scar depression, and behind is a long sharp laterally extended spine directed slightly backwards. The lateral surfaces are covered in a reticulation network, with the exception of the caudal process. Juvenile instars are smooth, with a deeper median sulcus, and a finely spinose margin.

Calcified inner lamella very narrow with a small anterior vestibule. Hinge of left valve a simple bar, which at the ends become denticulate, small terminal sockets; right valve has a thin groove.

Remarks. Kaye (1964a) and Neale (1978) regard "*Cytheropteron*" *umbonatum longispinata* Jones & Hinde as the adult of *Bythoceratina umbonata* Williamson, 1847, while Weaver (1982) suggests that it belongs to a separate species [*B. (B.) pedatoides* (Bonnema, 1941)]. The confusion may arise from specimens in Natural History Museum catalogued as "*Cytheropteron*" *umbonatum longispinata* Jones & Hinde belonging to both species. Specimens under In19318-24 (Jones & Hinde) belong to *B. (C.) pedatoides,* while Io374 formerly I.2476 (probably from Chapman) is certainly an adult of *B. (B.) umbonata*. The author supports the opinion of Weaver (1982) that the spinose variants of Jones & Hinde, described as *Cytheropteron umbonatum longispinata,* belong to different species, but here placed in *Bythoceratina*

(Cuneoceratina) pedatoides (Bonnema, 1941). This species can be distinguished from both *B. (C.) pedata* and *B. (C.) pedatella* by the interrupted anterior marginal rib which is continuous in those species. Older specimens from the Cenomanian and Turonian have weaker hinges than those from the Campanian.

Range. Found throughout the Turonian of the sections studied. Reported from the Cenomanian of southern England (Weaver 1982), the Marls (Santonian?) of The Netherlands (Bonnema 1941), the Santonian and Lower Campanian of northern Germany (Clarke 1983) and the Campanian *B. mucronata* Zone of Norfolk (Jones & Hinde 1890).

Bythoceratina (Cuneoceratina) staringi conmacula ssp. nov. Pl. 13, fig. 2; Pl. 25, fig. 3

Name. Latin; *con,* meaning with and *macula,* meaning mesh; this subspecies is characterised by its reticulation.

Material. 3 specimens; LGSD21, 1LV (broken); LGSD26a, 1LV, 1RV (broken). Further material from the Coniacian and Santonian.

Holotype. LV, IJS18/24, from sample LGSD26, below Navigation Hardground 1, Upper Turonian, *S. plana* Zone; from Langdon Stairs, Dove, Kent.

Diagnosis. A subspecies of *B. (C.) staringi* (Bonnema, 1941, p. 29, pl. 6, figs 63-68), with a network of reticulation meshes developed over the lateral surface.

Measurements. IJS18/24, LV hol. 640 - 260 - 200

Description. Valve elongate wedge shaped, dorsal margin long and straight, with weak elevations at the cardinal angles in the right valve, small hinge ear in the left. Ventral margin subparallel to dorsal margin but with a concavity at mid-length, behind this it rises at an angle towards the caudal process. Anterior margin bluntly rounded, almost straight. Caudal process set just below the dorsal margin by a short straight section of the dorsal margin.

Front face of anterior marginal rib rises steeply to a sharp crest behind which is a deep furrow, which gives the structure the appearance of a crescentic dune. The even line of the crest is broken by a small flexure at about mid-height. Behind the furrow the valve becomes moderately well inflated, particularly in the anterodorsal area where there is a large well developed swelling. The median sulcus is rather weak and broad. The posterodorsal lateral field has a prominent ridge which runs parallel to the dorsal margin then turns through an oblique angle to terminate at about mid-height. Lateral spine is long and sharp and angled slightly backwards. Marginal ribs are present but weak with sharp crests.

Surface ornament consists of reticulation in the anterolateral field, behind the longitudinal elements become dominant; these are inclined downwards as six subparallel ribs: one skirts around the base of the anterodorsal swelling, below this the second joins with the curved rib which extends backwards from the base of the spine, the third is not as inclined as other ribs and consequently converges with the second rib then bifurcates and skirts around the base of the lateral spine, the remaining ribs pass beneath the spine onto the ventral surface. Between each of these are small cross ribs which continue the reticulate appearance. The surface of the anterodorsal swelling is covered reticulation, again the longitudinal elements are dominant. In the posterodorsal field three ribs run concentrically with the main posterodorsal rib, each having cross ribs in a regular reticulate pattern. The posterior field and caudal process are covered in a very weakly defined reticulation.

Calcified inner lamella rather narrow at anterior with small vestibule, wider at posterior, vestibule not observed. Eight or nine widely spaced, short, stout marginal pore canals arranged around the lower edge of the anterior margin. Hinge of left valve, a long thin median bar which thickens towards the ends and become denticulate; terminal sockets.

Remarks. This is very similar to *Bythoceratina (Cuneoceratina) staringi staringi* (Bonnema, 1941) in terms of its shape and gross ornament. It differs however, by the development of a coarse network of reticulation over most of the surface of the valves. The illustration of the nominate subspecies from the Upper Campanian, given by Clarke (1983, pl. 15, fig. 2), is a good match for the specimens on Bonnema's slide O.2344; from NNII Schuinesloot. Deposited in the Geological Survey of The Netherlands. The specimen from the Lower Maastrichtian illustrated by Clarke (1983, pl. 15, fig. 1) is smoother and does not possess the characteristic strongly bent posterodorsal rib, but has a weakly reticulate swelling in its place. This would appear to be a younger subspecies of *B. (C.) staringi* with a continuing trend towards reduction in sculpture. Six specimens labelled by Bonnema as *Monoceratina staringi* on slide O.2086 in the Geological Survey of The Netherlands are smaller, and lack both the anterodorsal node and the posterodorsal bent rib. These possibly belong to either *B. (C.) hispida* (Veen) or *B. (C.) howei* (Szczechura).

The British Coniacian specimens also have the reticulation that is present on the Turonian forms, but by the Santonian, the reticulation has given way to ribbing alone, except for that on the anterodorsal swelling. These latter specimens are true *B. staringi staringi*.

The position in the subgenus *Cuneoceratina* accords with the analysis of Herrig (1966), who included this species in his form group 1 (see remarks for family Bythocytheridae).

Range. First appearance at the lowest of the Kingston Nodular Chalks, *S. plana* Zone, Upper Turonian. It is found rarely in the Coniacian (Slipper in press, Appended).

Genus MONOCERATINA Roth, 1928

Type species. By monotypy; *Monoceratina ventrale* Roth, 1928, p. 16, figs 1a-c; from the Carboniferous (Pennsylvanian) of Oklahoma, USA

Diagnosis. Outline subrectangular, moderately well inflated. Surface smooth or pitted. Lateral spine short with very broad base. Simple hinge with a long median ridge in the left valve, sometimes with a swollen posterior end.

Remarks. See remarks for *Bythoceratina*.

Monoceratina minangulata sp. nov. Pl. 13, figs 6, 7; Pl. 25, fig. 4

Name: Latin; *minimus*, meaning small and *angulus*, meaning angle; after the small angle made by the alae with the horizontal plane.

non v 1936 *Monoceratina aculeata* van Veen; p. 34, pl. 1, figs 67-69.

v.1941 *Monoceratina aculeata* van Veen; Bonnema, p. 41, pl. 7, figs 10-14.

1958 *Monoceratina aculeata* van Veen; Howe & Laurencich, p. 403.

pars. 1966 *Monoceratina* (sgen. n. ? 2) *aculeata* Veen, 1936; Herrig, p. 912, pl. 37, figs 2, 3., *non* figs 4-6 [= *Monoceratina aculeata* van Veen].

. 1983 *Bythoceratina aculeata* (Veen, 1936); Clarke, p. 134, pl. 12, figs 11-14.

. 1996 *Monoceratina aculeata* van Veen, 1936; Slipper, p. 52, pl. 2, fig. 7.

Holotype. LV IJS12/2, from sample LGSD24, uppermost of the Kingston Nodular Chalks, Upper Turonian, *S. plana* Zone; from Langdon Stairs, Dover, Kent.

Material. 9 valves; ABCMR3 1RV, (Slipper 1996, pl. 2, fig.7), AKSD41 2RV, AKSD53 1RV 1LV, LGSD5 ?1RV, LGSD8 1RV, LGSD19 1RV, LGSD24 1LV.

Diagnosis. Monoceratina with short arched dorsal rib lying over the median sulcus. Ventrolateral spine directed outwards with very little backwards sweep. Surface smooth except for a row of punctae on dorsal rib and reticulation around the base of the lateral spine.

Measurements.	IJS7/19, RV frag.	h = 373
	IJS12/2, LV	600 - 337
	IJS18/23, RV	550 - 380 - 320

Description. Outline oval to subquadrate; dorsal and ventral margins nearly straight and parallel, maximum height behind mid-length. Anterior margin evenly rounded with anterior extremity at or below mid-height, distinct anterodorsal angle, whereas anteroventrally continuous with ventral margin. Anterior fifth compressed rises up gradually to anterior inflated area which connects dorsal rib to ventrolateral swelling. A short, broadly arched dorsal rib sits above the median sulcus and carries five or six normal pores. The median sulcus terminates against the ventrolateral swelling from which arises, just behind mid-length, a broad conical spine. The base of the spine is reticulate and two thin parallel ribs are developed on the anterior edge of the ventrolateral swelling. The posterior halves of the valves are divided into an anterior inflated section and a posterior compressed section. The posterior extremity is a short caudal process at or immediately below the dorsal margin. Surface of the valves is smooth apart from the pores and reticulation mentioned above. Internally the marginal areas are rather broad. Hinge poorly preserved and muscle scars obscured by matrix.

Remarks. This can be distinguished from *Monoceratina aculeata* van Veen, 1936 by the angle made by the alar extension with the sagittal plane; the alae extend horizontally in *M. minangulata* sp. nov., whereas, in *M. aculeata* they overhang the ventral margin considerably. This difference was explained by Bonnema (1941, p. 41) as distortion of Veen's specimen, which was the only valve found. Herrig (1966) gives a good description of this species, making no reference to the difference between the illustrations of Veen and Bonnema. His illustration (Bonnema 1966, pl. 37, fig. 6) is similar to that of Veen, and he attributes this to being a juvenile of *M. aculeata*. The illustration of Howe & Laurencich (1958) has introduced error by showing a crenulated anterior margin where this is a result of redrawing the photograph given by Veen (1936, fig. 67) which has a slightly broken anterior margin. It may also be distinguished by the dorsal rib which does not extend any further back than the posterior margin of the median sulcus; *M. aculeata* has a dorsal rib which extends from the median sulcus to just in front of the caudal process. The inflation is not as great as *M. longispina* Bosquet, 1941.

Of the four specimens in the Geological Survey of The Netherlands, Haarlem, labelled as *M. aculeata,* that labelled as F_1 0.1934 from the Coprolithenlaag, Slavante is that illustrated by Veen (1936, pl. 1, figs 67-69), which can be taken to be the type specimen of that species. The remaining three are from Bonnema's collection; the specimen labelled as F_2 0.2348 from NN IV de Krim was illustrated by Bonnema (1941) as *M. aculeata* van Veen, but this is not conspecific with F_1 0.1934, and has thus been taken as a new species.

Range. First appearance datum at ABCMR3, Lulworth Marl, *Mytiloides* spp. Zone, t the top of the Lower Turonian; it occurs sporadically throughout the overlying Turonian. Reported from the Turonian to Santonian of Holland (Bonnema 1941), and the Maastrichtian of Germany (Herrig 1966, Clarke 1983).

Genus PARICERATINA Gründel & Kozur, 1972

Type specimens. By original designation, *Cytheropteron cuspidatum* var. *tricuspidata* Jones & Hinde, 1890, p. 38, pl. 3, figs 6, 7; from the Upper Chalk of Britain.

Diagnosis. (emended from Gründel & Kozur 1972; Boomer 1994) Two to four large spine-like nodes of varying strength in a row in the ventral half of the lateral surface. A marginal rib is developed around the periphery, more strongly at the anterior. Marginal spines are present at the anterior and on the dorsum. The hinge bar is weakly crenulate in the left valve, very weak terminal elements may be present in the right valve.

Remarks. In their subgeneric diagnosis Gründel & Kozur (1972) stated that a row of two to three lateral spines are of approximately equal strength, hence their name for the subgenus. However, the spines on the type species are of variable strength; that at the posterior is elongate and slender, the central spine is short and slender while the anterior spine is short and quite stout. Also included in this subgenus was *Monoceratina pecten* van Veen 1936. This clearly has four ventrolateral nodes. The type species also has a fourth small anterior ventrolateral spin; a broken base is seen in the illustration of Jones & Hinde (1890). The subgeneric diagnosis is therefore emended to include these features. The emendation to the generic diagnosis (Boomer 1994) is unnecessary since antero- and posteromarginal denticles were included by Gründel & Kozur (1972) "Randdornen sind nicht nur vorn und hinten, sondern meist auch längs des Dorsalrandes vorhanden." *Pariceratina* was raised to generic level by Dingle (1981) when a new species from the Maastrichtian of South Africa was described.

Neale (1975) erected the genus *Cretaceratina* based on a new species from the Upper Cretaceous of Australia. The author agrees with Boomer (1994) that this is a junior synonym of *Pariceratina*.

Pariceratina tricuspidata (Jones & Hinde, 1890) Pl. 13, figs 4, 5

* 1890 *Cytheropteron cuspidatum,* sp. nov., *tricuspidata,* nov. (vel *cuspidatum-tricuspidatum*); Jones & Hinde, p. 38, pl. 3, figs 6, 7.

1936 *Monoceratina tricuspidata* (Jones & Hinde); van Veen, p. 42, pl. 2, figs 4-11.

v 1941 *Monoceratina tricuspidata* Jones & Hinde; Bonnema, p. 40, pl. 6, figs 77-80.

pars 1964a *Monoceratina tricuspidata* (Jones & Hinde); Kaye, p. 56, pl. 3, figs 8a, b, *non* pl. 3, fig. 7.

1966 *Monoceratina* ? *tricuspidata* (Jones & Hinde, 1890); Herrig, p. 916, pl. 36, figs 10a, b, pl. 37, figs 1a, b.

1978 *Nemoceratina (Pariceratina) tricuspidata* (Jones & Hinde); Neale, pl. 14, figs 7, 8.

1983 *Bythoceratina tricuspidata* (Jones & Hinde, 1890); Clarke, p. 146, pl. 15, figs 5-10.

Lectotype. Selected Kaye, 1964a, p. 56, pl. 3, figs 8a, b; BM Io. 1583, right valve; from the Upper Chalk, Keady Hill, N. Ireland.

Material. 5 valves; AKSD 31, 3RV, 1LV; AKSD 33, 1RV.

Diagnosis. Elongate *Pariceratina* with a prominent posterodorsal oblique rib, truncated posteroventral margin. The anterior lateral spine is greatly swollen with smaller spines on its anterodorsal surface. Surface smooth with small spines, traces of reticulation in the dorsal half.

Measurements.	IJS19/2, LV	587 - 250 - 237
	IJS19/3, RV	562 - 237 - 212
	IJS18/22, RV	580 - 230 - 170

Description. Carapace small, elongate and inflated. Dorsal and ventral margins parallel and straight, ventral margin truncated by posterior margin; dorsal margin interrupted by a single square process at the cardinal angle, and slightly raised up at the posterior cardinal angle. Anterior margin very broadly rounded, almost straight at mid-height, ten or more fine denticles project from the anterior margin. Ventral margin has an incurvature in front of mid-length; where it turns up and merges into the posterior margin 11 or 12 marginal spines project beyond the margin and continue up to the caudal process. The posterior margin has an acuminate caudal process below the dorsal margin.

A marginal rib is developed around the periphery and particularly well at the posterior, in front of the caudal process where it is sideways chevron shaped. The rib is weak at the dorsal margin and broken into smaller segments. The anterior marginal rib is well developed with a sulcus immediately behind. The anterior lateral field slopes up steeply to the anterior face of the first lateral spine where several small tubercles are developed. The spine is very broadly based, has a domed crest with a tubercle at its summit, and is not symmetrically rounded, but rather diagonally elongated. Above the first spine is a weak median sulcus which reaches the dorsal margin. The second spine lies behind mid-length and below mid-height. It is the smallest of the three with a narrow base and a short, narrow square topped spire. The narrow base of the third spine is higher than that of the second, almost at mid-height; the spine is very long, pointed and directed down and back.

The surface of the valves is covered with a very weak reticulation, noticeable in the posterodorsal lateral field, also below the spines where longitudinal elements of the reticulation become rib-like. Small tubercles are present over the surface of the valves and the spines.

Calcified inner lamella rather broad at the anterior. Other internal details not seen.

Remarks. Kaye (1964a) figured a specimen from Upper Chalk, *coranguinum* Zone, Sonning, Berkshire. This specimen appears to have a much smaller length to height ratio than the type specimen, and the development of a large spine projecting above the dorsal margin suggests that this is not conspecific with the lectotype from N. Ireland.

Range. Very long ranging through the Late Cretaceous, but only recovered in the Middle Turonian from the chalk below the Glynde Marls.

Genus PATELLACYTHERE Gründel & Kozur, 1972

Type species. By original designation; *Monoceratina williamsi* Stephenson, 1946, p. 314, pl. 43, fig. 18; from the Eocene of Smithville, Texas.

Diagnosis. Outline subrectangular to rounded; ventral margin straight to weakly convex; anterior, posterior, anteroventral and posteroventral margins compressed; broad ventrolateral swelling, often also a weak dorsal rib; distinct broad median sulcus; surface smooth to pitted; hinge in the left valve has a smooth median bar; narrow anterior vestibule.

Remarks. Distinguished from *Bythoceratina, Monoceratina and Pariceratina* by lacking lateral spines, in place of which is a broad ventrolateral swelling. The practise of illustrating the dorsal and anterior views is of great help in distinguishing between the genera *Monoceratina* and *Patellacythere*, since the degree of development of the lateral swelling or spine is made clear. In their absence, stereo-pairs are ideal.

Patellacythere pseudosulcata (van Veen, 1936) Pl. 13, fig. 8

v* 1936 *Monoceratina pseudosulcata* nov. spec. van Veen, p. 33, pl. 1, figs 41-44.

. 1996 *Patellacythere pseudosulcata* (Van Veen, 1936); Slipper, p. 52, pl. 2, fig. 2.

Holotype. No types designated. The illustrated figures of Veen are from Bemelen, and correspond to slide 0.895 in the Geological Survey of The Netherlands, Haarlem.

Material. 7 valves; ABCMR2 1RV (illustrated Slipper 1996, pl. 2, fig. 2), LGSD9 1LV juv, LGSD10 1LV, LGSD23 1LV, 1RV (broken), LGSD26 2LV (1 juv). Only the specimen from ABCMR2 shows the full development of the ribs, the others are probably A-1.

Diagnosis. A *Patellacythere* with two ventrolateral ribs divided by a groove, which extends from the ventrolateral swelling forward and up to mid-height where they coalesce; broad anterior margin; smooth anterodorsal node with sharp crest.

Measurements. IJS7/16, RV 512 - 275

Description. Carapace elongate and inflated ventrolaterally. Dorsal and ventral margins straight to sinuous and parallel. The dorsal margin has a slight concavity above the median sulcus and a low broad convexity behind. The anterior margin is evenly broadly rounded with a weak peripheral flange. Ventral margin is straight and truncated posteriorly by the posterior margin. Caudal process is situated just below the dorsal margin at the posterior extremity.

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Patellacythere weaveri sp. nov.   Pl. 13, fig. 9; Pl. 25, fig. 2

Name. After Dr. P.P.E. Weaver in recognition of his studies on the Cenomanian Ostracoda of Britain.

Holotype. LV IJS18/21, from sample LGSD8, 2.5m below Caburn Marl, Upper Turonian, *T. lata* Zone; from Langdon Stairs, Dover, Kent.

Diagnosis. *Patellacythere* with a thin but prominent anterior marginal rib lacking in deep pits, a thin connecting rib from the central part of the anterior rib which flows into the ventrolateral swelling. Large bulbous termination to ventrolateral swelling with five feint vertical ribs. Surface with small scattered punctae.

Material. 7 valves; ABCMR 1a, 1LV; AKSD33, 1LV; AKSD36, 1LV; DOE8A, 1LV; LGSD5, 1RV (broken); LGSD8, 1 LV; LGSD21, 1LV (broken).

Measurements. IJS18/21, LV   470 - 250 - 190

Description. Carapace small, elongate rectangular, strongly inflated ventrolaterally. Dorsal and ventral margins straight to sinuous and subparallel. The dorsal margin has a slight concavity above the median sulcus and a low convexity behind, above the vertical median lobe. The ventral margin is obscured by the overhang of the ventrolateral swelling, but viewed internally is seen to be straight. The anterior margin almost straight above mid-height, then rounded below. The posterior margin has a short caudal process which terminates below the dorsal margin.

Marginal ribs are strongly developed at the anterior and dorsal margins. The anterior marginal rib is set back slightly from the anterior margin to give a very narrow shelf above mid-height. The rib is slightly curved and terminates just below mid-height. The dorsal rib connects with the anterior rib and slopes gently up to the median lobe. It passes through this and continues to terminate in front of the caudal process. A thin anteromedian rib connects the lower part of the anterior rib with the ventrolateral swelling. This thin rib divides the anterolateral field into two depressed areas. Behind these the valve becomes inflated and forms an inclined median lobe which extends from the dorsal margin down and forwards to intersect the ventrolateral rib at about one-third length; it has a pyramidal cross section. Behind is a deep median sulcus, bounded ventrally by the inflated ventrolateral swelling. At its extremity the swelling has a bulbous node which carries five vertical ribs, the smallest of which is reduced to a tubercle in the centre of the node, each becoming longer towards the posterior.

The lateral surface of the valves is smooth with scattered punctae.

Calcified inner lamella is narrow. The hinge in the left valve is a long straight thin bar, with weak terminal crenulate sockets; only one fragment of a right valve has been recovered, the hinge was not discernible.

Remarks. A very rare bythocytherid which is present sporadically throughout the Turonian. It is distinguished from *Patellacythere pseudoutilazea* (Weaver, 1982) by the absence of the deep elongated pits on the anterior marginal rib and absence of pitting on the lateral surface. In dorsal view the bulbous swelling is slightly more elongate. This species is descended from the Cenomanian *Patellacythere pseudoutilazea*.

Range. From ABCMR1a, Gun Gardens Marl 1, *Mytiloides* spp. Zone, Lower Turonian to LGSD21, The Kingston Nodular Chalks, *S. plana* Zone Upper Turonian.

Patellacythere sp. aff. **P. parva** Weaver, 1982 Pl. 13, fig. 10

aff. 1982 *Patellacythere parva* sp. nov.; Weaver, p. 44, pl. 7, figs 8-10.

Material. 4 valves; ABCMR 4, 1LV (fragment); AKSD50, 1LV (juv.); AKSD 53, 1LV; DOE 8A, 1 LV.

Measurements. IJS18/20, LV 510 - 250 - 140

Description. Carapace small, elongate and moderately inflated. Dorsal and ventral margins sinuous and subparallel. Maximum height at two-thirds length. Dorsal margin obscured in the centre by gently arched dorsal rib. Ventral margin straight at anterior convex towards the posterior then merges up into posterior margin. Short caudal process situated just below dorsal margin.

Marginal ribs weakly developed and only conspicuous where the dorsal marginal rib merges into the anterior marginal rib. The latter is short and terminates above mid-height. Behind the anterior marginal rib is a small sulcus which gives way medially to an anterior inflated bulge separating the anterolateral field into dorsal and ventral slightly depressed areas. The anterior median bulge divides into two in front of centre; the dorsal section thins and becomes the prominent dorsolateral rib which is gently arched upwards and extends to the limit of the inflated area in the posterolateral field; the ventral section becomes the ventrolateral swelling which is bowed downwards and terminates in a blunt node. Between the two structures is a deep median sulcus.

Viewed dorsally, two thin ribs can be seen en echelon between the valve margin and the main dorsolateral rib; the first is more anterior the second set slightly behind the first and in front of the main rib.

The surface is smooth with traces of longitudinal ribbing beneath the ventrolateral swelling.

The calcified inner lamella is narrow.

Remarks. Similar to *Patellacythere parva* Weaver, 1982, but can be distinguished by the anterior constriction in the dorsal and ventral margins, more prominent dorsal rib and the smoother anterolateral surface.

Range. Restricted to the Middle Turonian and the lower part of the Upper Turonian; found very rarely between the lower New Pit Member up to 2m below Southerham Marl 1.

Family CYTHERETTIDAE Triebel, 1952

Diagnosis: Carapace moderately large, with obliquely rounded ends, posterior end narrower. Left valve overlapping right valve over terminal teeth. Surface smooth, pitted or reticulate, sometimes with 3 longitudinal ribs. Muscle node reduced, eye tubercle absent. Broad inner lamella with small anterior vestibule. Marginal pore canals long, sinuous to bulbous.

Genus GOLCOCYTHERE Gründel, 1968

Type species. By original designation; *Golococythere costanodulosa* Gründel, 1968, p. 34, pl. 2, figs 23-26; from the Santonian of Germany.

Diagnosis. Elongate carapace with prominent dorsal, median and ventral ribs; the ventrolateral rib not connected to the anterior marginal rib. Anterior margin swollen or with peripheral ribs. Hinge ear of left valve with praeocular depression where left valve overlaps right. Surface smooth, pitted or reticulate.

Remarks. Triebel & Malz (1969) consider *Golcocythere* to be a junior subjective synonym of *Paracytheretta* Triebel, 1941, since the hinge and the marginal zones are the same. Ohmert (1970) points out that these features are the same in many other genera of the Cytherettinae. That author also points out that *Golcocythere* does not have the keel-like "kielartig" extremities of *Paracytheretta*, but shows swollen anterior and posterior margins. Furthermore, *Golcocythere*, unlike *Paracytheretta*, has connections between the median and dorsal ribs and the ventral rib with the ventral surface at their posterior ends. Also the manner in which the dorsal and ventral ribs curve in anteriorly towards the centre line in front of the muscle node is characteristic of the genus *Golcocythere*. Both Gründel (1978) and Pokorný (1984) consider *Golcocythere* to be a valid genus.

This genus inhabited shallow water near-shore areas, rarely found in offshore shallow water deposits (Ohmert 1970).

Ohmert (1970, 1971) found species of *Golcocythere* from the Middle Turonian of Bavaria. Pokorný (1984), on the basis of the occurrence of the genus in the Late Turonian of Bohemia, suggested that the genus may be of Tethyan origin. The discovery here of *Golcocythere* in the Middle Turonian of the English Chalk casts doubt on that suggestion.

Golcocythere calkeri (Bonnema, 1941) Pl. 14, figs 1, 2

v* 1941 *Cythereis calkeri* Bonnema, p. 9 pl. 5, figs 1-7.

1969 *Paracytheretta calkeri* (Bonnema); Triebel & Malz, p. 437, pl. 1, figs 1, 2.

1971 *Golcocythere calkeri* (Bonnema); Ohmert, p. 606, fig. 4.

v 1984 *Golcocythere calkeri* (Bonnema); Pokorný, p. 138, pl. 1, figs 1, 2.

v 1990 *Golcocythere*? *calkeri* (Bonnema); Horne *et al.*, pl. 1, fig. 5.

Syntypes. The specimens illustrated by Bonnema (1941) are on slide 0.2307 F_6 in the Geological Survey of The Netherlands, Haarlem; from borehole NNIV de Krim.

Material. 3 specimens; AKSD54, 1LV; LGSD26, 2RV.

Diagnosis. Lateral surface of the valves with three narrow, smooth longitudinal ribs and reticulate intercostal fields.

Measurements.	IJS18/19, RV	640 - 320 - 140
	IJS19/1, LV	675 - 387 - 156

Description. Dorsal margin of right valve converging with ventral margin towards the posterior, both sinuous. Dorsal margin obscured by thick dorsal rib. Anterior margin evenly rounded with approximately twelve fine denticles projecting beyond the periphery. Ventral margin with oral concavity in front of mid-length, convex behind then straight to the posterior margin. Short blunt caudal process situated just below mid-height.

Behind the anterior margin lies a rib with small riblets projecting forwards. The anterolateral field is compressed anteriorly then rises to the anterocentral tubercle which has the median rib running through. The dorsal rib rises from the dorsal anterolateral field, below the small hinge ear, and traces an arc to the dorsal margin behind the hinge ear. At its posterior end the dorsal rib turns sharply downward and connects with the posterior end of the median rib above mid-height. Median rib is straight or slightly curved in one specimen and connects with the muscle node. A small extension of the median rib passes through the node, then divides; one branch fades into the reticulation of the anterolateral surface, the other turns downward and weakly connects to the anterior end of the ventrolateral rib. The path of this rib somewhat mirrors that of the dorsal rib in that it curves down towards the ventral margin, then arcs gently up again, and finally straightens out before terminating below the posterior ends of the dorsal and median ribs.

In ventral view, the posterior end of the ventrolateral rib turns towards the sagittal plane and then curves sharply back on itself to run along the ventral margin as a true ventral rib. This in turn connects with the ventral part of the anterior marginal rib. Between the two ribs is a zigzag pattern of reticulation.

The intercostal surfaces of the valve is covered in a coarse reticulation. One of the muri between the muscle node and the anterior arc of the dorsal rib is slightly thickened.

Broad anterior calcified inner lamella without vestibule, long marginal pore canals, 13-15 at posterior, 15-18 at anterior. Other internal features not seen.

Remarks. Comparison with material in the collections of Bonnema and Pokorný shows that the British specimens are conspecific.

Range. The earliest British record of this genus is from the flint band beneath Southerham Marl 1, Upper Turonian. Horne *et al.* (1990) also recovered a carapace from the highest of the Kingston Nodular Chalks. Reported from the Lower and Middle Santonian of northern Germany (Triebel & Malz 1969), the Middle Turonian to Coniacian of Regensberg and the Santonian to Campanian of the Helvetikum (Ohmert 1971), the Upper Turonian to Lower Coniacian of Bohemia (Pokorny 1979, 1984), and the Late Cretaceous of the Netherlands (Bonnema 1941).

Family CYTHERIDEIDAE Sars, 1925

Diagnosis. (after van den Bold & Reyment *In* Moore, 1961 and Athersuch *et al.*, 1989) Carapace ovate, quadrate or reniform, thick shelled, pitted or smooth. Margins smooth or denticulate. Inner lamella variable, with or without vestibules. Hinge merodont or entomodont. Four adductor muscle scars in a vertical row, frontal scar U-, V- or Y- shaped.

Subfamily CYTHERIDEINAE Sars, 1925

Diagnosis. Surface smooth, pitted or reticulate. Hinge antimerodont or holomerodont. Inner lamella widest at anterior, vestibules present; numerous radial pore canals; muscle scars in a vertical row of four, with two ovate scars in front.

Genus ASCIOCYTHERE Swain, 1952

Type species. By original designation; *Bythocypris rotundus* Vanderpool, 1928, from the Lower Cretaceous of Texas, USA.

Diagnosis. Small, inflated, subovate carapace; dorsal margin arched. Merodont hinge with crenulate terminal elements and smooth or crenulate median element; left valve has accommodation groove above median bar. Inner lamella narrow.

Remarks. The genus *Stravia* Neale, 1962 differs only by having a crenulate median bar. Pokorný (1986) suggested that the two may be congeneric, and that *Asciocythere* is the senior name. Gründel (1970a, 1974) considers that *Stravia* is a subgenus of *Asciocythere*.

Asciocythere nana Nuyts, 1990 Pl. 14, figs 3, 4

non 1936b *Cytheridea falcoburgensis* nov. spec.; van Veen, p. 173, pl. 9, figs 47-51.

1966 *Asciocythere falcoburgensis* (van Veen); Deroo, p. 86, pl. 7, figs 76, 77.

* 1990 *Asciocythere nana* sp. nov.; Nuyts, p. 4, pl. 1, figs 1-5.

Holotype. A right valve, van Veen Collection, slide 0.1481, Geological survey of The Netherlands, Haarlem; from Gemeentegrot, Valkenburg, South Limburg, The Netherlands.

Material. 6 specimens; LGSD21, 1LV, 2RV; LGSD23, 1RV; LGSD28, 2RV.

Diagnosis. Asciocythere with smooth surface; right valve subtriangular, inflated centrally and compressed at extremities; left valve more inflated than right with thicker valve edges. Hinge with crenulate median element.

Measurements.		
	IJS18/17, LV	400 - 310 - 170
	IJS18/18, RV	360 - 250 - 140

Description. Left and right valves of unequal shape, left overlapping right around entire margin. Maximum height and inflation in both valves just in front of mid-length. Left valve subovate with evenly rounded high dorsal margin, which blends into the anterior margin without an angle; anterior extremity at mid-height. Ventral margin evenly convex with slight angle at the posterior. Posterior extremity just below mid-height. In dorsal view a slight compression is seen at the anterior margin. The right valve differs by having a more angular outline. The dorsal margin has an angle at maximum height, the posterodorsal margin has a slight flexure at four-fifths length, and the more acute posterior extremity is set below mid-height almost at the ventral margin. Surface of the valves smooth.

Calcified inner lamella narrow with small vestibules. Hinge of left valve consists of elliptical crenulate terminal sockets, the anterior socket is the larger of the two, the median bar is thin and crenulate. Above the median bar is a distinct accommodation groove.

Remarks. Distinguished from *Asciocythere bonnemai bonnemai* Deroo, 1966 by the lower anterior; *Asciocythere bonnemai senior* Pokorný, 1986, *Asciocythere bonnemai brevior* Pokorný, 1986 and *Asciocythere falcoburgensis* (van Veen, 1936b) are all larger with greater elongation in the posterior half. *Asciocythere pokornyi* Nuyts, 1990 has a row of blunt denticles along the anteroventral border.

Range. Rare specimens are found near the top of the Upper Turonian, *S. plana* Zone, from LGSD21, the lowest of the Kingston Nodular Chalks to the Navigation Hardground 3. Reported from the Upper Maastrichtian of The Netherlands and Belgium (Nuyts 1990).

Subfamily SCHULERIDEINAE Mandelstam, 1959

Diagnosis. Left valve larger than right. Hinge merodont, with well developed accommodation groove. Inner lamella of moderate width; marginal pore canals numerous and fan-like.

Genus SCHULERIDEA Swartz & Swain, 1946

Type species. By original designation; *Schuleridea acuminata* Swartz & Swain, 1946, p. 363, pl. 52, figs 1-10; from the Upper Jurassic of Louisiana, USA.

Diagnosis. Carapace subtriangular to subovate in lateral view; dorsal margin convex in left valve, obliquely sloping in the smaller right valve. Surface smooth or pitted; valves strongly calcified. Hinge of right valve with crenulate terminal teeth connected by a smooth hinge bar; left valve with an accommodation groove.

Schuleridea langdonensis sp. nov. Pl. 14, figs 5-7;
Pl. 25, figs 5, 6

Name: After the type locality Langdon Stairs, Dover, Kent.

? 1890 *Cytheridea perforata* (Römer); Jones & Hinde, p. 29.

Holotype. Female LV, IJS18/15, from sample LGSD26, beneath Navigation Hardground 1, Upper Turonian, *S. plana* Zone; from Langdon Stairs, Dover, Kent.

Material. 15 specimens; LGSD26, 5RV, 1car; LGSD26a, 3RV, 1LV; LGSD28, 3RV. Further specimens from the Coniacian.

Diagnosis. Schuleridea with indistinct eye tubercle, smooth surface; one terminal spine at the posterior extremity of the right valve

Measurements.	IJS18/14, F, RV	585 - 370 - 160
	IJS18/15, F, LV	590 - 415 - 180
	IJS18/16, M, RV	590 - 330 - 170

Description. Valves of unequal shape and size, smaller right valve is overlapped entirely by the left valve. Maximum inflation just behind mid-length, anterior and anterodorsal areas slightly compressed. Left valve has a high vaulted dorsal margin which merges smoothly into the evenly rounded anterior margin. Posterodorsal margin slopes down to oblique posterodorsal cardinal angle. Posterior extremity is below mid-height. Ventral margin is convex anteriorly and straight to concave behind mid-length. Right valve differs in having a slight hump on the dorsal margin, at the point of maximum height, above the weak eye tubercle, a well defined posterodorsal cardinal angle, a sharply pointed posterior extremity possessing a small terminal spine, and the ventral margin has a marked convexity at mid-length between straight anterior and posterior sections.

Calcified inner lamella broad. Holomerodont hinge with elongate crenulate sockets in the left valve separated by a denticulate groove, a thin bar separates this from an accommodation groove.

Remarks. This species is very close to *Schuleridea babinoti* Rodrígues Lázaro, 1988, but Dr. Julio Rodríguez Lázaro was kind enough to send me some of his material, and that species has a very clearly developed eye tubercle and a less ovate right valve. *Schuleridea jonesiana* (Bosquet, 1852) is distinguished by having a well developed eye tubercle and a strongly pitted surface. *Schuleridea medwayensis* Weaver, 1982, has two posterior marginal denticles in the right valve and anterior marginal denticles in the left valve.

The figures of Jones & Hinde (1890), from the Lower Cretaceous, have been shown by Kaye (1964a) to be of *Schuleridea jonesiana,* but the report by Jones & Hinde (1890) of this species from the Upper Chalk of Horstead, Norfolk and the Chalk-Rock of Dunstable are most probably of *S. langdonensis* sp. nov.

Range. First appearance at the *Zoophycos* maximum below Navigation Hardground 1, *S. plana* Zone, Upper Turonian, present in the Coniacian to the top of the *M. coranguinum* Zone.

Family CYTHERURIDAE G.W. Müller, 1894

Subfamily CYTHERURINAE G.W. Müller, 1894

Genus EUCYTHERURA G.W. Müller, 1894

Subgenus EUCYTHERURA G.W. Müller, 1894

Type species. By subsequent designation; Alexander, 1936, p. 692; *Cythere complexa* Brady, 1867, p. 210; from the Recent off the Hebrides, Great Britain.

Diagnosis. Small, subquadrate, surface reticulate, tuberculate or with thin ribs. Inner lamella wide, without vestibules. Hinge merodont, with smooth terminal teeth and smooth to crenulate median groove in right valve.

Eucytherura (Eucytherura) cf. E. (E.) tuberculata Bonnema, 1941

Pl. 14, fig. 8

cf.*pars*1941 *Eucytherura tuberculata* nov. spec.; Bonnema, p. 12, pl. 5, figs 52-55, *non* pl. 5, figs 56, 57.

1982 *Eucytherura (Eucytherura)* cf. *E. (E.) tuberculata* Bonnema, 1941; Weaver, p. 88, pl. 16, figs. 8-10.

Material. LGSD19 1RV.

Measurements. IJS18/10, RV 270 - 150 - 70

Description. Very small right valve, sub-ovoid shape, tapering towards posterior. Dorsal margin straight, inclined down towards posterior. Anterior margin angulate just below mid-height, above and below are straight anterodorsal and anteroventral sections. Ventral margin gently convex, slightly obscured by ventral tumidity. Posterior has short, compressed caudal process which terminates above mid-height. Strong eye tubercle present anterodorsally. Short, strong posterodorsal rib is composed of coalesced spines. Ventrolateral rib is only developed in the posterior half of the valve and is crowned by three spines. Muscle node irregular. The valve is strongly inflated and the surface is covered in reticulation. A weak rib is seen to run from the pore conulus in the centre of the posterolateral field, between two offset pore conulae to the posterior, to terminate just below the extremity of the caudal process. Ventral surface has three longitudinal ribs which are developed in the anterior half, the central is weaker than the two surrounding ribs.

Calcified inner lamella broad at the anterior. A small vestibule may be present which would place this specimen in the subgenus *Vesticytherura*, but this is not confirmed.

Remarks. This differs from *E. (E.) tumida* in having strong ribs at the posterodorsal and posteroventral corners, and a muscle node. *Eucytherura (V.) dorsotuberculata* is more elongate, lacks reticulation, is more compressed and has four dorsal nodes.

The specimens illustrated by Weaver (1982), which were compared to *E. (E.) tuberculata* Bonnema, compare well with the specimen found in the Turonian, though the dorsal margin is slightly more arched. The dorsal margin of Bonnema's specimens is however, straight.

Range. Recovered from a single sample LGSD19, Bridgewick Marl 2, Upper Turonian, *S. plana* Zone.

Eucytherura (Eucytherura) tumida Bonnema, 1941 Pl. 15, figs 1, 2

* 1941 *Eucytherura tumida* nov. spec.; Bonnema, p. 23, pl. 5, figs 69-77.

1966 *Eucytherura tumida* Bonnema, 1941; Herrig, p. 879, pl. 29, figs 14-17.

1966 *Eucytherura tumida* Bonnema; Deroo, p. 113, pl. 15, figs 359-361.

Type specimens. No type specimens have designated. Bonnema's material was from marls and chalks of the Late Cretaceous from The Netherlands.

Material. 5 specimens; AKSD33, 1RV; LGSD5 1LV; LGSD24, 2LV, 1RV.

Diagnosis. A strongly reticulate, greatly inflated *Eucytherura* with short, sharp, caudal process; distinct eye tubercle; 2-3 concentric ribs in the anterior half of the ventral surface.

Measurements.	IJS18/12, LV	250 - 160 - 85
	IJS18/13, RV	290 - 180 - 115

Description. Small inflated subquadrate carapace. Dorsal margin straight, small hinge ear in left valve. Anterior margin very broadly rounded, almost straight above mid-height. Ventral margin obscured by ventrolateral rib. Acute caudal process is concave above and straight below. Distinct eye tubercle below hinge ear. Weak median sulcus. At the posteroventral corner is a tuberculate process. A slightly raised posterodorsal rib bears a row of small spines. On the basal surface two prominent curved concentric ribs run longitudinally. The ventrolateral rib runs from the ventral edge of the anterior margin, and terminates at about mid-length. The third and smallest rib could not be observed under a low power microscope. The surface of the carapace is covered with a coarse reticulation bearing many conjunctive spines.

Calcified inner lamella moderately wide, without vestibules. Hinge of right valve has terminal teeth and a median groove. The left valve has complementary elements.

Remarks. The specimens of *Eucytherura ventrocostata* Clarke, 1983 from the Lower Campanian of Northern Germany differ only in lacking an eye tubercle. Clarke (1983) did not discuss the relationship between that species and *E. tumida*, but only compared *E. ventrocostata* with *E. (V.) ? tumida* Bonnema *sensu* Gründel, 1966.

Range. This occurs rarely from the thin marl below Glynde Marl 1, *T. lata* zone, Middle Turonian to the highest of the Kingston Nodular Chalks, *S. plana* Zone, Upper Turonian. Reported from the Late Cretaceous of The Netherlands (Bonnema 1941), The Maastrichtian of The Netherlands (Deroo 1966), and the Lower Maastrichtian of Rügen (Herrig 1966).

Subgenus VESTICYTHERURA Gründel, 1964

Type species. By original designation; *Eucytherura neocomiana* Kaye, 1964, p. 98, pl. 4, figs 8-10; from the Barremian of Speeton, Yorkshire.

Diagnosis. *Eucytherura* with a distinct anterior vestibule; 7-10 straight anterior marginal pore canals, 3 at posterior.

Eucytherura (Vesticytherura) sp. cf. **E. (V.) dorsotuberculata** Veen, 1938

Pl. 15, figs 3, 4

v 1936b No. 8; van Veen, p. 179, pl. 10, figs 55-57.
cf. *1938* *Eucytherura dorsotuberculata* nov. spec.; Veen, p. 17.
pars 1982 *Eucytherura (Vesticytherura) multituberculata* Gründel; Weaver, p. 88, pl. 16, fig. 23, *non* pl. 16, fig, 22.

Material. 4 specimens; AKSD55, 1RV; LGSD5, 1RV 1LV; LGSD18, 1RV.

Measurements. IJS12/5, LV 287 - 162
IJS18/11, RV 295 - 150 - 70

Description. Carapace small, laterally compressed, anterior end higher than posterior. Anterior margin broadly rounded with stout marginal denticles, on its dorsal portion in the left valve sits a high hinge ear. Dorsal margin straight, sloping down to the posterodorsal angle, interrupted only by the most posterior of the three large, dorsal tubercles which project from the dorsolateral surface. These three tubercles are slightly spine like and evenly spaced, an oblique sulcus divides the first two which project normally from the valve surface, while the third is composed of two coalesced tubercles. They rise up and sweep backwards to jut out above the dorsal margin. The posterior margin has a thick rib around its periphery, and is irregular in shape; the most posterior extension of the caudal process is below mid-height and acutely triangular, while above this is a process which marks the posterodorsal corner. The ventral margin is a continuation of the anterior marginal rib which thickens in its central portion and ends at the posteroventral corner in two large, closely spaced tubercles. The surface of the valve appears smooth with three, small rounded pore cones in the posteroventral part of the valve and one near the anteroventral margin.

Basal surface bears two faint striations, the adsagittal is straight and follows the valve margin, the absagittal is curved and follows the ventrolateral edge. The two posteroventral tubercles cross the basal surface transversely to the inner margin.

Calcified inner lamella broad with anterior vestibule. Hinge details obscured.

Remarks. Eucytherura dorsotuberculata Veen, 1938, from the Maastrichtian of Holland, is larger than these specimens and has much more robust tubercles. Comparison with juveniles of *E. dorsotuberculata,* which are of a similar size, shows that the British species has tubercles which are fully developed. These are therefore not juveniles, but a smaller species. The hinge ear which is well developed in the left valve is absent in *E. dorsotuberculata*. It compares well with *E. ansata* Weingeist (1949, pl. 73, figs 1, 2, 4-7); *non E. ansata* Weingeist *sensu* Kaye (1964) = *E. (V.) multituberculata* Gründel, 1964), in that the tubercles are cone shaped, but differs in the relative position of the dorsal tubercles and also in the absence of the central ventrolateral tubercle.

The right valve illustrated by Weaver(1982) compares well with the specimens recovered here, but there are differences between this species and the left valve illustrated by Weaver (1982, pl.16, fig. 22). That specimen lacks the anterior denticles, has a less distinct eye tubercle and more rounded dorsal tubercles.

Range. The range begins in the Upper Cenomanian with the specimen figured by Weaver (1982, pl. 16, fig. 23). Only recovered in the Turonian from Southerham Marl 1, *T. lata* Zone, Upper Turonian up into the lowest Coniacian.

Subfamily CYTHEROPTERINAE Hanai, 1957

Genus CYTHEROPTERON Sars, 1866

Type species. By original designation; *Cythere latissima* Norman, 1865, p. 19, pl. 6, figs 5-8; from the Recent of the North Atlantic.

Diagnosis. Small to medium sized, subovate with ventrolateral alae. Surface smooth, punctate or weakly reticulate. Hinge of right valve consisting of terminal teeth separated by crenulate or smooth groove. No accommodation groove in the larger right valve.

Subgenus AVERSOVALVA Hornibrook, 1952

Type species. By original designation; *Cytheropteron (Aversovalva) aureum* Hornibrook, 1952, p. 57, pl. 13, figs 189-194; from the Recent of New Zealand.

Diagnosis. *Cytheropteron* with the left valve larger than the right; the left valve has an accommodation groove above the median element. Eye tubercle absent.

Remarks. Deroo (1966) raised *Aversovalva* to generic status on the strength of the differences in the hingement and reversed overlap. The author regards the differences as of subgeneric level.

Cytheropteron (Aversovalva) vscriptum (van Veen, 1936) Pl. 15, figs, 5, 6

v* 1936 *Cytheropteron V-scriptum* nov. spec.; van Veen, p. 18, pl. 3, figs 51-54.
v 1941 *Cytheropteron v. scriptum* van Veen; Bonnema, p. 26, pl. 6, figs 12-17.
1965 *Cytheropteron v-scriptum* Veen, 1936; Szczechura, p.490, pl. 2, fig. 12, pl. 19, figs 9-13.
1966 *Cytheropteron (Aversovalva) V-scriptum* Veen, 1936; Herrig, p. 884, pl. 31, figs 5-10, pl. 32, figs 1-4, pl. 44, fig. 9.
1966 *Aversovalva v-scriptum* (van Veen); Deroo, p. 112, pl. 7, figs 84, 85, pl. 15, figs 346-348.
1983 *Aversovalva V-scriptum* (Veen, 1936); Clarke, p. 132, pl. 11, figs 21-23.

Syntypes. The figured specimens (van Veen 1936) are on slide 0.144 F_3 in the Geological Survey of The Netherlands in Haarlem; from South Limburg.

Material. 19 specimens; ABCMR4, 1RV; AKSD19, 1LV, AKSD41, 1LV (juv); LGSD1, 1RV (broken); LGSD5, 2LV, 1RV; AKSD3/10, 1LV; LGSD8, 1RV; LGSD13, 1LV, 1RV (broken); LGSD26, 2LV, 1RV; LGSD28, 1LV, 3RV (juvs.).

Diagnosis. Carapace small with ovate outline, ventrolateral alae with a 'V' shaped depression on its lateral surface formed by the thickened margins. Surface of valves covered in punctae.

Measurements.	IJS7/20, RV	314 - 165
	IJS18/9, RV	300 - 170 - 105
	IJS18/8, LV	310 - 220 - 140

Description. Left valve outline ovate, with evenly rounded dorsal margin; right valve subovate, distinct anterodorsal angle and straight anterodorsal and centrodorsal margins. Anterior margin evenly rounded, ventral margin obscured by overhanging ala. Blunt caudal process at posterior extremity at mid-height.

Valve margins compressed, particularly the dorsal margin of the left valve. Central part of both valves strongly inflated. Ventrolateral alae well developed and strongly recurved. The margins of the ala are thickened to leave a 'V' shaped depression in the centre of its lateral surface. The ventral part of the ala may itself be formed of two small parallel riblets. The ornament on the surface of the valves is variably developed consisting always of punctae and sometimes of thin vertical riblets.

Calcified inner lamella moderately broad with small anterior vestibule. Hinge of left valve has two crenulate terminal sockets, a thick denticulate median bar, above which is an accommodation groove.

Remarks. The Turonian specimens are smaller than those from Limburg and the median sulcus is not quite as clearly developed, but in all other respects they are similar. There is variability in the Maastrichtian specimens from Slavante, while those most like the British specimens come from the borehole NNIII and NNIV de Krim.

Cytheropteron (Aversovalva) scriptellum Gründel, 1974, from the Santonian near Salzburg, can be distinguished by having a dorsal rib above both lateral sulci, and by having several diagonal ribs on the posterior lateral field.

Range. First appearance at the Middle Turonian *Mytiloides* spp. - *T. lata* Zone boundary at Abbots Cliff; found rarely through the overlying Turonian of the sections studied. Reported from the

Maastrichtian of The Netherlands (van Veen 1936), the Lower Maastrichtian of Germany (Herrig 1966), the Upper Campanian and Maastrichtian of Belgium and The Netherlands (Deroo 1966) and northern Germany (Clarke 1983).

Genus PEDICYTHERE Eager, 1965

Type species. By original designation; *Pedicythere tessae* Eager, 1965, p. 21, pl. 2, figs 6-8; from the London Clay of Reading, England.

Diagnosis. Compressed valves small and fragile, subtriangular in lateral view with pronounced caudal process, posteroventral spine and thin ventrolateral alae. Surface smooth. Hinge amphidont.

Remarks. *Pedellacythere* Gründel, 1975 is distinguished by having a merodont hinge, *Stillina* Laurencich, 1957 is more inflated, has stronger eye tubercles and a holomerodont hinge. Gründel (1975) included these three genera in his new tribe Pedicytherini, tentatively included within the Paracytherideinae Puri, 1957.

Pedicythere fluitans (Bonnema, 1941) Pl. 15, figs 7, 8

v* 1941 *Cytheropteron fluitans* nov. spec; Bonnema, p. 27, pl. 6, figs 29-36.

1958 *Cytheropteron fluitans* Bonnema; Howe & Laurencich, p. 299 [genus uncertain].

1965 ?*Stillina* cf. *fluitans* (Bonnema) 1941; Kaye & Barker, p. 380, pl. 48, figs 23-25.

1966 *Paracytheridea (Paracytheridea) fluitans* (Bonnema); Herrig, p. 866, pl. 32, figs 9-11.

1968 *Pedicythere fluitans* (Bonnema, 1940); King, p. 110, pl. 9, figs 4, 5.

1975 *Pedicythere fluitans* (Bonnema, 1941); Gründel, fig. 9.

1983 *Paracytheridea (Paracytheridea) fluitans* (Bonnema); Clarke, p. 119, pl. 9, figs 15-17.

Syntypes. The specimens illustrated by Bonnema (1941) are on slide 0.2339 F_6 in the Geological Survey of The Netherlands, Haarlem; from borehole NNIV de Krim.

Material. 5 specimens; AKSD54, 1RV; AKSD3/10, 1RV (juv.); LGSD5, 1RV; LGSD13, 1RV; LGSD26, 1LV (juv.).

Diagnosis. A species of the genus *Pedicythere* with roughly rhomb shaped outline, posterodorsal end extended above the dorsal margin. Long, narrow alae are directed backward from the centre of the valves. Strong anterior marginal spines are developed, which fuse to form a notched flange.

Measurements. IJS18/7, LV 310 - 150 - 150
IJS14/2, RV 381 - 156

Description. Outline elongate ovate, dorsal margin straight to slightly concave, but in one specimen the dorsal margin of the right valve is distinctly convex. Anterior margin rounded with the periphery occasionally broken by partly fused denticles. The straight ventral margin is obscured by the overhang of the ala. Strongly developed caudal process is slightly upturned at its extremity to terminate at the same height as the dorsal margin. In the middle of the posteroventral margin is a downwards curved spine.

The anterior margin is produced into a thin frill which is inclined away from the sagittal plane at the valve edge. Below the dorsal margin where it is convex, lies a series of six or seven vertically elongated pits. The ala rises from the centre of the ventrolateral surface and is angled down and backwards. On the anterior, dorsal and posterior surfaces of the ala are thin blades which extend from the lateral surface to the tip.

Calcified inner lamella quite broad, hinge details not seen.

Remarks. Comparison with the type material of Bonnema shows that there is some variation in the assemblages, particularly at the anterior margin where the spines are variously preserved. King [1968] also notes variation in the presence of the posteroventral spine and eye tubercle within the Maastrichtian assemblage. The straight margins variously illustrated are probably simply those with the thin frill broken off.

Similar to *P. pitstonensis* Weaver, 1982, but has a straighter dorsal margin in the left valve and a downwards curved spine on the posteroventral margin.

The inclusion of this species in *Paracytheridea* (*Paracytheridea*) by Herrig (1966) and Clarke (1983) is not supported due to the differences in carapace shape and ornament. *Paracytheridea (P.)* has much greater inflation of the carapace and has strong surface ornament of swellings, nodes and ridges.

Range. Kaye & Barker (1965) report a similar form in the Aptian. Absent in the Albian and Cenomanian. First appearance 1m below Southerham Marl 1, *T. lata* Zone, Upper Turonian; it occurs through the Coniacian and Santonian in Kent and is figured from the Maastrichtian of N. Ireland by King [1968].

Family EUCYTHERIDAE Puri, 1954

Diagnosis. Carapace ovate, reniform or quadrate, anterior broadly rounded, tapering posteriorly. Surface smooth or weakly ornamented. Hinge lophodont or antimerodont, broad marginal areas with vestibules and few, straight radial pore canals. Frontal scar V-shaped.

Genus PHODEUCYTHERE Gründel, 1978a

Type species. By original designation; *Pontocypris trigonalis* Jones & Hinde, 1890, p. 3, pl. 3, figs 25, 26, pl. 4, figs 1, 2; from the Gault at Folkestone.

Diagnosis. Carapace triangular in shape, highest towards anterior, hinge margin straight to convex, ventral margin weakly concave, carapace widest behind mid-length; hinge lophodont; marginal areas broad anteriorly.

Remarks. The outline, marginal zone and dimorphism are the same as in *Eucythere* Brady, 1868, but the hinge is lophodont as opposed to merodont.

Phodeucythere sp. A   Pl. 16, figs 1, 2; Pl. 25, fig. 7

Material. 13 specimens; AKSD50, 4LV (1juv), 1RV (juv); AKSD52, 3RV (juv.) 2LV; LGSD8, 1RV (broken juv); LGSD26, 1RV (broken juv).

Measurements.		
	IJS18/5, RV	550 - 310 - 150
	IJS18/6, LV	560 - 330 - 160

Description. Valves subtriangular, male much more elongated than female. Maximum inflation below mid-height. Dorsal margin smoothly arched from the posterior extremity, situated almost at the ventral margin, to the point of maximum height in front of mid-length. Anterodorsal margin curves evenly and turns through a slight angle to anterior margin. Anterior margin evenly rounded merging with ventral margin. Ventral margin is convex anteriorly, has a concavity at about mid-length and is straight behind, where it meets the dorsal margin in a sharply rounded angle. No surface ornament. The inflation is similar along the length of the valve. Calcified inner lamella broad at anterior with vestibule. Hinge imperfectly preserved.

Remarks. Only one male left and three female left valves have been recovered, the remaining specimens are juveniles of various stages. This is therefore left in open nomenclature until further specimens can determine the species more fully.

Range. First appears 5m below Southerham Marl 1, *T. lata* Zone, at the Middle/Upper Turonian boundary. Rare examples found up to the top of the Turonian.

Family KRITHIDAE Mandelstam, 1958

Diagnosis. Elongate carapace, straight or convex dorsal margin, weakly concave ventral margin; anterior margin rounded; posterior margin obliquely truncate or inturned; maximum inflation behind mid-length; surface smooth. Broad inner margin at anterior with large vestibule, small vestibule at posterior; adont hinge; muscle scars in a vertical row of four with a 'V' or 'U' shaped frontal scar.

Genus KRITHE Brady, Crosskey & Robertson, 1874

Type species. By subsequent designation of Brady & Norman, 1889; *Cythere (Cytherideis) bartonensis* Jones, 1857; from the Quaternary of the British Isles.

Diagnosis. Carapace oblong with greatest height at or behind mid-length, anterior end rounded, posterior obliquely truncate and inturned. Surface smooth. Hinge simple with groove in left valve receiving sharp edge of right valve.

Krithe simplex (Jones & Hinde, 1890) Pl. 16, figs 3, 4

* 1890 *Pseudocythere ? simplex* sp. nov.; Jones & Hinde, p. 30, pl. 2, figs 58-60, pl. 4, figs 37, 38.

1940 *Krithe cushmanni* Alexander; [sic] Bonnema, p. 118, pl. 2, figs 48-54.

1958 *Krithe ? simplex* (Jones and Hinde); Howe & Laurencich, p. 378.

1966 *Krithe bonnemai* nom. nov. (pour *Krithe cushmani* Bonnema, non Alexander); Deroo, p. 97, pl. 11, figs 243-245.

1966 *Krithe cushmani* Alexander, 1929; Herrig, p. 799, pl. 14, figs 3-5.

non 1971 *Krithe bonnemai* Deroo 1966; Damotte, p. 115, pl. 8, figs 11a-c.

1974 *Krithe bonnemai* Deroo 1966; Gründel, p. 108, pl. 2, figs 1-3.

Type specimens. No types designated. Jones & Hinde's material came from the Campanian *B. mucronata* Zone Chalk at Horstead, Norfolk.

Material. 8 specimens; AKSD51, 1LV (juv); LGSD5, 1RV; LGSD8, 1RV; LGSD18, 1car; LGSD26, 1car; LGSD28, 2RV.

Diagnosis. *Krithe* with a rounded anterior margin, strongly truncate posterior margin, gently arched dorsal margin in females and straight dorsal margin in males. Large fan shaped anterior vestibule with a narrow neck. Strong sexual dimorphism.

Measurements. IJS18/3, RV 540 - 280 - 120
IJS18/4, car. 545 - 275 - 210

Description. Carapace elongate, subrectangular, moderately inflated, with greatest width just behind mid-length. Left valve larger than right and overlaps completely with the exception of the posteroventral tip. Female right valve has a straight inclined anterodorsal margin and evenly arched centro- and posterodorsal margins. Female left valve is less arched than right and is evenly curved, it slopes up gently to maximum height at about mid-length, behind this the dorsal margin falls away to the posterior margin in a tightening curve. Anterior margin in both valves is obliquely rounded, with a steep slope above mid-height and an even curve into the ventral margin below. The posterior margin of both valves is obliquely truncate with the posterior extremity at the ventral margin. A slight indentation in the ventral margin of the left valve allows the right to overlap at this point. Ventral margin is straight to weakly concave. At the posterior in each valve is an indentation, which has a long flat edge next to the valve margin, and a curved edge adsagittaly. Surface of the valves is completely smooth.

The calcified inner lamella is very broad anteriorly with a large fan shaped vestibule with a narrow neck. The posterior inner margin is broad with a small vestibule.

Remarks. *Krithe kritheformis* (Veen, 1935a) has a smaller anterior vestibule and lacks the posterior indentations. *Krithe cushmani* Alexander, 1929 has a less truncate posterior margin. *Krithe polita* Damotte, 1965 has a narrower posterior in the right valve and a narrower calcified inner lamella. Some confusion has arisen over the identification of this species since the original illustration of Jones & Hinde (1890) showed only male valves and one juvenile. Female valves are more commonly found; no males were recovered in the Turonian, but this species becomes more common in the higher Chalk where males have been found which correspond to the forms of Jones & Hinde (1890).

Range. First appearance at the base of the Upper Turonian St. Margaret's Member, it occures rarely through the overlying Turonian in the sections studied. Reported from the Late Cretaceous of The Netherlands (Bonnema 1940), the Santonian of Salzburg (Gründel 1974), the Upper Campanian of Belgium (Deroo 1966) and the Lower Maastrichtian of Rügen (Herrig 1966).

Family PROGONOCYTHERIDAE Sylvester-Bradley, 1948

Diagnosis: Carapace ovate to subrectangular, inflated such that the lateral tumidity overhangs the ventral margin. Surface smooth to ornamented with concentric ribs or reticulation. Hinge merodont, lobodont, entomodont and various developments of amphidont.

Remarks: Howe, van den Bold & Reyment *in* Moore (1961) stated that the Progonocytheridae may be divided into subfamilies Progonocytherinae and Protocytherinae on the differences in hingement, the former having entomodont hinges and the latter with merodont hinges. However, genera with overall shapes similar to *Progonocythere* such as *Neocythere* Mertens, 1956 and the subgenus *Neocythere (Physocythere)* Kaye, 1963 show many variations in hingement which would place the subgenus in a different subfamily from the genus. Wakefield (1994) discusses this family and restricts it to having only entomodont hinges. Upper Jurassic members of the family posses amphidont, lobodont and entomodont hinges, while those in the Cretaceous have entomodont, paramphidont and antimerodont hinges. The status of the hinge in this family seems to be of use at subgeneric level only.

Genus NEOCYTHERE Mertens, 1956

(Synonyms: *Procytheropteron* Mandelstam, 1956;
Globoleberis Deroo, 1966)

Type species. By monotypy; *Neocythere vanveeni* Mertens, 1956, p. 205, pl. 12, figs 72-78, pl. 14, figs 100-102.

Diagnosis. Carapace ovoid with broadly rounded anterior, strong inflation. Valve surface reticulate. Paramphidont hinge, in the right valve crenulated anterior and posterior terminal teeth, between which is a locellate furrow deepened at its anterior end into a smooth circular socket. Left valve has complementary elements with an accommodation groove above.

Remarks. Weaver (1982) includes *Physocythere* Kaye 1963 as a synonym of *Neocythere* on the basis of the anteromedian tooth in the left valve of *Neocythere vanveeni* Mertens being progressively lost in the Upper Albian. The Cenomanian specimens may belong to a different species since the dorsal view of the Albian type specimen shows straight parallel sides, while Weaver's Cenomanian form has gently rounded, non parallel sides. This may also account for the difference in hingement, placing it in the subgenus *Physocythere*.

The genera erected by Deroo (1966), *Globoleberis* and *Tumidoleberis*, are, in the author's opinion, not sufficiently distinct to be separated at generic level from *Neocythere*. *Tumidoleberis* Deroo 1966 may be considered as a subgenus of *Neocythere* on account of its greater number of marginal pore canals. *Globoleberis* Deroo 1966 is considered as a junior synonym of *Neocythere*, since the differences in hingement are insufficient to be able to distinguish between them.

Mandelstam *in* Lubimova (1955) erected the genus *Procytheropteron* with *P. obesum* Lubimova, 1956 as the type species, subsequently Mandelstam (1956) described *Procytheropteron* as a new genus again, but with *Cythere punctatula* var. *virginea* Jones, 1849 as type species. Due to this confusion, *Procytheropteron* has been considered as a doubtful genus (Howe & Laurencich 1958), so the valid generic name is *Neocythere* Mertens, 1956.

The genus *Trochiscus* Mandelstam (1956) has as its type species *Cythere punctatula* Jones, 1849. *Cythere punctatula,* however, was not published by Jones but by Roemer (1840). It is clear nevertheless, that Mandelstam meant that the type species of *Trochiscus* to be the species illustrated by Jones as *C. punctatula*. The subgenus *Neocythere (Centrocythere)* Mertens, 1956 has as its type species *Centrocythere denticulata* Mertens, 1956. Kaye (1963, 1964a) has shown that Jones' specimens referred to *C. punctatula* belong to *N. (C.) denticulata*. So both *Trochiscus* and *Centrocythere* have the same type species, and are synonyms. But as pointed out by Howe & Laurencich

(1958) the uncertainty as to the type species of *Trochiscus* leaves that genus as doubtful.

Subgenus PHYSOCYTHERE Kaye, 1963

(Synonym *Sphaeroleberis* Deroo, 1966)

Type species: By original designation; '*Cythere*' *lingenensis* Mertens, 1956 [*recte* 1958, *nom. nov. pro* '*Cythere*' *costata* Mertens, 1956 *non Cythere costata* M'Coy, 1844], p. 190, pl. 9, figs 27-30, pl. 10, figs 31-32.

Diagnosis: A subgenus of *Neocythere* having the same features as the nominate subgenus but with antimerodont hinge.

Remarks: At the same time as erecting *Neocythere*, Mertens (1956) also placed four species into a group which he termed '*Cythere*' on account of differences in hingement. Kaye (1963) created the subgenus *Physocythere* for these species. Deroo (1966) erected *Sphaeroleberis* for forms similar to *Neocythere* or *Centrocythere* but with a less evolved hinge. His 'charnière entomodont' equates to antimerodont of Scott (*In:* Moore 1961). He also suggests that Merten's '*Cythere*' corresponds to *Sphaeroleberis*. The similarity in hingement would place *Sphaeroleberis* as a junior synonym of *Physocythere*. However, there is a difference in the development of the accommodation groove. '*Cythere*' *sensu* Mertens (1956) and *Sphaeroleberis* both posses an accommodation groove, whereas *Physocythere* has a wide shelf above the median element sloping down to the valve margin. A gradient of development of the accommodation groove between the two types suggests that the shelf of *Physocythere* is equivalent to the groove of *Sphaeroleberis* and that the latter is a junior synonym of the former.

Neocythere (Physocythere) verbosa (Damotte, 1962) Pl. 16, figs 5, 6

* 1962 "*Cythere*" *verbosa* n. sp.; Damotte, p. 192, pl. 1 figs 2a-c, pl. 3, figs 2a-c.

1971 *Neocythere (Physocythere) verbosa* (Damotte 1962); Damotte, p. 103, pl. 7, figs 2a,b.

. 1978 *Neocythere (Physocythere) virginea* (Jones, 1849); Neale, p. 358, pl. 13, fig. 10.

1985 *Neocythere verbosa* (Damotte, 1962); Babinot *et al.*, p. 230, pl. 58, figs 1, 2.

. 1990 *Neocythere (Physocythere) virginea* (Jones, 1849); Horne *et al.*, p. 127, pl. 2, fig. 5.

Holotype. A right valve deposited in the Laboratoire de Micropaléontologie in the University of Paris; from the Lower Turonian of Sainte-Maure-de-Touraine (Indre-et-Loire).

Material. 256 specimens of adults and juveniles.

Diagnosis. Small *Neocythere* with a truncated caudal process; maximum height at mid-length; centrodorsal margin of right valve straight; ventral margin straight. Ornament of concentric and spiral ribs parallel to the valve margins.

Measurements.	IJS18/1, RV	640 - 360 - 200
	IJS18/2, LV	620 - 375 - 200

Description. Carapace strongly inflated, elongate ovate. Left valve larger than right overlapping dorsally. Centrodorsal margin of right valve straight, inclined towards posterior; sharp posterodorsal angle; posterodorsal margin straight, inclined steeply to caudal process. Anterodorsal angle at point of maximum height which is variable within the assemblages at either mid-length or just in front of mid-length; anterodorsal margin slightly convex, merging with anterior margin. Left valve dorsal margin more rounded without distinct cardinal angles. Anterior margin evenly rounded. Ventral margin straight to weakly convex with marked antero- and posteroventral angles; oral incurvature in front of mid-length. Posterior margin drawn out into a caudal process with a ventral diagonal truncation; posterior extremity at mid-height.

At the anterior and posterior margins is a flattened rim, only weakly developed at the dorsal margin. Strong inflation reaches a maximum at mid-length, below mid-height, where the ventral tumidity overhangs the ventral margin. Ornament consists of a series of six concentric ridges. Near the centre of the valves and near the dorsal margin the ornament is very diffuse.

The calcified inner lamella is moderately broad with a well developed selvage and a small anterior vestibule. The hinge is antimerodont, the left valve has an accommodation groove.

Remarks. *Neocythere (P.) grekoffi* Damotte, 1971, a Santonian species, is larger and has the anterior extremity below mid-height of the valves. In the assemblages present in the Turonian, a considerable amount of variation exists in the outlines and sizes of *N. verbosa*. Once a more detailed survey of the Coniacian and Santonian strata has been carried out, a direct relationship between the two may species may be recognised.

This species has been confused with *Neocythere (Physocythere) virginea* Jones, 1849. The latter was erected on a juvenile carapace, from the Chalk at Gravesend, which was later designated as lectotype and re-illustrated by Kaye (1964a, pl. 1, fig 14). Kaye also illustrated further material conspecific with the lectotype from the collections of Jones & Hinde and Rowe. In addition, Kaye deposited in the NHM specimens of a variant of *N. (P.) virginea* with more pronounced ribbing, from his own collection of Santonian age from Sonning, Berkshire; these specimens, in the author's opinion, belong to *N. (P.) verbosa*. Neale (1978) selected this variant to be representative of the species, and this interpretation was used by Horne *et al.* (1990). As well as the more pronounced ribbing in *N. (P.) verbosa*, it may be distinguished from *N. (P.) virginea* by the pattern of ribs in the posterior lateral field; here, after rising steeply at mid-height, they turn forward and run obliquely in the direction of the anterior cardinal angle. In the latter species the ribs ascend steeply almost to the dorsal margin without a turn forwards. The ventral margin in *N. (P.) verbosa* is less sinuous than *N. (P.) virginea*, this has to be viewed internally since the ventral tumidity obscures the ventral margin.

Range. First appearance at the upper Glynde Marl (equivalent to Maxton Marl 5 of Robinson (1986), Middle Turonian *T. lata* Zone. Very common throughout the Turonian, diminishes in importance in the Lower Coniacian where *N. (P.) virginea* becomes more numerous. Reported from Turonian of Touraine (Damotte 1962; 1971; Babinot *et al.* 1985) and the Santonian of Berkshire (Kaye 1964a; Neale 1978).

Family PROTOCYTHERIDAE Lubimova, 1955

Diagnosis: Shape subtriangular to subrectangular, prominent hinge ear in left valve, ventral margin straight or convex. Surface of the valves usually with longitudinal ribs or depressions. Left valve much larger than right. Merodont to amphidont hinges. Antennal muscle scar with elongated posterior branch.

Remarks: Formerly included as a subfamily of Progonocytheridae (see above), the outline, lack of ventral tumidity and style of ornamentation serve to distinguish this family.

Genus KARSTENEIS Pokorný, 1963a

(Synonym MOSAELEBERIS Deroo, 1966)

Type species. By original designation; *Cytherina karsteni* Reuss, 1846, p. 104, pl. 24, fig. 19; from the Upper Cretaceous of the Czech Republic.

Diagnosis. (Emended from Pokorný 1963a) Carapace medium to large, ventral margin straight. Anterior and posterior strongly laterally compressed. Lateral surfaces with little inflation, may be smooth or reticulate, with or without longitudinal ribs and depressions on either side of the ribs. Paramphidont hinge. Left valve overlaps right valve at the anterior cardinal angle, hinge ear distinct.

Remarks. The specimens recovered from the British Turonian allow a series of morphologies to be observed which demonstrate a grade between the genera *Karsteneis* and *Mosaeleberis* occurring at specific and subspecific level. This has already been identified by Horne & Rosenfeld (*In* Jarvis *et al.* 1988) but an analysis is presented here which shows that these are congeneric.

Karsteneis Pokorný, 1963a was originally described for smooth species with two subgenera, *K. (Karsteneis)* for specimens with no longitudinal sculpture and *K. (Prosteneis)* for those with three longitudinal ribs. *Mosaeleberis* Deroo, 1966 included both smooth and reticulate, with or without longitudinal sculptural elements. The outlines of species referred to both genera are remarkably similar (Horne & Rosenfeld *In* Jarvis *et al.* 1988). Comparison of the muscle scars of the two type species show strong similarities; *Karsteneis karsteni* (Reuss, 1846) was illustrated by Pokorný (1963a, text-fig. 1) and *Mosaeleberis interrupta* (Bosquet, 1846) was illustrated by Deroo (1966, pl. 18, fig. 491). Both have the elongated posterior branch to the antennal scar; Deroo's photograph shows a divided adductor cap scar, while Pokorný's rather simplified diagram shows the cap scar to be medially constricted; all other details are the same. The marginal areas have the same features; *K. karsteni* has 43 sinuous to straight marginal pore canals, 5 crossing and 9 false (Pokorný 1963, text-fig. 1). *Mosaeleberis interruptoidea* has 45 sinuous to straight marginal canals, 6 crossing and 10 false (Pokorný 1980, text-fig. 2). The hinge in *K. karsteni* is described as "both terminal teeth notched" (Pokorný 1963a), while for *M. interrupta* the anterior tooth is "formé de quatre denticules" and the posterior tooth "trilobé avec lobe médian dominant légèrement les deux autres" (Deroo 1966). These features together with the intermediate forms seen by Horne & Rosenfeld (*In* Jarvis *et al.* 1988) and illustrated here suggest that *Mosaeleberis* is a junior subjective synonym of *Karsteneis*.

Karsteneis was originally placed in the Trachyleberididae by Pokorný (1963a), but here is considered as belonging to the Protocytheridae on account of its outline, ornament, valve overlap, hinge and shape of muscle scar.

The generic diagnosis is here emended simply to allow the increased scope of the genus to include reticulate forms as well as smooth forms. The use of the two subgenera is not supported as it seems to be a variation in the amount of inflation between the ribs. Transitional forms exist between the extremes of smooth and ribbed which cannot satisfactorily be placed in either subgenus.

Karsteneis nodifera nodifera (Kafka, 1886)   Pl. 16, figs 7, 8

* 1886 *Cythere nodifera;* Kafka, p. 54, pl. 1, figs 4a, b.

v 1963a *Karsteneis (Prosteneis) nodifera* (Kafka, 1886); Pokorný, pl. 3, figs 3, 4, 6.

pars 1990 *Mosaeleberis* sp. A (*sensu* Jarvis *et al.*, 1988); Horne et *al.*, p. 127, pl. 2, fig. 9 *non* fig. 10 [= *K. nodifera* *tabasca* ssp. nov.], *nec* fig. 11 [= *K. petasus antecursor* sp. *et* ssp. nov.].

Holotype. None designated, the female left valve from Kafka's collection illustrated by Pokorný (1963a) is taken as typical; from the Upper Turonian of Kostice, Czech Republic.

Material. 71 specimens.

Diagnosis. Smooth *Karsteneis* with three distinct longitudinal ribs; the ventral rib is bowed ventrally, the straight median rib has a thin connection to the muscle node at upper corner of its posterior end; the dorsal rib is long, continuous and bends at about mid-length. Small but prominent eye tubercle. Muscle node slopes downs evenly to anterior margin.

Measurements.	IJS17/21, LV	675 - 406 - 137
	IJS17/22, RV	656 - 362 - 162

Description. Carapace elongate, subrectangular, moderately inflated. Dorsal margin slopes down towards posterior, maximum height at hinge ear in left valve, at small but distinct eye tubercle in right valve; dorsal margin partly obscured by dorsal rib. Ventral margin straight in left valve; right valve has a marked oral incurvature in front of mid-length, it is straight behind this. Anterior margin evenly rounded without marginal denticles; right valve often has the remains of a thin flange. Caudal process is blunt in left valve, and more acute in the right valve; four weak marginal denticles are present on the ventral side of the posterior margin.

The muscle node is smooth, broad and low in front and high and narrow behind; it forms a smooth slope from the anterior margin to the point of maximum inflation just in front of mid-length. A thin, smooth dorsal rib rises from the dorsolateral field below and behind the eye tubercle, in continues straight to the dorsal margin at mid-length, then bends and follows the dorsal margin; the posterior section is thicker. The smooth median rib is joined to the muscle node by a thin connecting rib which is an extension of the dorsal side of the median rib; it terminates in front of the posterior end of the dorsal rib. The ventral rib rises in the ventral half of the anterolateral field, it is weakly convex ventrally and terminates below the posterior end of the median rib. Lateral surfaces are smooth.

The basal surface is concave near the valve contact; on the right valve are two longitudinal ribs, the innermost is short and weak, the outer is well developed with a rounded top; one cross rib was seen between these two. In the left, four longitudinal ribs vary in strength; the first adsagittal rib is short, it begins at mid-length and continues to the posterior margin; the second is stronger, running from the oral incurvature to the row of denticles on the posterior margin; the third and strongest rib is smooth and rounded, it connects the anterior margin to the posterior margin; the fourth outer rib bifurcates from the third and runs in the concave part of the basal surface between the main ribs and the principal ventrolateral rib.

Calcified inner lamella moderately wide, vestibules absent, marked selvage. Hinge of right valve with crenulate anterior tooth, postjacent rounded socket which narrows to a posteromedian groove. Posterior tooth is low in front, and rises to a crenulate crest. Left valve hinge has a smooth posteromedian bar. A very thin groove runs above all the hinge elements. Muscle scar with elongated posterior section of frontal v-shaped scar.

Remarks. Three smooth species and subspecies of *Karsteneis* occur in the British Turonian, the oldest, *K. nodifera nodifera* can be distinguished from *K. nodifera tabasca* ssp. nov. from the Upper Turonian by having thinner, more clearly defined longitudinal ribs. The connection of the median rib to the muscle node is more tenuous in *K. nodifera nodifera* than in *K. nodifera tabasca*, where the median rib is shorter, more rounded and has a definite connection to the muscle node. In *Karsteneis praekarsteni* the ribs can barely be discerned except at the posterior ends of the dorsal and ventral ribs, the median rib and the muscle node are absent.

The figure given by Horne *et al.* (1990, pl. 2, fig. 10) is a subspecies of *K. nodifera* restricted to the Upper Turonian, *K. nodifera tabasca;* the sample horizon for that specimen (upper Kingston Nodular Chalks) concurs with the range herein.

Range. From ABCMR2 1.5m above the *Filograna avita* bed at Abbots Cliff, Lower Turonian, it is found discontinuously throughout the Turonian. Reported from the Upper Turonian of Bohemia (Pokorný 1963a).

Karsteneis nodifera tabasca ssp. nov. Pl. 16, figs 9, 10;
Pl. 26, figs 1, 2

Name. Latin; *tabascere*, meaning to waste away; after the reduced gross ornament.

pars 1990 *Mosaeleberis* sp. A (*sensu* Jarvis *et al.,* 1988); Horne *et al.,* p. 127, pl. 2, fig. 10 only, *non* fig. 9 [= *K. nodifera nodifera*], *nec* fig. 11 [= *K. petasus antecursor* sp. *et* ssp. nov.].

Holotype. RV IJS17/28, from sample LGSD26, Navigation Hardground1, *M. cortestudinarium* Zone, Upper Turonian; from Langdon Stairs, Dover, Kent.

Material. 38 specimens in 8 samples.

Diagnosis. A subspecies of *Karsteneis nodifera with* poorly defined dorsal median and ventral ribs; median rib connected to muscle node; continuous dorsal rib. Reduced eye tubercle. Surface of valves smooth.

Measurements. IJS17/27, LV 700 - 425 - 275

IJS17/28, RV 725 - 412 - 212

Description. Outline and marginal features as for nominate subspecies. Left valve overlaps right at the anterodorsal corner, along the ventral margin and the dorsal section of the posterior margin. The greater inflation of the valves causes the longitudinal ribs to be smoothed into the lateral surface. The basal surface is concave towards the valve margins. A curved longitudinal rib delimits the area of concavity in each valve, in addition, in the left valve is a shorter inner rib. Internally as for the nominate subspecies.

Remarks. This can be variable in the development of the ribs. The existence of this subspecies is responsible for eliminating the subgenus *Prosteneis* Pokorný, 1963a, since it exhibits characters intermediate between *Karsteneis (Karsteneis)* and *Karsteneis (Prosteneis) sensu* Pokorný (1963a).

Range. First appearance 3m below Caburn Marl, *T. lata* Zone, Upper Turonian, ranging up to the top of the Turonian.

Karsteneis oculocosta sp. nov Pl. 17, figs 1, 2

Name. Latin; *oculus*, meaning eye and *costa*, meaning rib; after the characteristic rib connected to the eye tubercle.

Holotype. LV IJS17/29, from sample LGSD21, lowest of the Kingston Nodular Chalks, Upper Turonian *S. plana* Zone; from Langdon Stairs, Dover, Kent.

Material. 5 specimens; LGSD21, 1LV, 1RV, 1car.; LGSD23, 1LV; LGSD28, 1LV.

Diagnosis. Smooth species of *Karsteneis*, with distinct eye tubercle connected to a rib which projects forward and down towards the anterior margin, the rib then curves at mid-height and fades into the anterolateral surface; weak diagonal rib at the anterodorsal corner, in front of and above the latter rib. Well developed dorsal rib continuous with bend at mid-length. Well developed median and ventral ribs. Lateral surface smooth. Basal surface has four longitudinal sinuous ribs without cross ribs.

Measurements.	IJS17/29, LV	700 - 412 - 162
	IJS17/30, RV	662 - 362 - 150

Description. Carapace elongate ovate to subtriangular, moderately inflated, maximum width at position of muscle node, in front of mid-length. Dorsal margin slopes down towards posterior from maximum height in left valve at the hinge ear, and from the distinct eye tubercle in the right valve; posterior section of the dorsal margin is obscured by the dorsal rib. Ventral margin straight in left valve with oral concavity in right valve; obscured slightly by rib on basal surface. Posterior extremity just below mid-height, angular caudal process in right valve, blunt in left valve; six marginal denticles project from the ventral margin of the caudal process. Anterior margin broadly rounded in left valve, more evenly rounded in the right.

A short, weak diagonal rib at the anterodorsal corner runs between the anterior margin and the main anterior rib. Distinct eye tubercle is connected to a rib which projects forward and down towards the anterior margin, it then curves at mid-height and fades into the anterolateral surface without connecting to the ventral rib. Dorsal rib rises behind and below the eye tubercle and runs to the dorsal margin where it bends and follows the line of the dorsal margin to terminate at the posterodorsal angle in the right valve and in front of the same in the left; the dorsal rib carries slight indentations on its lateral surface. An elongate smooth muscle node rises from the anterolateral surface and is connected to the median rib. Median rib becomes thicker towards the posterior where a small process is developed on its ventral side. The ventral rib begins below and behind the anterior extension of the muscle node, it curves down and then runs backwards rising slightly towards the posterior termination of the median rib; it is composed of two closely spaced smooth ribs. Lateral surface is totally smooth.

Basal surface has a weak concavity near the valve margins, more strongly developed in the right valve. There are three longitudinal sinuous ribs; the inner rib is connected to the anterior margin, and runs straight to the posterior margin after bending in front of the oral concavity; the main central rib begins lateral to the anterior margin and bends three times before joining the third rib at the posterior margin of the ventrolateral surface; the third outer rib is the shortest and most sinuous. No cross ribs were observed.

Calcified inner lamella moderately broad with no anterior vestibule, very small posterior vestibule. Hinge of right valve has strong anterior crenulate tooth, postjacent socket, narrow median groove and a high crenulate posterior tooth. In the left valve, beneath the ventral rim of the anterior socket is a circular ocular sinus. Muscle scars are arranged as four in vertical row, the second is the widest; the frontal scar is a large 'V' shape with the posterior extension longer than the anterior and possessing a swollen dorsal tip.

Remarks. Distinguished from *K. nodifera* by the strongly developed rib which descends from the eye tubercle.

Range. Only found in the *S. plana* Zone, Upper Turonian, from the lowest of the Kingston Nodular Chalks up to the Navigation Hardgrounds.

Karsteneis petasus petasus sp. et ssp. nov. Pl. 17, figs 3, 4;
Pl. 26, figs 3, 4

Name: Latin; *petasus*, meaning hat; similar in shape to hats worn by farmworkers in the 15th century.

pars 1988 *Mosaeleberis* sp. A; Horne & Rosenfeld *In* Jarvis *et al.*, p. 45, figs 17d-g, *non* figs a-c [= *K. petasus antecursor* sp. *et* ssp. nov.].

Holotype. LV IJS17/23, from sample AKSD17, 1.5m above Round Down Marl, Middle Turonian, *T. lata* Zone; from Akers Steps, Dover, Kent.

Material. 52 specimens; ABCMR5, 7RV (2 juv.), 5LV, 1 car.; AKSD16 2RV (1 broken); AKSD17, 17LV, 16RV, 3car.; AKSD19, 1RV.

Diagnosis. Karsteneis with papillae in the reticulation meshes in the dorsal intercostal field; weak reticulation with papillae in the posterior part of the ventral intercostal field; smooth lateral surface in the anterolateral and anterior part of the ventral intercostal field. Two anterodorsal marginal ribs weakly developed, dorsal median and ventral ribs well developed; dorsal rib divided at mid-length. Anterior margin compressed. Denticulate anterior margin, spinose posterior margin.

Measurements. IJS17/23, LV 662 - 406 - 175
IJS17/24, RV 675 - 375 - 187

Description. Carapace elongate subrectangular; left valve larger than right overlapping at the anterodorsal angle. Straight ventral margin; dorsal margin slopes down towards the posterior with a raised hinge ear in the left valve; posterior part of the dorsal margin obscured by the dorsal rib. Maximum height at the hinge ear in the left valve and at the very distinct eye tubercle in the right valve. Anterior margin evenly rounded in the right valve, broadly rounded in the left; seven to ten denticles project from the ventral half of the anterior margin. Posterior margin has a short caudal process more acute in the right valve than the left; posterior extremity below mid-height in the right, at mid-height in the left; four posterior marginal denticles project from the ventral edge of the caudal process.

A weak anterodorsal marginal rib runs through the eye tubercle from the dorsal margin and meets the anterior margin at about mid-height. A second thicker anteromarginal rib begins beneath the eye tubercle and follows inside the line of the first; this rib fades into the anterolateral surface at about mid-height. The dorsal rib is composed of two sinuous en echelon ribs, the hindmost has a third descending spur. The posterior end of the dorsal rib is thickened slightly, behind this it turns sharply downwards and fades into the posterolateral field. A very elongated smooth muscle node rises from the anterolateral surface and connects with the median rib. The median rib is straight and horizontal, at its posterior end is a ventral process, and behind this it breaks up into a row of three small tubercles. The ventral rib rises in the anterolateral field below the anterior extremity of the elongate muscle node, it curves downwards and runs parallel to the ventral margin, ascending slightly before terminating in front of the posterior end of the median rib. The surface ornament consists of scattered reticulation particularly in the dorsal intercostal field with papillae in the meshes. This reticulation is weakly developed in the ventral intercostal field and absent from the anterolateral field.

Basal surface has a series of six longitudinal ribs. The first adsagittal rib, arises in front of the oral concavity, gently swings outwards and continues to the ventral edge of the caudal process, where it terminates in a small outward bend. The second, and thickest rib extends from the anterior marginal row of denticles to connect with the third rib just in front of the posterior edge of the ventrolateral surface. The third rib rises absagittaly of the second in front of the oral concavity, and connects with it as described above. The fourth is parallel to the third, but shorter, and reaches the posterior edge of the ventrolateral field. The fifth is an offshoot of the fourth at about mid-length. The sixth most absagittal rib defines the edge of the ventrolateral surface. Very weak cross ribs are present between ribs two three and between ribs three and four. The ribs of the left valve have a greater relief such that the basal surface is uneven, the right valve is slightly concave, while the left is convex.

Calcified inner lamella moderately broad with numerous marginal pore canals; more than twenty at the anterior, twelve at the posterior; vestibules absent. Hinge is paramphidont; in the left valve is a robust anterior tooth with a square top and five crenulations, behind is an anteromedian socket which narrows to a posteromedian groove; the posterior tooth is obscurely crenulate with a triangular top. The posteromedian groove is bounded above and below by thin bars, above the dorsal bar is very thin groove. In the left valve the anteromedian tooth and the posteromedian bar are smooth. Above the median element is very thin groove.

Remarks. Horne & Rosenfeld (*In* Jarvis *et al.* 1988) pointed out the confusion surrounding *Mosaeleberis interruptoidea* (van Veen, 1936a). Subsequently the author has examined material from the collections of Pokorný, Bosquet and van Veen, and can now clarify some details.

The Bohemian specimens of *Mosaeleberis interruptoidea* (van Veen, 1936a) *sensu* Pokorný (1980) are the same as the reticulate form of *Mosaeleberis* sp. A *sensu* Jarvis *et al.* (1988), from the British Turonian (here referred to *Karsteneis petasus antecursor* sp. *et* ssp. nov.) and the ranges are similar. Pokorný (1980) compared his specimens with a Maastrichtian specimen from Deroo's collection and could find no important differences between them. This statement is surprising since differences do exist. Comparison of the ventral views of the Turonian Bohemian material (Pokorný 1980, pl. 1, fig. 3) with ventral views of the Dutch Maastrichtian specimens (van Veen 1936a, pl. 3, fig. 34) and with the dorsal view of the Upper Maastrichian specimens from Limbourg (Deroo 1966, pl. 18, fig. 506) clearly show the Maastrichtian specimens possessing a thick anterior marginal rib with a constriction behind, while the Turonian forms slope gently towards the anterior margin. The Turonian and Maastrichtian forms should be considered as distinct species.

The original illustrations of *Cythereis interruptoidea* van Veen, 1936a comprise two distinct species, which has been previously noted by Deroo (1966) and Pokorný (1980). Van Veen considered the smaller of the two to be the juvenile stage. Szczechura (1965) described the smaller, more heavily ribbed form as *Cythereis compressa*, which was later placed in the genus *Imhotepia* by Gründel (1969) on account of its lateral and anterior marginal ribs. (Examination of the internal features also shows it to belong to the genus *Imhotepia*, particularly the broader calcified inner lamella at the anterior margin). Clarke (1983) illustrated a specimen from the van Veen collection as *Imhotepia interruptoidea* (van Veen). This, however was the specimen considered by van Veen to be the juvenile, and taken by Szczechura for *Cythereis compressa*. Thus the opinion of Horne & Rosenfeld (*op cit*) that "Pokorný's Turonian form is therefore probably a new species" is correct, but not for the reasons presented there.

Horne & Rosenfeld (*op. cit.*) show clearly in their figs 17 a-k that their semi-reticulate forms of *Mosaeleberis* sp. A (figs 17d-j) are in every respect the same as the fully reticulate and papillate forms (figs 17a-c), here referred to *Karsteneis petasus antecursor* sp. *et* ssp. nov., but with the loss of reticulation in the anterior ventrolateral and anterolateral fields. The present analysis of the Turonian material demonstrates the existence of six similar forms which are either very closely related, or may be examples of phenotypic variation within a single taxon. The fact that three of the forms occur together in the same samples in the Lower Turonian indicate that these belong to distinct species, perhaps each adapted to a microenvironment. The adaptations are suggested by morphological evidence. *Karsteneis* species of the reticulate type (*Karsteneis petasus antecursor*) have been shown to prefer very nearshore facies (Ohmert 1971), whilst forms like *K. nodifera,* are indicative of offshore shallow facies. The studies of Ohmert (1971) allocated palaeobathymetric ranges according to morphology. It is difficult to reconcile a similar change in water depth within one sample in the British Turonian. This problem could be approached from the energy level of the microenvironment rather than of depth change. At the same site it would be possible to reproduce the energy levels of these broader depth environments by considering the relationship of the animal with its living position in or on the sediment substrate. It is postulated that the highly reticulate form with a ribbed flatter venter, *K. petasus antecursor,* lived above the sediment water interface, and was comfortable in the energy levels that prevailed. The sediments at this stratigraphical level are predominantly nodular intraclastic chalks with coarse calcarenitic shell debris. *Karsteneis nodifera* is totally smooth in the anterior and lateral fields, and could be adapted for movement within the sediment, this would correspond to the lower energy of an offshore shallow facies. A alternative solution is that the morphology agrees well with an adaptation to the phytal microenvironment. The third type, *K. petasus petasus* has reticulation only in the dorsolateral and posterior ventrolateral fields, the anterior marginal rib is well developed in the dorsal half of the valve but reduced in the ventral half. This could be interpreted as being able to live at, or below, the sediment water interface, a position not occupied by either of the other two species, thus enabling the three to coexist. Once established the morphology is fixed, no plasticity is observed which indicates that these were unable to interbreed and must therefore be considered as separate species.

In the Upper Turonian, the long ranging *K. nodifera* becomes absent during the interval of the Southerham Marls and is replaced by *Karsteneis praekarsteni* sp. nov. Above the Southerham Marls this disappears and is replaced by *K. nodifera nodifera* again, together with a new variation *K. nodifera tabasca* which is intermediate between *K. nodifera* and *K. praekarsteni*. This then coexists with *K. nodifera nodifera*. This pattern may be representing the genetic plasticity of *K. nodifera*, demonstrating oscillations and reversal of morphogenetic trends. Conversely this could be an example of a species vacating a niche, which was then filled temporarily by a new less able species (*K.* praekarsteni). When the original inhabitant then returned to the area, the incoming species was forced out, to subsequently evolve to a form intermediate between the two. This being more successful was then able to coexist. The possibilities are that the data are incomplete and the problem cannot be resolved, or that this is an example of phenotypic variation, or that a second speciation event has taken place resulting in two new species, one short lived, the other two coexisting into the Coniacian. Further investigation is required to demonstrate the most probable explanation. On the present evidence the author prefers to treat these as subspecies, recognising the change in morphology, but retaining the possibility that this may have come about due to phenotypic variation.

Horne & Rosenfeld (*In* Jarvis *et al.* 1988), drew a comparison between their smooth form of *Mosaeleberis* sp. A (here referred to *Karsteneis nodifera)* to *Karsteneis macrophthalma* (Bosquet, 1847) as illustrated by Neale (1978) as *Mosaeleberis macrophthalma*. The author has examined specimens from the Bosquet collection and concludes that Neale's illustrations show two species (1978, pl. 17 figs 13 and 15 are not conspecific with pl. 17, fig. 14), both of which show significant differences from type *K. macrophthalma;* Deroo (1966) and Clarke (1983) have figured the latter, in the author's opinion, correctly. In *K. macrophthalma* the dorsal and ventral ribs are only well defined in the posterior half, two ribs are prominent at the posteroventral corner, with the uppermost more strongly developed; there is no significant posterodorsal angle in the left valve; all the gross ornament is very smooth and rounded; the hinge ear is lower. Neale's illustrations (1978, pl. 17, figs 13, 15) correspond more closely to *Karsteneis damottae* (Clarke, 1983), which the author has identified from the British Coniacian.

Range. A short range in the Middle Turonian, *T. lata* Zone from 2m below Round Down Marl up to 5m above.

Karsteneis petasus antecursor ssp. nov. Pl. 17, figs 5, 6; Pl. 26, figs 5, 6

Name. Latin; *antecursor*, meaning pioneer; the first of this species complex to become established in the Turonian.

1980 *Mosaeleberis interruptoidea* (van Veen, 1936); Pokorný, p.147, pl. 1, figs 1-3, pl. 3, fig. 5, text-figs 1-4.

pars 1988 *Mosaeleberis* sp. A; Jarvis *et al.*, p. 45, fig. 17a-c. *non* figs 17d-g [= *K. petasus petasus*].

pars 1990 *Mosaeleberis* sp. A (*sensu* Jarvis *et al.*, 1988); Horne *et al.*, p. 127, pl. 2, fig. 11, *non* pl. 2, figs 9, 10 [= *Karsteneis nodifera s.l.*].

Holotype. LV IJS17/19, from sample ABCMR4, 2.2m above Lulworth Marl, Middle Turonian, *Mytiloides* spp./*T. lata* Zone boundary; from Abbots Cliff, Dover, Kent.

Material. 41 specimens.

Diagnosis. *Karsteneis petasus* with well developed reticulation over all the valve surface with one or two papillae in each mesh. Inner anterior marginal rib continuous in the ventral half, connecting with rib on basal surface. Ventral rib clearly composed of two riblets with connecting cross ribs. Dorsal rib divided at mid-length.

Measurements.		
	IJS17/19, LV	693 - 406 - 187
	IJS17/20, RV	675 - 375 - 175

Description. Outline and marginal features as for nominate subspecies, ornament is much more developed over the entire surface. The inner anterior marginal rib is continuous round to the ventral surface where it connects with the third basal rib. The median rib has an irregular appearance with pinches and swells along its length. The muscle node has sinuous ribs on its surface; at the point where it connects with the median rib are three small finger-like ribs. The ventral rib appears to composed of two ribs with small cross ribs connecting them. The ribs on the basal surface are thicker than the nominate subspecies with a greater number of cross ribs. Internally as for the nominate subspecies.

Remarks. See remarks for nominate subspecies.

Range. First appearance 4.5 metres above the Plenus Marls at Dover, Lower Turonian, *Mytiloides* spp. Zone. Common up to Round Down Marl, then rare up to last occurrence 1.5 m below the Southerham Marls, Upper Turonian *T. lata* Zone.

Karsteneis praekarsteni sp. nov. Pl. 17, figs 7, 8;
Pl. 26, figs 7, 8

Name. The provisional name given to this species by V. Pokorný, but not published.

1963a *Karsteneis (Karsteneis) karsteni* subsp. n.; Pokorný, pl. 2, fig 2.

Holotype. LV IJS17/25, from sample LGSD1, Southerham Marl 1, Upper Turonian, *T. lata* Zone; from Langdon Stairs, Dover, Kent.

Material. 10 specimens; AKSD54, 1RV (broken); AKSD55, 3RV (1juv.); LGSD1, 4RV (2 broken juv.), 1LV; LGSD5, 1RV.

Diagnosis. A smooth shelled *Karsteneis* without muscle node or median rib. Swelling at the ventrolateral edge indicates the position of the ventral rib. Dorsal rib stronger in the posterior half of the valve making a posterodorsal angle.

Measurements.	IJS17/25, LV	650 - 375 - 168
	IJS17/26, RV	625 - 337 - 156

Description. Carapace elongate, oval to subrectangular, moderately inflated. Dorsal margin slopes down to posterior from maximum height at the hinge ear in left valve, and from just behind the weak eye tubercle in the right. Posterior section of dorsal margin obscured by dorsal rib. Ventral margin straight in left valve, nearly so in right where a slight oral concavity bends the margin in front of mid-length. Anterior margin evenly rounded with traces of a thin flange in the right valve. Caudal process is obtusely angled with the posterior extremity below mid height; four marginal denticles project from the ventral margin of caudal process.

Dorsal rib very weakly developed, raised slightly at the posterodorsal angle. Ventral rib is reduced to a slight swelling along the ventrolateral edge. Muscle node is absent, or occasionally seen as a slight swelling. Median rib absent. Surface of the valves smooth.

Inner lamella moderately broad without vestibules, with a marked selvage. Marginal pore canals few; fifteen at the anterior, ten at posterior. Hinge of right valve has a square topped high crenulate anterior tooth, postjacent socket which narrows to a very thin groove; posterior tooth is strong and crenulate.

Remarks. In Pokorný's collection is slide O-218 with two specimens of this species, labelled as *K. (K.) k. praekarsteni* one intended to be the holotype, which was never published. See remarks for *K. nodifera nodifera* for distinguishing features of smooth forms of *Karsteneis*.

Range. Short ranging species from 1m below Southerham Marl 1 up to 1m above Southerham Marl 2, *T. lata* Zone, Upper Turonian. Reported from the Upper Turonian of Bohemia (Pokorný 1963a).

Family SCHIZOCYTHERIDAE Mandelstam, 1960

This family has been attributed to Howe (*In* Moore 1961), but was preceded by the erection of the tribe Schizocytherini by Mandelstam (1960). Clarke (1983) followed Gründel (1975) in placing the genera *Schizocythere* Triebel and *Eucytherura* G.W. Müller in the subfamily Schizocytherinae Mandelstam, 1959, but she placed this in the family Cytheridae in its wider sense.

Genus AMPHICYTHERURA Butler & Jones, 1957

Type species. By original designation; *Cytherura*? *dubia* Israelsky, 1929, p. 6. pl. 4A, fig. 6; from the Upper Cretaceous of Arkansas, USA.

Diagnosis. Size small to medium, subrectangular to subquadrate in lateral outline. Valves strongly built with three longitudinal ribs on lateral surface, sometimes with reticulation between; dorsal and ventral ribs often over the margins. Hinge of right valve with subquadrate crenulate terminal teeth and crenulate median groove, deepened into a rounded socket at the anterior end.

Remarks. In the literature there is some question over the position of the genus *Amphicytherura* Butler & Jones, 1957, with regard to its differentiation from *Schizocythere* Triebel, 1950. They are alike in many respects; both genera have a schizodont hinge, similar valve outlines, the inner marginal zone and the surface sculpture.

Van Morkhoven (1963) notes that in some cases it is difficult to distinguish the two genera, but that the type of ornament and the hinge structure may be used to differentiate. Both genera however, have schizodont dentition.

Herrig (1966) is of the opinion that the differences between them are only subgeneric; he states that in *Amphicytherura* the laterally compressed posterior part of the valve is a little larger than in *Schizocythere* species, the anterior margin has some blunt denticles, in some species the valve surface is crudely sculptured, the inner lamella is narrower, and the marginal pore canals are a little more numerous. He places species previously assigned to *Amphicytherura* into *Schizocythere*.

Hanai (1970) separates the genera and notes that many *Amphicytherura* have a well developed central ridge, whereas the central ridge is obscure in *Schizocythere*. In the author's opinion, this is a feature of gross sculpture and in this group is worthy of generic status.

Amphicytherura aculeata (Bonnema, 1941) Pl. 18, fig. 1

v * 1941 *Eucytherura aculeata* nov. spec.; Bonnema, p. 21, pl. 5, figs 60-68.

1949 *Eucytherura aculeata* Bonnema 1941; Weingeist, p. 367, 369 [generic assignment erroneous].

1958 *Eucytherura aculeata* Bonnema; Howe & Laurencich, p. 333 [generic assignment uncertain].

1963 *Amphicytherura aculeata* (Bonnema, 1941); Morkhoven, p. 360.

1965 *Amphicytherura aculeata* (Bonnema, 1941); Szczechura, p. 547, pl. 19, figs 1-4.

1966 *Schizocythere aculeata* (Bonnema, 1941); Herrig, p.837, pl. 27, figs 4-12.

1983 *Schizocythere aculeata* (Bonnema, 1941); Clarke, p. 124, pl. 10, figs 13-15.

Syntypes. Slide 0.2322 F_6 contains 3 specimens which corespond to the original illustrations (Bonnema, 1941, pl. 5, figs 60-63); from NNIV de Krim. Slide 0.2185, from the same locality and 0.2067 from NNIII de Krim contain further specimens.

Material. 8 specimens; AKSD19, 1RV (juv); AKSD30 1RV; AKSD31, 1RV; AKSD33, 1LV (juv); AKSD54, 2RV (1 juv); LGSD24, 1RV. Further specimens from the Coniacian.

Diagnosis. Strongly ornamented with sharp ribs and reticulation; sinuous median rib crosses the valve surface diagonally from above the anteroventral corner to below the posterodorsal corner; ventral rib begins above the median rib above the anteroventral corner and runs diagonally downwards towards the posteroventral angle; ventral rib terminates in two spines posteriorly. Muscle node indistinct. Vertical rib descends from eye tubercle.

Measurements. IJS17/18, RV 406 - 237 - 112

Description. Only one adult right valve has been recovered. Carapace small, moderately well calcified, subrectangular. Dorsal margin straight to slightly concave in the central region. Straight ventral margin is obscured by ventral rib and peripheral spines. Anterior margin is evenly rounded with small projections where the lateral ribs intersect the margin. Very short caudal process at the posterior has a concave dorsal margin and a convex ventral margin.

The valves are moderately well inflated with a median sulcus; maximum width is behind mid-height. Strong ornament of sharp ribs and reticulation. A distinct eye tubercle is connected to the anteromedian rib by a short connecting rib; where this connects is a raised triple point. Anterior median rib intersects the anterior margin at mid-height, it crosses the anterior surface nearly horizontally and connects with the principal median rib in the centre of the valve. Median rib intersects the anterior margin above anteroventral corner and crosses the valve surface diagonally, following a sinuous path; in the posterior half two subvertical ribs ascend from the median rib. The first of two ventral ribs intersects the anterior margin below the median rib, from which it diverges and continues to the posteroventral corner; two or three prominent blade-like processes project from the posterior section of the ventral rib. A second and lower ventral rib follows the course of the first.

Calcified inner lamella broad without vestibules, with distinct selvage. Hinge of right valve consists of a strongly bifid anterior tooth, postjacent socket and narrow posteromedian groove bounded by thin bars above and below; posterior tooth is crenulate with four of five lobations, low in front and higher behind. Beneath the anterior tooth is a circular ocular sinus. The median sulcus is seen as a raised vertical ridge internally.

Remarks. These specimens are ancestral to the continental forms, since the first occurrence in Germany is reported from the Upper Santonian by Clarke (1983).

Range. From 3m below New Pit Marl 1, *T. lata* Zone, Middle Turonian, to the Coniacian at Dover. Reported from the Late Cretaceous of The Netherlands (Bonnema 1941), the Santonian to Maastrichtian of northern Germany (Herrig 1966; Clarke 1983), and the Upper Campanian and Maastrichtian of Poland (Szczechura 1965).

Amphicytherura sp. aff. **A. chelodon** (Marsson, 1880) Pl. 18, fig. 2

aff.1880 *Cythere chelodon* Marsson, p. 43, pl. 3, figs 13a-f.

Material. 3 specimens; AKSD33, 1LV (juv); LGSD8, 1LV (juv); LGSD21, 1LV.

Measurements. IJS17/17, LV 456 - 293 - 131

Description. Only left valves have been recovered, this description is of a single adult left valve. Carapace small, strongly calcified, subovate. Dorsal margin straight, obscured by dorsal rib; angular anterior hinge ear. Ventral margin gently convex, obscured in posterior half by ventral rib. Anterior margin almost straight but steeply sloping above mid-height, rounded below. Short caudal process at the posterior with extremity at mid-height.

Surface strongly ornamented with sharp ribs. Dorsal rib is connected to the very large eye tubercle by a short diagonal extension, two subvertical ribs descend from the dorsal rib in the posterolateral field, these connect with the median rib; dorsal rib terminates in a short downwards and backwards extension. In front of the eye tubercle a short strong rib descends towards the centre of the anterior margin but terminates rather abruptly. The median rib begins at the anterior extremity, descends slightly, then runs horizontally to the large irregular muscle node; the posterior continuation of the median rib rises towards the posterior and then bends down near its termination. Four small subsidiary ribs descend from the ventral surface of the median rib. A small oblique rib protrudes from the anterodorsal corner of the muscle node towards the ventral termination of the anterior eye rib, this has two small subsidiary ribs on its dorsal surface. The ventral rib starts below the median rib at he anterior margin, it makes a broad sweep to the ventral margin, and rise steeply before terminating in front of the posterolateral field. Eight smaller subsidiary ribs ascend from the ventral rib. Juveniles have the ribs more sharply defined.

The basal surface has a complex pattern of interlocking longitudinal ribs. A narrow rib close to the valve contact extends from the anterior to the posterior margin, at about mid-height this deviates slightly and bifurcates; the smaller offshoot runs for a short distance outside this narrow rib. The third rib continues from the lateral edge of the anterior marginal rib, this swings outward interlocking with the second offshoot rib, it terminates against the fourth rib behind mid-length. The fourth and strongest rib, is also visible in lateral view; it rises in the ventral part of the anterolateral field and curves closely round the third rib, at its posterior extremity it bends outwards and terminates against the main ventral rib.

The calcified inner lamella is broad, with selvage and list. The hinge comprises a large anterior socket, a large bifid anteromedian tooth, a denticulate posteromedian bar, and an elongate posterior socket.

Remarks. The Turonian specimens strongly resemble the Maastrichtian species *A. chelodon* as illustrated by authors (Kaye 1964a, pl. 1, figs 6, 7; Herrig 1966; Clarke 1983, pl. 10, figs 16-19). This has been placed into the genus *Schizocythere* (Herrig 1966; Clarke 1983), the author prefers to return the assignment of this and closely related species to *Amphicytherura* on account of the differences in the gross ornament. The intermediate Santonian and Campanian *Amphicytherura subchelodon* (Clarke, 1983) has fewer features in common with this species. Clarke distinguishes *A. chelodon* from *A. subchelodon* by the former having a strong eye tubercle whereas the latter has only a forked rib in the same position, also by the more weakly developed cross ribs in *A. subchelodon*. The differences between *A.* sp. aff. *A. chelodon* and *A. chelodon* are mainly in the character of the ribs which are much sharper and raised in the older form. The cross ribs are also much more defined and numerous particularly those arising from the dorsal and ventral ribs. This ancestral Turonian species then, may have given rise to the Santonian form without eye tubercle or ribs, and a Campanian form with rounded ribs.

The specimens illustrated by Neale (1978, pl. 13, figs 11, 12) are more closely allied with *A. subchelodon* (Clarke, 1983).

Range. Only recovered from the thin Marl below Glynde Marl 1, Middle Turonian, 2.5m below Caburn Marl, Upper Turonian, and the Uppermost of the Kingston Nodular Chalks, Upper Turonian.

Family TRACHYLEBERIDIDAE Sylvester-Bradley, 1948

Genus CURFSINA Deroo, 1966

Type species. By original designation; *Cythereis maior* van Veen, 1936a, pl. 6, figs 33-38; from the Maastrichtian of Holland.

Diagnosis. Carapace medium or small subrectangular possessing an elongate subcentral tubercle, which may or may not be connected to the median rib. Median rib can be connected posteriorly to the dorsal rib, by a vertical or slanting ridge. Lateral surfaces can be smooth or ornamented with reticulation or pits. Amphidont hinge.

Curfsina senior senior Pokorný, 1967a Pl. 18, figs 3, 4

v* 1967a *Curfsina senior* n. sp.; Pokorný, p. 346, pl. 1, figs 1, 2, pl. 3, figs 1,5, text figs 1A, 1F, 2.

pars 1983 *Curfsina senior* Pokorný, 1967; Clarke, p. 89, pl. 4, figs 1, 3, *non* pl. 4, fig. 2.

v 1988 *Curfsina senior* Pokorný, 1967; Jarvis *et al.*, p. 34, figs 18g-j.

Holotype. A left female valve O-276, (Pokorný 1967a, pl. 1, fig. 1); from the Lower Turonian of Kamajka Hill, Czech Republic.

Material. 15 specimens; ABCMR2, 1LV (broken), 1RV; ABCMR4, 3LV; ABCMR5, 2LV, 2 car.; AKSD43, 2LV; LGSD23, 1RV; LGSD28, 1LV, 2RV.

Diagnosis. *Curfsina* with distinct reticulation over lateral surface and a large elongate node in the dorsal intercostal field. Elongate median rib not connected to muscle node or dorsal rib. Basal surface flat and reticulate.

Measurements.	IJS17/15, LV	650 - 281 - 162
	IJS17/16, RV	600 - 300 - 150

Description. Carapace small and subrectangular, dorsal margin slopes down weakly towards the posterior. Anterior margin evenly rounded in the right valve, broadly rounded above mid-height and evenly rounded below in the left. Marginal spines project from just above mid-height round to the ventral margin. Ventral margin straight. Short caudal process at the posterior extremity, the dorsal part of which is straight in the left valve and concave in the right, three spines on the ventral part of the caudal process.

Marginal ribs well developed. The anterior rib is narrow with a sharp top, between this and the periphery is a row of small tubercles. Eye tubercle is well developed, below a small flat topped hinge ear in the left valve, and at the point of maximum height in the right. A short vertical rib descends from the ventral side of the eye tubercle. The dorsal rib is reduced to two tubercles in its anterior section, the foremost of the two is set lower than the hindmost, which is at the dorsal margin. At the posterior end of the dorsal rib is a large rectangular block like process, which descends vertically, often with a constriction in its central part or tapering to a wedge shape. In front of this process is a smaller node on the dorsal margin which often connects with the intercostal node. Posterior marginal rib has a rounded profile. Ventral rib is connected with ventral part of the anterior marginal rib, after which it curves upwards slightly, then runs with slight sinuosity to the posterior termination. Here is a vertically ascending process, but not as well developed as that at on the dorsal rib. Muscle node large and elongate, steep posterior margin and shallow anterior margin which merges into the anterolateral field. Median rib separate from the muscle node is elongate and bifurcated at the posterior extremity, the dorsal portion rising slightly, in some specimens this continues and connects with the descending block of the dorsal rib, noticed mostly on right valves. Between the dorsal and median ribs is a short elongate node.

Lateral surface has a strong ornament of reticulation with second order reticulation in the meshes. Below the gap between the muscle node and the median rib is a pore conulus.

Basal surface has four prominent longitudinal ribs, following the nomenclature of Pokorný (1967a, p. 347, fig. 1), rib 1 begins obscurely at about mid-length, just behind the oral incurvature and runs parallel to the valve contact. Rib 2 is a continuation of the peripheral row of anterior marginal spines, initially parallel with the valve contact then curving inwards to terminate against rib 1. Rib 3, the strongest, connects with the lateral edge of the ventrolateral surface where this departs from the anterior marginal rib, it follows a sinuous path to the posterior edge of the ventrolateral surface, then deviates in an inward curve to connect with the posterior row of spines on the caudal process. Rib 4 runs subparallel and outside of rib three, this bifurcates before reaching the posterior edge of the ventrolateral surface. Between each of these ribs are cross ribs.

Calcified inner lamella of moderate width with approximately 15 anterior and 11 posterior marginal pore canals. Hinge of right valve with a high crenulate anterior tooth, anteromedian socket and posteromedian groove, and a triangular posterior tooth. Median elements of the left valve are smooth.

Remarks. Pokorný (1967a) noted the similarity between this species and *Curfsina quadridentata* Deroo, 1966, stating that the difference lay in the ornamentation of the basal surface. The fourth rib in the latter is absent, and the absagittal region is smooth and concave. The ornament of the lateral surface is also similar to that of *Curfsina nuda* (Jones & Hinde, 1890) as figured by Kaye (1964a, pl. 7, fig. 13, *non* pl. 7, figs 11, 16) and Neale (1978, pl. 10, fig.

13), it also differs by the ornament on the basal surface. Examination of the basal surface of the lectotype of *C. nuda* in the British Museum (Natural History) shows a single prominent rib connected to the lateral edge of the anterior marginal rib, this begins to cross the basal surface towards the valve margin, then sharply bends and extends almost to the ventrolateral edge, where it bends sharply and runs back towards the valve margin once more. Behind mid-length it bifurcates; one branch continues then bends at a right angle to the connect with a smaller longitudinal rib near the valve contact; the other section again bends outwards for a short distance before running longitudinally to the posterior margin of the ventrolateral surface. This unique basal pattern serves to distinguish *C. nuda* from any other of this genus described here. The Cenomanian *Curfsina derooi* Weaver, 1982, can be distinguished by the reduced median rib and the papillate reticulation meshes. The form illustrated by Clarke (1983, pl. 4, fig. 2) does not have the node present in the dorsal intercostal field, which would place it closer to *C. kafkai kafkai* Pokorný, 1967a the microreticulate surface, however, suggests that it is an intermediate form between *Curfsina senior calo* ssp. nov. and *C. kafkai kafkai.*

Range. A single fragment was found 4.5m above the basal hardgrounds in the Lower Turonian, but the first good record is from Lulworth Marl, *Mytiloides* spp. Zone, Lower/Middle Turonian boundary. It is found rarely to the top of the Turonian and occurs in the Coniacian.

Curfsina senior calo ssp. nov. Pl. 18, figs 5, 6;
Pl. 27, fig. 1

Name: Latin; *calo*, meaning a batman; it occurs alongside the nominate subspecies.

Holotype. Carapace IJS17/14, from sample AKS3/10, 1m above Southerham Marl 2, Upper Turonian, *T. lata* Zone; from Akers Steps, Dover, Kent.

Material. 22 specimens; DOE8A, 2RV; AKSD54, 1LV; AKSD55, 2RV; LGSD1, 3LV, 2RV; AKS3/10, 2LV, 1car; LGSD7, 4LV; LGSD18, 1LV; LGSD19, 1RV; LGSD21, 1LV, 1car.; LGSD23, 1RV.

Diagnosis. Curfsina senior with reduced ornament of pits on the lateral surface; remnants of radial ribs of reticulation remain around the node in the dorsal intercostal field.

Measurements.	IJS17/13, RV	631 - 262 - 150
	IJS17/14, car.	650 - 350 - 293

Description. Shape and gross structural elements as for the nominate subspecies. The ornament is reduced in the anterolateral and ventral intercostal fields. Immediately behind the anterior marginal rib is a remnant of a single row of reticulation. The dorsal intercostal node is surrounded by radial riblets, four of which connect with the median rib, one connects with a tubercle on the dorsal side of the muscle node and one or two rise towards the dorsal node. Weak reticulation occurs between the muscle node and the eye tubercle.

Remarks. This subspecies is part of the lineage from *C. senior senior* to *C. kafkai kafkai* which demonstrates reduced sculpture. Some specimens were discovered above LGSD6 in which the sculpture was further reduced, but which retained the node, these are intermediate between this subspecies and *Curfsina kafkai* subsp. -1 of Pokorný, 1967, where the node is present but the ornament is absent. The latter should perhaps be placed as a subspecies of *C. senior* rather than *C. kafkai* since the possession of the node is a specific trait, whereas the details of ornament are only of subspecific value.

Range. First appearance 2m below Southerham Marl 1, *T. lata* Zone, Upper Turonian. It is found over the interval including the Southerham Marls but is absent in the section around Caburn Marl. *Curfsina senior calo* reappears at the Bridgewick Marls, Upper Turonian and is present up to the Top of the Kingston Nodular Chalks, *S. plana* Zone, Upper Turonian.

Curfsina kafkai kafkai Pokorný, 1967a Pl. 18, figs 7, 8

non 1860 *Cythere (Bairdia) gracilis*; Jones, p. 162, pl. 11, fig. 15 [*fide* Pokorný (1967a)].

non 1861 *Cythere gracilis* Mc Coy; Geinitz, p. 34 [*fide* Pokorný (1967a)].

1886 *Cythere gracilis* n. sp.; Kafka, p. 54, pl. 1.

v* 1967a *Curfsina kafkai kafkai* nom. nov.; Pokorný, p. 350, pl. 1, fig. 3, pl. 2, fig. 1, pl. 3, fig. 2.

1990 *Curfsina kafkai kafkai* Pokorný, 1967; Horne *et al.*, p. 127, pl. 1, figs 1, 2.

Lectotype: Designated Pokorný (1967a, p. 350); a male right valve, deposited in Kafka's collection at the National Museum (Natural History) in Prague, preparation no. 5. labelled as *Cythere* n. sp. - II; from the Upper Turonian of Kostice, Czech Republic.

Material. 5 specimens, LGSD9, LV; LGSD11, Caburn Marl; 3LV, 1RV, corroded.

Diagnosis. Smooth *Curfsina* without elongate node in the dorsal intercostal field; short vertical process descends from posterior end of dorsal rib; absagittal part of basal surface concave, transverse elements between longitudinal ribs of basal surface reduced.

Measurements. IJS17/7, LV 625 - 337 - 150

IJS17/10, RV 625 - 262 - 137

Description. Carapace small subquadrate, dorsal margin sloping weakly down towards the posterior. Prominent eye tubercle, at point of maximum height in the right valve. Anterior margin evenly rounded in the right valve, broadly rounded above mid-height and evenly rounded below in the left valve. Ventral margin straight. Short caudal process at the posterior, concave above and convex below, bearing three spines on the ventral section.

Marginal ribs well developed; anterior rib has a sharp lateral top; ventral, posterior and dorsal ribs are more rounded. The dorsal rib, behind mid-length is broken up into two tubercles. Muscle node large and elongate, separate from the elongate median rib. The descending posterior part of the dorsal rib may have a weak oblique connection with the posterior end of the median rib. Large pore conulus in the ventral intercostal field below the anterior end of the median rib.

Lateral surface smooth, without ribs, reticulation or punctae. Calcified inner lamella of moderate width with approximately 18 anterior and 11 posterior margin pore canals. Amphidont hinge imperfectly preserved. Muscle scars not seen.

Remarks. This represents the most extreme form of the group of *Curfsina* species and subspecies in which the ornament of the lateral surface is reduced. It is rare in the British Turonian. *Curfsina anorchidea* (Veen, 1936a) can be distinguished by its sharper anterior rib and a more continuous dorsal rib.

Range. Found just below and at Caburn Marl, upper part of *T. lata* Zone, Upper Turonian. Horne *et al.* (1990) also recorded this only from the Caburn Marl (Crab Bay Marl of Robinson 1986). Known from the upper part of the Middle Turonian to Lower Coniacian of Bohemia (Pokorný 1967a).

Genus CYTHEREIS Jones, 1849

Type species. By subsequent designation; Sutton and Williams, 1939; *Cytherina ornatissima* Reuss, 1846; from the Coniacian of the Czech Republic.

Diagnosis. Carapace large and heavily calcified, with a large subcentral tubercle. Prominent discontinuous longitudinal dorsal, median and ventral ribs, often as spines. Surface smooth to spinose or reticulate. Large hinge ear in left valve which overlaps right valve.

Cythereis kosticensis Pokorný, 1963 Pl. 19, fig. 5

? 1846 *Cytherina ornatissima;* Reuss, p. 104 (not pl. 24, fig. 12, 18) [*fide* Pokorný 1963].

v* 1963 *Cythereis kosticensis* n. sp.; Pokorný, p. 40, pl. 3, fig. 1, pl. 5, figs 6, 10, pl. 7, fig. 1.

pars 1964a *Cythereis longaeva longaeva* Pokorny; Kaye, pl. 8, fig. 3, *non* pl. 8, fig. 5 [= *Cythereis longaeva longaeva*].

Holotype. A silvered female carapace, slide no. O-104, deposited in the Department of Palaeontology, Charles University, Prague; from the Upper Turonian beds Xb, of Kostice, Czech Republic.

Material. 13 specimens; AKSD53, 2LV juv.; LGSD11, 1LV frag.; LGSD12, 1RV; LGSD13, 1RV juv.; LGSD18, 1RV; LGSD23, 1RV juv.; LGSD24, 1LV, 3RV juv.; LGSD28, 2RV juv.

Diagnosis. Large *Cythereis* with reticulate surface, ornamented with pore spines; dorsal ridge short with three spines on its crest; median rib with four to five spines separate from muscle node; ventral rib with six or seven spines.

Measurements. IJS16/24, RV 875 - 462 - 281

Description. Only one well preserved adult right valve has been recovered so details of the left valve in this description are lacking. Carapace large elongate, subtriangular, greatest height at the eye tubercle. Dorsal margin slopes down toward the posterior, partially obscured by the eye tubercle, centrodorsal spines and the dorsal rib. Anterior margin evenly rounded, nine or ten marginal spines project beyond the periphery. Ventral margin straight to weakly convex, keel-like spines on the basal surface project beyond the margin. Posterior margin drawn out into a triangular caudal process with the posterior extremity below mid-height, the dorsal section of the caudal process is weakly concave and bears one small spine, the ventral section is convex and has four marginal spines.

Anterior marginal rib very well developed, from the eye tubercle it is continuous with the ventral rib, seven or eight small tubercles sit on its lateral edge. The ventral rib is reduced to a series of seven spines, the hindmost is thickened into a large process. The dorsal rib is very short and blocky at the posterior end and reduced completely in its anterior and central sections to two centrodorsal processes which project above the dorsal margin. Below the eye tubercle is a short near vertical rib. The muscle node is large and steep sided, with a row of three spines on its crest; separated by two meshes of reticulation from the median rib which is composed of a low ridge with three spines on the crest, the hindmost is positioned above the central line of the median rib.

The ornament on the lateral surface consists of a weak reticulation with large conjunctive tubercles. On the basal surface are a series of longitudinal ribs which are broken up into strings of tubercles or flattened elongate keel-like spines. Close to the valve contact is a thin continuous rib, outside of this are five further ribs each becoming more prominent, more tuberculate and more widely spaced, the fifth of these is the main ventrolateral rib described above. On the posterior border of the ventrolateral surface are two large keel-like spines.

The calcified inner lamella is of moderate width, without vestibules. The hinge of the right valve consists of a flat topped anterior tooth with a stepped anterior margin, postjacent large socket which narrows to a groove bounded above and below by bars. This broadens out in front of the crenulate posterior tooth which has four lobations. Muscle scar details not seen.

Remarks. This species appears to be transitional between *Cythereis longaeva* and *Cythereis ornatissima*. It differs from the former by slightly less well defined reticulation, more spination, and a shorter dorsal rib; from the latter by the presence of lateral reticulation.

Range. First appearance 2m below Southerham Marl 1, *T. lata* Zone, lower part of the Upper Turonian, ranges up into the Coniacian. Recorded from the Upper Turonian of Dunstable (Kaye 1964a) and Bohemia (Pokorný 1963).

Cythereis longaeva longaeva Pokorný, 1963 Pl. 19, figs 1, 2

pars 1846 *Cytherina ornatissima* Reuss; Reuss, p. 104, *non* pl. 24, figs 12, 18 [= *Cythereis ornatissima*].

1940 *Cythereis ornatissima* (Reuss); Triebel, pl. 2, figs 27-30.

1948 *Cythereis ornatissima* (Reuss); Sylvester-Bradley, p. 795, pl. 122, figs 20-22 [redrawn from Triebel, 1940].

v* 1963 *Cythereis longaeva longaeva* n. sp., n. ssp.; Pokorný, p. 27, pl. 2, fig. 2, pl. 5, figs 1, 3, 5, pl. 7, figs 5-7.

pars 1964a *Cythereis longaeva longaeva* Pokorný; Kaye, p. 65-66, pl. 8, fig. 5, *non* pl. 7, fig. 12, pl. 8, fig. 3 [= *Cythereis kosticensis* Pokorný, 1963].

non 1986 *Cythereis (Cythereis) longaeva* Pokorný; Damotte, p. 29, pl. 1, figs 8, 9.

1988 *Cythereis* sp. cf. *C. longaeva longaeva* Pokorný; Jarvis *et al.*, p. 45, figs 18e, f.

pars 1990 *Cythereis* sp. cf. *C. longaeva longaeva* Pokorný; Horne *et al.*, p. 127, pl. 1, fig. 8, *non* pl. 1, fig. 7 [= *Cythereis triaculeata* Clarke, 1983], *nec* pl. 1, fig. 9 [= *Mauritsina*? *paradordoniensis* sp. nov.].

Holotype. A female carapace, slide O-105, in the Department of Palaeontology, Charles University, Prague; from the Upper Turonian of Kostice, Czech Republic.

Material. 43 valves, 1 carapace; 19RV (5 juv), 24LV (5juv).

Diagnosis. Large *Cythereis* with coarsely reticulate surface; median rib broken up into a row of four or five tubercles; a gap of one large reticulation mesh between the muscle node and the first tubercle; posterior section of dorsal rib broken up into four blade-like spines; no connection between dorsal and median ribs.

Measurements. IJS17/4, LV 812 - 462 - 250
IJS17/5, RV 837 - 450 - 260

Description. Carapace well inflated, large and heavily calcified, subquadrate outline. In dorsal view the point of maximum width is at the tubercle on the muscle node. Straight dorsal margin slopes gently down towards posterior, ventral margin straight and horizontal. Anterior margin broadly rounded in the dorsal half, more tightly rounded ventrally. Posterior has large blunt caudal process with maximum length below mid-height; the dorsal side of the caudal process is straight and steep, the ventral side is openly rounded.

Thick anterior marginal rib bears five or six tubercles and two rows of very fine pits on its lateral surface. A very large rounded eye tubercle sits just below the point of maximum height formed by the hinge ear and the top of the anterior marginal rib. A small postocular sulcus separates the eye tubercle from a conical tubercle on the dorsal margin. A gap separates this from the dorsal rib which arises at mid-length with a conical tubercle. The posterior section of the dorsal rib is broken up into four flattened spines which tend to have flat tops and lean backwards. The bases of these spines are surrounded by small pits. The large rounded muscle node is tuberculate and pitted, and is separated from the median rib by a large reticulation mesh. The median rib is reduced to a row of four or five tubercles in a horizontal line, separated only by rows of small pits. There is no connection between the dorsal and median ribs. The ventral rib is long, arising from the anterolateral field above the anterior marginal rib, continuing with a very slight convexity to terminate below the end of the median rib. It has several tubercles on its posterior section and carries a row of very small pits. The posterior lateral field is compressed, and bounded by the posterior marginal rib.

The entire lateral surface is covered with a very even reticulation network, which only varies in the row immediately behind the anterior marginal rib, where the meshes are square with thin walls, and in the posterior lateral field where there is a secondary smaller reticulation between much reduced muri. Small pits distributed as detailed above, and small conjunctive and disjunctive tubercles are present on the muri.

Ventral surface has a series of five parallel ribs running longitudinally with cross ribs between.

Remarks. The subspecies of *C. longaeva* recognised by Clarke (1983) are here thought to represent distinct species, which are not closely related to *C. longaeva s.l.* *Cythereis longaeva procera* Clarke, 1983 is considered as a junior subjective synonym of *Cythereis luzicensis* Pokorný, 1965a. *Cythereis longaeva triaculeata* Clarke, 1983 is raised to specific rank. *Cythereis longaeva prior*

Clarke, 1983 is more closely related to *Cythereis luzicensis* and should be regarded as subspecific to that species (see remarks for *Cythereis triaculeata*).

Range. First appearance in the hardgrounds at the base of the Holywell Member, *Mytiloides* spp. Zone, Lower Turonian. Present throughout the Turonian, Coniacian and Santonian, reported from the *mucronata* Zone of the Campanian by King [1968], and from the Middle and Upper Turonian of Bohemia (Pokorný 1963).

Cythereis luzicensis Pokorný, 1965a Pl. 19, figs 3, 4

*v 1965a *Cythereis luzicensis* n. sp.; Pokorný, p. 51, pl. 1, fig. 1, text-fig. 1.

. 1983 *Cythereis longaeva procera* n. ssp.; Clarke, p. 79, pl. 2, figs 4-6.

. 1983 *Cythereis longaeva prior* n. ssp.; Clarke, p. 77, pl. 2, figs 1-3.

Holotype. A female carapace, no. O-133, deposited in the Department of Palaeontology, Charles University, Prague; from the Coniacian of Luzny Creek, Luzice, Czech Republic.

Material. 3 specimens; LGSD23 1LV female, 1RV male; LGSD26 1LV. Further material from the Coniacian.

Diagnosis. Elongated *Cythereis* with distinctly reticulate surface except for the posterolateral field. Short median rib separated from the muscle node by three meshes of reticulation. Short dorsal rib reduced to a posterodorsal process. Above the muscle node is a patch of reticulation where the muri are wider than elsewhere.

Measurements.	IJS12/12, LV	875 - 437
	IJS17/6, RV	887 - 425 - 212

Description. Carapace fairly well inflated, outline elongate and subquadrate, anterior end higher than posterior. Dorsal margin slopes gently towards the posterior, more steeply behind the hinge ear, straight in the centre section and horizontally above the posterolateral field. A centrodorsal tubercle interrupts the straight section of the dorsal margin and projects above it. Ventral margin straight with a slight oral concavity. Anterior margin almost straight in the dorsal half and evenly rounded ventrally. Posterior margin is angular, caudal process extremity is below mid-height, five tubercles project from the ventral side.

Anterior marginal rib thick, carrying large tubercles on its lateral surface, dorsally reduced by a large praeocular depression. Distinct eye tubercle projects above the dorsal margin. Dorsal rib very short, restricted to a blocky posterodorsal process. Ventral rib indistinct, appearing to be a coalescence of two rows of reticulation muri which form a compound rib. Tubercles are present particularly in the posterior section. Median rib short, consisting of three tubercles, highest anteriorly, which are separated from the muscle node by three or four reticulation meshes. The muscle node is large and rounded bearing a spine like tubercle in its lower half.

The basal surface bears a coarse pattern of longitudinal ridges and short transverse connecting riblets. The arrangement of the ridges is the same for left and right, with the addition in the right valve of a very fine inner rib which runs the length of the valve, close to the valve margin. The second rib continues from a median row of small tubercles on the anterior marginal rib and extends to about mid-length, where it is joined by the third ridge. The third and strongest ridge, extends from the row of anterior marginal tubercles which project radially from the anterior marginal rib. It is straight in the anterior half, then curves adsagitally to cut out the second ridge, then continues towards the posterior marginal row of tubercles. The fourth ridge follows from the lateral row tubercles on the anterior marginal rib and runs parallel to the third ridge, curving inward, and terminating in a raised keel at the posterior margin of the ventrolateral surface. The fifth and sixth ridges are short and indistinct but are confined to the ventrolateral surface, the fifth terminates in a raised keel next to that of the fourth ridge. The basal surface undulates, it is concave near the margin at 1/3 length, convex in the anterior part of the ventrolateral surface, then concave also in the posterior part of the same surface.

The valve surface is covered in a very distinct coarse reticulation. This is reduced in the posterolateral field, and exaggerated in the area above the muscle node, such that the muri are much thicker than elsewhere.

Anterior and posterior calcified inner lamella of moderate breadth, narrow elsewhere; vestibules absent; prominent selvage. Hinge of right valve has a high flat topped crenulate anterior tooth, a postjacent socket bounded ventrally by a circular loop which extends from the tooth and dorsally by an extension of the upper median bar. The socket narrows to the long median groove, bounded dorsally and ventrally by thin bars. The crenulate posterior tooth is angled obliquely from a low anterior section down and backwards to a high posterior section. The left valve has complementary elements, the anteromedian tooth in the left valve is crenulate. It is difficult to tell if the median bar is crenulate due to the recrystallisation of the specimens. Muscle scars not seen.

Remarks. Cythereis luzicensis is illustrated from the Lower Campanian of Germany by Clarke (1983) as *C. longaeva procera*, and is shown as being derived from *Cythereis triaculeata* Clarke. Both of these species are found in the British Chalk but in reverse stratigraphical order. *Cythereis luzicensis* occurs in the Upper Turonian and *C. triaculeata* in the Lower Coniacian. The author does not take the view of Clarke (1983) that these are subspecies of C.

longaeva, but believes them to be distinct species (see remarks for *Cythereis triaculeata*).

Range. First appears in the Upper Turonian, *S. plana* Zone, just above the lowest of the Bridgewick Hardgrounds. Recorded from the Middle Coniacian of Bohemia and the Santonian of the Netherlands (Pokorný, 1965a), also from the Santonian and Campanian of Northern Germany (Clarke 1983).

Cythereis ornatissima altinodosa Pokorný, 1963 Pl. 19, fig. 6

v* 1963 *Cythereis ornatissima altinodosa* n. ssp.; Pokorný, p. 23, pl. 2, fig. 1, pl. 6, fig. 6.

1983 *Cythereis ornatissima altinodosa* Pokorný, 1963; Clarke, p. 80, pl. 1, figs 4-7.

1990 *Cythereis ornatissima* cf. *C. o. altinodosa* Pokorný, 1963; Horne *et al.*, p. 127, pl. 1, fig. 4.

Holotype. A female carapace, slide O-102, in the Department of Palaeontology, Charles University, Prague; from the Coniacian of Luzice, Czech Republic.

Material. 4 specimens; LGSD19, 2LV (broken); LGSD26, 2RV, (1 juv.).

Diagnosis. Large *Cythereis* with reduced reticulation over most of the lateral surface, remnants occur in the anterolateral field. Steep anterior margin of the muscle node. Ventral and median rib reduced to rows of spines, dorsal rib reduced to a single large posterior node. Muscle node tuberculate.

Measurements. IJS16/25, RV 875 - 450 - 237

Description. Carapace large, maximum height at the hinge ear, maximum width at the muscle node. Dorsal margin slopes down towards the posterior and is obscured partly by dorsally projecting tubercles. Anterior margin evenly rounded in both valves with many spines projecting beyond the periphery. Ventral margin straight, obscured partly by projecting spines. Posterior margin consists of a triangular caudal process with straight upper and lower segment in the left valve, the upper is concave in the right.

Anterior marginal rib well developed bearing many rounded tubercles on its lateral surface, ventrally these pass into the ventral rib which is reduced to a series of spines which become larger towards the posterior. The posterior marginal rib also carries low tubercles. Prominent eye tubercle set just below the hinge ear in the left valve and at the point of maximum height in the right. The dorsal rib is reduced to a single large node at its posterior end, and several smaller tubercles along the dorsal margin, one of which, just in front of mid-length, projects above the dorsal margin. Muscle node high with three pairs of vertically aligned tubercles, both anterior and posterior margins of the node are steep. Median rib reduced to series of three discreet spines.

Lateral surface almost totally smooth, some traces of reticulation may be seen behind the anterior marginal rib. Small scattered tubercles are found over the lateral surface, particularly in the dorsal and ventral intercostal fields.

The basal surface ornament consists of rows of tubercles which are longitudinally arranged, widely spaced at the posterior margin of the ventrolateral surface, they converge towards the anterior. The first row near the valve contact is very narrow and almost rib-like, the second is also narrow and becomes broken into tubercles towards the posterior. The third comprises four pairs of longitudinally arranged tubercles. The fourth has larger, widely spaced tubercles, while the fifth is the ventral rib which marks the lateral edge of the ventrolateral surface, which has been described above. Two large keel-like spines lie at the posterior border of the ventrolateral surface.

Calcified inner lamella moderately broad without vestibules, Strong oral incurvature. Hinge in the right valve has a strong knob-like anterior tooth, a large postjacent socket, a long median groove bounded above and below by thin bars. The groove broadens out at the posterior end to the large square crenulate posterior tooth with three distinct lobations. Median elements in the left valve are smooth.

Specimen attributed to a juvenile of this species has a reticulate surface, with thin curved muri.

Remarks. Pokorný (1963) redescribed the type material from Reuss' collection and erected three subspecies based on the degree of reticulation and the nature of the anterior margin of the muscle node. *Cythereis ornatissima ornatissima* (Reuss, 1846) has reticulation in the intercostal fields and a step-like anterior margin to the muscle node, while *C. ornatissima adictyota* Pokorný, 1963 has reduced or vestigial reticulation and a smooth transition between the muscle node and the anterolateral field. *Cythereis ornatissima* aff. *adictyota* Pokorný, 1963 is similar to latter but has spines reduced to papillae. These features serve to distinguish *C. ornatissima altinodosa* which has reticulation remnants in the anterolateral field and a steep anterior margin to the muscle node. The Cenomanian species *Cythereis* sp. A *sensu* Weaver, 1982 is similar and may be ancestral.

Range. Horne *et al.* (1990) report this from a single sample in the Middle Turonian below the Glynde Marls, *T. lata* Zone, but here it is found only in the Upper Turonian, *S. plana* Zone, from the upper Bridgewick Marl to Navigation Hardground 1. Further specimens have been recovered in the Coniacian. This subspecies has been found in the Upper Coniacian of Bohemia (Pokorný 1963) and the Santonian of Northern Germany (Clarke 1983).

Cythereis paraglabrella Pokorný, 1965 Pl. 19, figs 7, 8

v* 1965 *Cythereis paraglabrella* n. sp.; Pokorný, p. 77, pl. 2, figs 1a, b.

Holotype. A female carapace on slide number O-138 in the Department of Palaeontology, Charles University, Prague; from the Upper Turonian beds Xbc of Kostice, Czech Republic.

Material. 5 valves; LGSD24, 2RV, 1LV; LGSD25, 1LV, 1RV.

Diagnosis. Large *Cythereis* with ornament almost totally reduced over the lateral surface, only vestigial traces left between the muscle node and the dorsal margin.

Measurements.	IJS16/17, RV frag.	706 - 437 - 250
	IJS16/18, LV	732 - 450 - 237

Description. Carapace large, subquadrate dorsal and ventral margins straight and almost parallel; anterior margin evenly rounded with many small peripheral spines; posterior marginal extremity below mid-height in right valve. Maximum height at hinge ear in left valve and at prominent eye tubercle in the right.

Anterior marginal rib low and flat, the straight ventral rib arises above the ventral termination of the anterior marginal rib, and has six or seven slight swellings along its length which become more tuberculate towards the posterior. Dorsal rib is straight and high in the posterior section and reduced to a single centrodorsal process in front. The rear part of the dorsal rib has a descending section which connects with the posterior end of the median rib. The anterolateral field is smooth and rises smoothly to the crest of the muscle node, the posterior face of which is steep and separate from the median rib. The median rib is composed of coalesced tubercles, the posterior section is less well defined than the anterior, this rises slightly to meet the descending section of the dorsal rib. Large eye tubercle has a sinuous rib descending from it.

Lateral surface smooth or micropunctate, with traces of reticulation above the muscle node. Behind the anterior marginal rib is a deep furrow corresponding to the position of the first row of reticulation in other similar species. Basal surface has a pattern of longitudinal ribs which curve in to the valve margin towards the posterior. The first adsagittal rib is the weakest and terminates at about mid-length. The second rib is a continuation of the lateral edge of the anterior marginal rib, this follows a curved path across the ventral surface, and terminates at the valve contact at two-thirds length. The third rib begins in the anterior part of the ventrolateral surface and runs subparallel to the second rib, and terminates in a large process at the posterior edge of the ventrolateral surface. The fourth rib runs absagitally to the third and also terminates in a keel-like process next to the other. All ribs have smaller cross-ribs between.

Calcified inner lamella of moderate width without vestibules. Hinge in right valve consists of a high anterior crenulate tooth with four lobations, large postjacent socket which narrows to a groove bounded above and below by thin bars, posterior tooth not well preserved.

Remarks. Slight differences exist between these and the Bohemian specimens; the ventral rib in the British form has a number of small tubercles along its length while that in the Bohemian specimens is smooth. This may be interpreted as a transitional feature to the ventral rib as developed in *Cythereis lacertosa* Damotte, 1964, from the Campanian of France, where the posterior part of the ventral rib is composed of large vertical processes. Pokorný (1965) associated *C. paraglabrella* with shallow water sedimentation in the Bohemian Cretaceous Basin.

Range. Its entry corresponds to the small faunal turnover which is noticed below the Turonian-Coniacian boundary. Present in the overlying Coniacian (Slipper in press, Appended) and found by the author in Santonian chalks from Pinden Quarry, Kent. Reported from the Upper Turonian to the Lower Coniacian of Bohemia (Pokorný 1965).

Cythereis triaculeata Clarke, 1983 Pl. 20, fig. 1

* 1983 *Cythereis longaeva triaculeata* n. ssp.; Clarke, p. 78, pl. 2, figs 7-10.

pars. 1990 *Cythereis* cf. *C. longaeva* Pokorný; Horne *et al.*, pl. 1, fig. 7, *non* figs 8 [= *C. longaeva longaeva* Pokorný], *nec* pl. 1, fig. 9 [=*Mauritsina*? *paradordoniensis* sp. nov.].

Holotype. A left valve, SGPIH 2604, deposited in the Geological and Palaeontological Institute and Museum, Hamburg; from the Upper Santonian of Northern Germany.

Material. 1 specimen; LGSD28, 1RV, further specimens from the Coniacian and Santonian.

Diagnosis. Cythereis with dorsal rib reduced to a short posterodorsal process which connects to the median rib via a thin vertical rib at their posterior ends. Median rib short, separated from the muscle node by three or four meshes of reticulation. Basal surface with principal ribs curving adsagitally towards the posterior. Muscle node with steep posterior and sloping anterior faces.

Measurements. IJS16/26, RV 787 - 400 - 212

Description. The description here of left valve features are from Coniacian specimens. Valve well calcified and moderately inflated, outline elongate and subquadrate. Straight dorsal margin slopes down gently towards the posterior, interrupted only by a small centrodorsal tubercle, hinge ear present in left valve. The ventral margin is sinuous, with concavities in front of and behind mid-length where it is slightly convex. Anterior margin is evenly rounded in the right valve and with straight dorsal and rounded ventral sections in the left valve; marginal tubercles project beyond the outline. Posterior margin has a caudal process below mid-height, the dorsal side of which is concave, the ventral is straight bearing four short spines.

The well developed anterior marginal rib carries three rows of tubercles, two are peripheral and the third is lateral. The innermost row are very fine spines which can only be seen in dorsal or ventral view since they are hidden by the second row of much larger tubercles on the anterior margin of the rib. The lateral tubercles occur at the intersections of the radial muri of the first row of reticulation with the anterior marginal rib. Distinct eye tubercle at the point of maximum height is surrounded by praeocular and postjacent sulci, which are themselves bordered by slight elevations. The dorsal rib is reduced to a posterodorsal process composed of a posterior semicircular blade and an anterior right-angled blade, the anterior edge of which merges with the dorsal margin. A thin vertical rib descends from the posterior border of the dorsal rib to connect with the posterior end of the median rib, slightly above mid-height. Ventral rib is not very well developed, composed of two coalesced concentric ribs of reticulation, which become tuberculate posteriorly. A short square process projects below the end of the ventral rib. The median rib is short, composed of three coalesced tubercles which are separated from the muscle node by three meshes of reticulation. A raised rib runs round the posterior margin. The muscle node is very well developed which rises from the anterolateral surface with a convex rounded face, then descends with a straight posterior face. It bears one prominent spine in its lower half which is directed backwards, and may have other lesser spines.

The basal surface of the right valve has four longitudinal ribs, and an irregular pattern of ribs on the ventrolateral surface. the innermost of the ribs is very thin and is a continuation of the first row of peripheral spines; this runs from anterior to posterior margins. The second rib, in its anterior section, is a row of small tubercles absagitally of the main row of peripheral tubercles, this thickens and continues to behind mid-length and is cut out by the third rib. The third thicker rib is a continuation of the main row of peripheral tubercles, this runs in a straight line to mid-length, then swings inwards, merges with the second rib and continues in a straight line to the row of tubercles on the ventral side of the caudal process. The fourth rib is thinner than the third and runs from the lateral row of tubercles on the anterior marginal rib, in a sinuous path to the posterior margin of the ventrolateral surface where it terminates in a raised keel. Absagitally of this is a rib which bifurcates and connects the lateral rib. A second keel-like process sits outside the continuation of the bifurcated rib. Cross ribs are present between the main ribs.

With the exception of the posterolateral surface, the valves are heavily and distinctly reticulated in a radial and concentric pattern. A small patch above and slightly anterior of the muscle node has muri which are thickened, and the first row in the anterolateral field have radial muri which are thinner.

The calcified inner lamella is moderately broad at the posterior and anterior, without vestibules, and narrow elsewhere. Selvage continuous around the margin. The anterior tooth of the right valve is high trilobate, with four fine crenulations on its anterior surface. Anteromedian element is a crenulate socket which opens into a narrow groove. The bar above the groove continues above and in front of the anterior tooth. Posterior tooth not well preserved. Muscle scars not seen.

Remarks. Clarke (1983) described this as a subspecies of *Cythereis longaeva* Pokorný, 1963, but several features disqualify it from that species. *Cythereis longaeva s.l.* has a dorsal rib composed of four spines, a median rib separated from the muscle node by one reticulation mesh and longitudinal ribs on the basal surface, all of which reach the posterior margin of that surface. None of these features correspond to *C. triaculeata* Clarke, 1983, thus it is here regarded as a distinct species.

Cythereis luzicensis Pokorný, 1965a is very similar to *C. triaculeata*, but can be distinguished by the greater elongation and the absence of the connection between dorsal and median ribs in the former. Similar reasoning as above applies to the two subspecies of *C. longaeva* described by Clarke (1983) as *C. longaeva prior* and *C. l. procera*, neither of which are considered to belong to *C. longaeva s.l.* but are thought to be junior synonyms of *C. luzicensis*.

Range. First appearance at the top of the Upper Turonian LGSD28, below Navigation Hardground 3, *S. plana* Zone. Present through the Coniacian and found by the author in Santonian sediments from Pinden Quarry, Longfield, Kent. Reported from the Upper Santonian and basal Campanian or northern Germany (Clarke 1983).

Cythereis sp. cf. **agedincumensis** Damotte, 1964 Pl. 20, fig. 2

cf. 1964 *Cythereis agedincumensis* n. sp.; Damotte, p. 101, pl. 1, figs 1a-d.

Material. 3 specimens; LGSD10, 1LV; LGSD 24, 2RV, (1 broken) Further material from the Coniacian.

Measurements. IJS16/15, LV frag. 800 - 481 - 225
IJS16/16, RV 850 - 462 - 262

Description. Carapace large, elongate subquadrate, dorsal margin slopes down towards the posterior very slightly. Anterior margin evenly rounded, ventral margin straight or weakly sinuous, posterior extremity below mid-height ending in a short caudal process.

Anterior marginal rib well developed with eight elongated tubercles arranged like spokes around the margin. At the periphery of the rib are approximately twelve small marginal spines. Prominent eye tubercle is at maximum height in the right valve and sitting lateral to the hinge ear in the left valve. Behind the eye tubercle is a short gap before the dorsal rib begins at mid-length. The rib is composed of two ribs joined together such that it gives the impression of a linked chain; it continues to the posterior cardinal angle then turns abruptly through 90° downwards for a short distance before turning evenly through 90° to connect with the median rib. This rib is also chain-like, but with a row tubercles on its top. A gap of one reticulation mesh separates the median rib from the steep posterior face of the muscle node. The ventrolateral rib begins above the ventral edge of the anterior marginal rib, it has the same chain link pattern as the other ribs.

Behind the anterior marginal rib is a deep furrow, in which is the first row of reticulation. The remainder of the lateral surface is covered with a very strong open reticulation. On the muscle node the pattern is reduced to punctae.

The basal surface has a strong oral concavity which is hidden in lateral view. There are five longitudinal ribs, the second and third of which curve in towards the valve contact towards the posterior. The first is a thin rib close to the valve contact, the second is a continuation of the anterior peripheral marginal spines, it terminates against the first just behind mid-length. The third runs outside of the second. The fourth and fifth are part of the reticulation on the ventrolateral surface.

Calcified inner lamella of moderate width without vestibules. Hinge of right valve has a high crenulate anterior tooth, postjacent socket, posteromedian groove bounded above and below by thin bars and a triangular posterior tooth. The anteromedian tooth in the left valve is smooth and rounded, the posteromedian bar is smooth.

Remarks. The original illustrations of Damotte (1964) are unclear, though later illustrations by SEM of topotypes (Babinot *et* *al.* 1985, pl. 65, fig. 1) agree with the original description. *Cythereis zygopleura* Pokorný is very closely related, but has a straighter anterior margin, and less chain-like ribs. *Cythereis latebrosa confinis* Szczechura, 1965 is very similar, but has a finer reticulate pattern in the anterolateral field. *Cythereis trentoniensis* Bonnema, 1941 appears not to have the connected dorsal and median ribs, but is similar in other respects. King [1968] suggests that *C. trentoniensis, C. agedincumensis, C. zygopleura varia* Herrig, 1965 and *C. latebrosa confinis* are all synonyms of *C. wrighti* Jones & Hinde, 1890, which he illustrates. That species has a fine reticulation pattern in the anterolateral field, *C. trentoniensis, C. agedincumensis* the reticulate variant of *C. zygopleura varia* and this species however, do not, but possess an open reticulation pattern in that area.

Range. First appearance 0.5m below Caburn Marl, Upper Turonian; occurs rarely through the overlying Turonian, and has been recovered by the author from the Coniacian at Langdon Stairs.

Genus IDIOCYTHERE Triebel, 1958

Type species. By monotypy; *Idiocythere lutetiana* Triebel, 1958, p. 106, pl. 1, figs 1-4; from the Lutetian of Grignon, Paris Basin.

Diagnosis. Size moderate to small. Valves laterally compressed in dorsal view. Left valve often with large hinge ear. Distinct outer tooth lies in front of anterior hinge element in left valve which overlaps dorsal margin of right valve.

Remarks. The author concurs with Weaver (1982) that the subgenus *Idiocythere (Herrigocythere)* Gründel, 1973 is not sustainable on the single feature of a large hinge ear in the left valve, since this can be variably developed within the genus.

Idiocythere caburnensis sp. nov. Pl. 20, figs 3, 4; Pl. 27, fig. 2

Name: the species enters just below the Caburn Marl at the Langdon Stairs; the Caburn Marl was named after Caburn Pit, near Lewes.

Holotype. Carapace IJS16/27, from sample LGSD10, marl seam below Caburn Marl, Upper Turonian, *T. lata* Zone; from Langdon Stairs, Dover, Kent.

Material. 10 specimens; LGSD10, 1car., 1LV, 1RV; LGSD11, 2LV poorly preserved; LGSD13 1RV; LGSD18, 3RV; LGSD21, ?1juv car., LGSD23, 1RV, further specimens from the Coniacian.

Diagnosis. A species of *Idiocythere* with a median rib which extends forward from the muscle node and curves upwards to join the posterodorsal process; surface reticulation coarse in the median part of the valve and fine in the anterior and posterior fields.

Measurements.		
	IJS12/9, RV	562 - 300
	IJS16/27, car.	637 - 362 - 300

Description. Valves moderately compressed. Dorsal margin straight in right valve, with raised hinge ear in the left valve, and sloping down towards the posterior, interrupted only by a small central tubercle. In dorsal view the left valve overlaps the right at the anterodorsal corner. Ventral margin straight and horizontal with a slight flexure in front of mid-length. A small concave notch exists in front of the hinge ear. Anterior margin broadly rounded dorsally becoming more curved ventrally and passing into the ventral margin. The anterior margin possesses 8-9 spines which project from the outer margin. The posterior margin has a short caudal process below mid-height, above is a concave notch which dorsally passes into the dorsal margin, and below is a straight section at 45° which bears four robust clavate spines.

The anterior marginal rib is narrow and has on its lateral surface 8-9 low tubercles, between which are two rows of minute pits. The anterolateral field is compressed with 3 or 4 pore conulae. The central muscle node is elongate horizontally and more inflated posteriorly, in dorsal view a small tubercle is seen on the crest of the muscle node. A thin rib extends posteriorly from the muscle node composed of two thin riblets with cross ribs between them; this rises at a low angle to connect with a large posterodorsal process. The compound block-like posterodorsal process connects the dorsal and median ribs, it has an angular dorsal corner, which slopes steeply down and forward, then curves anteriorly to meet the median rib. It appears to be made of four ribs each with cross riblets between them. The ventrolateral rib has the characteristic shape present in *Idiocythere*; it rises gradually from the lateral surface, in front of the muscle node, and curves sinusoidally down and then horizontally to terminate in a block-like process situated below the junction of the median and posterodorsal ribs. This posteroventral process flares out and has a vertical posterior face. The ventrolateral rib is composed of three ribs which are more coalesced than other ribs described above, such that the cross ribs have merged leaving only rows of pits between. Two pore conulae occur on the ventrolateral surface. The posterolateral surface is compressed and carries a thin marginal rib which is interrupted where the caudal process projects out; one pore conulus is present on this surface.

The basal surface has five ribs running longitudinally. The first adsagittal rib is very thin and only occurs in the anterior half, the second is the longest rib which runs in a straight line from the anterior margin to the posterior border of the ventrolateral surface, then curves absagitally and terminates at the ventral edge of the posterior margin. The third rib is thicker than the second and runs from the lateral edge of the anterior marginal rib to the posterior margin of the ventrolateral surface. The third rib is the thickest and most raised, but shortest of the ribs; it divides from the second rib behind the anterior border of the ventrolateral surface, then curves to run parallel with it. The fourth is the most delicate rib and runs absagitally of the third. Between all the ribs are many very small cross ribs giving the appearance of a pitted surface.

The ornament consists of several zones with different styles of reticulation. Immediately behind the anterior marginal rib is a row of larger meshes with thin muri, behind this is a zone of reticulation where the muri have expanded into the meshes to create an area of evenly spaced large pits. In the dorsolateral and ventrolateral intercostal fields there are some larger rounded raised reticulation muri which enclose several smaller secondary meshes arranged in small subcircular groups of three to five. The posterolateral field is ornamented with micropunctation.

Inner calcified lamella very broad at the anterior and posterior, without vestibules, narrow ventrally. Prominent selvage and list. Hinge of right valve with large flat topped finely dentate anterior tooth, the anterior side of which is vertical and the posterior side is proximally sloped and distally vertical. The ventral side of the anterior tooth circles round the anteromedian socket which opens out into a smooth posteromedian groove bounded dorsally and ventrally by two bars. The groove opens out slightly at its posterior end to the posterior tooth which is low and dentate. Hinge in the left valve has two anterior lobes separated by a socket, a thin median bar and an oval posterior socket with a small projection on its anterior face.

Remarks. Very similar to *Idiocythere definita* Herrig, 1965a, from the Campanian of Northern Germany, but can be distinguished from that species by greater length relative to height, a median rib which extends forward from the muscle node and curves upwards to join the larger posterodorsal process, coarser reticulation, a longer ventral rib and a straighter dorsal rib. *Idiocythere donzei* Weaver, 1982 is more closely allied to *I. definita* since it too lacks the median rib and has finer punctate ornament, but has a reduced dorsal rib, which distinguishes it from both *I. definita* and *I. caburnensis*.

The Coniacian specimens illustrated by Clarke (1983) as *Idiocythere (Herrigocythere) definita* Herrig, 1965a has a rib which connects the median rib to the posterodorsal process, and is therefore not conspecific with that species. Clarke (1983) put this down to differences in preservation between the Lower Campanian material from Rügen and the Middle Coniacian material from Lägerdorf, but since details of the muscle scars, hinge and marginal pore canals are clearly shown by Herrig (1965a), this is thought not to be the case. However, the reticulation in *Idiocythere (Herrigocythere) definita* Herrig, 1965a *sensu* Clarke is not as well developed as in *I. caburnensis*. It is probably intermediate between the two since it first appears in the Middle Coniacian. British specimens from the Santonian show a reduced middle rib and reduced reticulation.

Range. First appearance 50cm below Caburn Marl, *T. lata* Zone Upper Turonian to the Middle Coniacian at Langdon Stairs.

Genus IMHOTEPIA Gründel, 1969

Type species. By original designation; *Cythereis marssoni* Bonnema, 1941, p. 9, pl. 4, figs 67-71; from the Upper Cretaceous of N.E. Netherlands.

Diagnosis. Small to moderate size. Anterior margin broadly rounded, dorsal and ventral margins converge towards the posterior. Anterior marginal rib usually well developed, valve surface with three longitudinal ribs between which are either small inclined ribs, reticulation meshes or pits, occasionally smooth. Hinge paramphidont to holamphidont with only weakly dentate teeth.

Remarks. Gründel (1969) suggested that transitional forms between *Imhotepia* and *Phacorhabdotus* Howe & Laurencich, 1958 might exist, where the sculpture between the lateral ribs is reduced as in *I. marssoni anteglabra* (Pokorný, 1964). However, *Imhotepia* has a well developed anterior marginal rib and an ornamented surface. The eye tubercle in *Phacorhabdotus* is indistinct, and the latter genus is generally less elongate.

Praephacorhabdotus Gründel 1974a was originally described as a subgenus of *Phacorhabdotus*, and requires distinction from *Imhotepia*. However, there is some confusion concerning the identification of *Praephacorhabdotus*. Gründel (1974a) states that *Praephacorhabdotus* has the characters of *Phacorhabdotus* but with a distinct eye tubercle. He designated *Cythereis bonnemai* Triebel, 1940 as the type species. Two problems arise from this, firstly Triebel's description states that the eye tubercle is indistinct, secondly, Howe & Laurencich (1958) in their diagnosis of *Phacorhabdotus* state that an eye spot is present, but indistinct. Pokorný (1963b) concludes from a study of paratypes of the type species of *Phacorhabdotus* that the eye tubercle is lacking in the genus, but questions the usefulness of this feature since its absence may be a secondary feature, related to the reduction in sculpture. There are other arguments which relate to the validity of *Praephacorhabdotus*; in *Cythereis bonnemai* Triebel, 1940 the ventrolateral rib is continuous with the anteromarginal rib, a feature which removes it from the *Imhotepia-Phacorhabdotus* nexus, since in the latter the ventrolateral rib is unconnected with the anteromarginal rib. These features indicate that the genus *Praephacorhabdotus* Gründel 1974a is not sustainable and should be discontinued.

Imhotepia marssoni anteglabra (Pokorný, 1964) Pl. 20 figs, 6, 7

v* 1964 *Cythereis marssoni anteglabra* Pokorný, p. 269, pl. 2, fig. 1.

1969 *Imhotepia marssoni anteglabra* (Pokorný); Gründel, p. 359.

1971 *Cythereis* sp. 4 *anteglabra* Pokorný; Damotte, p. 71, pl. 3, fig. 11.

1983 *Imhotepia marssoni anteglabra* (Pokorný); Clarke, p. 96, pl. 4, figs 14, 15.

Material. 20 specimens; LGSD18, 2LV; LGSD23, 2LV, 2RV; LGSD24, 4LV, 5RV; LGSD26, 2LV, 1RV, 1car.; LGSD28, 1RV juv., 1car.

Measurements.	IJS16/22, LV	662 - 375 - 175
	IJS16/23, RV	631 - 331 - 153

Description. Carapace small elongate subovate, moderately compressed, left valve larger than right overlapping at the anterodorsal corner, maximum width equally at the muscle node and at the posterior limit of the ventral rib. Dorsal margin slopes evenly down towards the posterior. Maximum height at rounded hinge ear in left valve and at small distinct eye tubercle in the right. Anterior margin evenly rounded in both valves, without marginal spines. Ventral margin straight with slight oral incurvature in front of mid-length. Posterior margin terminates in a short angular caudal process below mid-height. Up to six spines are present on the ventral border of the caudal process.

Anterior marginal rib is complex, formed by an inner rib which runs from the dorsal margin, through the eye tubercle, broadly curves down to mid-height, then curves tightly, running concentrically with the anterior margin, where it then merges into the ventral part of the anterolateral field. A second shorter anterodorsal rib travels obliquely across the field defined by the inner rib and the outer marginal rib. A very thin rib is present around the outer anterior margin which is continuous with both the dorsal and ventral margins. The dorsal rib rises from the anterolateral field below and behind the eye tubercle, from where it travels obliquely up towards the dorsal margin, then turns and runs parallel to the margin to terminate in a short downwards projection in front of the posterodorsal cardinal angle. The ventral rib appears to be connected to the swollen part of the anterolateral field below and in front of the muscle node, it then curves sharply and runs parallel to the ventral margin. The ventral rib is clearly composed of two thin riblets which are fused at each end and distinct in the centre. The median rib is connected by a thin dorsal extension to the posterodorsal corner of the muscle node. Muscle node elongate.

Anterolateral field smooth. A row of small tubercles lies in front of the inner anterior marginal rib. Ornament only present in the posterolateral intercostal fields; ventrally there are two short parallel longitudinal ribs, with cross ribs between connecting to the ventral and median ribs; dorsally are three obliquely sloping ribs, each with cross rib between.

The basal surface has a complex pattern of longitudinal ribs with five in the left valve and three in the left. The distal part of the ventrolateral surface is reticulate.

Calcified inner lamella moderately broad. Hinge of right valve has a high triangular anterior tooth with a finely crenulate flattened crest, small postjacent socket, a narrow posteromedian groove bounded above and below by thin bars, and a high asymmetric crenulate posterior tooth. Anteromedian tooth in left valve is higher anteriorly. A small ocular sinus is present beneath the anterior hinge elements.

Remarks. There are some slight differences from the typical Bohemian *I. marssoni anteglabra*; the ventral rib curves up in the anterior section to connect with the anteriorly descending part of the muscle node, whereas in the type specimens this is straight, though this feature becomes less obvious above Navigation Hardground 1; the dorsal rib is not straight, but curves down towards the anterior; the median rib is not divided into two behind the muscle node. The early forms of this subspecies show intermediate features tending towards *Imhotepia marssoni* subsp.-1 (Pokorný 1964, p. 262, pl. 1, fig 3); there are traces of reticulation in the anterior lateral field, but not sufficient to place it in *Imhotepia marssoni* subsp.-1. The illustration of a Santonian form from northern Germany by Clarke (1983, pl.4, fig 15) also shows this slight anterior reticulation.

Range. First appearance at the hardground above Bridgewick Marl 1, *S. plana* Zone, Upper Turonian. Present throughout the remaining Turonian, and continuous into the Coniacian. Reported from the Upper Coniacian of Bohemia (Pokorný 1964), the Coniacian to Santonian of the Paris Basin (Damotte 1971) and the Santonian of northern Germany.

Imhotepia marssoni multipapillata (Pokorný, 1964) Pl. 20, fig. 5

v* 1964 *Cythereis marssoni multipapillata* Pokorný, p. 260, pl. 1, fig. 2.

1969 *Imhotepia marssoni multipapillata* (Pokorný); Gründel, p. 359.

1971 *Cythereis* sp. 4 *multipapillata* Pokorný; Damotte, p. 71, pl. 3, fig. 9.

1990 *Imhotepia marssoni* (Bonnema); Horne *et al*., p. 127, pl. 1, fig. 6.

Holotype. A left valve, slide no. O-107, in the Department of Palaeontology, Charles University, Prague; from the Upper Turonian of Kostice, Czech Republic.

Material. 20 specimens; 1 carapace, 6LV (3 broken, 1 fragment), 13RV (4 fragments, 2 juv).

Diagnosis. *Imhotepia* with several pore papillae within the reticulation meshes; dorsal rib long and continuous; anterodorsal rib runs obliquely in front of anterior marginal rib; undifferentiated reticulation pattern in the ventral intercostal field.

Measurements. IJS17/3, RV 575 - 300 - 112

Description. Carapace moderately inflated, maximum width at two-thirds length, outline elongate ovate. Dorsal margin slopes down gently towards the posterior; ventral margin straight and horizontal; anterior margin very broadly rounded in the dorsal two-thirds, then broadly rounded in the ventral one-third; posterior margin has a caudal process which makes an right angle, the dorsal section slopes at 60° and carries one small spine, the ventral section is also straight but bears four large spines which obscure the outline.

The main anterior marginal rib is indistinct in the ventral half of the valve and rises at about mid-height, a short straight section then bends backwards and runs towards the dorsal margin in a straight line, the rib then curves and runs through the eye tubercle at the point of greatest height where it merges into the dorsal rib. A secondary smaller anterior marginal rib runs diagonally in the space between the long straight section of the primary rib and the outer margin. In some specimens this rib is poorly formed. The dorsal rib is complex with three ribs in the dorsolateral field running gently up and merging with the main dorsal rib. The muscle node is elongate and divided into two anteriorly. The long thin raised median rib extends from the dorsal side of the muscle node, and terminates at the point where the valve becomes compressed. The ventrolateral rib rises from the anterolateral field and runs, with a slight flexure to terminate in front of, and below the posterior end of the median rib. The posterior marginal rib is interrupted in its central section at the point of maximum length.

The basal surface has four straight longitudinal ridges, the innermost is the longest and becomes the lateral edge of the posterior marginal rib; the second is a continuation of the lateral edge of the anterior marginal rib, this terminates against the third rib in front of the posterior border of the ventrolateral surface; the third ridge begins above the anteroventral corner and terminates in a raised keel at the adsagittal edge of the posterior margin of the ventrolateral surface; the fourth rib is the shortest and runs obliquely, parallel to the ventrolateral rib. Small cross ribs exist between all the main longitudinal ridges.

The lateral surface is covered by a coarse reticulation network, within each of the reticulation meshes are up to five small papillae.

Internal features obscured by matrix, the fragile nature of the specimens precluded cleaning.

Remarks. This is easily recognised and a stratigraphically useful species. A specimen was recovered from the lowest of the Kingston Nodular Chalks which had an aberrant anterior marginal rib. Transitional specimens to *I. m. anteglabra* were seen in the Navigation Hardgrounds.

Range. This species occurs fairly continuously in the Upper Turonian from its first appearance 3m below Caburn Marl, *T. lata* Zone, to the top of the Kingston Nodular Chalks, *S. plana* Zone. After this, is appears sporadically up into the Late Coniacian. Reported from the Upper Turonian and Lower Coniacian of Bohemia (Pokorný 1964) and the Turonian and Lower Coniacian of the Paris Basin (Damotte 1971).

Imhotepia sp. aff. **euglyphaea** Weaver, 1982 Pl. 20, figs 8, 9

aff. 1982 *Imhotepia euglyphaea* sp. nov.; Weaver, p. 71, pl. 14, figs 1-4.

Material. 4 specimens; AKSD 3/10, 1 car., 1RV; LGSD 8, 2 car.

Measurements. IJS12/3, RV 562 - 312

Description. Carapace moderate size, outline elongate ovate. Both dorsal and ventral margins are overlapped by ribs. The anterior margin is tightly rounded, almost semicircular. Ventrally it passes into a concave section of the ventral margin which is then hidden by the ventral rib. The posterior margin has a caudal process below mid height, the dorsal section is straight, the ventral slightly convex, and the angle between them obtuse. The ventral margin of the caudal process carries four evenly spaced marginal spines.

The anterior margin is compressed and bears a thin frill. The anterior marginal rib is continuous into the anterior section of the dorsal rib and has the eye tubercle within it at the point of maximum height. In the left valve there is a small hinge ear at this point. The anterior marginal rib curves round parallel to the outer margin and flows into the thicker and more rounded ventrolateral rib which continues to the posterior border of the ventrolateral surface. The remainder of the dorsal rib is in two segments, the anterior segment slopes diagonally up and back, turns through a large angle and then continues down towards the posterodorsal corner. The second and more posterior segment has a similar shape but the initial diagonal slope is not as steep as that of the anterior section. It passes into the posterior marginal rib on the dorsal side of the caudal process. The muscle node is oval and oriented on a diagonal similar to that of the posterior segment of the dorsal rib. Its anterior face is continuous with the anterolateral surface. The straight, horizontal median rib projects backwards from the posterodorsal corner of the muscle node, and terminates where the valve becomes compressed. A tubercle is present on the ventral side of the median rib at its termination. In the ventral intercostal field lies a smaller horizontal rib, which terminates in front of the median rib. A tubercle is present above this near the muscle node. Above the median rib in the dorsal intercostal field are two faint *en echelon* ribs; the higher and foremost extends from the posterior face of the dorsal edge of the muscle node, the second lies under this nearer to the median rib, and extends further towards the posterior. Below the ventrolateral rib is a slightly convex, keel-like ventral rib which runs from in front of the oral concavity in the ventral margin to terminate below the end of the ventrolateral rib.

The lateral surface of the valves is smooth except for three tubercles in the compressed part of the anterolateral field, and those mentioned above. In dorsal view, the inflated part of the carapace has rounded contours, the point of maximum width is at the muscle node. In ventral view, the ventral rib is seen to consist of two parallel ribs which join loosely at the posterior border of the ventrolateral surface. The left valve has a long thin adsagittal rib which runs from anterior to posterior border. No cross ribs were seen on the ventral surface.

Internal features not seen.

Remarks. Very similar in appearance to the Cenomanian *Imhotepia euglyphaea* Weaver, 1982, but the dorsal rib is divided into two oblique ribs, and it lacks the minor rib in the dorsal intercostal field and the minor ventrolateral rib between the main ventrolateral rib and the muscle node.

Range. Restricted occurrence to just above the Southerham Marls between AKS3/10 and LGSD 8, *T. lata* Zone, Middle Turonian.

Genus ISOCYTHEREIS Triebel, 1940

Type species. By original designation; *Isocythereis fissicostis* Triebel, 1940, p. 209, pl. 7, figs 71-74, pl. 10, fig. 108; from the Albian of Wenden, Germany.

Diagnosis. Carapace small and compressed. Inner marginal zone broad with few marginal pore canals. Anterior marginal rib blade-like. Surface reticulate.

Isocythereis postelongata sp. nov. Pl. 21, figs, 2, 4;
Pl. 27, figs 3, 4

Name: Latin; *post*, meaning after; implying the younger relative of *Isocythereis elongata* Weaver, 1982.

Holotype. LV IJS12/10, from sample LGSD10, marl seam below Caburn Marl, Upper Turonian, *T. lata* Zone; from Langdon Stairs, Dover, Kent.

Material. 8 specimens: LGSD 9; 1LV, LGSD 10; 1RV (male) 1LV, 2RV fragments, LGSD 15; 1 carapace, LGSD 21; 1 broken RV, LGSD 23; 1LV.

Diagnosis. Species of *Isocythereis* with anterior marginal rib which follows the anterior margin and then bends in across the ventral part of the anterior lateral field leaving a large flange in the anteroventral area. This rib then continues into the ventral rib which, in the lateral field is paralleled, dorsally, by two more longitudinal ribs. Sharp median rib connected to dorsal rib.

Measurements.	IJS12/10, LV	587 - 312
	IJS16/21, M, RV	587 - 269 - 106

Description. Carapace small, laterally compressed, elongate. Anterior margin broadly rounded from the indistinct hinge ear in the left valve round to the oral concavity. Ventral margin straight behind oral concavity to the posteroventral angle. Dorsal margin slopes down in a straight line to the posterodorsal angle. Caudal process rounded triangular bearing five spines, the highest projects from the apex of the caudal process. The five spines are grouped into three higher, which are evenly spaced, and two lower, which are shorter and more closely spaced. The anterior margin has a strong flange which begins above the eye tubercle in the left valve, and splits from the anterior marginal rib, below the eye tubercle, in the right valve. Anterior marginal rib runs from the centre of the eye tubercle concentric with the outer margin in the upper two-thirds of the valve's height, then in the lower third of the valve, it cuts into the anterior lateral field and passes by a straight section to connect with the ventral rib. Ventral rib straight, runs as far as the inflated section of the valve and ends where the valve becomes compressed in the caudal process. Above the ventral rib is a second slightly shorter sharp rib, above that is a third short less distinct rib, which blends with the reticulation. The dorsal rib is broken into three sections; one of which, the continuation of the anterior rib, begins immediately behind the centre of the eye tubercle and curves down to connect with the second section. This runs obliquely upwards from below the eye tubercle to the dorsal margin in curved subsections, at each junction bearing a distinct pore conulus. The third section of the dorsal rib runs obliquely from below the second section and then bends obliquely to follow the descending dorsal margin. The dorsal rib ends in front of the posterodorsal angle where it turns downward and connects with the posterior extension of the median rib. The third section of the dorsal rib is paralleled by another rib in the intercostal field, while below that is a third longitudinal rib which is not as bent as the upper two. The median rib is straight and runs posteriorly from the upper edge of the subcentral tubercle to meet the descending section of the dorsal rib at the rear of the posterolateral field. It is composed of two very closely spaced ribs. The subcentral tubercle is not raised above the height of the median rib and has an anterior extension which projects downwards into the anterolateral field. The surface is covered with distinct reticulation; in the posterolateral fields this is composed mainly of cross ribs between the longitudinal ribs, while in the anterolateral field the reticulation meshes have papillae within them. In dorsal view the sides are parallel at the position of the median ribs, the maximum width is at the position of the muscle node, which is elongate with a flat top. Left valve overlaps right anterodorsally. In ventral view the carapace has an elongate arrowhead shape, given by two weak ventral projections. The ventral surface possesses five parallel longitudinal ribs in each valve. The strongest is a continuation of the anterior marginal flange and runs the length of the valve to the posterior border. Adsagittally of this is a concavity which has a weaker rib near the valve edge. Absagittally is a shorter rib, close to the main rib, starting at the point where the anterior flange becomes the main ventral rib and running to the posterior edge of the ventral projections. A fourth rib, shorter than the third runs parallel absagittally to it. The fifth is the main ventral rib, which limits the ventral surface. Small cross ribs occur between these main longitudinal ribs.

Internally the calcified inner lamella is quite broad, no vestibules present. Hinge in left valve with anterior socket, postjacent anteromedian tooth which is higher anteriorly and slopes down to a lower posterior section, a straight median bar and a posterior socket. Anterior tooth of right valve, high and conical, posterior tooth elongate, higher posteriorly. Details of muscle scars not seen.

Remarks. This species is very similar to *I. elongata* Weaver, 1982, but it is slightly more elongate, has better developed longitudinal ornamentation, and a different arrangement of the connection between the anterior and ventral ribs. Of the two species of *Isocythereis* described by Triebel (1940) from the Albian of Germany, *I. postelongata* sp. nov. can be distinguished from *I. fissicostis* Triebel, 1940 by the stronger longitudinal elements of ornament in the intercostal fields. *Isocythereis fortinodis* Triebel, 1940 has a strong subcentral tubercle, a very different aspect in dorsal and ventral views and weaker longitudinal ribs. This species should probably be placed in the genus *Imhotepia* Gründel, 1969. *Isocythereis similis* Herrig, 1967b, from the Upper Coniacian of the Isle of Rügen, is similar in respect of its doubled dorsal rib, but can be distinguished by the shorter median rib which does not connect to the posterodorsal process, also the anterior marginal rib passes in front of the eye tubercle and not through it.

Isocythereis postelongata sp. nov. occurs together with specimens of *Imhotepia marssoni multipapillata* (Pokorný, 1964) and can be mistaken for juveniles of that species. However, the connection between the dorsal and median ribs and the connection between the anterior and ventral ribs in *I. postelongata* can distinguish the two.

Range. It is of limited stratigraphical range and therefore of use as an indicator of the Upper Turonian; from 2m below the Caburn Marl, *T. lata* Zone, to middle of the Kingston Nodular Chalks, *S. plana* Zone.

Genus MAURITSINA Deroo, 1962

Type species. By original designation; *Cypridina hieroglyphica* Bosquet, 1847, p. 17, pl. 3, figs 4a-d.

Diagnosis. Medium to large sized, well calcified, moderately well inflated with ornament of dorsal, median and ventral longitudinal ribs. Muscle scar pattern complex with three frontal scars comprising a large inverted L shaped scar and two smaller oval scars in front, each parallel to a branch of the main frontal scar. Five adductor muscle scars, the top two lie above a vertical row of three, the rear topmost scar is U-shaped, and the topmost of the vertical lower three scars is bifurcated towards the anterior.

Mauritsina? paradordoniensis sp. nov. Pl. 21, figs 1, 3;
Pl. 27, fig. 5

Name. According to the similarity with *Mauritsina dordoniensis* (Damotte, 1971).

? 1971 *Cythereis* gr. *dubiorta* Ohmert; Damotte, p. 70, pl. 3, figs 7a-c.

? 1986 *Cythereis (Cythereis)* gr. *dubiorta* Ohmert 1967; Damotte, p. 29, pl. 1, fig. 7 [Illustration distorted].

pars 1990 *Cythereis* cf. *C. longaeva* Pokorný; Horne, Jarvis & Rosenfeld, pl. 1, fig. 9, *non*. pl. 1, figs 7 [= *C. triaculeata* Clarke, 1983], *nec*, pl. 1, fig. 8 [= *C. longaeva longaeva* Pokorný, 1963].

Holotype. RV IJS16/19, from sample LGSD7, 3.2m below Caburn Marl, Upper Turonian, *T. lata* Zone; from Langdon Stairs, Dover, Kent.

Material. 39 specimens; 21LV, 18RV.

Diagnosis. Large, heavily calcified carapace with papillae in the reticulation meshes; median and dorsal ribs not connected; ventral rib composed of two parallel riblets; reticulate muscle node. Deep furrow behind anterior marginal rib containing the first row of reticulation.

Measurements. IJS16/19, RV 775 - 450 - 212

Description. Carapace large and well inflated, dorsal margin almost parallel to ventral margin. Greatest width at muscle node, greatest height at hinge ear in left valve and at the eye tubercle in right valve. Anterior margin evenly rounded with 18 or 19 very small peripheral spines. Ventral and dorsal margins straight, the latter slopes slightly down towards the posterior. Blunt caudal process at the posterior with a short concave upper margin and a longer convex lower margin bearing four peripheral spines.

Anterior marginal rib well developed with a flat lateral edge with eight or nine radial riblets. A well developed ventral rib arises in the lower part of the anterior lateral field, and continues with a slight downward curve to terminate at three quarters length. It is composed of two parallel riblets which each possess small tubercles along their length, with connecting cross-ribs. Dorsal rib is a complex composed of two sections, an oblique anterior part near the centre of the dorsal margin and a posterior straight part, both sections are ribbed and tuberculate. Posterior marginal rib is low and poorly developed.

Behind the anterior marginal rib is a deep first row of reticulation where the muri are thin. The anterolateral field rises up to the muscle node which has a steep posterior face. The median rib is separate from the muscle node and is strongly tuberculate. The ornament consists of a strong network of reticulation present over all the lateral surface including on the muscle node. The individual meshes have a tendency to be stretched out in a concentric pattern around the muscle node, this is particularly noticeable below the node itself. Papillae are present in the meshes. The eye tubercle is very large and has a descending rib.

Basal surface has a pattern of three longitudinal ribs which curve in to the valve contact towards the posterior, each has strong cross-ribs between. Absagittally of these on the ventrolateral surface is a strong reticulation network in an elongated diamond pattern.

Calcified inner lamella of moderate width without vestibules, strong selvage. Hinge of right valve with very strong terminal elements; anterior tooth is high, steep sided with a lobate crown, posterior crenulate tooth has a sloping anterior and a steep posterior face. Anteromedian socket and posteromedian groove are smooth, the latter is bounded above and below by thin bars.

Remarks. The muscle scar pattern could not be identified undoubtedly as that of *Mauritsina* due to the preservation, but the general shape is similar to other species assigned to that genus and illustrated by Babinot *et al.* (1985), thus this is only tentatively given that generic assignment.

The similarity to *M. dordoniensis* raises some doubt as to the identification of that species when compared to the illustrated topotypes (Babinot *et al.* 1985, pl. 65, figs 7-9). Their fig. 9 has the characteristics described by Damotte (1971) but their figs 7 and 8 lack the connection of the median and dorsal rib which is a specific trait of *M. dordoniensis*. In outline those two specimens are similar to *Cythereis parareticulata* Colin, 1974, but have a different style of reticulation. *Mauritsina*? *paradordoniensis* sp. nov. is similar to *M. dordoniensis* in terms of outline and style of reticulation but lacks the connection between the dorsal median ribs, it also does not have the fine secondary reticulation of figs 7 and 8 of Babinot *et al.* (1985), nor the open reticulation of *Cythereis parareticulata*.

Range. Restricted to the Turonian, from 4m below New Pit Marl 1, T. lata Zone, Middle Turonian to the hardground above Bridgewick Marl 1, *S. plana* Zone, Upper Turonian.

Genus OERTLIELLA Pokorný, 1964a

Type species. By monotypy; *Cythere reticulata* Kafka, 1886, p. 53, pl. 1, figs 2a-c; from the Upper Turonian of Bohemia.

Diagnosis. Valves of moderate size, lateral surface strongly reticulate, anterior marginal rib narrow, dorsal rib low or reduced to spines, median rib absent, ventrolateral rib well developed. Terminal teeth in right valve with weak crenulations, and a smooth median element. Strong sexual dimorphism with males longer and often with more developed dorsal rib.

Remarks. The relationship between *Oertliella* Pokorný, 1964a and *Hermanites* Puri, 1955, is similar to that between *Cythereis* Jones, 1849 and *Trachyleberis* Brady, 1898, in that the hinge of the more ancestral form, in this case *Oertliella*, has crenulate terminal and median elements, while the younger *Hermanites* has smooth hinge elements. In other respects of gross morphology the two genera are similar.

Ohmert (1971) considered this genus to inhabit deeper ranges of shallow seas, and the upper ranges of the deep sea.

Oertliella reticulata (Kafka, 1886) Pl. 21, figs 5, 7

* 1886 *Cythere reticulata* Kafka, p. 53, pl. 1, figs 2a-c.

v 1964a *Oertliella reticulata* (Kafka, 1886); Pokorný, pl. 1, figs 2-4.

Type specimens. No type has been designated, Kafka's material was from the Upper Turonian of Bohemia, Czech Republic, and Pokorný's illustrations of specimens from the Upper Turonian of Kostice are taken as typical; deposited in the Department of Palaeontology, Charles University, Prague.

Material. 44 valves of adults and juveniles.

Diagnosis. Anterior, ventral, dorsal and posterodorsal ribs all raised and narrow. Posterodorsal rib connects with dorsal rib and slants downward and forwards. The ventral rib begins in the anterolateral field and gently curves up to end in the posterolateral field. Strong reticulation covers the entire carapace. Strong sexual dimorphism.

Measurements. IJS16/14, LV 675 - 412 - 225

Description. Carapace medium sized, subquadrate; maximum height at eye tubercle in both valves, maximum width at posterior termination of ventrolateral rib. Straight dorsal margin slopes down towards posterior; anterior margin evenly rounded with approximately twelve very small peripheral spines; ventral margin slightly sinuous; posterior margin with a blunt caudal process below mid-height, the upper section is concave with one or two spines, the lower section is convex carrying three or four larger spines.

Anterior marginal rib is narrow, prominent eye tubercle sits behind the dorsal termination of the rib, behind the eye tubercle is a backwardly directed spine on the dorsal margin, and below is short vertical rib. Dorsal rib arises at around mid-length is narrow and carries two backwardly directed centrodorsal spines, and terminates posteriorly in a cluster of two or three spines; from the posterior end of the dorsal rib is a short descending rib forming an acute angle, pointing slightly forwards. Ventral rib is narrow raised and conspicuous with swellings where the muri of the reticulation meshes intersect. Median rib represented by a single tubercle on the centreline at two-thirds length. Muscle node is elevated but weak tending to be nothing more than an area of raised reticulation.

Ornament is strongly reticulate over the entire carapace, with high conjunctive spines at some intersections. On some specimens is very prominent spine directed back wards from the crest of the muscle node. The basal surface has a single sinuous longitudinal rib close to the valve contact which is a continuation of the anterior marginal rib. Between that rib and the ventrolateral rib is a strongly reticulate area.

Calcified inner lamella is moderate to narrow without vestibules. The hinge of the right valve has a high columnar anterior crenulate tooth, postjacent socket, posteromedian groove and a triangular crenulate posterior terminal tooth. The median elements of the left valve are smooth.

Males are much more elongate than females, with a more prominent dorsal rib without as much spination.

Range. First appearance 4m below New Pit Marl 1, *T. lata* Zone Middle Turonian, present throughout the remaining Turonian. Reported from the Middle Turonian to the Lower Coniacian of Bohemia (Pokorný 1979).

Genus PARVACYTHEREIS Gründel, 1973

Type species. By original designation; *Curfsina subparva* Pokorný, 1967a, p. 355, pl. 3, figs 6, 7, pl. 4, figs 2, 3; from the Upper Turonian of Bohemia.

Diagnosis. Small carapace, compressed and fairly strongly calcified. Anterior broadly rounded, dorsal and ventral margins converge towards the posterior which ends in a triangular caudal process. Ventral margin concave. Anterior marginal rib is composed of two ribs, the inner being the stronger, joined by small cross ribs. This is connected with the concave ventral rib. Hinge in the right valve with smooth anterior tooth and groove, with a smooth or weakly crenulate posterior tooth.

Parvacythereis subparva (Pokorný, 1967a) Pl. 21, figs 6, 8;
Pl. 22, fig. 1

*pars**v1967a *Curfsina subparva* sp. n.; Pokorný p. 355, pl. 3, figs 6, 7, pl. 4, fig. 2, *non* fig. 3.

1973 *Parvacythereis subparva* (Pokorný); Gründel, p. 1471, fig. 5 [redrawn from Pokorný, 1967a].

pars 1983 *Parvacythereis subparva* (Pokorný, 1967); Clarke, p. 100, pl. 6, fig. 4, *non* figs 2, 3.

v 1988 *Parvacythereis subparva* (Porkorný, 1967)[sic]; Jarvis *et al*., p. 34, fig. 19e.

v 1990 *Parvacythereis subparva* (Pokorný, 1967); Horne *et al*., p. 127, pl. 1, fig. 3.

Holotype. A ?male carapace no. O-190, deposited in the Department of Palaeontology, Charles University, Prague, fig. Pokorný, 1967a, pl. 4, fig. 2 and text figs 5C, D; from the Upper Turonian of Kostice, Bohemia.

Material. 105 valves and carapaces.

Diagnosis. Reticulate surface with several rounded pore papillae within each mesh; delicate median rib, separated from muscle scar node and from dorsal rib.

Measurements.	IJS17/1, LV	550 - 300 - 135
	IJS17/2, RV	525 - 275 - 100

Description. Carapace small, compressed, elongate, subquadrate. Maximum width at posterior termination of the ventrolateral rib, maximum height at eye tubercle in right valve and at weak hinge ear slightly anterior to the eye tubercle in the left valve. Left valve overlaps right at anterior cardinal angle. Dorsal margin converges with the ventral margin posteriorly. Anterior margin evenly rounded in both valves, with five peripheral spines, dorsal margin straight, ventral margin straight but can appear concave due to the curve of the ventral rib. Posterior margin has a caudal process below mid-height, with a concave upper section and a convex lower section bearing three marginal spines.

The narrow anterior marginal rib has a weak connection to the eye tubercle, from where it follows the anterior margin and flows into the ventral rib. Between the anterior marginal rib and the anterior margin is a series of spoke-like ribs. Ventral rib is convex anteriorly, just in front of mid-length it bends and becomes horizontal, it terminates in a swelling. Dorsal rib is continuous from just behind the eye tubercle to its posterior termination where it bends downwards in a thickened block-like process, this does not connect to the median rib. Posterior rib is weak and set back from the posterior margin. The muscle node is a weak swelling separate from the median rib. Median rib is distinct but narrow, slightly thicker in some specimens. The ornament consists of a reticulate pattern with papillae in the meshes. Basal surface has a thin rib running from the anterior to the posterior close to valve contact; a larger second rib absagittal to the first which is a continuation of the lateral edge of the anterior marginal rib, this terminates at the posterior border of the ventrolateral surface; the third rib arises in the anterior part of the ventrolateral surface and terminates absagittally of the second. Between the third rib and the main ventrolateral rib is an area of diffuse reticulation.

Calcified inner lamella moderate to broad at the anterior and posterior, narrow elsewhere, with a small vestibule at the anterior. Hinge of right valve has a conical weakly crenulate anterior tooth, shallow anteromedian socket, a posteromedian groove and a conical posterior tooth. Muscle scar details not seen.

Remarks. Two specimens from the Upper Santonian illustrated by Clarke (1983, pl. 6, figs 2, 3) lack the median rib and are similar to the form of Pokorný (1967a, pl. 4, fig. 3). Both authors have older specimens with a median rib and younger specimens without the rib; thus it would seem that the latter should separated into a new species, which is intermediate between the Turonian and Coniacian *P. subparva* and *P. parva* (Bonnema, 1941) as illustrated, from the Lower Maastrichtian, by Clarke (1983, pl. 6, figs 5, 6). The latter may be distinguished by having a single strong row of reticulation behind the anterior marginal rib, lacking the median rib and having less well developed surface reticulation.

Range. Together with *Cythereis longaeva, P. subparva* is one of the first cytheraceans to populate the Turonian Chalk Sea of southern England; present from the *Mytiloides* spp. Zone, Lower Turonian, up into the overlying stages of the Late Cretaceous. The range in Bohemia is similar, from the Lower Turonian, it has been found into the highest Coniacian (Pokorný 1967a). In northern Germany it has been recovered from the Upper Santonian (Clarke 1983).

Genus PLANILEBERIS Deroo, 1966

Type species. By original designation; *Cythere lepida* Bosquet, 1854, p. 99, pl. 6, figs 11a-d; from the Maastrichtian of Holland.

Diagnosis. Carapace strongly laterally compressed, muscle node weak or absent, surface reticulate or pitted, sometimes with small tubercles. Anterior marginal rib continuous with the ventral rib. Marginal pore canals numerous, straight and simple.

Planileberis cuneata (Kafka, 1886)   Pl. 22, figs 2, 4

* 1886 *Cythere cuneata* Kafka, p. 54, pl. 1, fig. 4.

? 1889 *Cythere cuneata* Kf.; Fric, p. 92, fig. 106.

1969a *Planileberis cuneata* (Kafka); Gründel, p.85, pl. 1, figs 20-22.

v 1979 *Planileberis cuneata* (Kafka); Pokorný, pl. 57, fig. 25.

Type specimens. No type designated. Kafka's material has recently been re-discovered in the National Museum of Prague.

Material. 50 specimens; 21LV (4 broken), 22RV (5 broken), 3 carapaces of adults, 2RV, 1LV, 1 carapace juveniles.

Diagnosis. Planileberis with very finely punctate surface except for a coarse patch of reticulation above the muscle node, small tubercles scattered on the lateral surface, three behind the muscle node marking the position of the median rib, the central being the highest.

Measurements.	IJS12/11, LV	625 - 362
	IJS16/13, RV	625 - 337 - 137

Description. Medium to small sized, compressed carapace with wedge shaped outline. Maximum width at the posterior border of the ventrolateral ribs. Dorsal margin slopes down from slight hinge ear in left valve to posterodorsal corner. There are two centrodorsal tubercles, an anterodorsal and a posterodorsal rib which interrupt the line of the dorsal margin. Ventral margin is fairly straight with small concavity in front of mid-length and a slight convexity behind this. The anterior margin is broadly rounded dorsally and more tightly rounded ventrally where it passes into the concave section of the ventral margin. The ventral part of the anterior margin possesses several spines on its periphery. Posterior margin is an acute caudal process below mid-height which carries five short marginal spines.

The anterior margin is strongly compressed to give a flange-like rim, behind which is a strong, thin raised anterior rib which follows the outline of the anterior margin. This rib does not connect with the eye tubercle, nor with the ventrolateral rib. Two tubercles are present in the gap between the anterior and ventrolateral ribs. A small secondary anterior rib sits in front of the main anterior rib and runs parallel to it down to just below mid-height. The dorsal rib is complex and composed of two distinct segments. The foremost of these sits above the dorsal margin and has a sharp crest, it is bent in its central part. A small gap then exists in front of mid-length, and the dorsal rib resumes behind this but is much more rounded and bearing tubercles. At its posterior end the dorsal rib bends downwards, becomes thicker, and dips steeply backwards to terminate at mid-height. The lateral edge of this rib is covered in small pits. Immediately behind the anterior rib is a shallow depression in the anterolateral field running parallel to the valve margin. On its posterior border are five tubercles in an arched row. The muscle node is large and smooth with only the smallest of pits only discernible on SEM photographs. The eye tubercle sits on the dorsal ridge and has an ocular ridge descending vertically from it which connects with a node. Above the muscle node is a large patch of very coarse reticulation. Behind the muscle node are four tubercles in an arched group; one below mid-height, the other three on a line where the median rib would be, the central tubercle is the strongest. The posterior marginal rib is low and rounded, and carries small tubercles. The ventral rib is short and slightly sinuous, it runs from below the muscle node sinusoidally downwards then horizontally and finally down to terminate in a posteroventral process.

Basal surface has an asymmetrical arrangement of ribs. Both valves have a very thin rib close to the valve margin, that in the right valve is more conspicuous. The right valve has two sinuous ribs which are joined centrally and again near the posterior border of the ventrolateral surface. The left valve has two stronger ribs; the adsagittal is a continuation of the anterior margin, the absagittal splits from it behind the anterior margin of the ventrolateral surface, then runs parallel in a wide arch until they coalesce to a single rib which continues into the posterior margin. Between the ribs are widely spaced cross ribs.

The surface ornament consists of a very fine network of reticulation meshes whose muri have slightly coalesced to give polygonal holes between rather than well defined meshes. Apart from the coarse patch above the muscle node, this pattern only changes towards the periphery of the lateral surface where the walls become thinner and stretched such that the meshes are more elongate.

Calcified inner lamella moderately broad anteroventrally and posteriorly, narrower anterodorsally and very narrow ventrally; without vestibules, and with a strong selvage. Amphidont hinge with anterior tooth of right valve high and finely denticulate, postjacent socket opens into thin median groove bounded by a straight bar above and a lesser edge below. Posterior tooth distinctly crenulate, higher posteriorly. Left valve with complementary elements.

Remarks. This bears a resemblance to the illustration of *Planileberis cuneata* (Kafka, 1886) by Pokorný (1979). That drawing has insufficient detail to be certain of the identification. The author has examined material from Pokorný's collection of this species and the only differences are that the Bohemian form is slightly larger. The author also has a sample containing this species from Kystra, Czech Republic, and the British specimens are slightly larger. Pokorný (1965) states that this species marks, together with *Cythereis perturbatrix,* the position of the Middle-Upper Turonian boundary in Bohemia. In Britain its occurrence predates that range.

Very similar to *Cythereis perturbatrix* Pokorný, 1965 in outline and pattern of tubercles, but is much more laterally compressed, has a much reduced muscle node, stronger reticulation and different pattern of ridges on the basal surface. Distinguished from *Parvacythereis imhotepi* (Gründel, 1970) by the absence of a median rib. *Planileberis camperi* (Veen, 1936) is much more heavily calcified and robust around the margins. *Planileberis subtilis* Babinot, 1980, has a fine network of reticulation meshes connecting many of the nodes and has no muscle node. *Cythereis divisa* Damotte, 1962 from the Lower Turonian of Touraine has a similar aspect but the median rib is reduced to a single elongated tubercle.

Range. From 3m above New Pit Marl 2, *T. lata* Zone, Middle Turonian to the hardground above the lower Bridgewick Marl, *S. plana* Zone, Upper Turonian. Reported from the Upper Turonian to the Lower Coniacian of Bohemia (Pokorný 1979) and the *plenus*-Zone of Saxony (Gründel 1969a).

Genus REHACYTHEREIS Gründel, 1973

Type species. By original designation; *Cythereis luermannae* Triebel, 1940, p. 201, pl. 6, fig 63-66; from the Albian of Hoheneggelsen bei Hildesheim, West Germany.

Diagnosis. Subtriangular shape, large hinge ear and dorsal and ventral margins converging posteriorly. Anterior marginal rib narrow, raised and set back from anterior margin. Caudal process acute. Dorsal and ventral ribs not subdivided, dorsal rib usually ends in large block-like process. Middle rib short and often separated from the muscle node.

Remarks. Damotte (1977) suggested that *Rehacythereis* should be retained as a subgenus of *Cythereis* for species with continuous longitudinal ribs. Examination of the type of the genus, *Cythereis luermannae* Triebel, shows a considerable difference in overall shape, degree of inflation and development of the muscle node, features which are sufficient to separate it as a distinct genus. Weaver (1982) illustrates several species which he assigns to the genus *Rehacythereis* which are consistent with the diagnosis: *R. luermannae luermannae* Triebel (1940), *R. luermannae bemerodensis* (Kemper, 1971), *R. paranuda* Weaver, 1982 and *R. barringtonensis* Weaver, 1982. However, *R. cantabrigensis* Weaver, 1982 falls outside the generic diagnosis in the development of the muscle node, inflation, and in the style of anterior marginal rib. Witte *et al.* (1992) raise *R. bemerodensis* to specific status and retain a consistent concept of *Rehacythereis*.

Rehacythereis stellatus sp. nov. Pl. 22, figs 3, 5;
Pl. 27, fig. 6

Name. Latin; *stella*, meaning star; refering to the rayed star shape of the reduced central rib.

1996 *Cythereis* sp. aff. *C. chlomkensis* Pokorný 1965; Slipper, p. 52, pl. 1, figs 7, 8.

Holotype. RV IJS7/14, from sample ABCMR5, 2.1m below Round Down Marl, Middle Turonian, *T. lata* Zone; from Abbots Cliff, Dover, Kent.

Material. 22 specimens; ABCMR2, 1LV, 1RV; ABCMR3, 1car; ABCMR5, 2LV, 1RV; AKSD19, 7LV, 1RV; AKSD23, 1LV, 3RV; AKSD25, 1RV; AKSD29, 1LV; AKSD33, 1LV, 1RV.

Diagnosis. Small species of Rehacy*thereis* with central rib reduced to single node, from which extends remnants of reticulation in the form of radial riblets such as to give the appearance of a rayed star. Lateral surfaces smooth with fine punctae. Ventral rib not connected to anterior marginal rib, but arising in the anterolateral field, above the top edge of the anterior marginal rib.

Measurements.	IJS7/13, F, LV,	557 - 329
	IJS7/14, F, RV,	571 - 308

Description. Small sized, subtriangular outline. Left valve overlaps right at the dorsal margin of the caudal process. Maximum width at the muscle node, maximum height at the hinge ear in front of the eye tubercle in the left valve, and at the weak hinge ear behind the eye tubercle in the right valve. Dorsal margin slopes strongly down towards the posterior. Anterior margin evenly rounded in the right valve, broadly rounded above mid-height and more tightly rounded below in the left valve. Approximately eight weak peripheral spines project beyond the anterior margin. Ventral margin straight with weak oral incurvature. Posterior margin has caudal process which is acute in the right valve and blunt in the left; upper section concave, lower section convex carrying approximately four small peripheral spines.

Anterior marginal rib narrow, connected dorsally to the hinge ear in the left valve by a thin flange, and ventrally to second rib on the basal surface. On its lateral edge, the anterior rib carries approximately six small tubercles. Dorsal rib is weakly tuberculate and terminates in short vertical process at its posterior end. Posterior rib low, following the posterior margin. The ventral rib arises below the anterior extension of the muscle node, it is not connected to the anterior rib, it is straight and becomes thicker towards the posterior. The muscle node is raised and smooth with a sloping anterior and a steep posterior face. The median rib is reduced to a single node which is surrounded by small ribs and tubercles giving the impression of a rayed star.

The lateral surface of the valves is smooth, or micropunctate. A pore conulus is sighted below and behind the muscle node. The basal surface has three longitudinal sinuous ribs with cross ribs in the proximal part and a tuberculate area in the distal part.

Calcified inner lamella of moderate width, without vestibules. Amphidont hinge imperfectly preserved. Muscle scars not seen.

Remarks. This is similar to *Cythereis chlomkensis* Pokorný, 1965a, but comparison with the type material from Pokorný's collection shows this to be distinct. In *C. chlomkensis* the anterior marginal rib runs continuously into the ventral rib, there are slight differences in the shape of the hinge ear and the top edge of the anterior marginal rib. *Rehacythereis stallatus* also resembles *Rehacythereis paranuda* Weaver, 1982, from the Albian and Cenomanian, which also has connected anterior and ventral ribs, but is devoid of intercostal ornament.

Range. Only recovered from Abbots Cliff and Akers Steps from the Melbourn Rock, *Mytiloides* spp. Zone, Lower Turonian, to the thin marl below Glynde Marl 1, *T. lata* Zone, Middle Turonian.

Rehacythereis venticursus venticursus sp. et ssp. nov. Pl. 22, figs 6, 7; Pl. 27, fig. 7

Name. Latin; *ventus*, meaning wind and *cursus*, meaning speed; after the dorsal rib shaped like a wind speed marker on meteorological charts.

Holotype. LV IJS16/12 from LGSD5, 1.1m above Southerham Marl 2, *T. lata* Zone, Upper Turonian; from Langdon Stairs, Dover, Kent.

Material. 9 specimens; DOE8A, 1RV; LGSD5, 3LV, 1RV; AKS3/10, 3LV; LGSD8, 1RV.

Diagnosis. *Rehacythereis* with short, thick, weakly curved median rib, separate from or only weakly connected to posterior vertical rib. Dorsal rib with two posterior descending vertical ribs. Punctate ornament sparse over lateral surface.

Measurements.	IJS22/2, RV	650 - 337 - 162
	IJS16/12, LV	712 - 412 - 168

Description. Carapace small, moderately well inflated, subtriangular in outline, left valve overlaps right at anterior and posterior cardinal angles. Maximum width at the muscle node, maximum height at hinge ear in left valve and at eye tubercle in the right. Dorsal margin slopes down towards the posterior, its posterior end is obscured by the dorsal rib. Anterior margin evenly rounded in the right valve, broadly rounded above and narrowly rounded below in the left valve. Four small peripheral spines project from the lower half of the anterior margin. Ventral margin straight in left valve, with a slight oral incurvature in the right obscured by the ventral rib. Caudal process at the posterior margin is acute in the right valve, more blunt in the left, the upper section is concave and the lower is convex with four peripheral spines.

Anterior marginal rib well developed with approximately seven lateral tubercles. A thin dorsal extension connects to the eye tubercle, passes through it and merges into the dorsal margin. The ventral end of the anterior marginal rib is connected to the ventrolateral rib, which is straight or weakly sinuous, and becomes thicker towards the posterior; it has weak pits on its dorsal surface. Posterior marginal rib is weakly tuberculate. The dorsal rib arises below and behind the eye tubercle, it is tuberculate at around mid-length where it rises to meet the dorsal margin, then it becomes thicker towards the posterior where two vertical descending ribs depart. The front rib is about half the length of the rear rib which is also the termination of the dorsal rib. Most specimens have a distinct gap between the ventral end of the rear descending rib and the posterior end of the median rib, but two show a weak connection. The median rib is elongate. The well rounded muscle node is separate from the median rib, it has a steep posterior face and a smooth sloping anterior face.

The lateral surface is smooth apart from scattered punctae. The basal surface has a pattern of longitudinal ribs. The left valve has a narrow rib which continues from the adsagittal side of the row of peripheral spines at the anterior margin, it runs longitudinally and curves outwards, near the posterior margin of the ventrolateral surface it curves in towards the valve contact. The second more prominent rib arises from the absagittal side of the same row of spines, this follows the first but curves in and terminates against it at mid-length. The third rib arises absagittally of the second in the anterior section of the ventrolateral surface, following and curving round to terminate against the first rib at three quarters length. Outside of the third rib is a tuberculate area. Cross-ribs are present between the longitudinal ribs.

Calcified inner lamella is moderate to broad, without vestibules. 12-15 anterior marginal pore canals, 7-9 posterior marginal pore canals. The amphidont hinge of the right valve consists of crenulate terminal teeth, and smooth median elements. Muscle scars not seen.

Remarks. Similar to *Cythereis paraglabrella* but is smaller and more tapered towards the posterior, reticulate ornament is lacking above muscle node, and the median rib is separate from, or in some specimens only weakly connected to the posterior vertical rib. The Cenomanian species of *Rehacythereis* (*R. barringtonensis, R. luermannae, R. bemerodensis* and *R. paranuda*) are more triangular in outline with more acute caudal processes, and none have the second vertical posterior rib descending from the dorsal rib.

Range. Restricted to the lower part of the Upper Turonian, *T. lata* Zone. First appearance is 2.5 m below Southerham Marl 1 at Langdon Stairs, it continues up as far as 2.5m below Caburn Marl.

Similar forms have been found in the Lower Turonian (see remarks for *R. venticursus patbrowni*).

Rehacythereis venticursus patbrowni ssp. nov. Pl. 22, figs 8, 9

Name. After Patrick Brown, who undertook the printing of the stereo-pairs for this work.

Holotype. RV IJS16/11 from AKSD48, 4.8m above Lydden Spout Flint, *T. lata* Zone, Middle Turonian; from Akers Steps, Dover, Kent.

Material. 4 specimens; AKSD48, 1RV; AKSD53, 1RV; AKSD54, 1car, 1RV.

Diagnosis. Rehacythereis venticursus with sparse punctate ornament over lateral surface except above muscle node where a small patch of larger pits cluster in a group; median rib thin and straight.

Measurements.	IJS16/11, RV	737 - 362 - 150
	IJS22/4, LV	725 - 400 - 312

Description. Shape as for the nominate subspecies, but with a thinner more elongate, straight median rib.

In the field between the muscle node, the eye tubercle and the posterior end of the median rib is a patch of pits.

Remarks. Similar to *Cythereis paraglabrella* but smaller, more tapered towards the posterior, and having pitting above the muscle node rather than papillate reticulation; in addition the generic feature of continuous lateral ribs separates this from similar smooth *Cythereis* species.

Range. First appears in the upper part of the Middle Turonian, *T. lata* Zone, and occurs rarely in the short section 5m below the Southerham Marls, Upper Turonian *T. lata* Zone. It is replaced at the level of the flints below Southerham Marl by the nominate subspecies.

Two right valves were found in the Lower Turonian ABCMR3, *Mytiloides* spp. Zone, which have the patch of pits above the muscle node, and also possess a second area of coarse punctation below and behind the muscle node. These two valves may represent a third subspecies which is ancestral to *R. venticursus patbrowni*.

Genus SPINOLEBERIS Deroo, 1966

Type species. By original designation; *Cythere eximia* Bosquet, 1854, p.96, pl. 7, figs 6a-d; from the Maastrichtian of Holland.

Diagnosis. Carapace small; two large tubercles are present at the posterodorsal and posteroventral corners; muscle node is large and prominent; ocular rib often connecting with the anterodorsal portion of the muscle node.

Spinoleberis krejcii Pokorný, 1969 Pl. 23, figs 1, 3

* v 1969 *Spinoleberis krejcii* Pokorný; p.376, pl. 1, figs 1-4.
1970a *Spinoleberis* sp.; Gründel, p. 59, pl. 2, figs 14-16.
1983 *Spinoleberis krejcii krejcii* Pokorný, 1968; Clarke, p. 107, pl. 7, figs 4, 5.
. 1983 *Spinoleberis krejcii tenuireticulata* n. ssp.; Clarke, p. 108, pl. 7, figs 6-10.
v 1990 *Spinoleberis krejcii* Pokorný, 1968; Horne *et al*., p. 127, pl. 1, fig. 10.

Holotype. A female carapace, slide no 0-182, deposited in the Department of Palaeontology, Charles University, Prague; from the Coniacian beds Xe of Luzice, Czech Republic.

Material. 12 specimens; LGSD15, 1LV; LGSD18, 1LV, 1RV; LGSD19, 3LV, 1RV; LGSD21, 1LV; LGSD23, 2LV, 1RV; LGSD28, 1LV.

Diagnosis. Lateral surface reticulate; reticulation meshes with second order reticulation or pitting; median rib irregular and variable, posterior end of median rib bent upwards to connect with the vertical extension of the dorsal ridge. Posterior corner of the ventrolateral ridge not extending below the ventral margin.

Measurements.	IJS16/9, M, LV	612 - 331 - 162
	IJS16/10, M, RV	612 - 312 - 169

Description. Carapace small, left valve larger than right, maximum height at process behind eye tubercle in both valves, maximum width at the posterior extension of the ventrolateral rib. Dorsal margin slopes down towards the posterior, obscured by tubercles on top of dorsal rib. Anterior margin evenly rounded in both valves. Ventral margin straight. Caudal process at posterior margin below mid-height, acute in right valve, blunt in left; concave upper section with one peripheral spine at the posterior extremity, and convex lower section with four peripheral spines in two groups of two.

Anterior marginal rib well developed, square topped with approximately eight tubercles on its lateral surface. Large eye tubercle has two hinge ears on either side in left valve, and a postjacent tubercle in the right. Dorsal rib raised and narrow with two centrodorsal tubercles projecting above the dorsal margin, it terminates in a large process which descends to two-thirds height, the dorsal corner of this process also projects above the dorsal margin. Posterior margin is low and rounded, it follows the posterior margin. Ventral rib has a weak connection to the ventral edge of the anterior marginal rib from where it rises slightly towards the posterior, terminating in a large tuberculate process. A compound rib connects the ventral side of the eye tubercle with the anterodorsal side of the muscle node. From the anteroventral side of the muscle node, a thick rib descends towards the anteroventral corner but fades into anterolateral surface before reaching the margin. The muscle node is high and rounded with steep posterior face, separate from the median rib. The median rib is above mid-height spaced from the muscle node by on reticulation mesh, from there it rises slightly then bends down. At the point of flexure a dorsal offshoot rises towards the hindmost of the two centrodorsal tubercles on the dorsal margin. The median rib again bends upwards and connects with the descending process at the posterior end of the dorsal rib. At the second point of flexure a ventral offshoot connects with the reticulation pattern in the ventral intercostal field.

The ornament on the lateral surface of the valves is varied. In the anterolateral field are small pits separated by low radial muri. Above and below the muscle node and in the dorsal and ventral intercostal fields is a coarse reticulation with secondary reticulation in the meshes. the posterolateral field is smooth. The basal surface has a pattern of longitudinal ribs, the first of which is a continuation of the lateral edge of the anterior marginal rib, this curves in towards the valve margin just behind mid-length. The second rib departs from the first in the anterior area of the ventrolateral surface, it runs parallel to the first and terminates where the first starts to deviate. Cross-ribs are present between the main ribs. Reticulation is present on the ventrolateral surface.

Calcified inner lamella of moderate width without vestibules. Hinge of right valve has a high anterior tooth with a constriction beneath its crest, smooth postjacent rounded socket, a smooth posteromedian groove and a large triangular posterior tooth. Muscle scars not seen.

Remarks. The specimens described by Clarke (1983) as *S. krejcii tenuireticulata* were separated from the nominate subspecies on the basis of weaker reticulation. The author considers this not to be sufficient to warrant subspecific separation. In the original description of *S. krejcii,* Pokorný (1969) states that there is 2nd order reticulation, though this is not apparent from the illustrations. Clarke's specimens fall within the variation allowed in the type material.

Range. From the flint below the Bridgewick Marls, boundary between *T. lata* and *S. plana* Zones, Upper Turonian, to *M. testudinarius* Zone, Santonian. Reported from the Middle Turonian to the Coniacian of Bohemia (Pokorný 1969), the Middle to Upper Turonian of Saxony (Gründel 1970a) and the Coniacian to Campanian of northern Germany (Clarke 1983).

Genus TRACHYLEBERIDEA Bowen, 1953

(Synonym *Spinicythereis* Pokorný, 1964a)

Type species. By original designation; *Cythereis prestwichiana* Jones & Sherborn, 1887, p. 454, pl. 11, fig. 11; from the London Clay of Alum Bay, Isle of Wight.

Diagnosis. Carapace subquadrate, tapering strongly from anterior to posterior. Dorsal margin straight, ventral margin with oral concavity. Larger left valve overlaps right at anterodorsal angle. Broadly rounded anterior with marginal rib and ventral denticles. Posterior margin compressed and triangular with ventral denticles. Reticulate ornament sometimes with small spines projecting into reticulation meshes.

Remarks. Haskins (1963) amended the generic diagnosis to clarify the position of the type species, which had been confused with *Trachyleberidea aranea* (Jones & Sherborn, 1887).

Pokorný (1964a) erected the genus *Spinicythereis* with *Cythere geinitzi* Reuss, 1874 as the type species. This has subsequently been placed in the genus *Trachyleberidea* (Kaye in: Szczechura, 1965, p. 538); Neale, 1978; Horne *et al.*, 1990) and so *Spinicythereis* is considered as a junior synonym of *Trachyleberidea*. There are differences, however, between the diagnoses of the two genera. That of Haskins (1963, p. 71) states "three longitudinal ridges are present", while Pokorný (1964a, p. 283) states "Median ridge absent".

The median rib in *T. geinitzi* is reduced to a node. This single feature, however, is not sufficient to serve as a generic diagnostic. The diagnosis should therefore be further emended to median ridge may be present.

Trachyleberidea geinitzi (Reuss, 1874) Pl. 23, figs 2, 4

* 1874 *Cythere Geinitzi* Reuss, p. 146, pl. 2, figs 4a, b.

1880 *Cythere acutiloba* Marsson, p. 42, pl. 3, figs 11a, b.

1889 *Cythere Geinitzi* Reuss; Fric, p. 92, fig. 103 [cop. Reuss, 1974].

1890 *Cythereis spinicaudata* Jones & Hinde, p. 28, pl. 2, figs 17, 18.

1940 *Cythereis acutiloba* (Marsson); Bonnema, p. 132, pl. 4, figs 59-66.

1964a *Spinicythereis geinitzi* (Reuss); Pokorný, p. 238, pl. 1, fig. 1.

1964a *Trachyleberidea acutiloba* (Marsson); Kaye, p. 70, pl. 8, figs 7, 8, 10.

1964 *Planileberis ? fastigata* Damotte, p. 106, pl. 1, figs 8a-e.

1965 *Trachyleberidea acutiloba* (Marsson); Szczechura, p. 536, pl. 3, figs 4, 5, pl. 17, figs 1-3.

1965a *Planileberis ? acutiloba* (Marsson); Damotte pl. 6, figs 33, 34.

1966 *Trachyleberidea acutiloba* (Marsson); Herrig, p. 824, pl. 17, figs 3-6.

1966 *Planileberis ? acutiloba* (Marsson); Deroo, p. 163, pl. 25, figs 798-800.

1970a *Trachyleberidea geinitzi* (Reuss); Gründel, p. 60, pl. 2, figs 12, 13.

1970 *Trachyleberidea acutiloba* (Marsson); Donze, p. 91, pl. 13, figs 15-17.

? 1971 *Trachyleberidea acutiloba acutiloba* (Marsson); Damotte, p. 96, pl. 6, figs 6a, b.

1971 *Trachyleberidea acutiloba fastigata* (Damotte); Damotte, p. 96, pl. 6, figs 7a, b.

1978 *Trachyleberidea geinitzi*(Reuss, 1874); Neale, p. 362, pl. 15, figs 5-9.

1983 *Trachyleberidea acutiloba* (Marsson, 1880); Clarke, p. 105, pl. 7, figs 1-3.

1985 *Trachyleberidea geinitzi* (Reuss); Babinot, Colin & Damotte, p. 240, pl. 63, figs 3-5.

? 1986 *Trachyleberidea acutiloba acutiloba* (Marsson); Damotte, p.36, pl. 3. fig. 17.

1986 *Trachyleberidea acutiloba fastigata* (Damotte); Damotte, p. 38, pl. 3, figs 18, 19.

1990 *Trachyleberidea geinitzi* (Reuss); Horne *et al.*, p. 127, pl. 1, fig. 11.

1990a *Trachyleberidea acutiloba* (Marsson); Nuyts, pl. 1, fig. 14.

Type specimens. No types designated; Reuss' material was from Strehlen, Saxony.

Material. 31 specimens; LGSD10, 1RV; LGSD12, 1RV; LGSD13, 1car.; LGSD15, 1RV; LGSD19, 1LV; LGSD21, 2LV, 2RV, 1 car.; LGSD23, 1car., 1LV, 2RV, 2juv.RV; LGSD24, 1car., 4LV; LGSD25, 3LV, 1RV; LGSD26, 1LV, 4RV; LGSD28, 2LV (1 broken).

Diagnosis. Elongate laterally compressed carapace with broadly rounded anterior, dorsal margin sloping down to posterodorsal corner, acute triangular caudal process with posterior extremity below mid-height. Anterior marginal rib well developed, continuous with ventral rib which has a concave section behind mid-length. Dorsal rib weak in the centre and more strongly developed at its posterior end where it bends down and backwards. Muscle node weakly developed. Median rib absent. Surface covered with trefoil reticulation.

Measurements.	IJS16/7, LV	662 - 350
	IJS16/8, RV	675 - 344 - 112

Description. Carapace elongate, subtriangular and strongly laterally compressed. Valves of equal size, the left overlapping right only at the anterior cardinal angle. Maximum height at the weak eye tubercle in both valves, maximum width at the posterior extremity of the ventral ribs. Dorsal margin slopes down strongly towards the posterior, partly obscured by the dorsal rib. Anterior margin evenly rounded in both valves, small peripheral spines occasionally preserved in the ventral half. Ventral margin convex in front of oral incurvature, straight behind, obscured at the posterior end by the ventral rib. Caudal process at the posterior margin acute in both valves, below mid-height, occasionally marginal spines are preserved on the lower border.

Anterior marginal rib high and narrow, passes beneath the eye tubercle and is continuous with the ventral rib. Dorsal rib occasionally composed of two parallel ribs, terminates in an enlarged process at the posterior end. Posterior marginal rib is low and tuberculate. Straight to concave ventral rib is weakly developed with a weak connection to the anterior marginal rib. Muscle node is often a slight elongate raised area in the reticulation at mid-height in front of mid-length, in some specimens it is manifest as a low rounded node. Juvenile valves tend to have a well developed muscle node. Median rib absent or reduced to a small node at mid-height in the posterior part of the intercostal field.

Surface ornament is a strong reticulation on both lateral and basal surfaces, often with small spines projecting into the meshes giving a spongeous sculpture.

Calcified inner lamella narrow without vestibules. Hinge amphidont, right valve with high crenulate anterior tooth, other hinge elements imperfectly preserved. Muscle scars not seen.

Remarks. The confusion with *T. acutiloba* arises mostly from the muscle node being variable in strength, often indistinct, sometimes raised and rounded. Gründel (1970a) distinguishes *T. geinitzi* from *T. acutiloba* by its smaller size, longer dorsal rib, development of cross ribs between both parts of the anterior marginal rib and not so strong distension in the posterior area of the dorsal rib. Damotte (1971) distinguishes *T. acutiloba fastigata* from *T. a. acutiloba* by a more massive anterior marginal rib without indentations, and in dorsal view the muscle node is less clear. The author believes these features are within allowable variation for this which is widely distributed and has a long range.

Trachyleberidea corrosa (Veen, 1936a), from the Maastrichtian, can be distinguished by its large hinge ear. *Trachyleberidea arta* (Damotte, 1971a), from the Cenomanian of the Dordogne, has stronger ribbing around the anterior and ventral margins and a weak elongate median rib. *Trachyleberidea vezerae* Colin, 1973, from the Upper Turonian of the Dordogne, has a short rib descending from the eye tubercle.

Range. From the flint immediately beneath Caburn Marl, St. Margaret's Member, *T. lata* Zone, Upper Turonian, present throught the overlying Turonian of the sections studied. Widely distributed across northern Europe from the Turonian to the Maastrichtian.

Family XESTOLEBERIDIDAE Sars, 1928

Genus XESTOLEBERIS Sars, 1866

Type species. By subsequent designation Brady & Norman, 1889; *Cythere nitida* Liljeborg, 1853, p. 169, pl. 19, figs 6, 7; from the Recent of Norway.

Diagnosis. Size small to medium, carapace inflated ovoid with strongly arched dorsal margin, straight or sinuous ventral margin, sometimes overhung by swollen posteroventral area. Posterior margin evenly rounded, anterior margin more acute. Greatest width behind mid-length. Valve surfaces smooth. Hinge merodont, right valve with crenulate teeth separated by curved groove. Anterior vestibule broad, whereas it may be small or absent posteriorly.

Remarks. Athersuch *et al*. (1989) have *Cythere nitida* Liljeborg, 1853 by subsequent designation of Brady & Norman (1889) as the type species of the genus, while other authorities (Howe, *In* Moore 1961; Morkhoven 1963; Deroo 1966; Weaver 1982) have *Cythere aurantia* Baird, 1838 designated by Brady and Norman (1889) as the type species. Although *Cythere nitida* was the original species used by Sars for *Xestoleberis*, Brady & Norman included it as a junior synonym of *Cythere aurantia* which has since been taken as the type of the genus. Whittaker (1978, 1978a) demonstrates that these two species are separable and that *Cythere nitida* must be taken as the type species of *Xestoleberis*.

Uroleberis Triebel, 1958 differs by having a caudal process, a smooth median hinge element, and an accommodation groove above in the left valve.

Xestoleberis bidentata Bonnema, 1941 Pl. 23, fig. 5

* v 1941 *Xestoleberis bidentata* Bonnema, p. 43, pl. 7, figs 31-38.

pars 1966 *Uroleberis marssoni* (Bonnema); Deroo, p. 170, pl. 27, fig. 857, 858 (right), *non* pl. 27, figs. 856, 858 (left) [= *X. marssoni* Bonnema].

pars v1990 *Xestoleberis* sp. A; Horne *et al.*, p. 127, pl. 2, fig. 7. *non* fig. 8 [= *X. ovata* Bonnema].

Syntypes. The figured specimens (Bonnema pl. 7, figs 31-38) are ON SLIDE O.2356; from NNIII Schuinesloot, The Netherlands. Further specimens are on slides O.2235-O.2237; from NNIV de Krim, O.2419; from NNII Kaskenbosch, and slide O.2381; from Zuid barge. All specimens are deposited in the The Geological Survey of The Nethlands.

Material. 92 specimens; 46RV (9 juv.), 43LV (5 juv.), 3 car.

Diagnosis. Large *Xestoleberis* with a thin keel at the join of the lateral and ventral surfaces, developed at its posterior extremity into a small spine. Small anterior and posterior flange at the valve extremities.

Measurements. IJS16/6, RV 475 - 300 - 181

Description. Carapace well inflated ovoid to subtriangular shape. Sexual dimorphism strong, the centrodorsal margin slopes down towards the posterior more steeply in the males than the females. the females show a greater inflation in the posterior half of the carapace. Left valve larger than right overlapping from the anterior extremity all along the dorsal margin and round to the posteroventral corner. Maximum height just in front of mid-length, maximum width just behind mid-length. Anterior margin narrowly rounded, dorsal margin high and vaulted with short centrodorsal section in males, longer in females, steeply dipping posterodorsal margin. Posterior extremity below mid-height. Ventral margin completely obscured by the ventral tumidity, viewed internally it has an oral concavity in front of mid-length, weakly convex at the anterior and posterior.

A weak flange is developed at the extremities. A thin keel-like ridge separates the lateral and ventral surfaces, this becomes stronger towards the posterior where it terminates in a small backwardly directed spine. No other ornament is present on the valves.

Calcified inner lamella of moderate width with anterior vestibule. Merodont hinge with elongate crenulate terminal teeth in the right valve.

Remarks. Horne *et al.* (1990) stated that only the female possesses the small spine at the posterior. It can now be shown that both male and female have the posterior spine, the male being recognised by a truncated posterodorsal margin; the male of *X.* sp. A *sensu* Horne *et al.* (1990) is recognised as *X. ovata* Bonnema. The British specimens are very slightly larger than the type material from NNIV de Krim. *Xestoleberis planus* Weaver, 1982 is very similar but lacks the small posteroventral spines.

Range. First appearance at the thin marl beneath Glynde Marl 1, Middle Turonian, *T. lata* Zone, common throughout the remaining Turonian. Found by the author in the Coniacian and Santonian chalks of Kent. Reported from the Late Cretaceous of The Netherlands (Bonnema 1941), and the Upper Campanian of Belgium (Deroo 1966).

Xestoleberis marssoni Bonnema, 1941 Pl. 23, fig. 7

* v 1941 *Xestoleberis marssoni* Bonnema, p. 43, pl. 7, figs 46-50.

pars 1966 *Uroleberis marssoni* (Bonnema); Deroo, p. 170, pl. 27, figs. 856, 858 (left) *non* pl. 27, fig. 857, 858 (right) [= *X. bidentata* Bonnema].

Syntypes. Specimens in tray 87, in the Geological Survey of the Netherlands, relate to the original illustrations (Bonnema 1941, pl. 7, figs 46-50).

Material. 19 specimens; LGSD24, 1LV; LGSD26, 1LV; LGSD28, 6LV, 10RV, 1car.

Diagnosis. Ovate *Xestoleberis* with strong tumidity in the posterior two-thirds, less so towards the anterior, the junction between the two areas forming a concavity. Anterior narrowly rounded, posterior broadly rounded. Strong overlap of right valve by left at the dorsal margin just behind mid-length.

Measurements.	IJS16/1, LV	487 - 325
	IJS16/3, RV	475 - 325

Description. Carapace ovoid, moderately well inflated, maximum height at or slightly behind mid-length. Elliptical in dorsal view, maximum width behind mid-length. Left valve larger than right overlapping along the entire dorsal margin, and more strongly just behind mid-length. Dorsal margin strongly arched, anterodorsal margin slopes down to about mid-height and merges with anterior margin which is narrowly rounded with a small flange; anterior extremity below mid-height. Centrodorsal margin slopes at a small angle down towards the posterior to about three quarters length where it turns down into the posterior margin. Ventral margin obscured by lateral tumidity in posterior two-thirds, less so anteriorly, a small concavity is formed at the junction of the two sections.

Surface of valves totally smooth. Calcified inner lamella narrow, with small anterior vestibule. Hinge of right valve with elongate crenulate curved terminal teeth and median groove. Left valve with curved median bar and terminal sockets. Muscle scars not seen.

Remarks. Deroo (1966) placed this species in *Uroleberis* Triebel, 1958, on account of similarities in the hinge to that genus, but *X.*

marssoni does not have the caudal process, nor the accommodation groove in the left valve which are characteristic of *Uroleberis*. Deroo states that this species possesses a small spine at the posteroventral margin, in the author's opinion, this form belongs to *X. bidentata* Bonnema. *Xestoleberis marssoni* is similar to *Xestoleberis pergensi* van Veen, 1936, but is distinguished by the more angular dorsal margin.

Range. First appearance at the top of the Kingston Nodular Chalks, *S. plana* Zone, Upper Turonian, present throughout the overlying Turonian. Also found by the author in the Coniacian from Langdon Stairs. Reported from the Late Cretaceous of The Netherlands (Bonnema 1941) and from the Upper Campanian of Belgium (Deroo 1966).

Xestoleberis ovata Bonnema, 1941 Pl. 23, figs 6, 8

* v 1941 *Xestoleberis ovata* Bonnema, p.43, pl. 7, figs 39-45.

non 1974 *Xestoleberis ovata* Bonnema 1941; Gründel, p. 111, pl. 2, figs 9-11.

pars v1990 *Xestoleberis* sp. A; Horne *et al.*, p. 127, pl. 2, fig. 8. *non* fig. 7 [= *X. bidentata* Bonnema].

Syntypes. 2 specimens on slide O.2357 from NNIII de Krim and 4 specimens on slide O.3358; from NNIV de Krim correspond to the original illustrations (Bonnema 1941, pl. 7, figs 39-45). Further material on slides O.2094 (males) and O.2095 (females); from NNIII Schuinesloot, slides O.2238 (males), O.2239 (females) and O.2240 (juveniles); from NNIV de Krim. All specimens are deposited in the Geological Survey of The Netherlands, Haarlem.

Material. 53 specimens; 25LV, 25 RV , 3 car.

Diagnosis. Medium sized *Xestoleberis* with smooth elongate outline. Weak ridge at border of lateral and ventral surfaces. Left valve distinctly larger than right, which has an acute posteroventral angle.

Measurements.	IJS16/4, LV	450 - 275 - 131
	IJS16/5, RV	425 - 262 - 137

Description. Carapace elongate ovoid, maximum height at mid-length in the left valve, just behind mid-length in the right. Left valve larger than right overlapping along the anterior, dorsal and posterior margins. Centrodorsal margin slopes down weakly towards the posterior and turns into the posterior margin at the posterodorsal angle. Posteroventral angle acute in the right valve, rounded in the left. Ventral tumidity convex in the posterior three quarters, with a small concavity behind the anterior one quarter. Anterior margin narrowly rounded with a small peripheral flange.

Surface of valves smooth. A weak ridge runs along the border between the lateral and ventral surfaces. Calcified inner lamella narrow with anterior vestibule. Hinge of right valve has elongate weakly crenulate terminal teeth. Left valve has a weak median bar with a narrow groove above. Muscle scars not seen.

Remarks. The male of *X.* sp. A *sensu* Horne *et al.* (1990) belongs to this species (*q.v.* their pl. 2, fig. 8, and Bonnema 1941, pl. 7, fig. 43). The lateral outline of the form illustrated by Gründel (1974) differs considerably from *X. ovata* by being less elongate, more rounded at the posteroventral margin, lacking the anterodorsal angle, having the position of maximum height at mid-length in the right valve and by having a greater degree of inflation at mid-length.

Range. First appearance 1m above Southerham Marl 2, *T. lata* Zone, Upper Turonian, common through the remaining Turonian and present in the Coniacian. Reported from the Late Cretaceous of The Netherlands (Bonnema 1941).

5 BIOSTRATIGRAPHY

Introduction

The character of the ostracod fauna from southern England is distinctly different in the Turonian when compared with the underlying Cenomanian. Although the diversity is similar between the two stages, 117 species in 48 genera for the Cenomanian (Weaver 1982) and 103 species in 41 genera for the Turonian, at the specific level the elements in common are few. There is a closer correspondence between the two stages at the generic level than at the specific. Of the 57 Cenomanian and Turonian genera, 32% (18) are restricted to the Cenomanian and do not appear in the Turonian, while 16% (9) are new appearances in the Turonian. The remainding 53% (30) are common to both stages. Those not found in the British Turonian fall into two groups; Cenomanian genera which have younger representatives: *Clithrocytheridea, Hemicytherura, Hemiparacytheridea, Phthanoloxoconcha, Platella, Saida, Trachyleberis* and *Veenia,* and those which become extinct during the Cenomanian: *Chapmanicytherura, Cornicythereis, Dolocytheridea, Habrocythere, Mandocythere, Matronella, Protocythere, Paranotacythere, Platycythereis* and *Pseudobythocythere*. The nine new genera first appearing during the Turonian are *Asciocythere, Golcocythere, Karsteneis, Krithe, Mauritsina, Neonesidea, Parvacythereis, Spinoleberis* and *Trachyleberidea*. The faunas from the Turonian and Cenomanian from southern England are quite disparate at the species level, with only 6% (13) as elements in common of a total of 204 species group taxa in the two stages. 51% (103) are restricted to the Cenomanian and earlier, while 43% (88) are restricted to the Turonian and later.

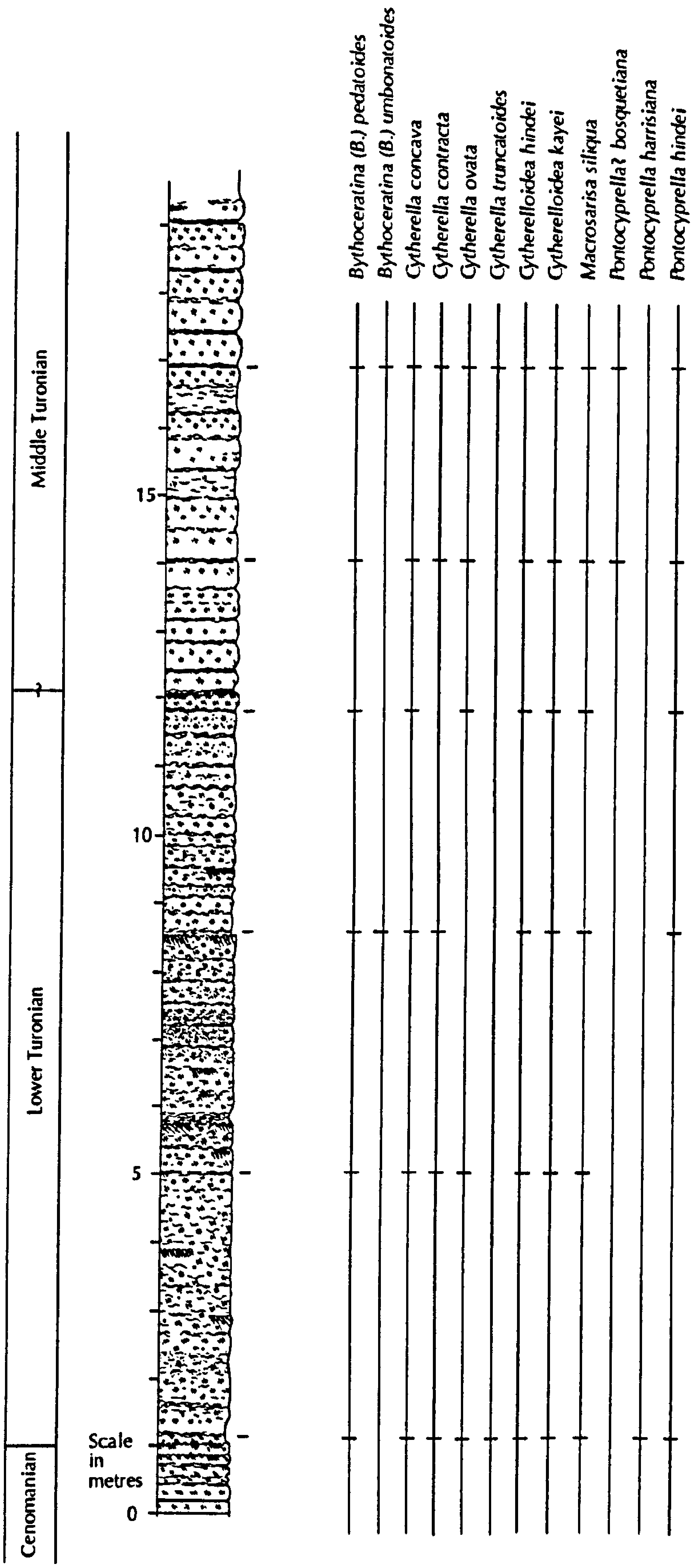
This represents a very large faunal turnover at the Cenomanian-Turonian boundary. The processes which lead to the boundary event have been the cause of much discussion (Schlanger & Jenkyns 1976; Jarvis *et al.* 1988; Jeans *et al.* 1991; Gale *et al.* 1993; Jenkyns *et al.* 1994). In the latest Cenomanian a large positive $\delta^{13}C$ spike can be recognised world-wide, and is thought to represent a major oceanographic change which involved rising sea levels and lowering of dissolved oxygen content of the water. While a discussion of the so-called Oceanic Anoxic Event 2 (OAE2) is beyond the scope of this work, a comment can be made regarding the interpretation of the relationship between the OAE2 and the distribution of the Platycopida. Whatley (1990) suggested that the platycopid ostracods were able to survive in conditions of poorly oxygenated water by virtue of their being filter feeders, and thus better able to circulate more water over their respiratory organs than other groups of Ostracoda. This then produced a record of increasing relative abundance of platycopids in the stratigraphical column which was termed the platycopid spike (Whatley, 1991). Earlier, it had been noted that platycopids formed the major part of the assemblages over the boundary interval, this being attributed to their having brood care (Jarvis *et al.* 1988). Four of the major higher taxonomic groups are represented in the twelve species which survived the boundary event; Platycopida: *C. ovata, C. concava, C. contracta, C. truncatoides, C. hindei* and *C. kayei;* Cypridacea: *M. siliqua;* Bairdiacea: *P. harrisiana* and ?*P. bosquetiana;* Cytheracea: *B. (B.) umbonatoides, B. (C.) pedatoides* and *P. tricuspidata*. While platycopids do dominate numerically, it is interesting to note that the cytheracean survivors all belong to the family Bythocytheridae, and that the trachyleberidid component underwent a complete species overhaul. These facts indicate a deeper water setting for the Cenomanian-Turonian boundary interval. Shallow water species would then have tracked their habitat to the basin margins, become isolated, speciated, and moved back to the area as sea-level lowered after the transgressive maximum in the Lower Turonian. The data here support this notion which was first suggested by Horne *et al.* (1990). This accounts for the very different nature of the two assemblages.

The distribution of Ostracoda with either first appearances or extinctions in the Turonian is given for each section; Abbots Cliff, Text-fig. 5.2; Akers Steps. Text-fig. 5.4; Langdon Stairs, Text-fig. 5.6. Long ranging species found in each section are given in Text-fig 5.1 for Abbots Cliff, Text-fig. 5.3 for Akers Steps and Text-figs 5.5 and 5.6 for Langdon Stairs.

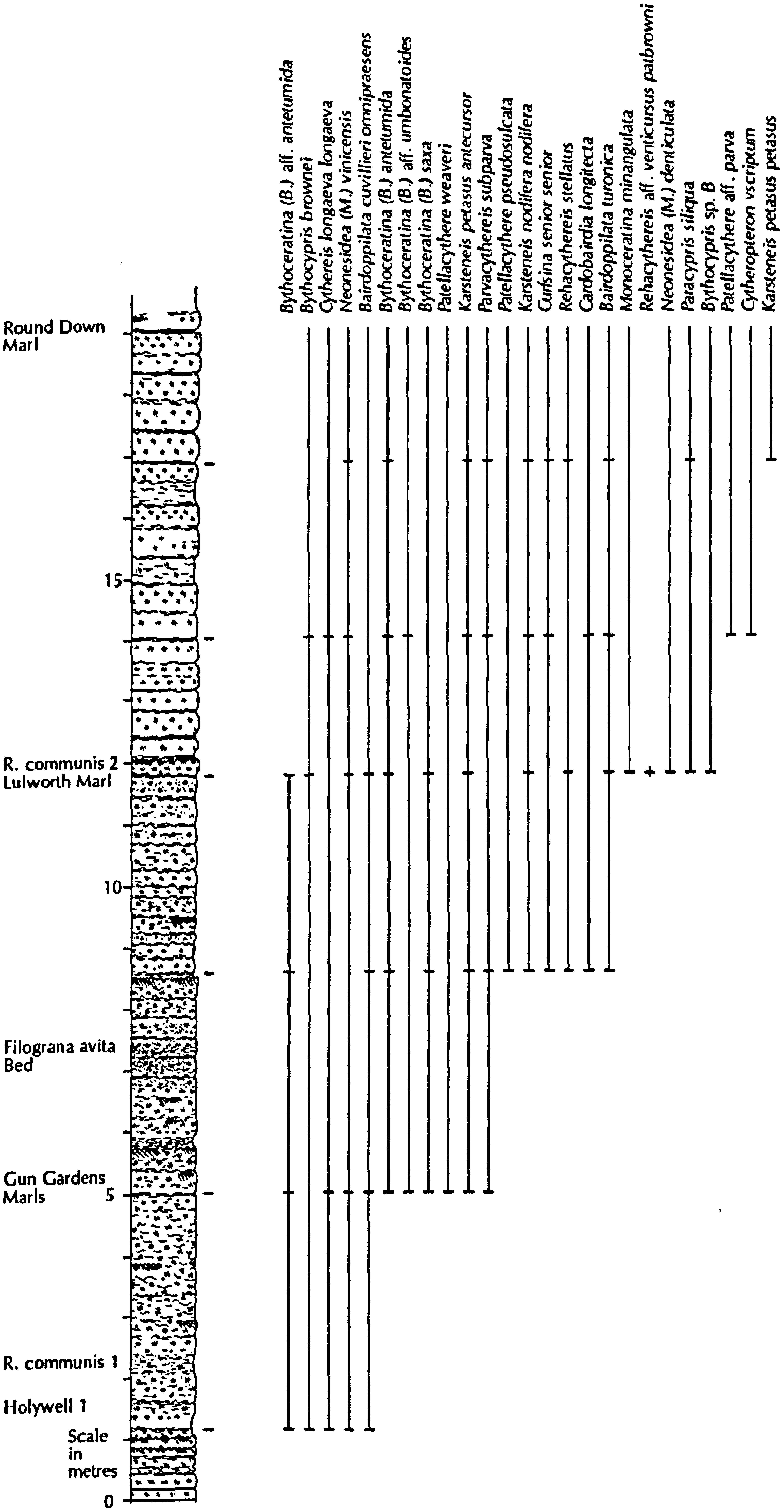
5.1 Abbots Cliff

Samples taken at 3-4m intervals between the fifth hardground above Plenus Marl bed 8 and the Round Down Marl. Twelve long ranging species, which range from the Cenomanian up into the overlying section, are given in Text-fig. 5.1; species with first appearances or extinctions in the section at Abbots Cliff are given in Text-fig. 5.2.

At Dover this part of the Turonian is condensed by one-third when compared with deeper parts of the basin; much of it consists of nodular chalk with bioclastic debris and hardground surfaces. So it is difficult to assess accurately the timing of introduction of new species into the area. Twenty-five first appearances occur in the section with one extinction, together with the twelve long ranging species gives a diversity at the Round Down Marl of 37 species; most abundant are the platycopids, and most diverse are the bythocytherids. This increase in diversity has been discussed by Slipper (1996).



Text-fig. 5.1 Long ranging species in the section at Abbots Cliff, with both stratigraphically younger and older records from other sections. For key to lithologies, see Text-fig 3.2.



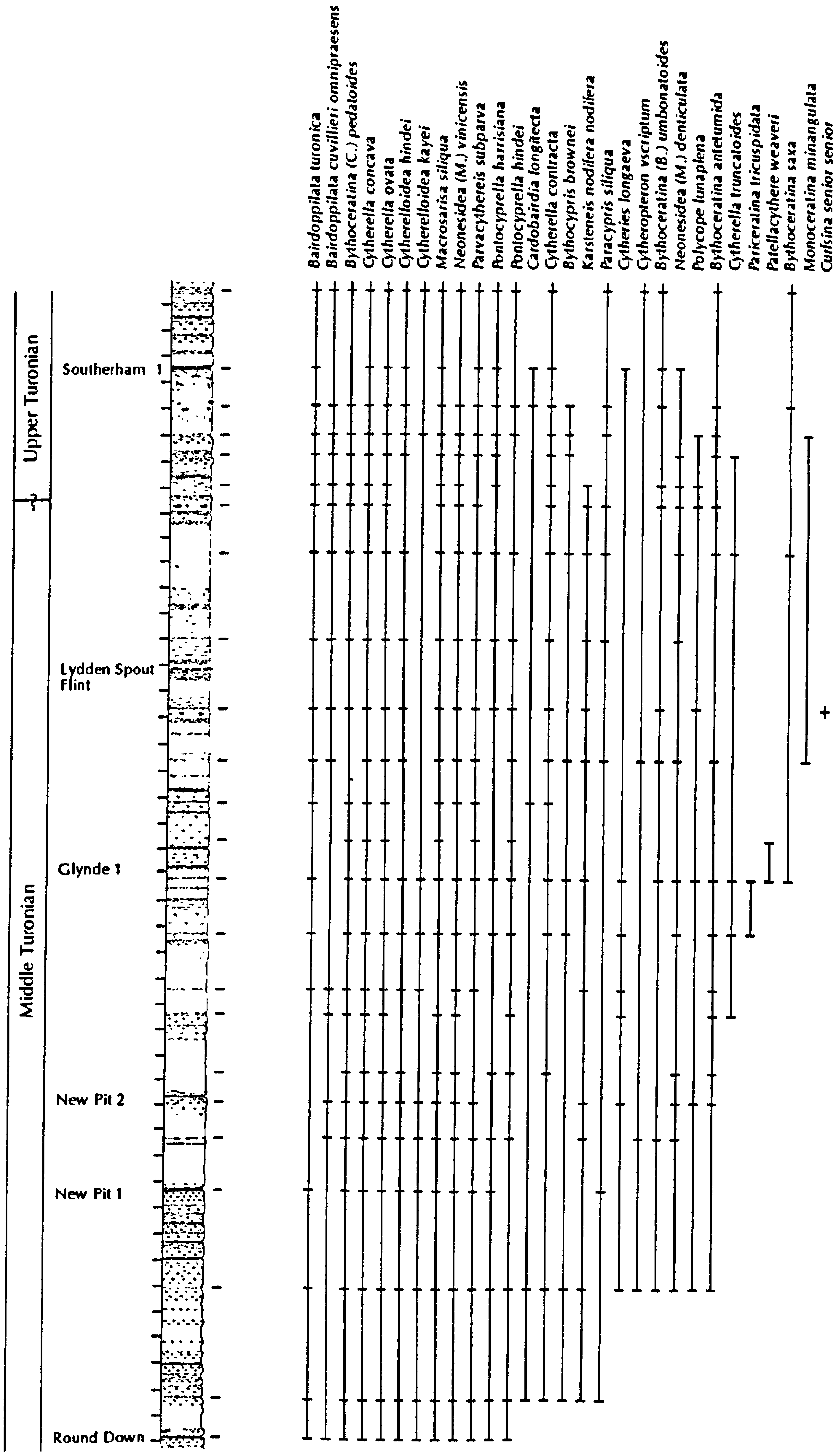
Text-fig. 5.2 Ranges of species with first appearances or extinctions in the Abbots Cliff section. For key to lithologies see Text-fig. 3.2.

The first sample contains species which mark the base of the Turonian: *Bythoceratina (B.) aff. antetumida, Cythereis longaeva, Neonesidea (M.) vinicensis* and *Bairdoppilata cuvillieri omnipraesens*. The first of these quickly becomes extinct near the Lower-Middle Turonian boundary, and is survived by *B. (B.) antetumida*, a characteristic element of the Turonian chalks, which first appears at Gun Gardens Marl 1 and continues into the Coniacian. The strongly reticulate *Karsteneis petasus antecursor* is common in the Lower Turonian up to Round Down Marl. Also with a first appearance at Gun Gardens Marl 1 is the long ranging and common *Parvacythereis subparva*. Two species which first appear at the level of the chalk-marl couplet 44 (Gale 1996) are *Curfsina senior senior* and *Karsteneis nodifera nodifera;* both species are long ranging but undergo morphological changes through the Turonian, which have here been given subspecific status. The following species appear at the Middle-Lower Turonian boundary: *M. minangulata, N. (M.) denticulata, P. siliqua, Bythocypris* sp. B and a precursor to the uniquely Turonian *R. venticursus patbrowni*.

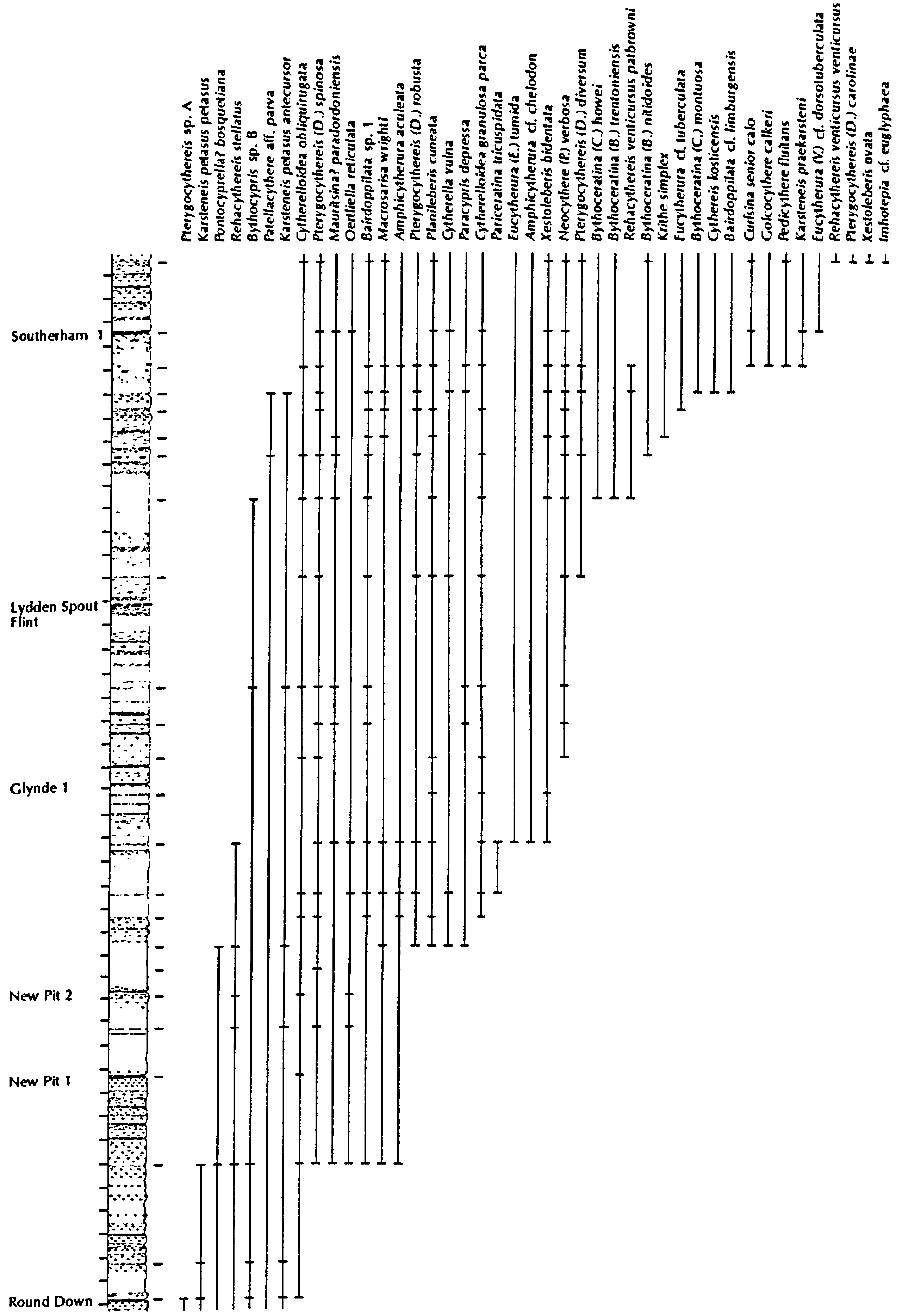
5.2 Akers Steps

While still retaining some nodularity in the lower part of the section, the majority of the chalk above New Pit Marl 1 is softer, with numerous marl seams. It is also notable for the presence of the first flint band in the Late Cretaceous Chalk facies. When compared to more basinal sections, this is expanded by 50% and the timing of first appearances may be considered as relatively accurate.

Twenty-nine long ranging species are shown in Text-fig. 5.3, which have been found below Round Down Marl, within the section at Akers Steps and above Southerham Marl 2.



Text-fig. 5.3 Long ranging species through Akers Steps section. For key to lithologies see Text-fig. 3.2.

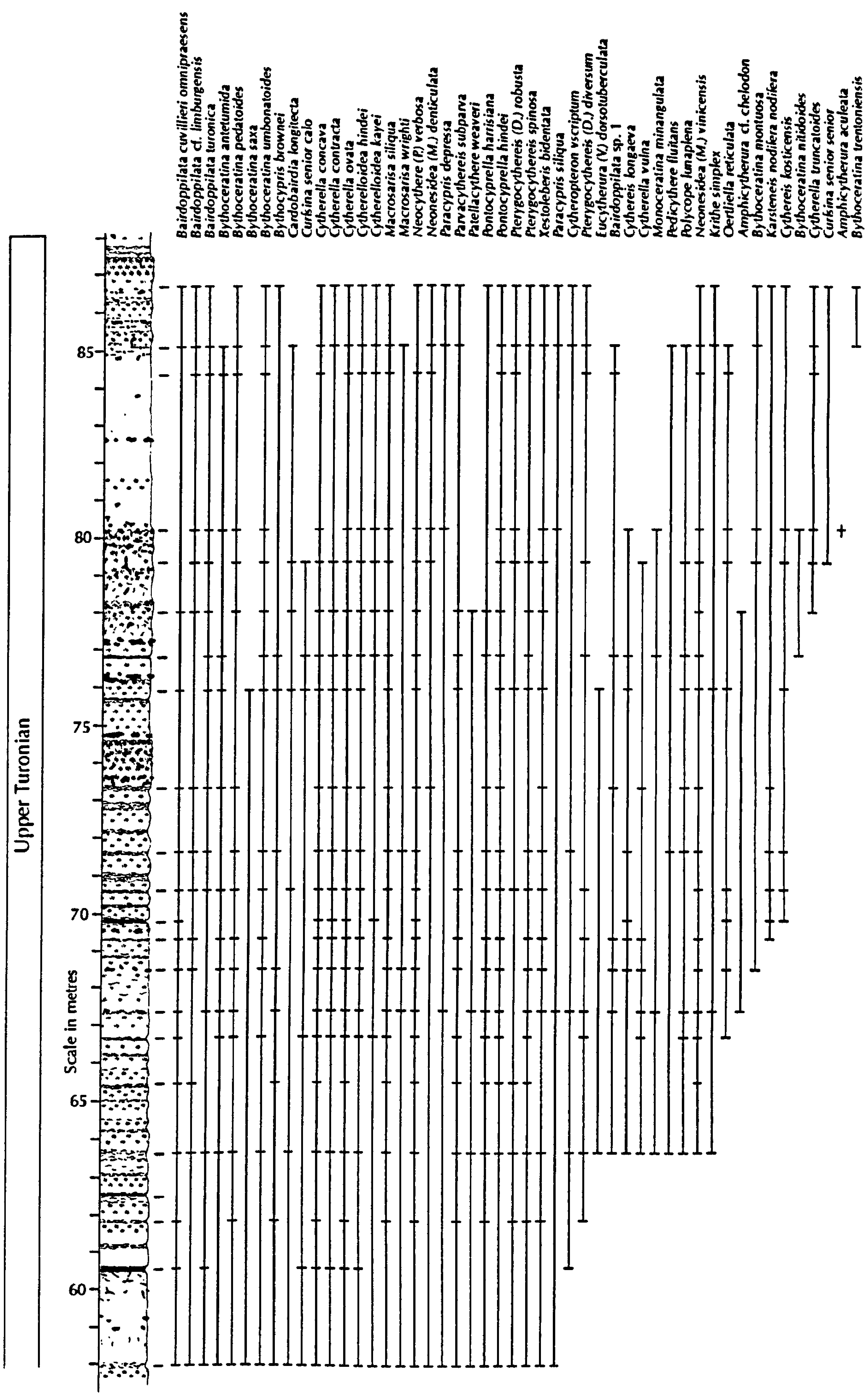


Text-fig. 5.4 Ranges of species with first appearances or extinctions in the Akers Steps section. For key to lithologies see Text-fig. 3.2.

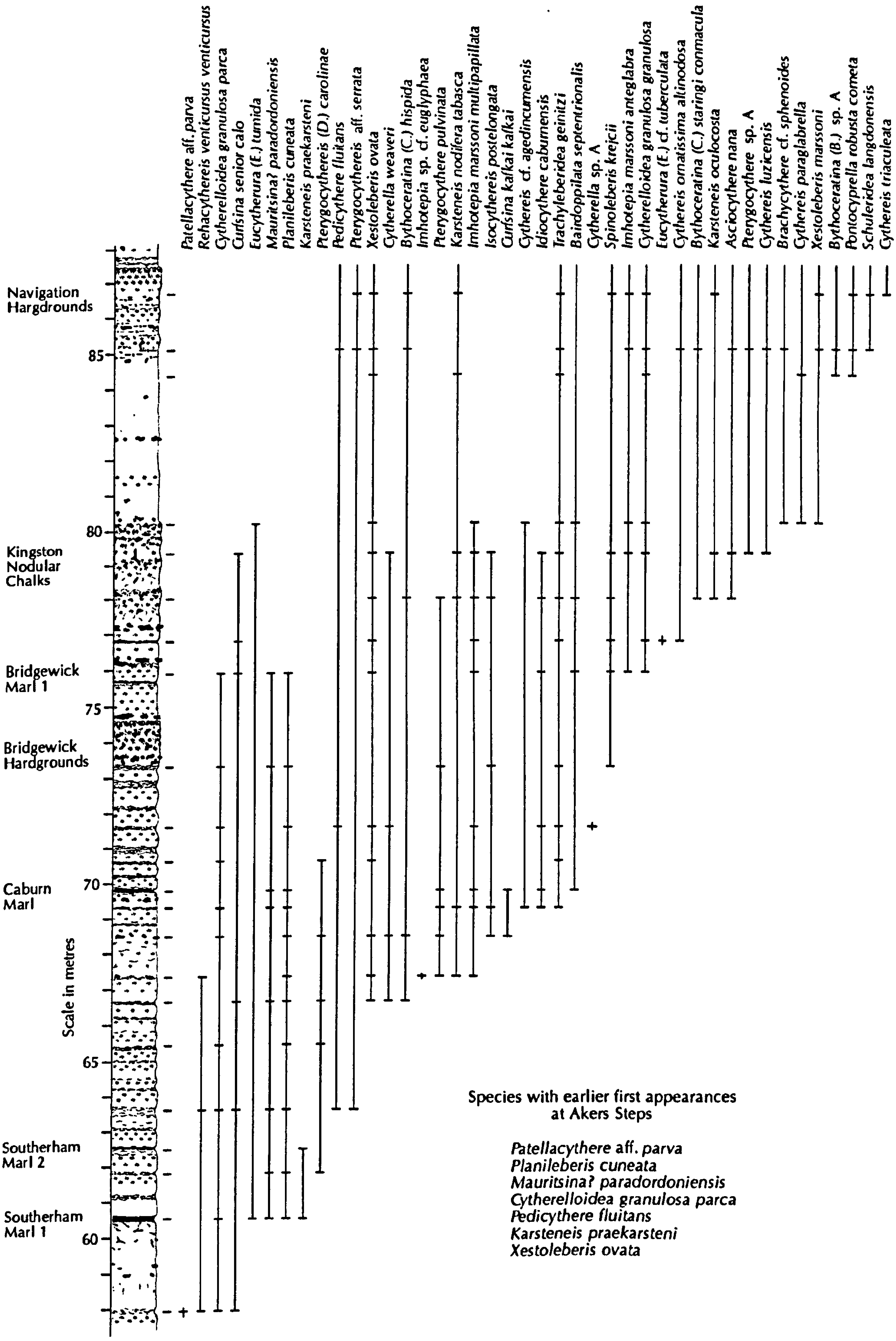
Cytherelloidea obliquirugata first appears at the *Mytiloides* spp./*T. lata* boundary. A significant level 3.7m below New Pit Marl 1 sees the demise of the semi-reticulate *Karsteneis petasus petasus* and the simultaneous appearances of five species which are then long ranging: *P. (D.) spinosa, M.? paradordoniensis, O. reticulata, Bairdoppilata* sp. 1, *M. wrighti* and *A. aculeata.* These become common in the white chalks of the New Pit Member. The interval around the New Pit Marls has few new introductions, but just above, in a 4m section between the New Pit Marls and the Glynde Marls, are the stepped appearances of ten species and the loss of two. This is a significant event within the Middle Turonian. The base of this faunal turnover is marked b the loss of ?*P. bosquetiana* and the first appearances of *P. (D.) robusta, P. cuneata, C. vulna* and *P. depressa.* The upper horizon has the disappearance of *R. stellatus*, which is common in the lower part of the Middle Turonian, and the introductions of *E. tumida, A. chelodon* and the important marker of *X. bidentata.* Between the two horizons is the first appearance of the common and easily recognised *C. granulosa parca* and the only occurrence in the Turonian of the long ranging *P. tricuspidata.* There follows a gap of 10m of chalk, which represents approximately 350,000 years, where there are no speciation events. This stasis is interrupted, at first slowly, 4m above the first flint, where within 4m is one extinction and five appearances, notably including species of supposed deep water genera: *Bythoceratina (C.) howei, B. (B.) trentoniensis* and *B. (B.) nitidoides* together with *Krithe simplex.* Then speciation apparently became more rapid at the beds below Southerham Marl 1, where in 3m there are two extinctions and ten first appearances.

5.3 Langdon Stairs

Above the Bridgewick Marl the section at Langdon Stairs is condensed almost by half of that in the centre of the basin. The section is represented by chalks with marls and three series of nodular hardgrounds; flints become more common toward the top. The occurrence of Forty-nine long ranging species are shown in Text-fig 5.5 which are also found below Southerham Marl 1, within the section at Langdon Stairs and above Navigation Marl. Species with first appearances or extinctions in the section at Langdon Stairs are shown in Text-fig. 5.6.



Text-fig. 5.5 Long ranging species in the section at Langdon Stairs, with both stratigraphically younger and older records from other sections. For key to lithologies, see Text-fig 3.2.



Species with earlier first appearances
at Akers Steps

Patellacythere aff. *parva*
Planileberis cuneata
Mauritsina? paradordoniensis
Cytherelloidea granulosa parca
Pedicythere fluitans
Karsteneis praekarsteni
Xestoleberis ovata

Text-fig. 5.6 Ranges of species with first appearances or extinctions in the Langdon Stairs section. For key to lithologies see Text-fig. 3.2.

Above the Southerham Marls is the introduction of *X. ovata* which becomes common in the Upper Turonian. In the 3.5m below Caburn Marl is a faunal event where two species become extinct and eleven species enter. The significant level is at the last occurrence of *R. venticursus venticursus* and *I.* sp. cf. *euglyphaea*, and the first appearances of *P. pulvinata, K. nodifera tabasca* and *I. marssoni multipapillata*. The only significant entrance at the *lata/plana* zonal boundary is that of *S. krejcii*. A second faunal event is heralded by the triple extinction of *P. cuneata, M.*? *paradordoniensis* and *C. granulosa parca* and the appearances of *C. granulosa granulosa* and *I. marssoni anteglabra* at the Bridgewick Marl 1. This event terminates at the top of the Kingston Nodular Chalks, where seven short lived species, which first appeared between Southerham Marl 2 and Caburn Marl, become extinct, at the same time as five new species enter. Extinctions here are of *I. postelongata, I. caburnensis* and *I. marssoni multipapillata*. Near the top of the Turonian is the first appearance of *S. langdonensis,* and the increase in abundance of *X. marssoni* (Slipper in press, Appended).

6 DISCUSSION OF FAUNAL RANGES

Introduction

Having built range charts for those species which show first appearances in the Turonian, a pattern emerges which shows that the rate of speciation was not constant. Several cycles can be discerned where there is a period of relatively few species being introduced, and shorter periods, where the rate of speciation increases. This pattern is linked to the lithologies and therefore to changing environmental conditions. Similar patterns have been recognised before (van Harten & van Hinte 1984) and used as chronoecologic tools to deduce sea-levels. This approach is critically examined and re-evaluated in the light of a more complete data set. A model is proposed to account for the patterns.

An examination is made into the possibility of erecting a zonation scheme for the Turonian using Ostracoda by comparing the Kent fauna with that from Beer in Devon. Other zonal schemes which have been erected are critically discussed.

6.1 Apparent evolutionary cyclicity

Although the sampling resolution at Abbots Cliff is not as fine as at other sections, the distribution of the ostracod fauna shows a steady introduction of new species from the base of the Turonian up to the Lulworth Marl. Above this horizon, the rate of new introductions decreases. The lithological character changes at the Lulworth Marl from bioclastic nodular chalks with hardgrounds below, to nodular chalks with marls above. This corresponds closely to the position of the Lower/Middle Turonian boundary.

The fauna discovered in the section at Akers Steps shows three cycles of introductions over short stratigraphical intervals between longer intervals with little change in the fauna. The first, below the New Pit Marls, the second, between New Pit Marls and Glynde Marls, and the third, below the Southerham Marls. Each of these events is associated with white chalks and hardgrounds, together with the absence of marl beds, while the periods of stasis are associated with chalks with marls.

Two cycles of activity can be detected in the section at Langdon Stairs, the first begins above the Southerham Marls and culminates at Caburn Marl, while the second occurs within the Kingston Nodular Chalks. Below Caburn Marl are nodular chalks with thin flaser marls, while the section between Caburn Marl and Bridgewick Hardgrounds is characterised by nodular chalks with thick flaser marls. The distinction between the lithologies in this part of the Turonian is less clear.

In the above six cycles, in each case, there is a link between lithology and rate of new species entering. For chalks with marls the rate is low, for chalks without marls but with hardgrounds the rate is higher.

The above pattern could very readily be interpreted as one of short periods of evolutionary activity which have interrupted longer periods of stasis. The link to lithology is such that the periods of stasis occur during the deposition of chalks and marls, which are indicative of stable environments in deeper water, while the periods of speciation occur in the nodular chalks with hardgrounds. These would have been deposited under higher energy conditions, in shallower water, perhaps a more stressful environment which may have driven the speciation events. A case for the punctuated equilibria model of Eldredge & Gould (1972).

There is, however, and alternative explanation which may be derived from examining the lithology in terms of changing sedimentation rates. It has been shown how the section at Dover is both condensed and expanded at various levels relative to the more basinal sections. The chalk and marl beds tend to be preserved in the expanded sections, while the nodular chalk and hardgrounds are preserved where there is condensation. The link now is between sedimentation and numbers of species entering. It is possible that the rate of speciation was constant through the Turonian and the pattern is a reflection of the changing rates of sedimentation and erosion, as evidenced by the preserved lithologies. A case now for the phyletic gradualism model (Eldredge & Gould 1972).

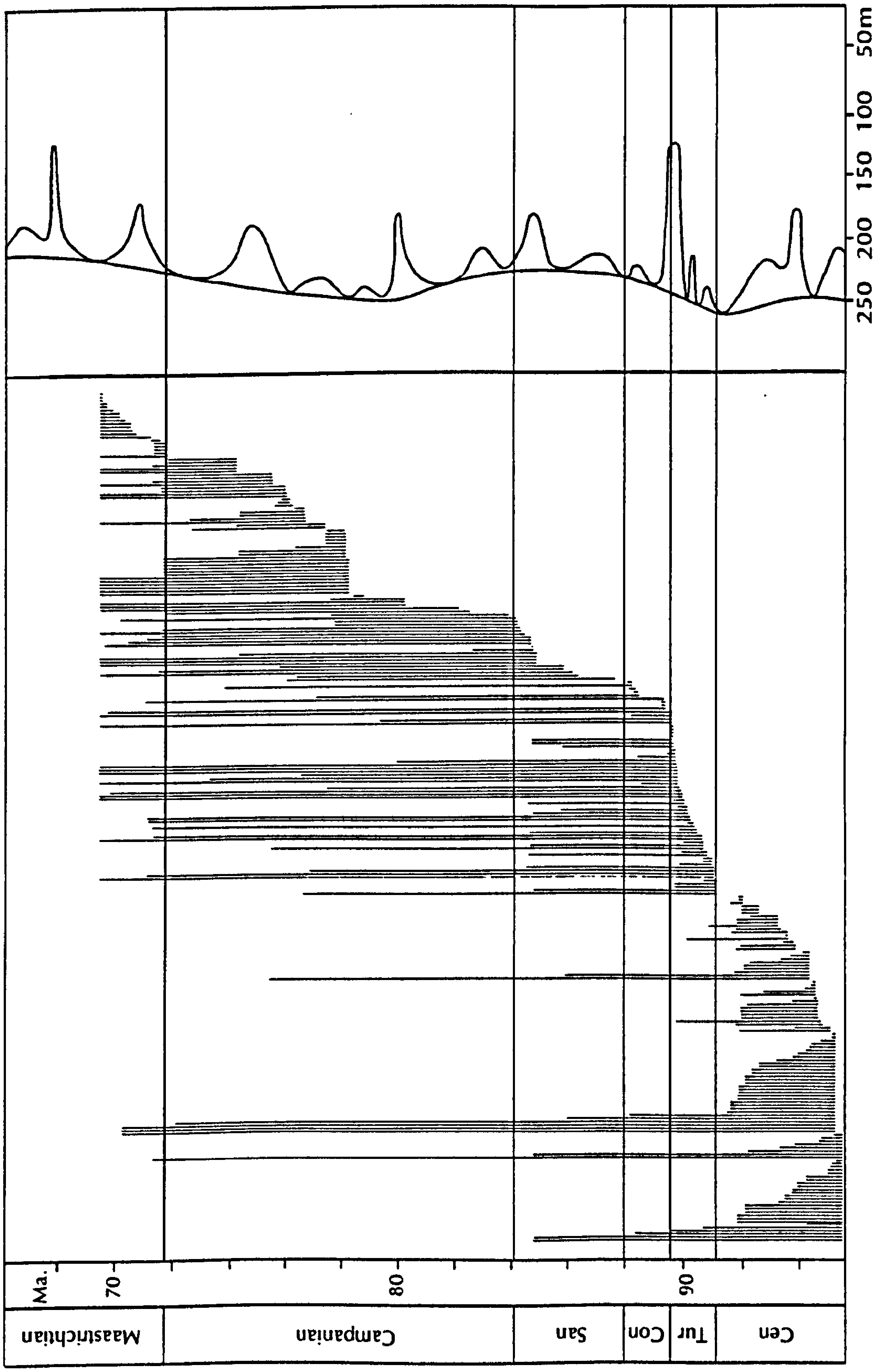
To enable this problem to be resolved, it is necessary to examine the expanded basinal sections at equivalent horizons to those which are condensed at Dover. The best location which for this would be Beachy Head, Sussex, at the interval between the Bridgewick Hardgrounds and the Navigation Hardgrounds. If the pattern is repeated over this section, then the changing environmental conditions are creating conditions which are conducive to speciation. If, on the other hand, the pattern is shown to be one of constant speciation, then it is clear that the pattern at Dover is an artefact of differential sedimentation. This might then have consequences for interpretations of environments, based upon range charts, at other locations, unless the sedimentology is closely controlled.

6.2 Chronoecologic charts

These types of diversity patterns have been used as chronoecologic tools (van Harten & van Hinte 1984) to link diversity to eustatic changes in sea-level. They postulated that by examining the patterns created by range charts that it was possible to infer rising sea levels from increasing diversity, conversely, reduced diversity is the product of falling sea levels. This approach has been used uncritically by others (Flexer *et al.* 1986; van Harten 1988) to infer sea-level from range charts. The data here, however, suggest an opposite interpretation. The highest diversity, and rate of speciation in the Turonian occurs during deposition of chalks with hardgrounds, which are formed under conditions of lowered sea-level (Hancock 1990, 1993; Gale 1996), similarly the periods of stasis occur in the chalks with marls between the hardgrounds, which represent higher sea-levels. This has also been demonstrated using ostracods over the Turonian-Coniacian boundary (Slipper in press, appended). In the course of preparation of a broader work (Slipper, submitted 1993), the author collated ostracod range data from the Late Cretaceous (King 1968, Weaver 1982; Wilkinson 1988, Jarvis *et al.* 1988; Horne *et al.* 1990) and combined them with the present data set. Text-fig. 6.1 shows this against the eustatic sea-level curve of Haq *et al.* (1988). It emphasises the two most significant effects in the Late Cretaceous;

- At the Cenomanian-Turonian boundary, the greatest extinction of species is linked to the highest sea-level.
- At the Turonian-Coniacian boundary, the greatest increase in species is linked with the largest second order sea-level fall.

Both of these are in direct opposition to the assertions of van Harten & van Hinte (1984). An explanation might lie in the fact that the range charts selected by van Harten & van Hinte (1984), for the Jurassic and Cretaceous, upon which their hypothesis was based, were taken from Sheppard (1978). These charts contained only a partial data set of stratigraphically useful species. When a more complete data set is used, the interpretation is reversed. The use of chronoecologic range charts as identifiers of sea-level should therefore be treated with caution.



Text-fig. 6.1 Chronoecologic chart showing duration of ostracod species through the Late Cretaceous of Britain (King 1968; Weaver 1982; Wilkinson 1988; Jarvis et al. 1988; Horne et al. 1990; and data herein) set against the eustatic sea-level curve of Haq et al. (1987).

6.3 Integrated model

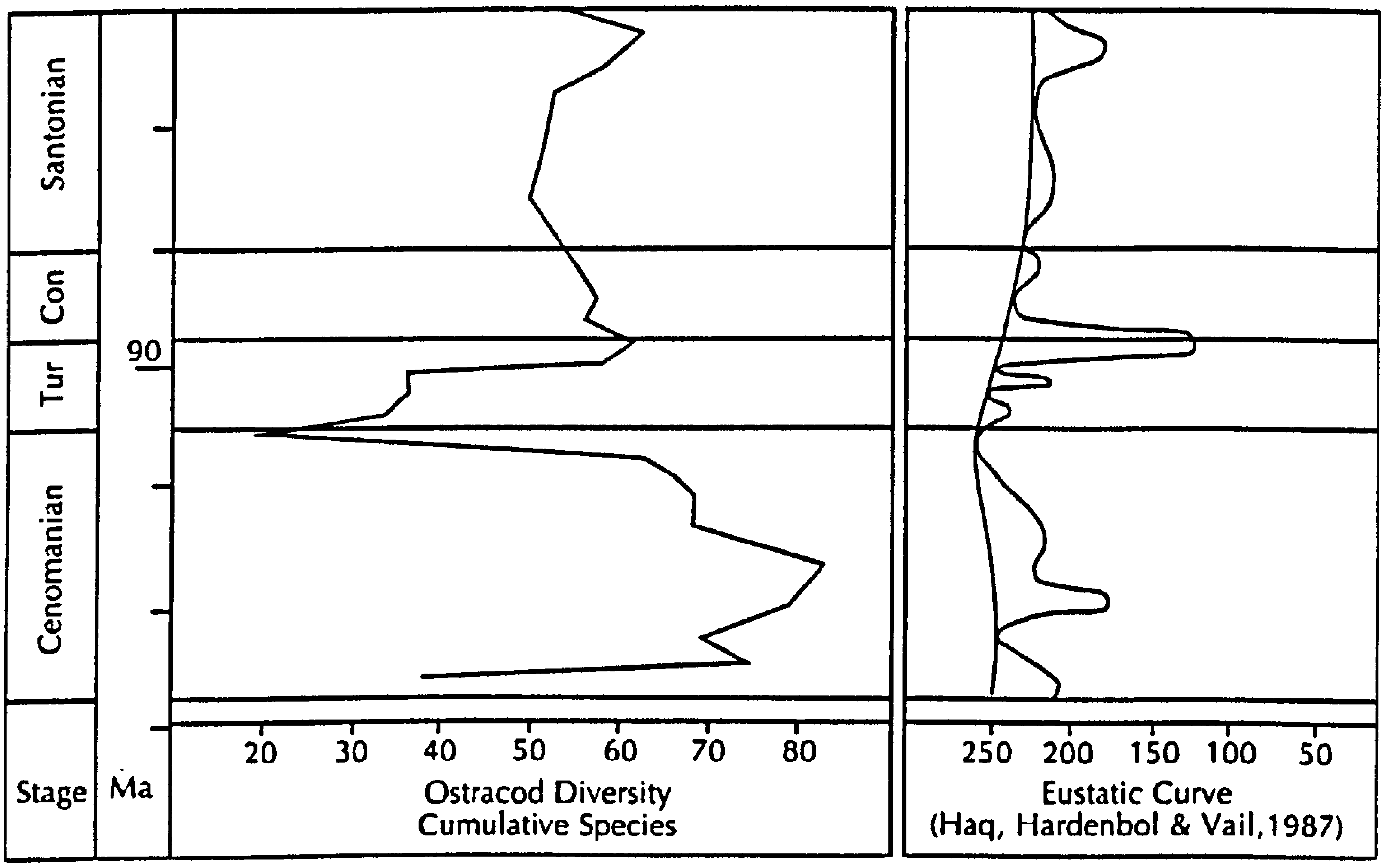
From the above discussion it is clear that an alternative interpretation should be sought which would explain the changing patterns of diversity in the Late Cretaceous. A model is developed here which links the cumulative species diversity pattern, from the Cenomanian to the Santonian, with the sea-level curve as given by Haq *et al.* (1987).

Pokorný (1971) investigated diversity curves for two cores in the Bohemian Cretaceous Basin and demonstrated two opposing diversity patterns for the same oceanic event. Which pattern emerged depended upon the position within the basin. For a central basinal position, diversity increased with regression and decreased with transgression. Conversely, for a more marginal position, the diversity was shown to increase with transgression and decrease with regression. This was explained by invoking an ostracod optimum zone which was moved shorewards or basinwards depending upon the change in sea-level. Below the optimum zone, the food supply and light conditions become poor, and the diversity decreases, above the zone the energy levels become too high for many species to survive, and again the diversity reduces.

In order to obtain a smoothed diversity curve, using simple number of species in a sample, it is necessary to invoke the cumulative species curve. This is defined as the number of species which would be found in a sample, if all species known to be extant at the time represented by the sample, are included in the species count. Slipper (1996) has shown how this simple cumulative species curve indicates the same trend as the computed Simpson index.

The cumulative species diversity (Text-fig. 6.2) rises through the Turonian from a minimum at the Cenomanian-Turonian boundary to a maximum at the Turonian-Coniacian boundary. So, from an assessment of Dover in a marginal position within the Anglo-Paris Basin, it would appear that the diversity is responding to a transgressive event. It has already been shown, however, that the reverse is the case at the Turonian-Coniacian boundary, where the conditions are regressive. The paradox may be resolved by suggesting that the position which Dover occupied, within the Anglo-Paris Basin, although marginal, was one of deeper water than had previously been thought.

To obtain a broader picture, data have been abstracted from Text-fig. 6.1 and replotted as a cumulative diversity curve for the interval from the Cenomanian to the Santonian, and placed against the eustatic sea-level curve of Haq *et al.* (1987). This shows an inverse correlation of diversity with sea-level. For an increase in sea-level the diversity reduces, and for a lowering of sea-level, the diversity is seen to rise.



Text-fig. 6.2 Cumulative species curve (Weaver 1982; Wilkinson 1988; Jarvis et al. 1988; Horne et al. 1990; and data herein) against the eustatic sea-level curve of Haq et al. (1987).

The model developed here, for that interval, explains the changes in diversity in terms of the basinal position of the optimum zone, being affected by changes in sea-level. Text-fig. 6.3 shows a series of time frames from the Cenomanian to the Santonian for the position of Dover.

1) Early Cenomanian.

Conditions - High sea-level, low diversity.

Interpretation - The high sea-level moved the optimum zone up the shelf slope, such that Dover was in the impoverished zone below, and experienced low diversity.

2) Mid-Cenomanian.

Conditions - Regressive trough, diversity maximum.

Interpretation - A lower sea-level brought the optimum zone downshelf to the position occupied by Dover such that a high diversity is achieved.

3) Cenomanian-Turonian boundary.

Conditions - Transgressive maximum, diversity minimum.

Interpretation - The very high sea-level has two effects, firstly moving the optimum zone upshelf, away from the study area, secondly allowing the oxygen minimum zone to impinge upon the outer shelf. This has the effect of reducing the diversity to a minimum. At the same time, with high sea levels, it is likely that barriers to migration may have been breached allowing new species to migrate into the area. It is shown below in section 6.4 that west to east migrations took place in the Early Turonian of the Anglo-Paris Basin and east to west migration took place between that basin and the Bohemian Cretaceous Basin, at the same time.

4) Turonian-Coniacian boundary.

Conditions - regressive maximum on regressive trend, diversity peak.

Interpretation - As with the situation in the Early Cenomanian, the lowered sea-level allowed the optimum zone to move downshelf, which increased the number of species at the site at Dover.

5) Coniacian-Santonian boundary

Conditions - Minor peak on regressive trough, diversity moderate.

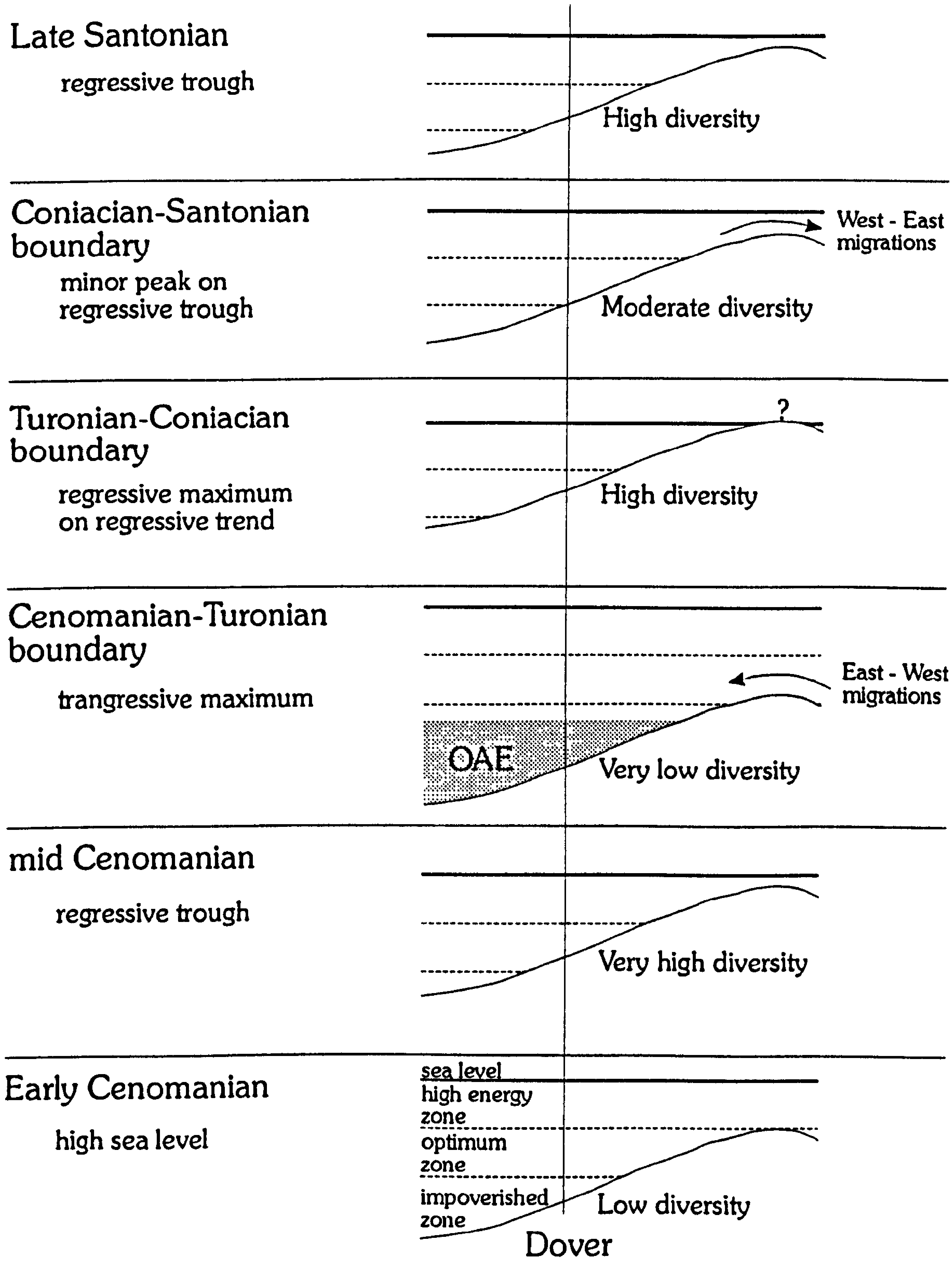
Interpretation - An intermediate situation where the sea-level has risen, but not far enough to remove the optimum zone completely from the area, the resultant diversity is neither high nor low.

6) Late Santonian.

Conditions - regressive minimum on regressive trough, diversity peak.

Interpretation - The same conditions as for the Mid-Cenomanian and Turonian-Coniacian boundary exist at the end of the Santonian where the sea-level is lowered to bring the optimum zone back into the area, which in turn allows the diversity to rise.

The model above is coherent and links the changing sea-level with the observed diversity. It needs to be tested by examining further sites around the basin, in different baythmetric positions, to see if the movements correspond to different water depths.



Text-fig. 6.3 Integrated model of sea-level and ostracod diversity for the interval from the Cenomanian to the Santonian Stages of the Late Cretaceous

6.4 Zonal scheme

A Zonal scheme has not been erected for the Turonian using the present data set. There is evidence that within the chalk facies the first appearances of ostracods may be diachronous within the basin and also between basins. This is analysed by making comparisons between the first appearances of ostracod species, firstly within the Anglo-Paris Basin, taking Beer in Devon as the most westerly point and Dover on the opposite margin. Then a comparison is made between first appearances from the Bohemian Cretaceous Basin with those from Dover in the Anglo-Paris Basin.

6.4.1 Comparison with the fauna from Beer, Devon.

In the late 1970's, Dr. P.P.E. Weaver, of the Institute of Oceanographic Sciences, collected a suite of samples from the Beer Roads section, Devon. These were processed, picked and many mounted on stubs for SEM photography, and a draught manuscript was prepared. Unfortunately the plates and negatives were lost, and subsequent changes in his work has not allowed him to continue the study of Cretaceous ostracods. In 1989 he passed all his specimens and a field description of the sample locations to the present author, who has drawn up a log of his sample sites and thanks to the detail of his field log has been able to match bed for bed with the logs published by Jarvis & Tocher (1987).

The section at Beer is comparable to that at Dover in that it is near the basin margin, and is condensed. Mortimore & Pomerol (1987) were unable to include a conclusive correlation for this section and as such it is difficult to be sure of equivalent time horizons. Gale (1996) showed a correlation for the lower part of the section in Devon and equated the Haven Cliff Hardground with the Holywell Marl 2, the West Ebb Marl is below the *Filograna avita* bed, while the Branscombe Hardground is equivalent to the hardground above the Lulworth Marl. The *Mytiloides* spp./*lata* boundary has been identified and is used as the junction between the Connet's Hole Member and the

Beer Roads Member (Jarvis & Tocher 1987), so the Hall Flint may be correlated approximately with the Round Down Marl. No published information exists for a correlation of the Two Foot Band and the Four Foot Band, with the successions in the east of the basin, but there is evidence that they may equate with New Pit Marls 1 and 2 (A.S. Gale pers. comm.)

The lower section at Beer, like that of Dover, consists of nodular chalks and hardgrounds. A major difference is the level of the first incoming of flint, which is much lower in the succession to the west. At Beer, the Upper Turonian is inaccessible so the *S. plana* Zone was not sampled.

Fifteen samples were taken and twelve of these produced ostracods. A similar situation to that at Dover is seen in the lowest beds, with a rapid rise in the diversity from four to twenty species in the first 7m. There is also a reduction in the rate of introduction of new species above this level. The diversity rises again in the lower *lata* zone beds; a similar pattern is seen below the Glynde Marls at Dover. Again above this the rate slows down and increases again as can be seen below the Southerham Marls at Dover. The pattern of diversity changes and first appearance corresponds very well to that seen on the opposite margin of the basin.

There are some significant differences, however, in the timing of entry of some species. 46 species were obtained over all the samples. Three very distinctive species: *Imhotepia marssoni multipapillata*, *Spinoleberis krejcii* and *Idiocythere caburnensis* all occur in the lowest levels in the west, 6m above the base of the Turonian *M. mytiloides* Zone *sensu* Jarvis & Tocher (1987). In the east, however, all three do not appear until the upper part of the Middle Turonian; *S. krejcii* first appears at the *lata/plana* boundary. Within the basin there is a sense of migration from west to east.

6.4.2 Comparison with the Bohemian fauna

The ranges of fifteen species from the Bohemian Turonian and Coniacian (Pokorný 1979 and unpublished data) have been compared with the ranges found at Dover (Slipper in press, Appended, text-fig. 4). Three groups emerged when considering the relative timing of the first appearances. The first group comprises those species first appearing in the Bohemian sediments, and then appearing later in the Dover section: *Karsteneis petasus antecursor, Curfsina senior, Karsteneis nodifera, Oertliella reticulata, Spinoleberis krejcii and Phacorhabdotus semiplicatus.* The second group are those species with approximately simultaneous appearances at both locations: *Curfsina kafkai kafkai, Rehacythereis zygopleura* and *Imhotepia marssoni multipapillata.* This latter *Imhotepia* subspecies also appears at the same level in the Paris Basin (Damotte 1971). The third group consists of species and subspecies with a later first appearance in the east than in the west: *Planileberis cuneata, Cythereis paraglabrella, Golcocythere calkeri, Cythereis chlomkensis, Cythereis luzicensis* and *Imhotepia marssoni anteglabra.* In the Paris basin the first appearance of *Imhotepia marssoni anteglabra* is coincident with the later Coniacian horizon as seen in Bohemia. The records of Gründel (1970, 1970a) show some species in common, notably *Spinoleberis* sp. R. *sensu* Gründel (= *S. krejcii*) and *Cythereis chlomkensis* - both of which appear at intermediate stratigraphical levels between England and Bohemia.

Having established these groups, a pattern appears such that they may be characterised as stratigraphically distinct. The migrations of the first group, of east to west migrations, occur mainly in the Early and Middle Turonian, the one exception to this is *P. semiplicatus.* The group with simultaneous appearances are found in the Middle Turonian and at the Middle-Late Turonian boundary. The migrations of the third group, of west to east migrations are found stratigraphically higher from the Middle-Late Turonian boundary to the Early-Late Coniacian boundary.

6.4.3 Problems of Zonation

From the Beer section it is shown that within basin migrations took place in the Lower Turonian in an easterly direction. From the Bohemian data, for interbasinal migrations it is suggested that movements took place in the Lower and Middle Turonian in a westerly direction, and in the Late Turonian and Early Coniacian, this direction was reversed. Slipper (in press, appended) has shown the link between oceanographic, lithological, and faunal change at this point in the Turonian.

The two patterns are contradictory, and as such demonstrate the diachronous nature of species in the chalk facies, and their limited use for zonal purposes. This does, however, indicate the possibility of more than one source for the origin of the Turonian fauna. One to the west and another to the east, each being allowed to have an influence after the transgressive maximum had overcome barriers to migration at the Cenomanian-Turonian boundary.

Local zonal schemes could be erected, but would be worth little. It is necessary to detail the biostratigraphy from all sections to be able to identify those species which may serve as biostratigraphical markers. For this reason no zonal scheme using Ostracoda was attempted for the Turonian.

The Turonian could be zoned far more effectively by using a fossil group with a more rapid method of dispersal than Ostracoda. This has been achieved in the past but each scheme has its difficulties. The ammonite zonations of Hancock (1991) and Gale (1996) are worthy in that they allow international correlation, but the British Turonian ammonite fauna is very scarce; additionally, proxy species have to be used to allow correlation on a global scale, thus reducing their reliability. Inoceramid zonal schemes have gained some favour and been employed recently (Gale 1996), but while abundant, Turonian inoceramids suffer from poor preservation and difficulties in identification. The traditional zonal scheme of Barrois (1876), using inoceramids, brachiopods and echinoids is usable but gives a very coarse stratigraphical resolution. The finest resolution obtained so far is by the foraminiferal studies of Hart *et al.* (1989); however, the lithostratigraphical control on that scheme is so poor as to make it unusable. In text-figs 7.11 and 7.20 of Hart *et al.* (1989) only 41.3m and 40.2m respectively are shown of Turonian Chalks at Dover, Kent, whereas in the sections measured by Horne *et al.* (1990) there are 83m, Jenkyns *et al.* (1994) have 82.5m, and the scheme of Gale (1996) used here has 82m of Turonian Chalk from Dover. Marker horizons are not used by Hart *et al.* (1989), and the foraminiferal zonation is tied in to *labiatus/lata/planus* division of the Turonian, which as has been shown is subject to diachroneity. The benthonic zonation consists of only two zones since majority of benthonic foraminifera species in the Turonian are long ranging. The planktonic zonation is fraught with difficulties, such as the use of subjective transitional morphotypes to define zonal boundaries, e.g. *Praeglobotruncana helvetica;* species which are not traceable outside the southern province, e.g. *Marginotruncana sigali;* and facies controlled species, e.g. *Marginotruncana coronata.*

A dinoflagellate cyst zonation of the Turonian has been erected by FitzPatrick (1995) using sections across the basin from Compton Bay in the west to Dover in the east. There are many points arising from that zonation and they are addressed in the following critical analysis.

In that scheme the base of the Turonian is redefined to the first appearance of *Heterosphaeridium difficile*. There are problems, however, to using this species as an index to mark the base of the Turonian. FitzPatrick (1995) states that the first appearance "coincides approximately with the lithostratigraphic base of the Melbourn Rock Beds", at samples AS7 and HW2. An examination of the lithological sections for these samples (FitzPatrick 1995, text-figs 3, 5) show that the first appearance at Akers Steps is 8m above the base of the Melbourn Rock Beds, halfway through the Lower Turonian *M. nodosoides* zone, and at Holywell Steps is 2m above the base of the Melbourn Rock beds at a level equivalent to the Mead Marls 1 in the Cenomanian *N. juddii* zone. *Heterosphaeridium difficile* is thus shown to be diachronous between Eastbourne and Dover, with an easterly sense of movement with time, and as such should not be used as an index fossil to redefine the base of the Turonian. Fitzpatrick (1995) states that "the first appearance of *H. difficile* is found to vary from section to section, but is consistently within the lower Turonian". If this is so, it cannot define the base of the stage. Its unsuitability as a zonal index taxon is emphasised since FitzPatrick (1995) states that it is a boreal to sub-boreal species, and could not be found in assemblages from northern France.

No definition of the base of Palynozone I of FitzPatrick (1995) is given in the text, and it must be assumed that it corresponds to the redefinition of the base of the Turonian using *H. difficile*. The discussion above has demonstrated that this can not represent a datum plane, therefore Palynozone I as a concept is unsound.

Similarly, Palynozone *II* of FitzPatrick (1995) suffers from inconsistencies of stratigraphy which render it unusable. This is defined by FitzPatrick (1995): "*Florentinia torulosa* first appears at the top of the *M. labiatus* Zone or base of the *Terebratulina lata* Zone (LS1, BH12) and disappears just above the base of the latter."

There is uncertainty as to the definition of the *labiatus/lata* Zone boundary *sensu* FitzPatrick (1995). In her text-fig. 3 for Akers Steps, it is drawn at the lower of the Warren Marls, at the junction of the Shakespeare Cliff and Aycliff Members in the terminology of

Robinson (1986); this is equivalent to New Pit Marl 1 herein. Robinson (1986, text-fig. 4), however, placed the zonal boundary lower, within his Shakespeare Cliff Member, but did not explicitly state where it occurred in relation to his lithological scheme.

For the section at Beachy Head (west), Eastbourne (FitzPatrick 1995, text-fig.5), it is difficult to interpret where the *labiatus/lata* boundary has been placed, since her log shows only 18.7m of chalk between Gun Gardens Main Marl and New Pit Marl 1, whereas Gale (1996) has measured 51.5m for the same section. Furthermore, the correlation between the three sections at Holywell Steps, Southerham and Beachy Head is unclear. Reference to FitzPatrick (1995, text-fig. 13) shows that the boundary has been placed at her sample level BH7, and the *labiatus/lata* boundary on the column on text-fig. 3 corresponds to this. However, for the section at Southerham on text-fig. 3, it appears to have been placed lower in the succession, approximately 1.5 above the Gun Gardens Main Marl. Mortimore (1986) explicitly places the *labiatus/lata* boundary at the Malling Street Marl, which is correlated with the Lulworth Marl of Gale (1996). Jenkyns *et al.* (1994) placed the boundary approximately 2.5m higher, which is the usage followed here.

For the section at Compton Bay, FitzPatrick (1995, text-fig. 7) shows the *labiatus/lata* boundary at sample horizon CB31, approximately 9.5m below New Pit Marl 1. Though no marker horizons are shown at this level this probably corresponds closely to the definition for Beachy Head above.

So, FitzPatrick (1995) has two definitions of the *labiatus/lata* boundary separated by approximately 12m of section equivalent at Dover, neither of which relate to published definitions for the same sections (Mortimore 1986; Robinson 1986; Jenkyns *et al.* 1994; Gale 1996).

There are more serious problems, however, with the interpretation of the first appearance of *F. torulosa* and its relationship to the *labiatus/lata* boundary. Firstly the sample quoted as having the first appearance of the taxon, LS1, is equivalent to LGSD1 herein, Southerham Marl 1 at Langdon Stairs. This is not supported by the range chart of FitzPatrick (1995, text-fig. 11), which indicates that the first appearance is higher, at sample LS2. This horizon is approximately 32m higher in the succession than the highest interpretation of the *labiatus/lata* boundary, at which this species is supposed to first appear.

Secondly, the first appearance at Beachy Head (sample BH12) is subject to doubt. It is shown to occur a short distance above Gun Gardens Main Marl, which is below the position of the *labiatus/lata* boundary of authors. On the log of sample positions (FitzPatrick 1995, text-fig. 5), sample BH12 is stratigraphically higher than samples BH10 and BH11 but lower than samples BH9 to BH1, while on the corresponding range chart (FitzPatrick 1995, text-fig. 13) the samples are shown in numerical order with BH12 stratigraphically lower than samples BH11 to BH1. Now while *F. torulosa* is shown to occur only in sample BH12 and not in BH10 or BH11, it may be that the first occurrence is stated correctly, but other species on the same range chart (*Cleistosphaeridium ?multispinosum*) are shown as occurring contiguously between samples BH9 and BH10 in a younging sense, while on the log this is seen in the opposite sense. The source of the error therefore is ambiguous and it cannot be discerned whether the horizon marked as BH12 on the log is truly the first appearance of *F. torulosa*.

The first appearance at Compton Bay, while not quoted in the definition of Palynozone II, is shown on the range chart (FitzPatrick 1995, text-fig. 16) as occurring at CB21, approximately 1m above New Pit Marl 1. This places it in the order of 9m above the *labiatus/lata* boundary as defined for that section.

So, Palynozone II as defined by the first appearance of *F. torulosa* may begin near New Pit Marl 1 at Compton Bay, near Lulworth Marl at Eastbourne or near Southerham Marl at Dover. If plotted on the same section at Beachy Head these events are separated by 52.7m of chalks. It is worrying also that this species was not found in the overlapping samples from Akers Steps which correspond to those from Beachy Head, though these sites are only 4.5km apart.

Further contradictions occur with the proxy species *H. difficile* and *Cyclonephelium distinctum*. FitzPatrick (1995) states for Palynozone II, referring to *F. torulosa* "The first appearance of this species defines the base of Palynozone II, which is also characterised by acmes of *Heterosphaeridium difficile* (AS32, NP11) and *Cyclonephelium distinctum* (AS30, NP15)."

It is unclear whether the acme defines the base of the zone or defines the zone itself, but as will be shown, due to inconsistencies of data both situation may be proved. There is an indication from text-fig. 18 of FitzPatrick (1995) that the acme defines the zone since it is shown to occur in the middle of the zone, and not the base. In addition, sample AS32 is in the middle of the zone. On her text-fig. 18 it is however, confusingly referred to as "influx" rather than acme. However, FitzPatrick (1995, text-fig. 11) shows the acme of *H. difficile* to occur at AS12 where it makes up >70% of the assemblage rather than at AS32 where it accounts for only 20-40% of the assemblage. Sample AS12 is approximately equivalent to the level of the Lulworth Marl, which is close to the *labiatus/lata* boundary. This now proves that the acme defines the base and not the zone.

There is confusion over the definition of the *labiatus/lata* boundary to which the zone is tied, diachronism of the first appearance of the index taxon and confusion over the position of the acme of the proxy species. This renders Palynozone II of Fitzpatrick (1995) unusable.

Palynozone III of Fitzpatrick (1995) suffers from similar problems to the previous zones, as the following will show. Fitzpatrick (1995) states "The last occurrence of *Endoscrinium campanula* defines the base of Palynozone III" and "the last appearance of *Endoscrinium campanula* is within the upper Turonian (in samples LS11, NP25 and CB42)".

The last occurrence at Dover is given as LS11, this is in the *lata* Zone 1.5m below Caburn Marl. Fitzpatrick (1995, text-fig. 12), however, shows the last occurrence to be at sample LS18, which is at the level of the Bridgewick Hardgrounds in the *plana* Zone, 5m higher than sample LS11. At New Pit the last occurrence is much lower in the succession at sample NP25 which is at the flint band beneath Southerham Marl 1 in the *lata* Zone, 10m below the stated last occurrence on the Dover section. The last occurrence at Compton Bay is at sample CB42. This is just below the onset of nodularity at the base of the St. Margaret's Member of Gale (1996), lower in the succession in the *lata* Zone, at an equivalent horizon to AS49 at Dover, 4.5m below the last occurrence at New Pit. Thus it is demonstrated that the last occurrence of *E. campanula* is diachronous across the basin, moving in an easterly sense with time. The diachronism is such that the base of palynozone II at Langdon Stairs is stratigraphically higher than the base of palynozone III at Compton Bay and New Pit. This is clearly undesirable in a zonal scheme.

I recommend that the redefinition of the base of the Turonian stage and the palynozonation scheme erected by FitzPatrick (1995) be disregarded.

It would seem that a reliable, easily usable, high resolution biostratigraphical scheme for the Turonian is evading attempts to be designed. At present, the Ostracoda, due to their diachroneity, are yet another group to fail in this pursuit. With increased sampling resolution, the situation is likely to worsen, since the dispersal of any benthonic fossil group is, by its nature bound to be diachronous. However, given the high quality lithostratigraphical correlations which are available, it calls into question whether a biological zonation of the Chalk by Ostracoda is required at all. The fact that it is possible to determine species movements from the diachroneity underlines the areas toward which Cretaceous ostracod studies should move, those of palaeoecology, palaeobiogeography and evolutionary studies.

7 CONCLUSIONS

For concluding remarks it is useful to review the aims of the project and assess its success or failure at each point, making a brief summary of each area of study.

- "To critically analyse the technical difficulties of extracting Turonian ostracods from the chalks of southern England."

Chapter 3, section 2 - Experimental Techniques - dealt with comparative processing methods and concluded that for marls, and marly chalks the white spirit method gives the best breakdown of the rock, the best recovery in terms of ostracods per gram of residue and also as faunal diversity. For chalks and hardgrounds the glauber salt - freeze thaw method gave the better result for breakdown, recovery and diversity. Since most of the Turonian consists of hard nodular chalks, the latter method was chosen as standard technique. The use of hydrogen peroxide in processing chalk samples was shown to destroy ostracod valves.

- "To document and illustrate systematically the Turonian ostracod fauna from southern England".

This formed the major part of the work and has described and illustrated 103 species and subspecies where, beforehand, the published record indicated only 28. Twenty-five species and subspecies have been described as new. This improvement is a direct result of the work done on assessing the processing methods. While there has been success in increasing the knowledge of the Turonian fauna, there has been failure to cover as much geographical area as was originally intended. This has resulted from time constraint and poorer recovery from central basinal samples.

- "To analyse the Turonian Ostracoda biostratigraphically, and examine the possibility of erecting an ostracod zonation scheme".

Chapters 5 and 6 have addressed the issue of biostratigraphical distribution, detailing where important species first appear and die out. In addition, discussion brought about the discovery of apparent evolutionary cycles, then by comparison with other work carried out by the author that chronoecologic charts should not be used to infer sea-level changes. Slipper (in press, appended) has given biostratigraphical ranges across the Turonian-Coniacian boundary, which prevents a myopic view of the Turonian Stage in isolation. This part of the aim has been completed successfully.

Attempts to erect a zonal scheme have been thwarted by the discovery of both intrabasinal and interbasinal diachronism within certain key taxa in the Turonian and Coniacian as shown in Chapter 6 section 3.

- "To examine the relationship between the ostracod fauna and the sedimentology, and to assess the use of ostracods as palaeoenvironmental indicators in the chalk seas".

For this, the reader is directed to Slipper (in press, appended). Included within this work is an analysis of the character of the fauna using triangular plots of Cytheracea, Cytherellidae, and Cytheracea plus Bairdiacea. This was linked to changing sea-levels as interpreted by lithology. Two recent schemes of sea-levels were contrasted. This resulted in the ostracods agreeing with a general shallowing of sea-level near to the Turonian-Coniacian boundary from a maximum near the Cenomanian-Turonian boundary.

- "To assess the palaeobiogeography of the Turonian Ostracoda within a basinal context, detailing, where present, any migration pathways which may give an indication of the origins of the Turonian fauna".

This has been covered as a result of the biostratigraphical analysis, and has succeeded in showing contradictory migrations directions between interbasinal and intrabasinal studies. So there is a possibility of more than one source for the origin of the Turonian ostracod fauna.

Now that the Turonian fauna is better known, it must be looked at in other areas to test the ideas put forward here about evolutionary cyclicity and lithology, to refine the biostratigraphical occurrences and to constrain more accurately the timing of movements of species within the Anglo-Paris Basin and between this and the Bohemian Cretaceous Basin.

ACKNOWLEDGEMENTS

- For supervision of this project, much discussion, criticism and inspiring my interest in Late Cretaceous Ostracoda I thank Dr. D. J. Horne.
- For additional supervision and support, Profs. A. S. Gale and A. R. Lord.
- For financial support of a grant in aid, I thank the British Micropalaeontological Society.
- For help in examining collections at the British Museum (Natural History) I thank Dr. John Whittaker and Mr. Richard Hodgekinson; the Bosquet collection in Brussels, Dr. Annie Dhondt; the Pokorný collections in Prague, Drs. Jaromir Zelenka and Dana Štemprakovà; the van Veen and Bonnema collections in Haarlem, Drs. Leendert Witte and Theo Lissenberg.
- For help in translation of foreign literature I thank Drs. D. Danielopol, I. Morawiecka and Prof. Jan Jania.
- For help in collection of field samples, Drs. P. Carey, I. Jarvis, K. Jarvis, N. Johnson and Miss C. Frost.
- For printing of the stereo-pairs, Pat Brown.
- I thank my employers at the School of Earth and Environmental Sciences, University of Greenwich for allowing me time to undertake this research project, and for financial support which enabled my attendance at many international meetings.
- I thank Caroline Frost for her encouragement and support which gave me the confidence, when I needed it most, to complete this work.

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PLATE EXPLANATIONS

Fig. PLATE 1 Page

Polycope lunaplena sp. nov. 50

ABCMR1a, Gun Gardens Marl 1, Lower Turonian.

1 Holotype. Left valve, IJS7/9. External lateral (stereo-pair), x110.

Cytherella concava Weaver, 1982 52

ABCMR1, first marl above Ballard Cliff Member, Lower Turonian.

2 Female, left valve, IJS15/21. External lateral (stereo-pair), x80.

LGSD23, middle of Kingston Nodular Chalks, Upper Turonian.

3 Female, right valve, IJS15/20. External lateral (stereo-pair), x72.

Cytherella contracta van Veen, 1932 54

ABCMR4, 2.5m above Lulworth Marl, Lower Turonian.

4 Male, carapace, IJS15/22. External lateral (stereo-pair), x83.

8 Male, right valve, IJS15/25. External lateral (stereo-pair), x73.

6 Female, right valve, IJS15/23. External lateral (stereo-pair), x68.

ABCMR1a, Gun Gardens Marl 1, Lower Turonian.

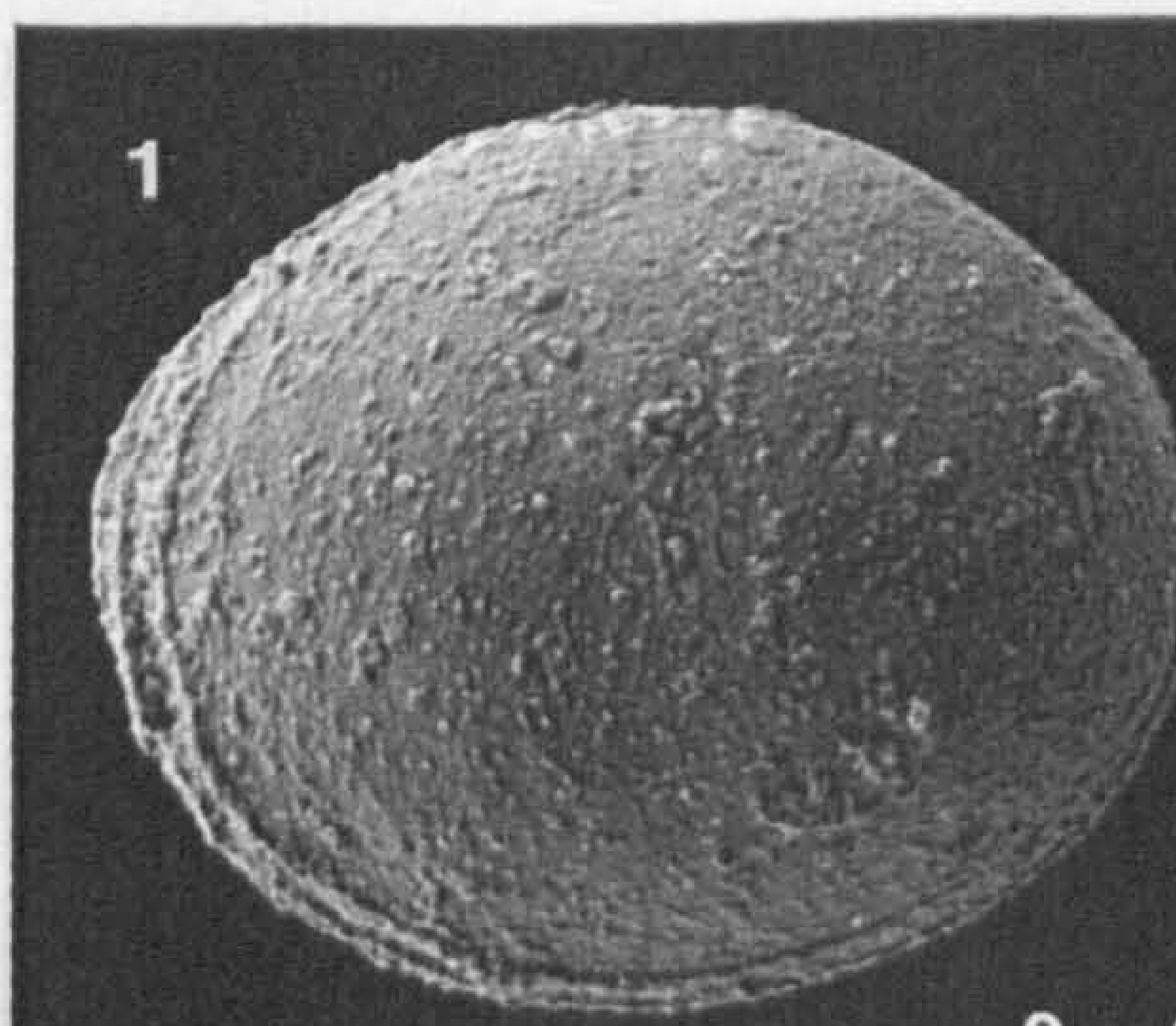
5 Female, left valve, IJS15/24. External lateral (stereo-pair), x73.

AKSD16, Round Down Marl, Middle Turonian.

7 Male, left valve, IJS15/26. External lateral (stereo-pair), x72.

PLATE 1

1



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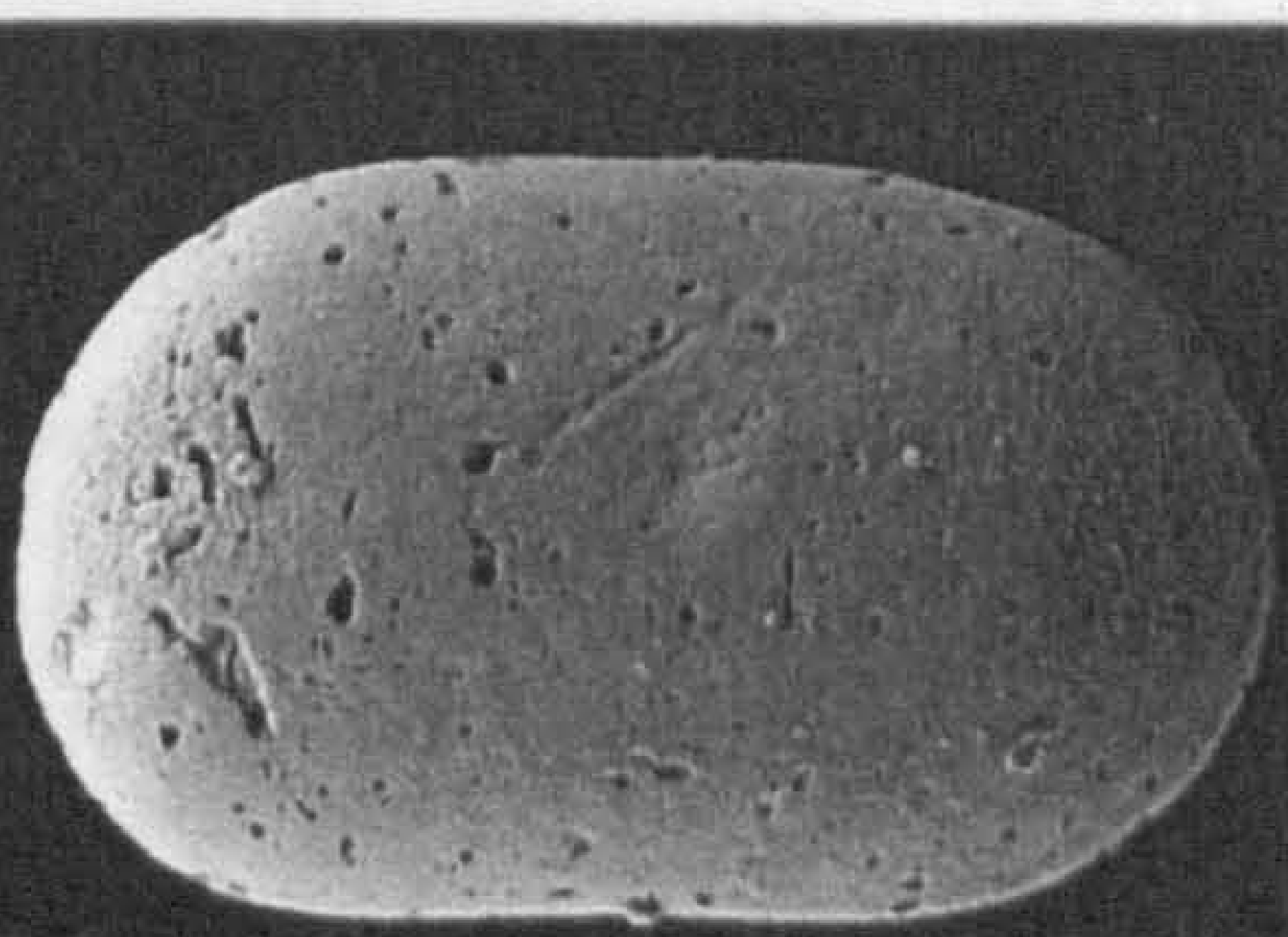

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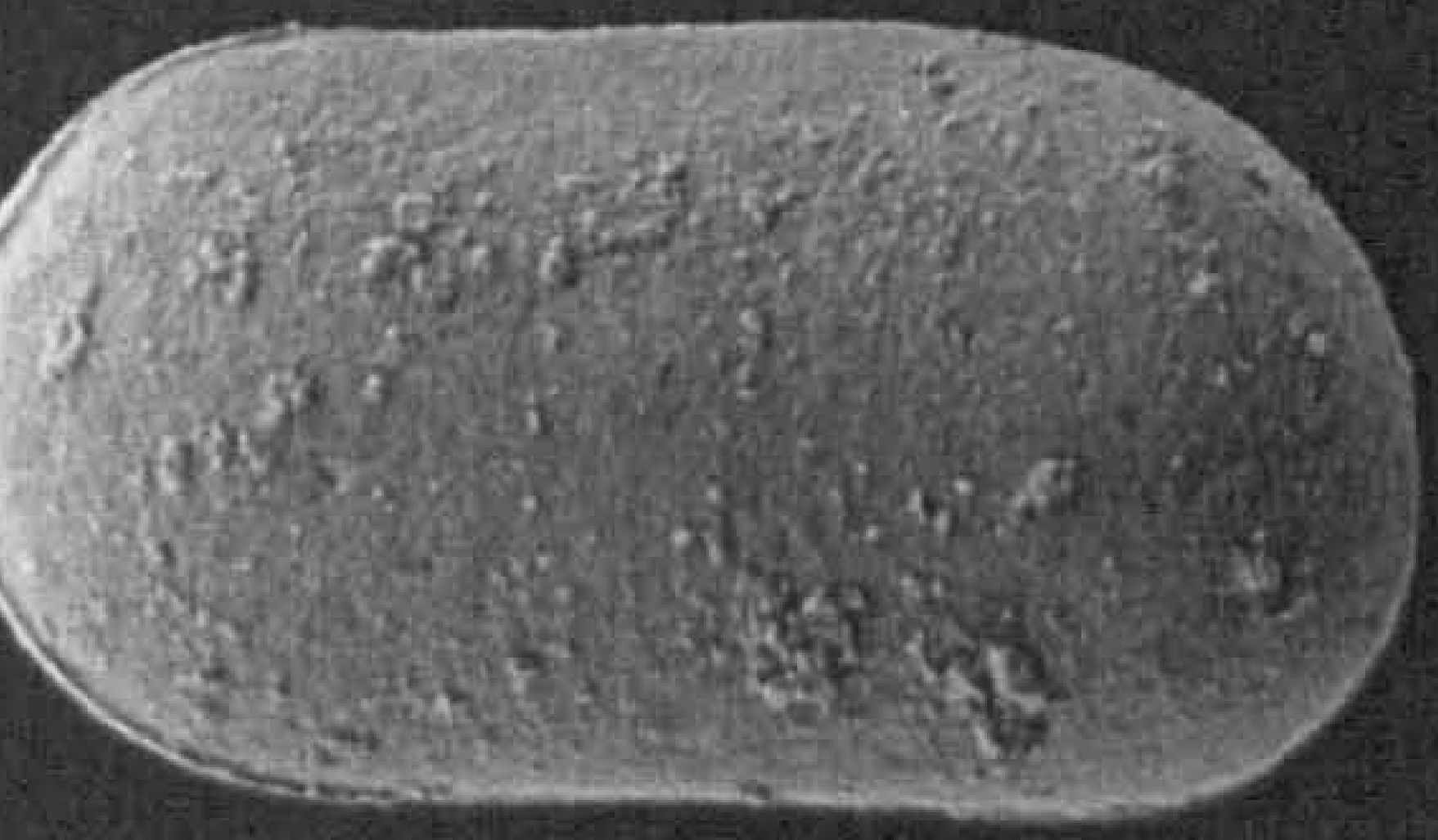

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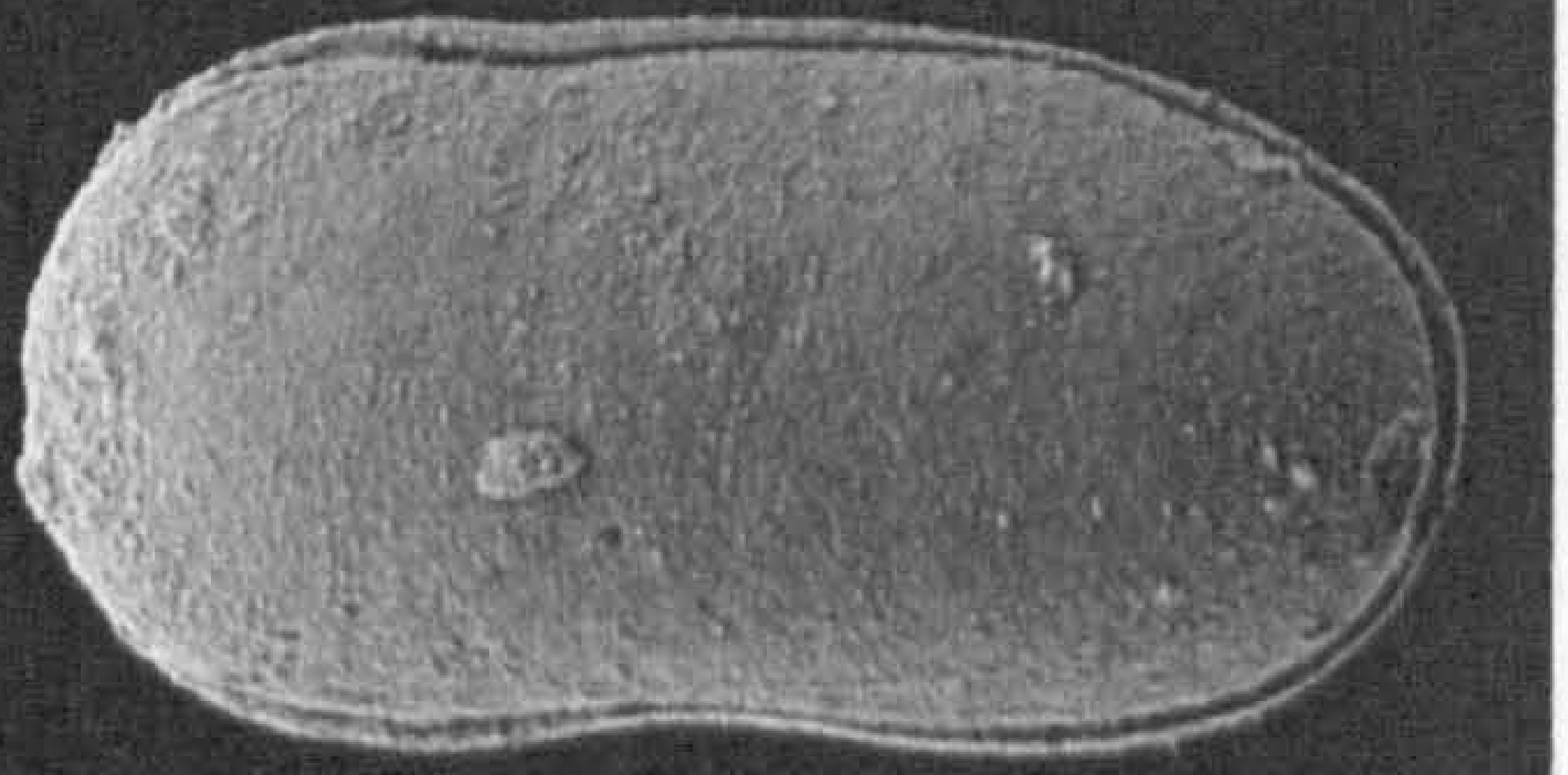

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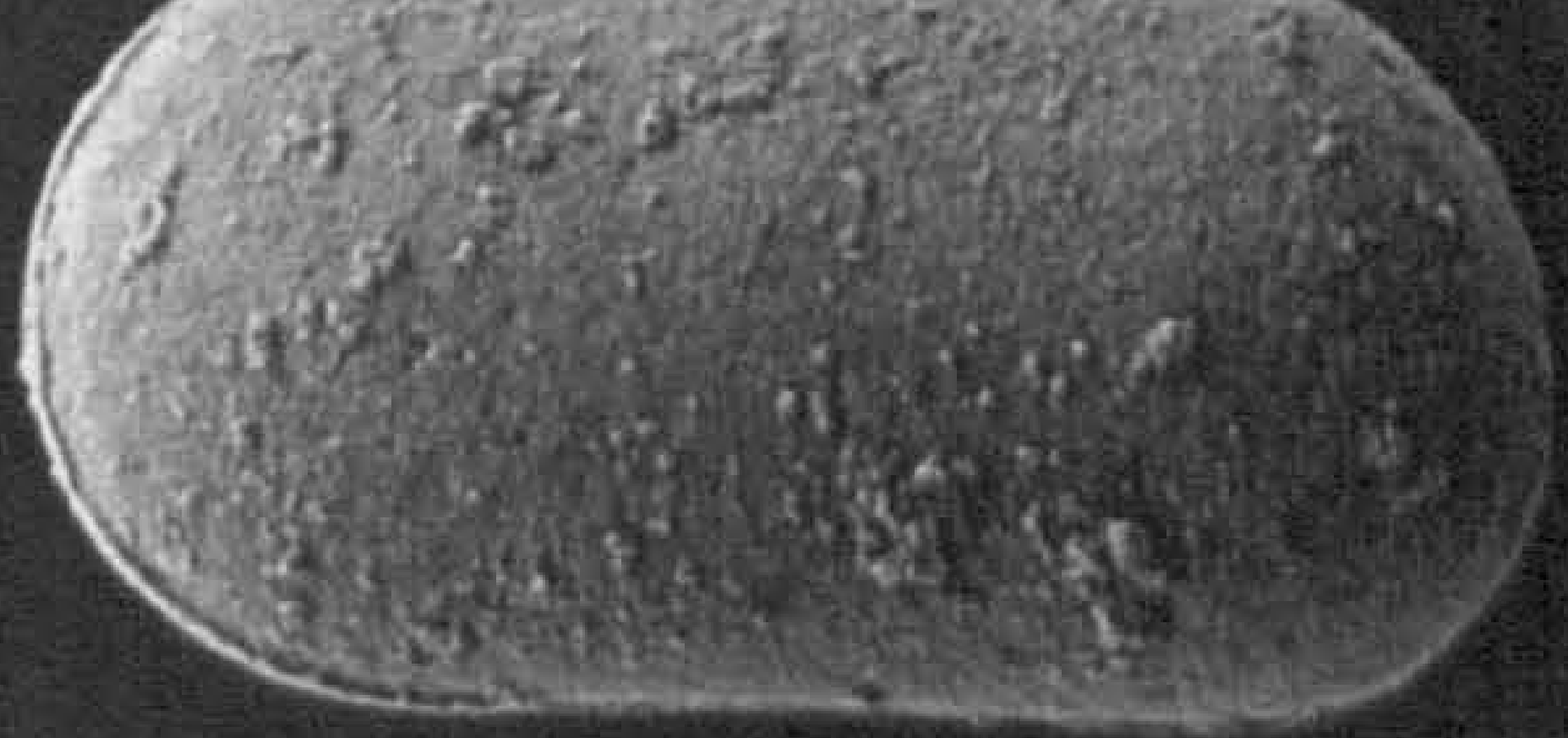

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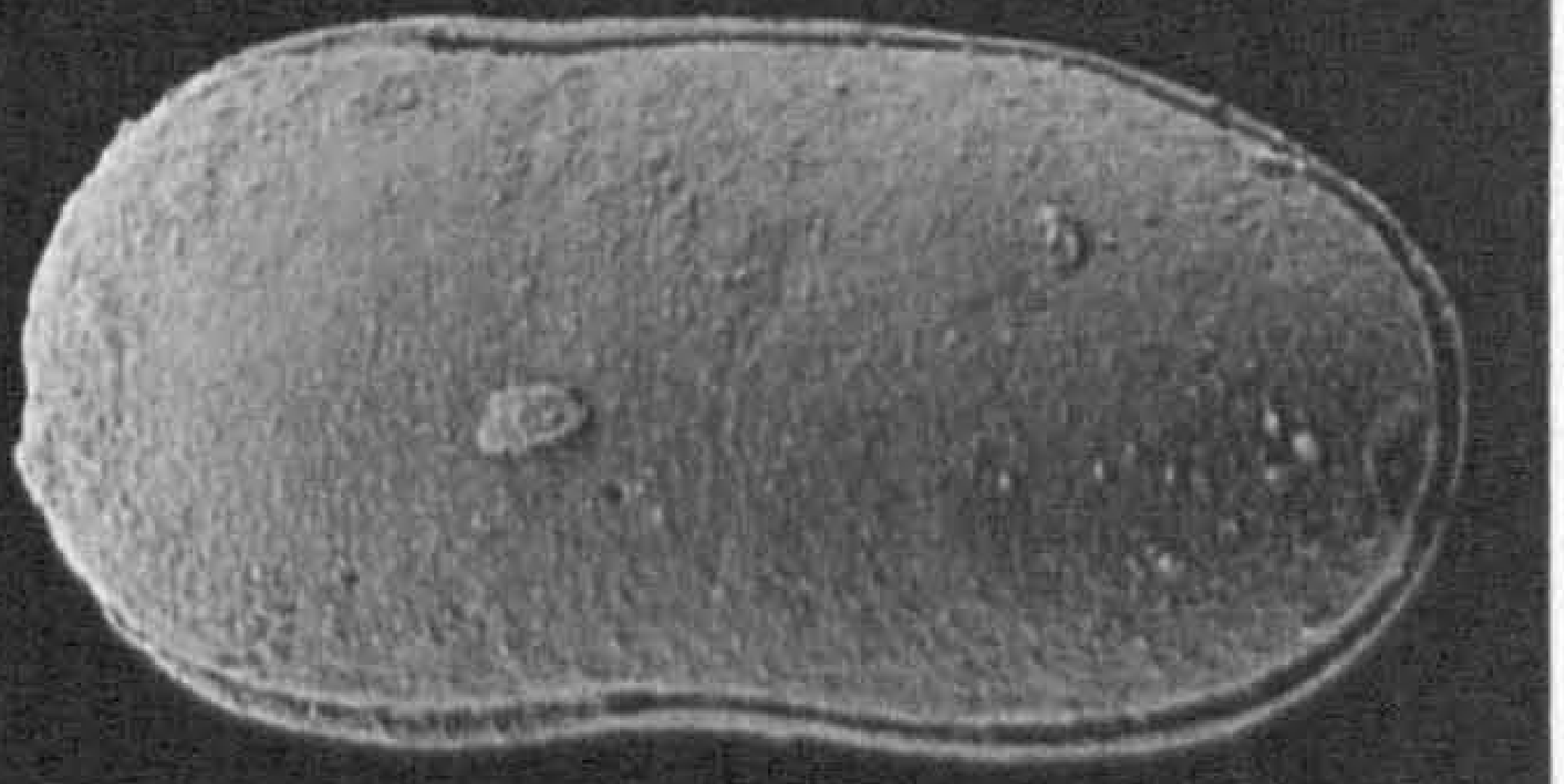

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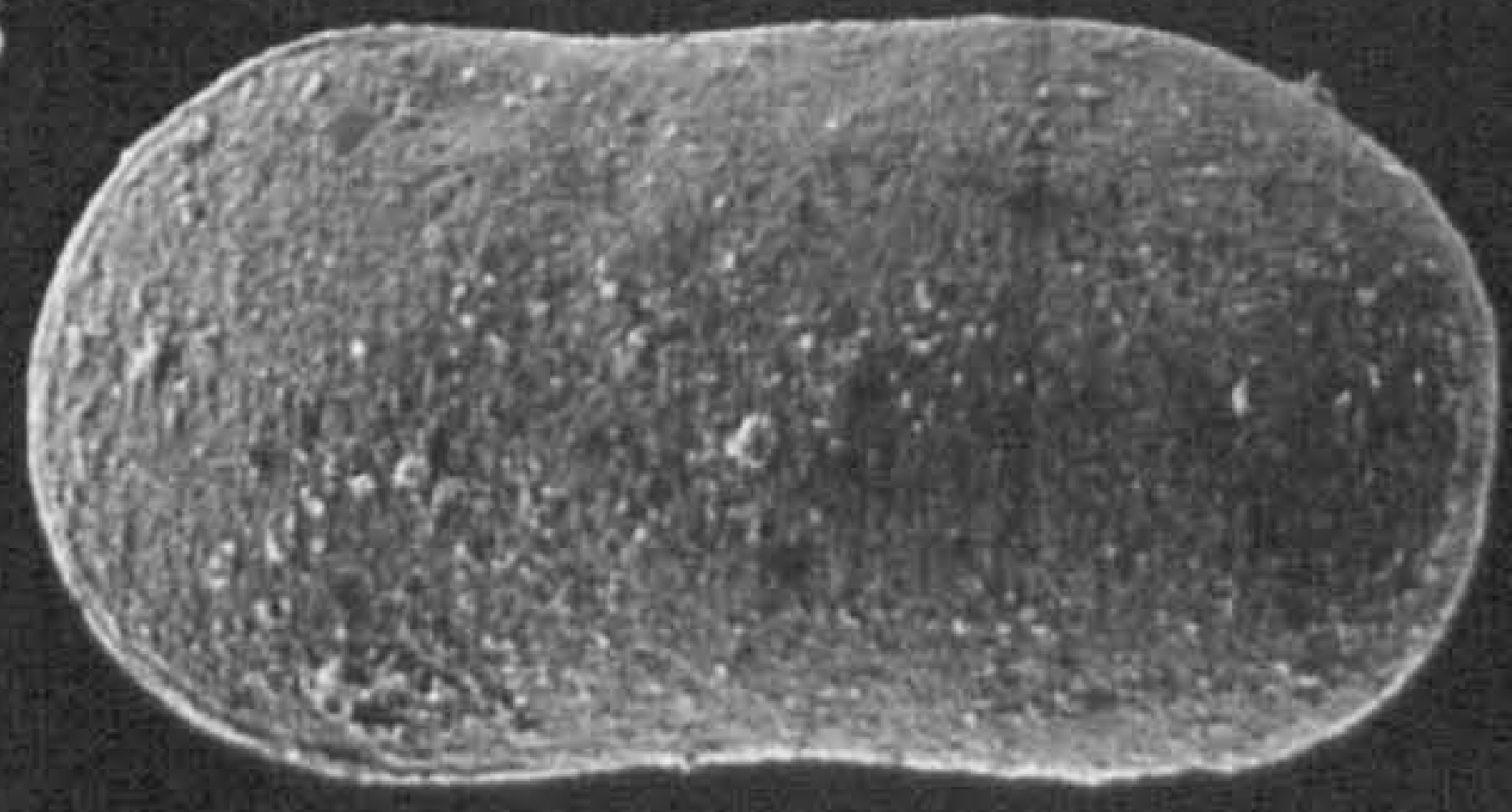

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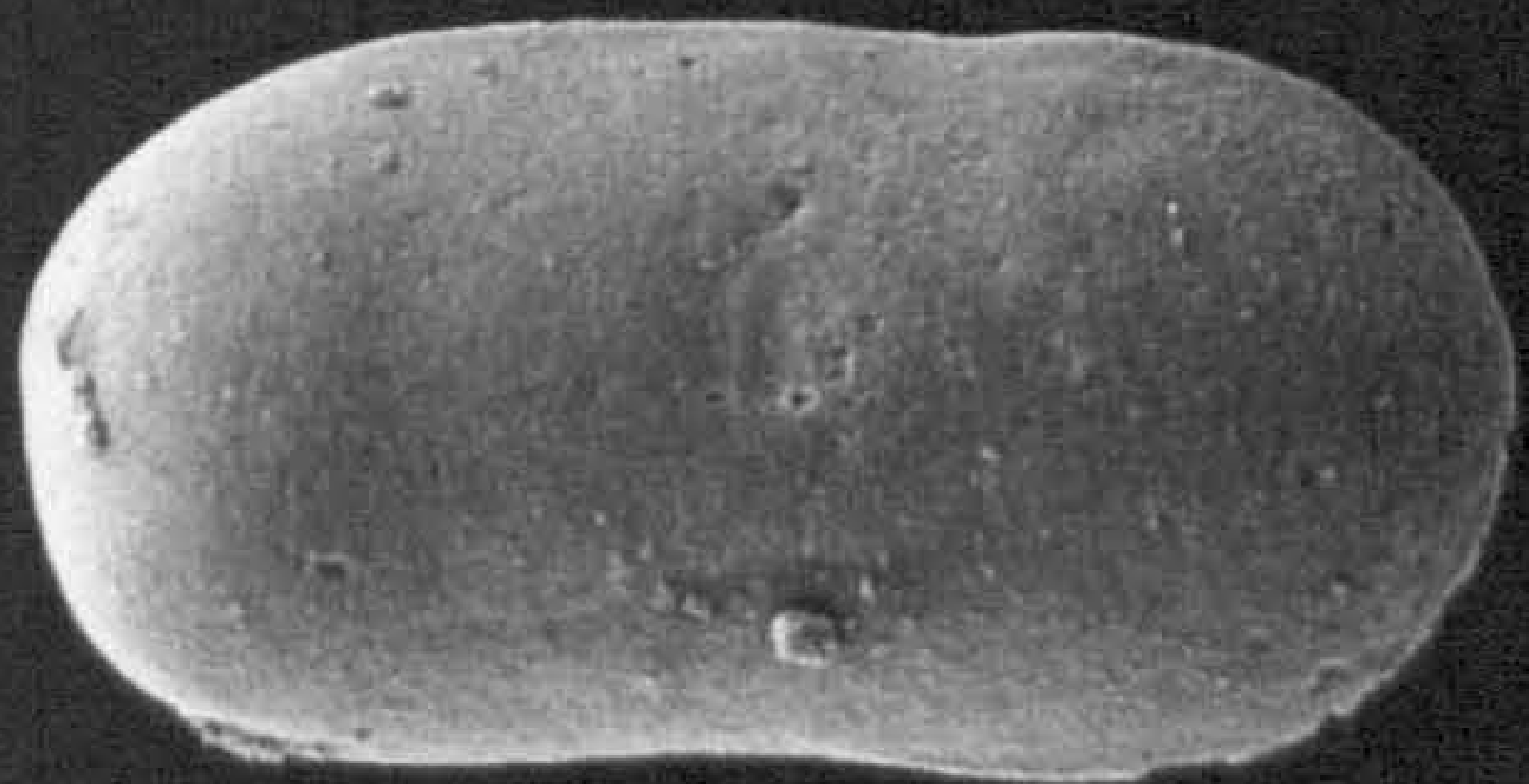

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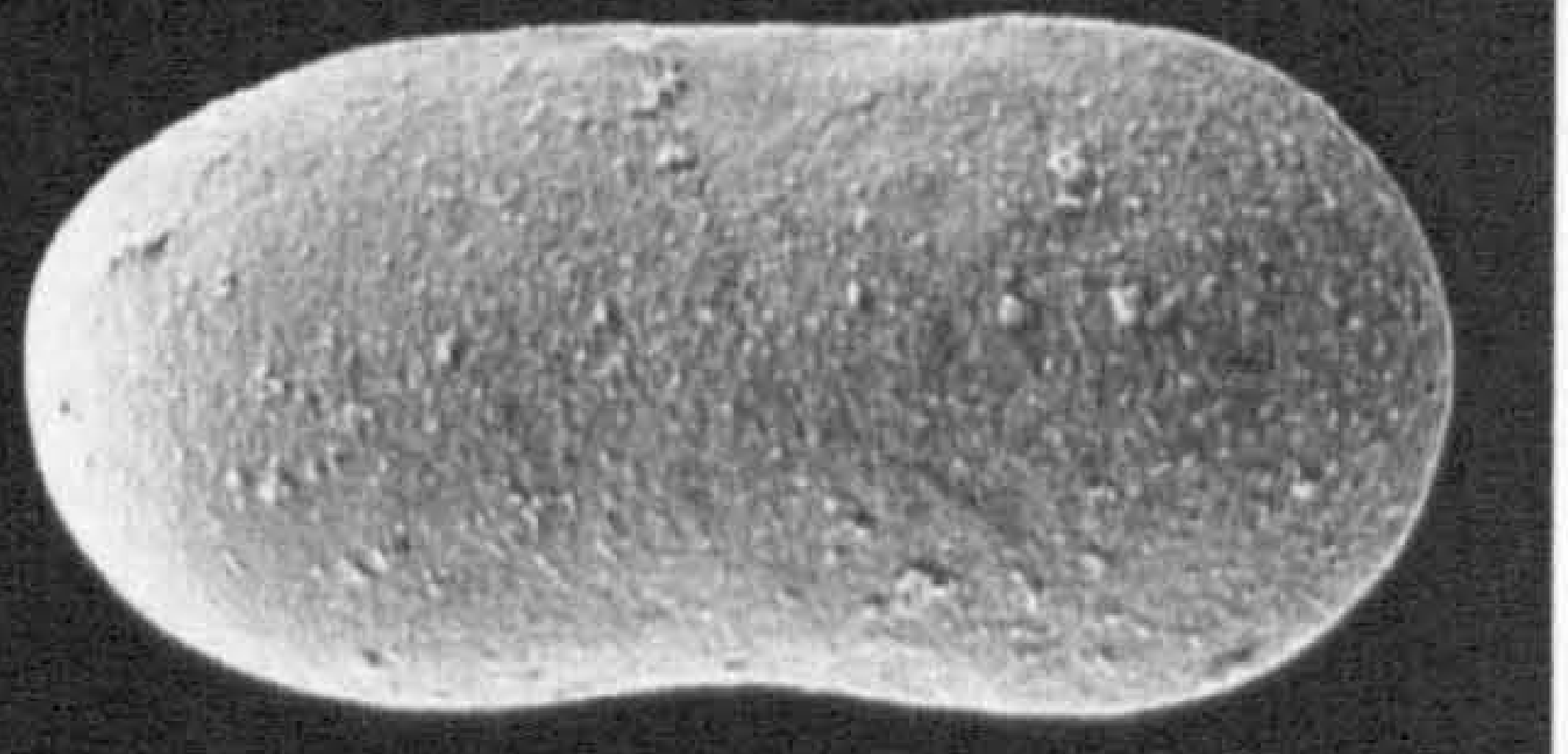

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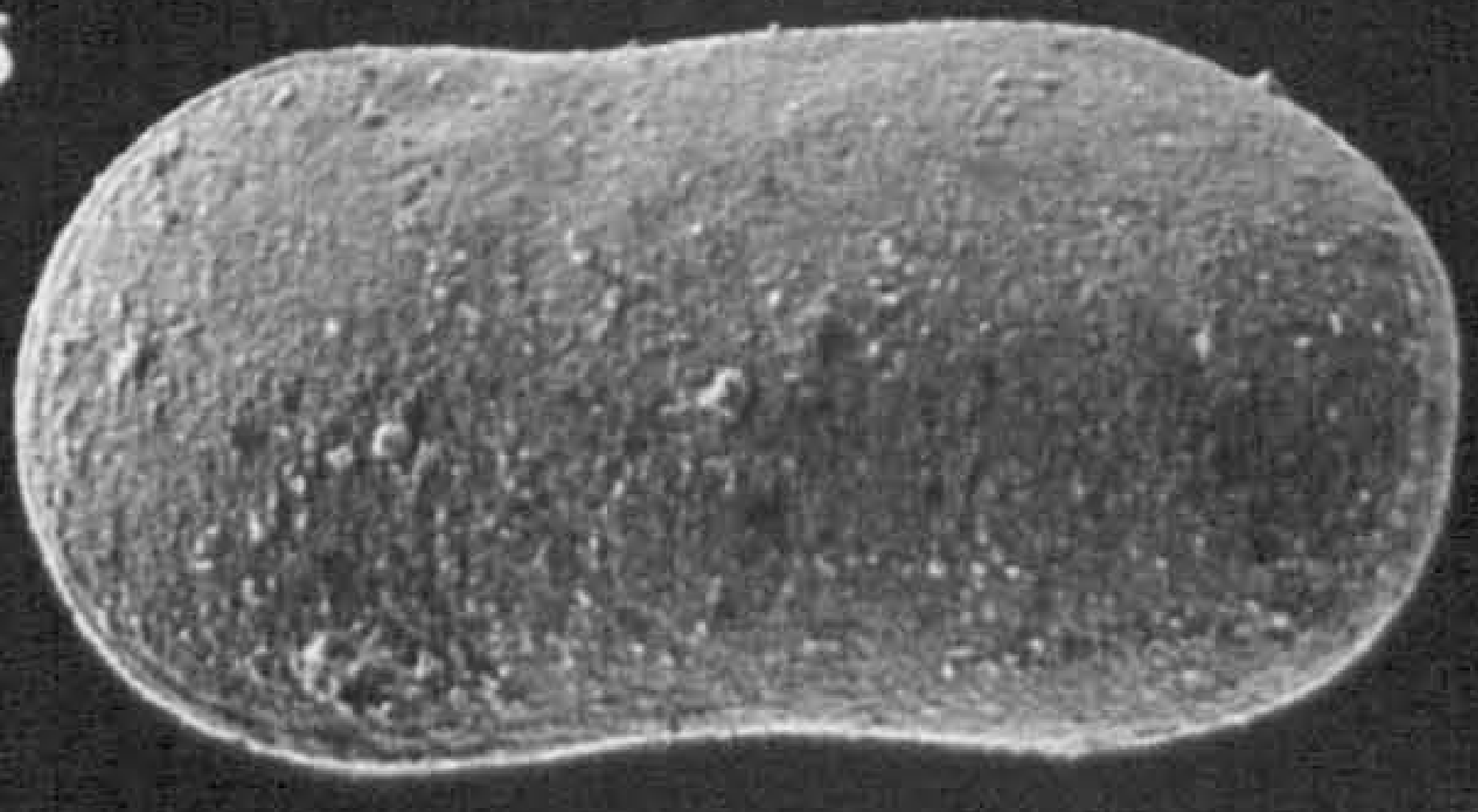

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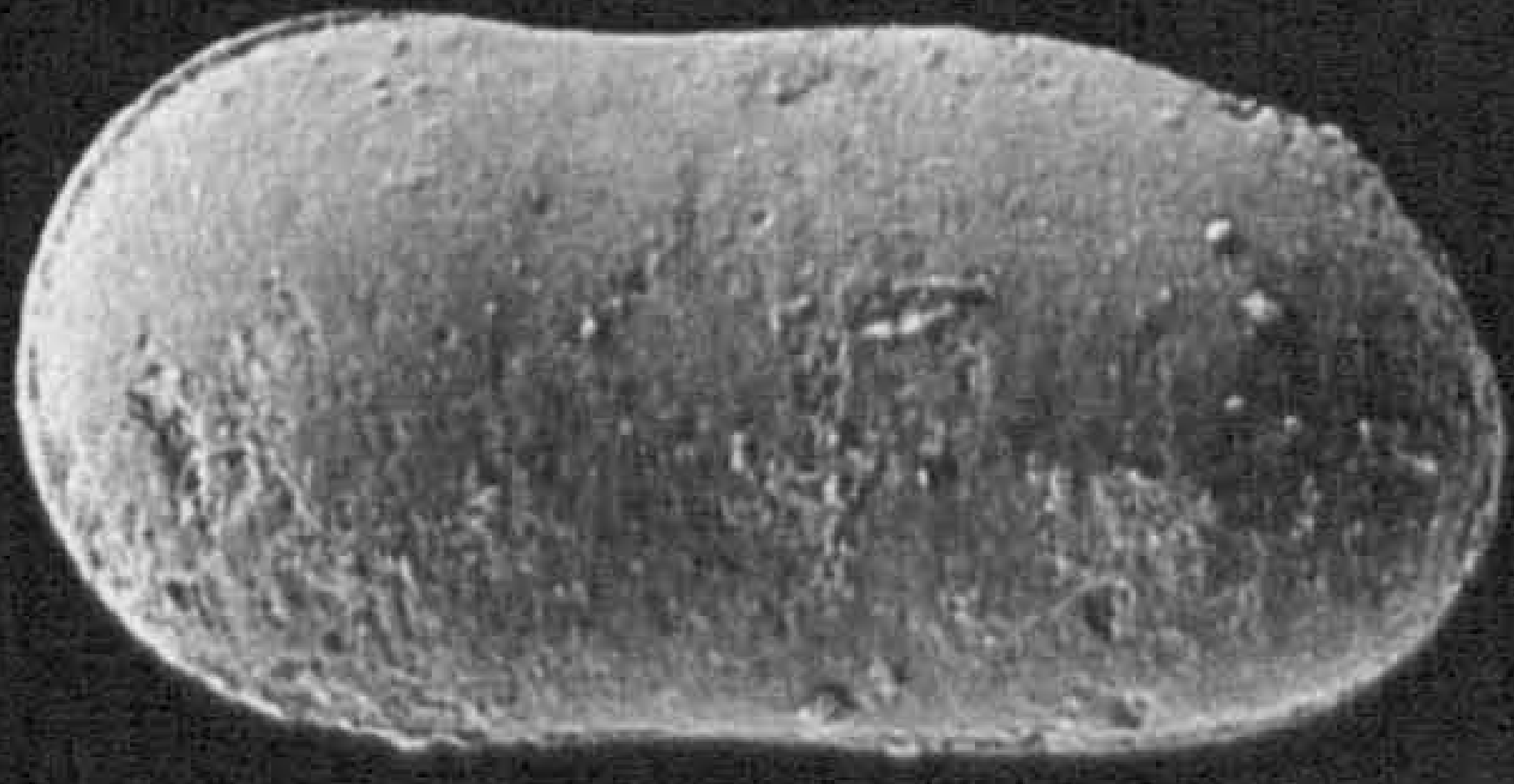

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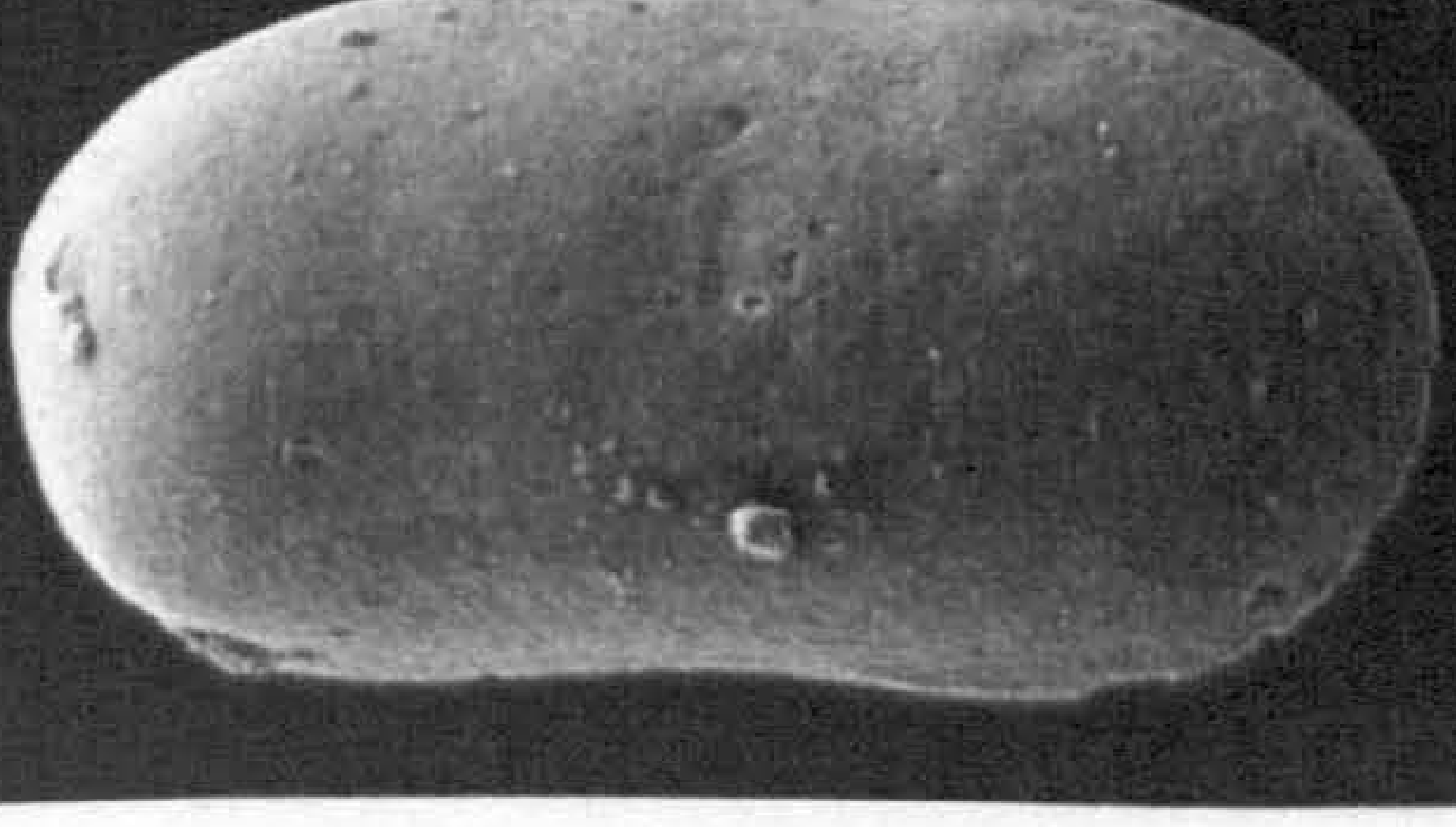

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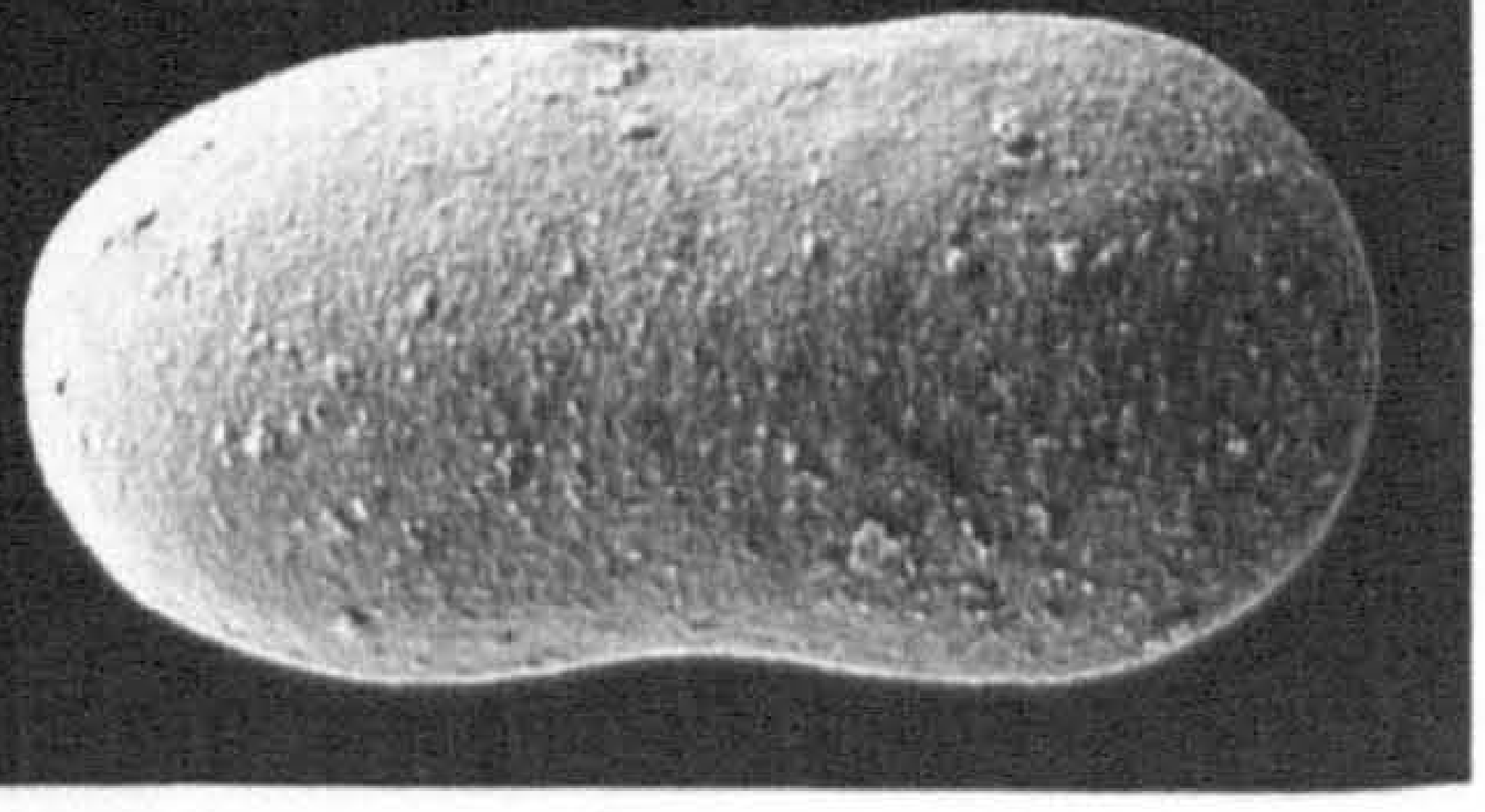

Fig.

PLATE 2

Page

Cytherella ovata (Roemer, 1841) 55

LGSD9, 1.2m below Caburn Marl, Upper Turonian.

1 Female, right valve, IJS15/18. External lateral (stereo-pair), x86.

AKSD55, Southerham Marl 1.

2 Left valve, IJS15/16. External lateral (stereo-pair), x62.

Cytherella truncatoides sp. nov. 57

AKSD33, Glynde Marls, Middle Turonian.

3 Holotype. Female, right valve, IJS15/29. External lateral (stereo-pair), x72.

8 Female, carapace, IJS15/30. Left lateral (stereo-pair), x75.

AKSD29, 3.1m above New Pit Marl 2, Middle Turonian.

4 Male, right valve, IJS15/27. External lateral (stereo-pair), x75.

Cytherella vulna sp. nov. 60

LGSD23, middle of Kingston Nodular Chalks, Upper Turonian.

5 Female, left valve, IJS15/14. External lateral (stereo-pair), x73.

LGSD10, 0.6m below Caburn Marl, Upper Turonian.

6 Holotype. Female, right valve, IJS15/13. External lateral (stereo-pair), x78.

7 Male, right valve, IJS15/12. External lateral (stereo-pair), x72.

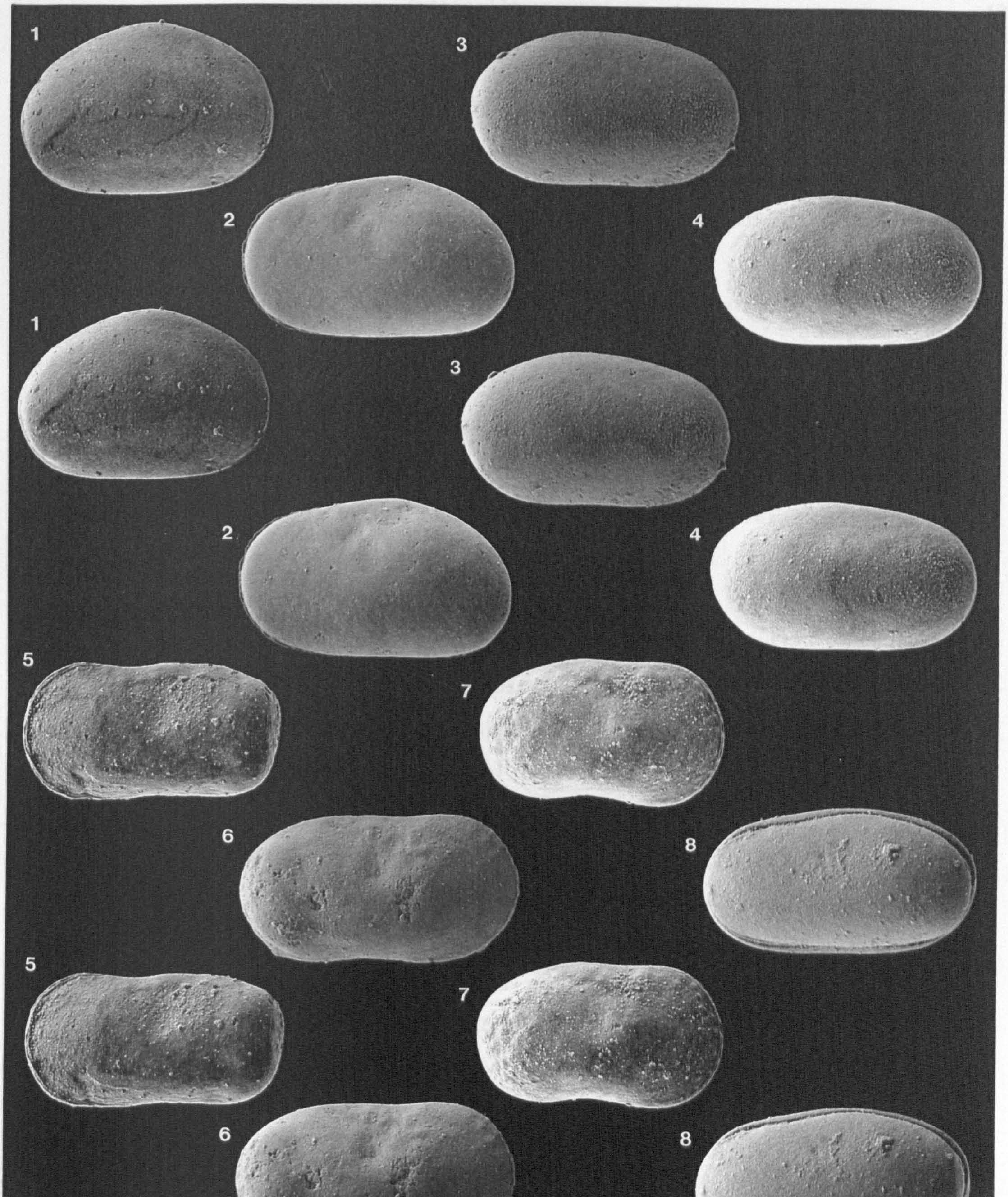
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PLATE 3

Fig.		Page
	Cytherella weaveri sp. nov.	62
	LGSD7, 3.1m below Caburn Marl, Upper Turonian.	
1	Holotype. Female, right valve, IJS15/11. External lateral (stereo-pair), x73.	
	LGSD13, 1.8m above Caburn Marl, Upper Turonian.	
2	Female left valve, IJS15/10. External lateral (stereo-pair), x72.	
3	Male, right valve, IJS15/9. External lateral (stereo-pair), x76.	
	Cytherella sp. A	64
	LGSD13, 1.8m above Caburn Marl, Upper Turonian.	
4	Left valve, IJS15/8. External lateral (stereo-pair), x84.	
7	Right valve, IJS15/7. External lateral (stereo-pair), x82.	
	Cytherelloidea granulosa granulosa (Jones, 1849)	65
	LGSD28, below Navigation Hardground 3, Upper Turonian.	
5	Female, right valve, IJS15/4. External lateral (stereo-pair), x61.	
	LGSD24, top of Kingston Nodular Chalks, Upper Turonian.	
6	Female, left valve, IJS15/2. External lateral (stereo-pair), x62.	
	LGSD23, middle of Kingston Nodular Chalks, Upper Turonian.	
8	Male, left valve, IJS15/1. External lateral (stereo-pair), x63.	

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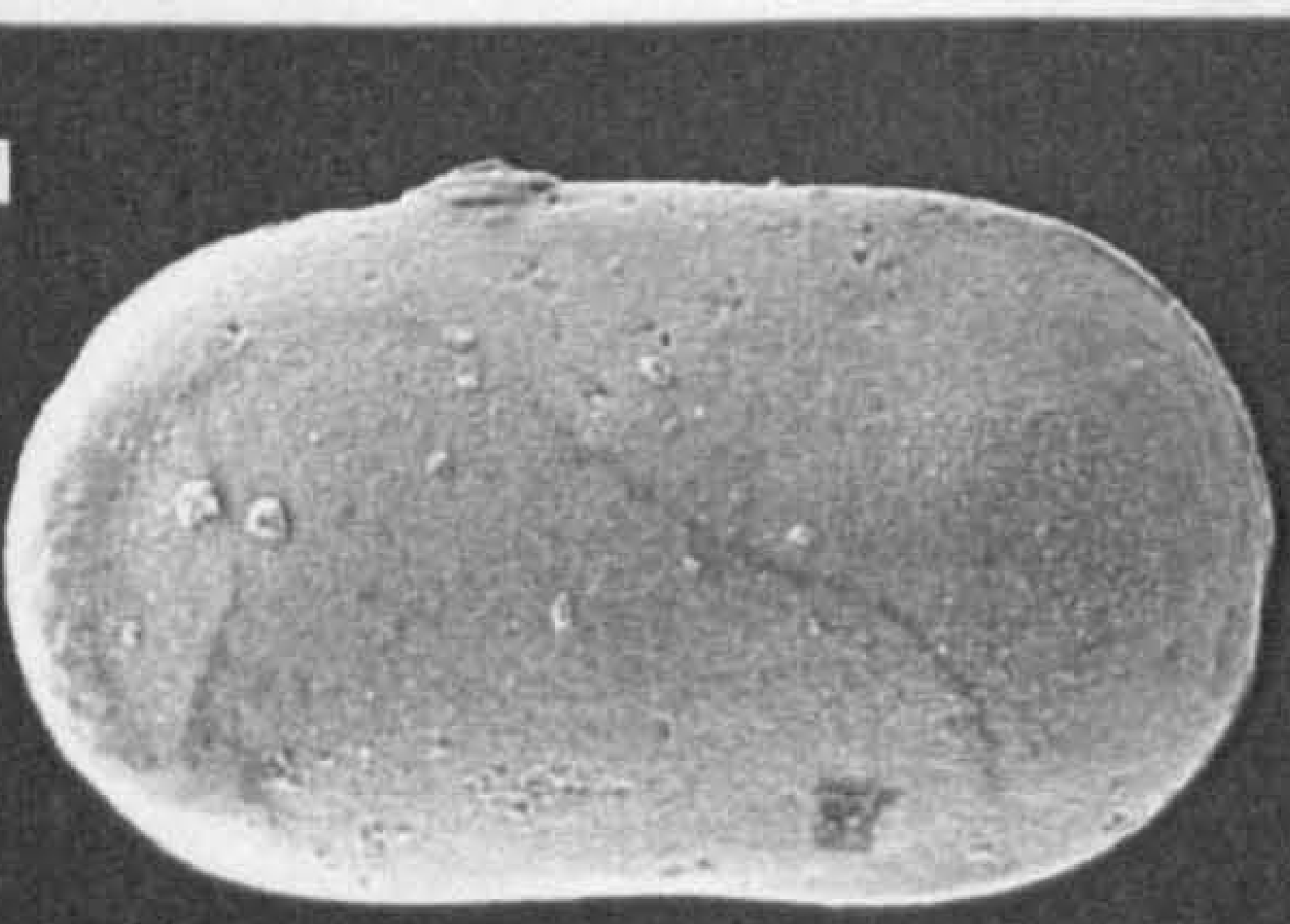

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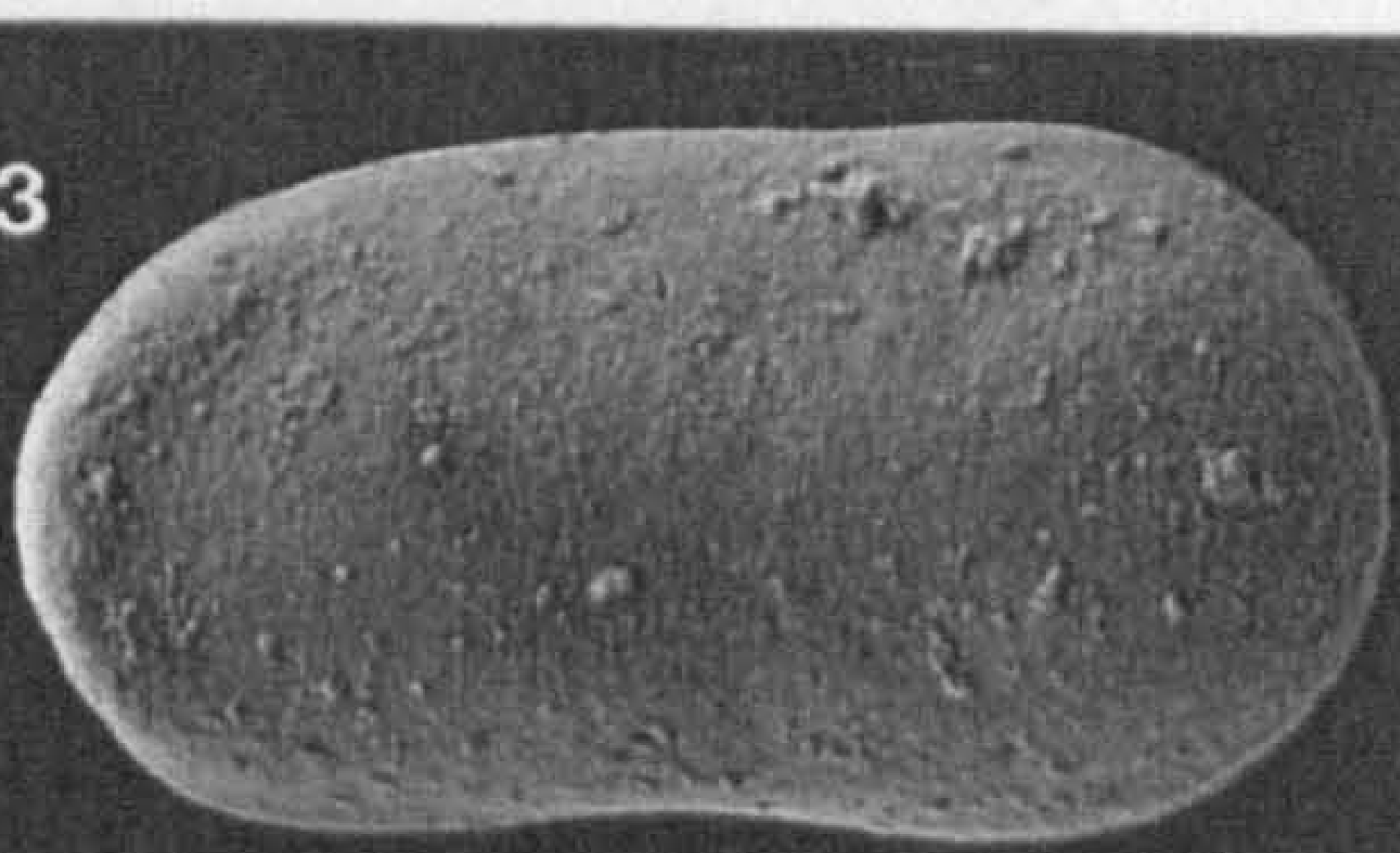

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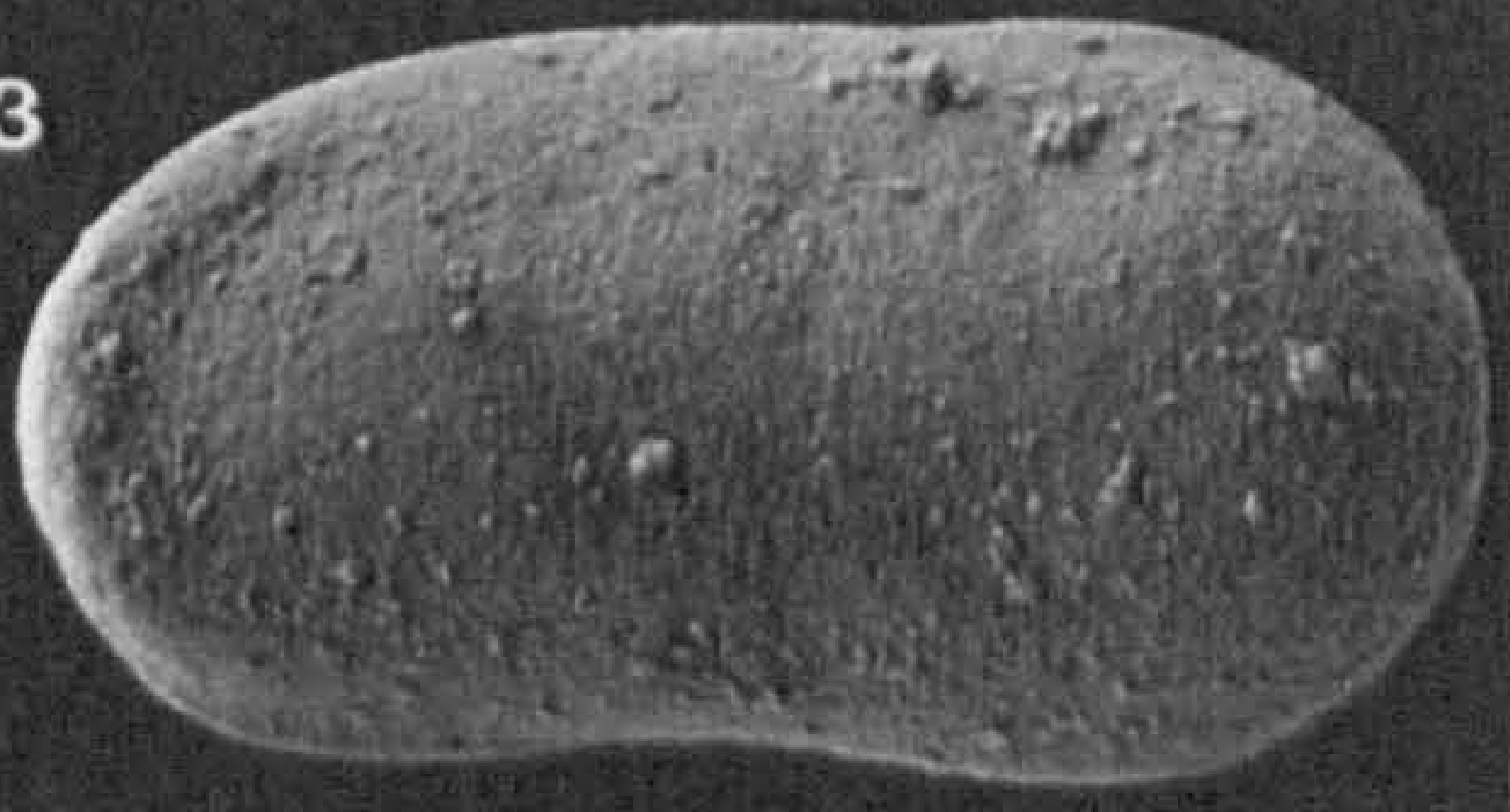

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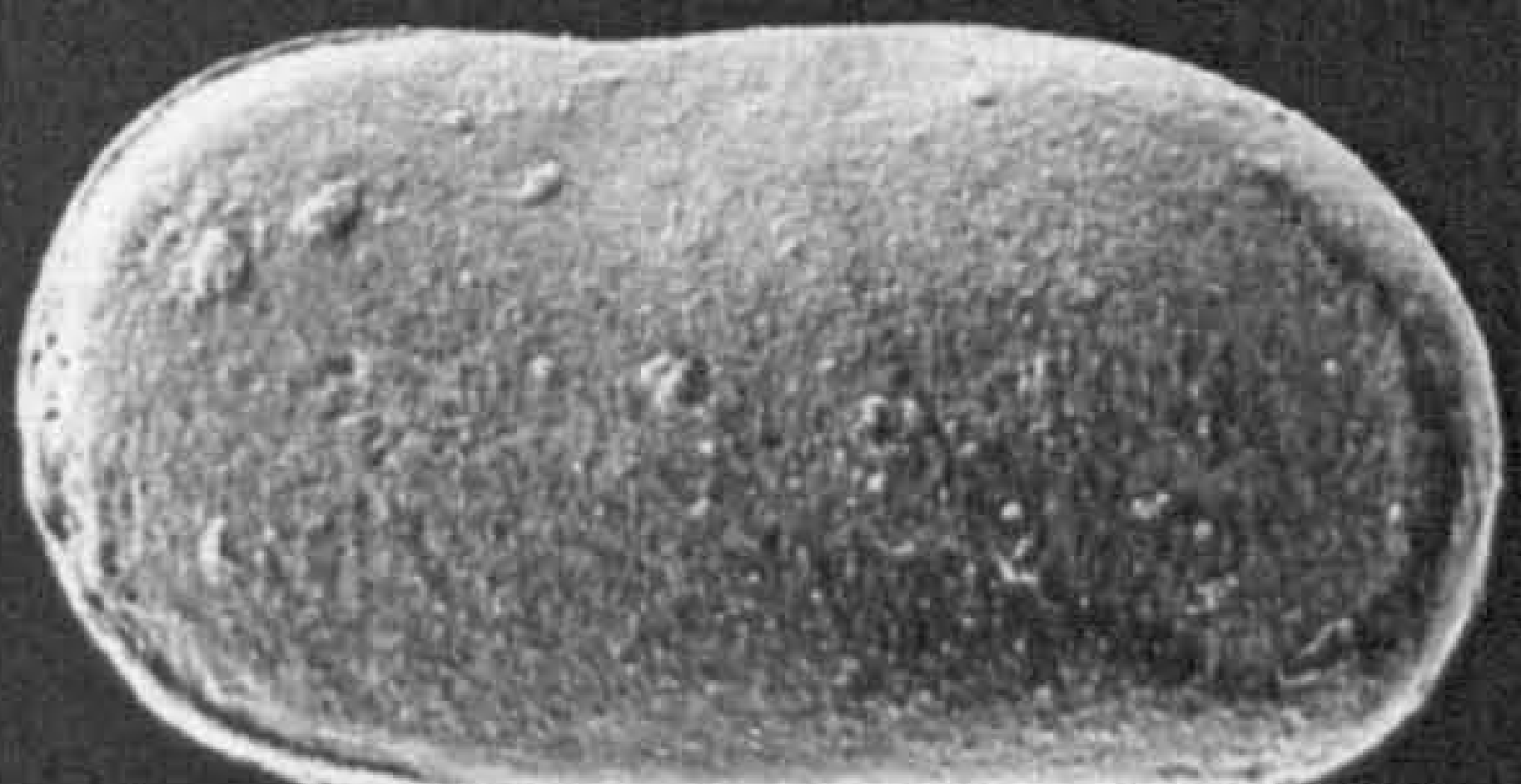

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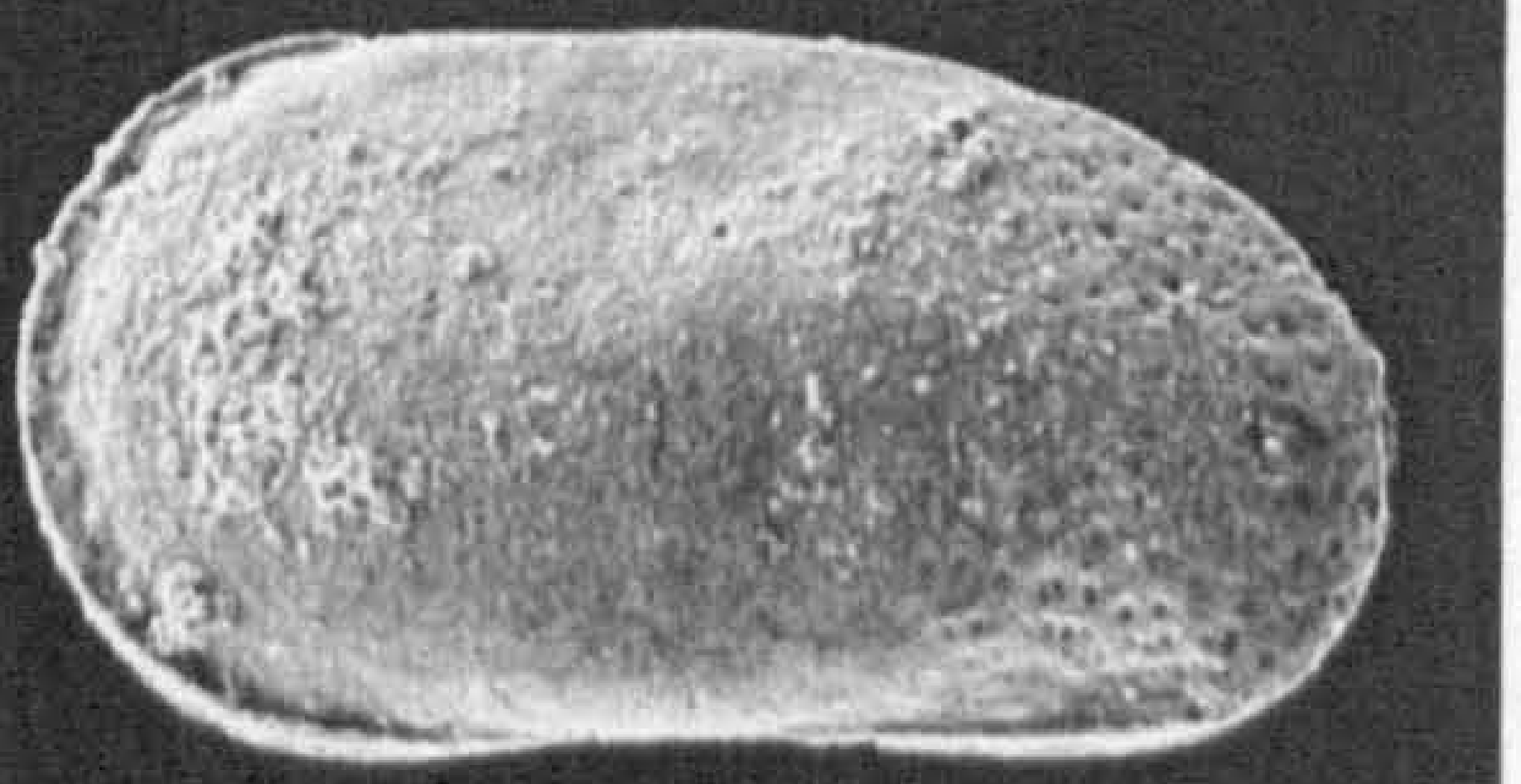

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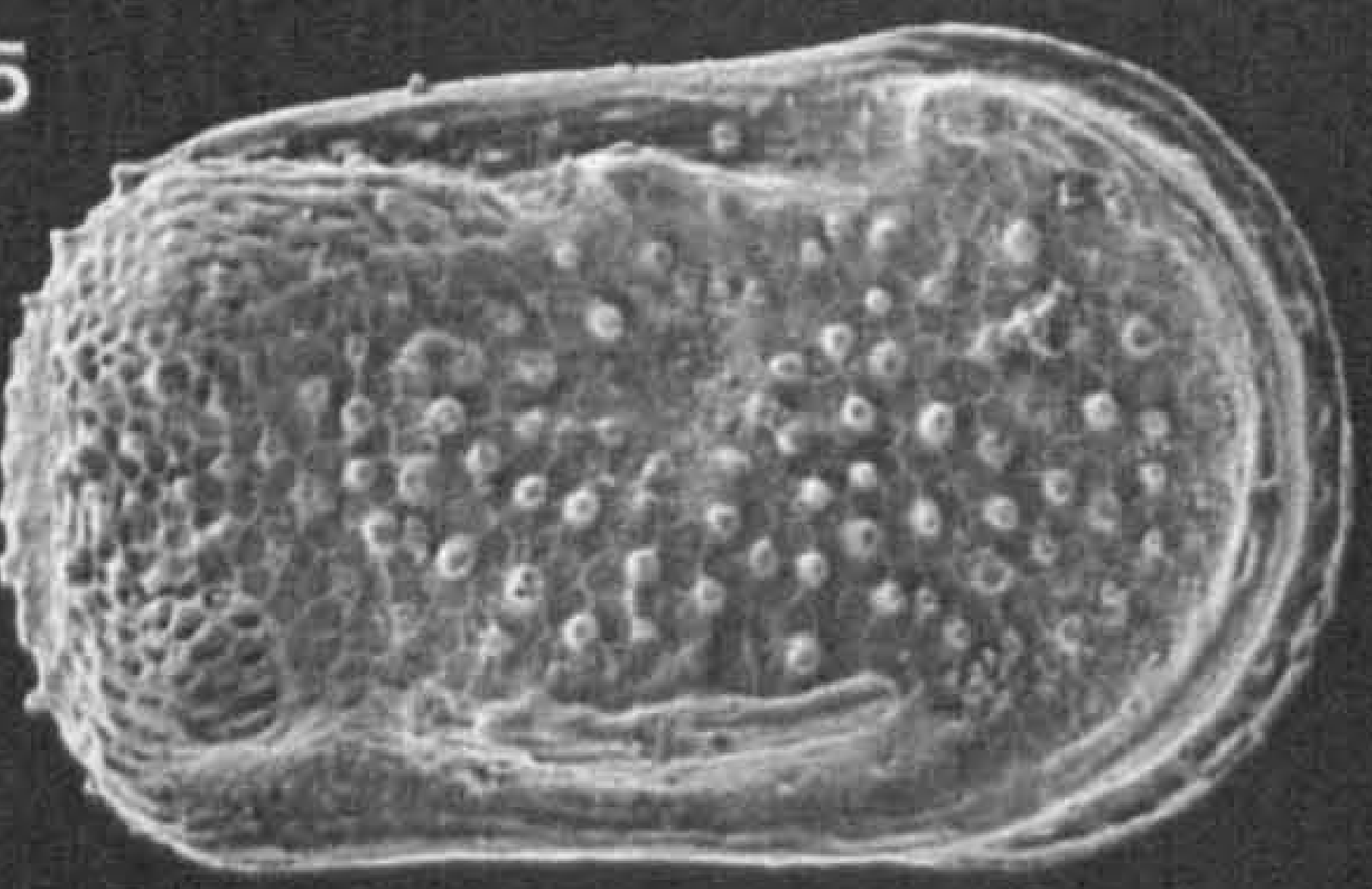

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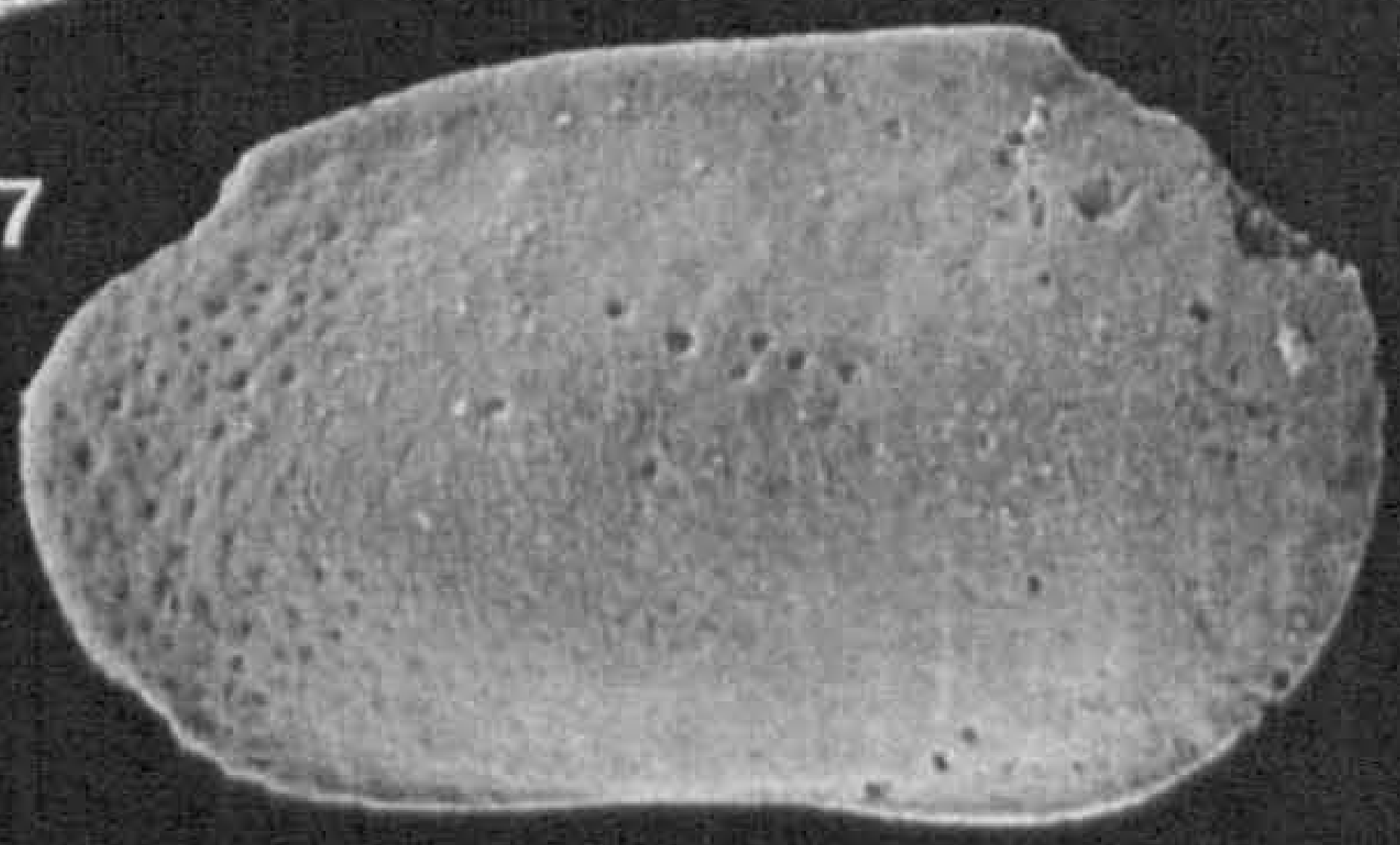

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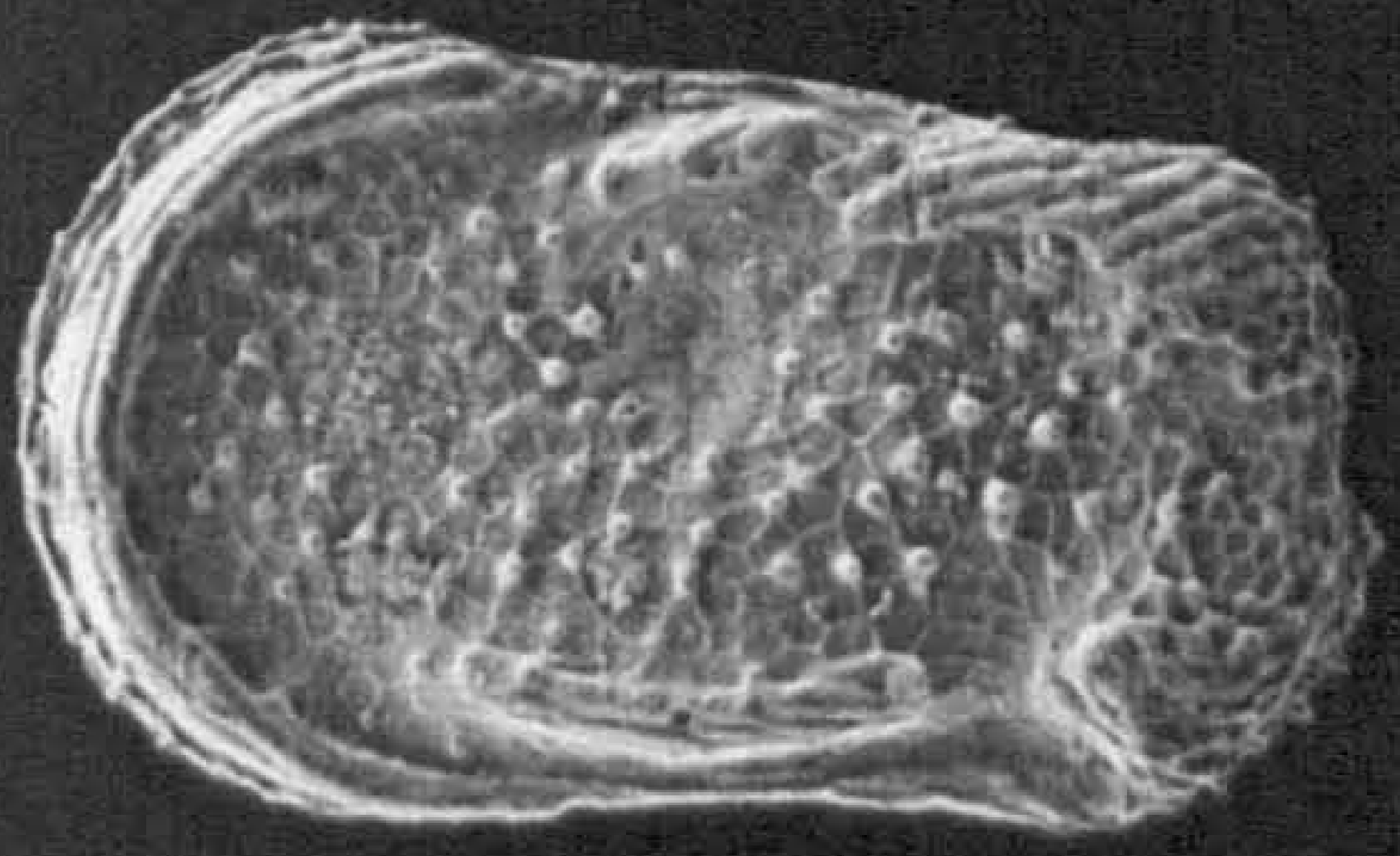

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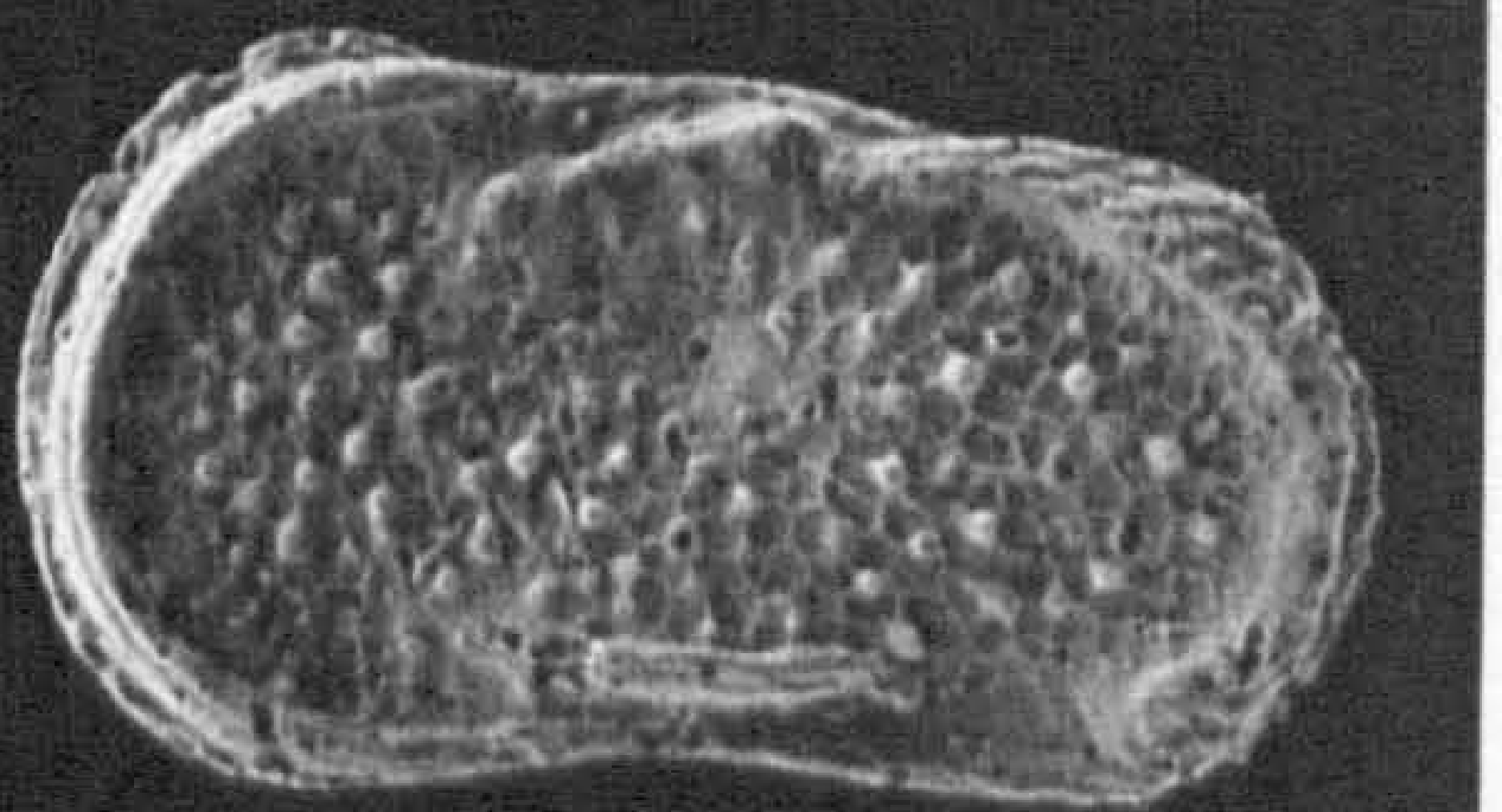

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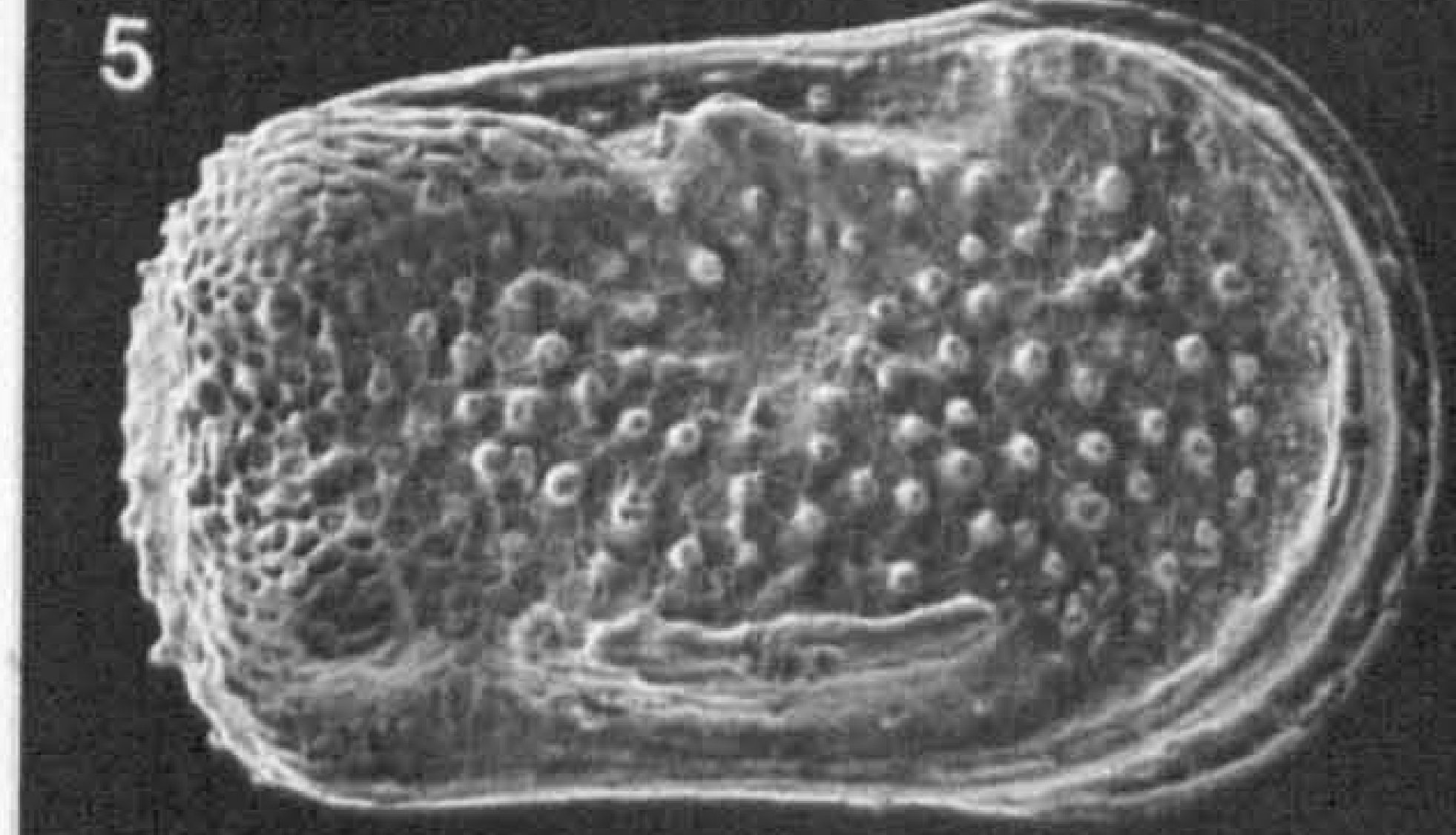

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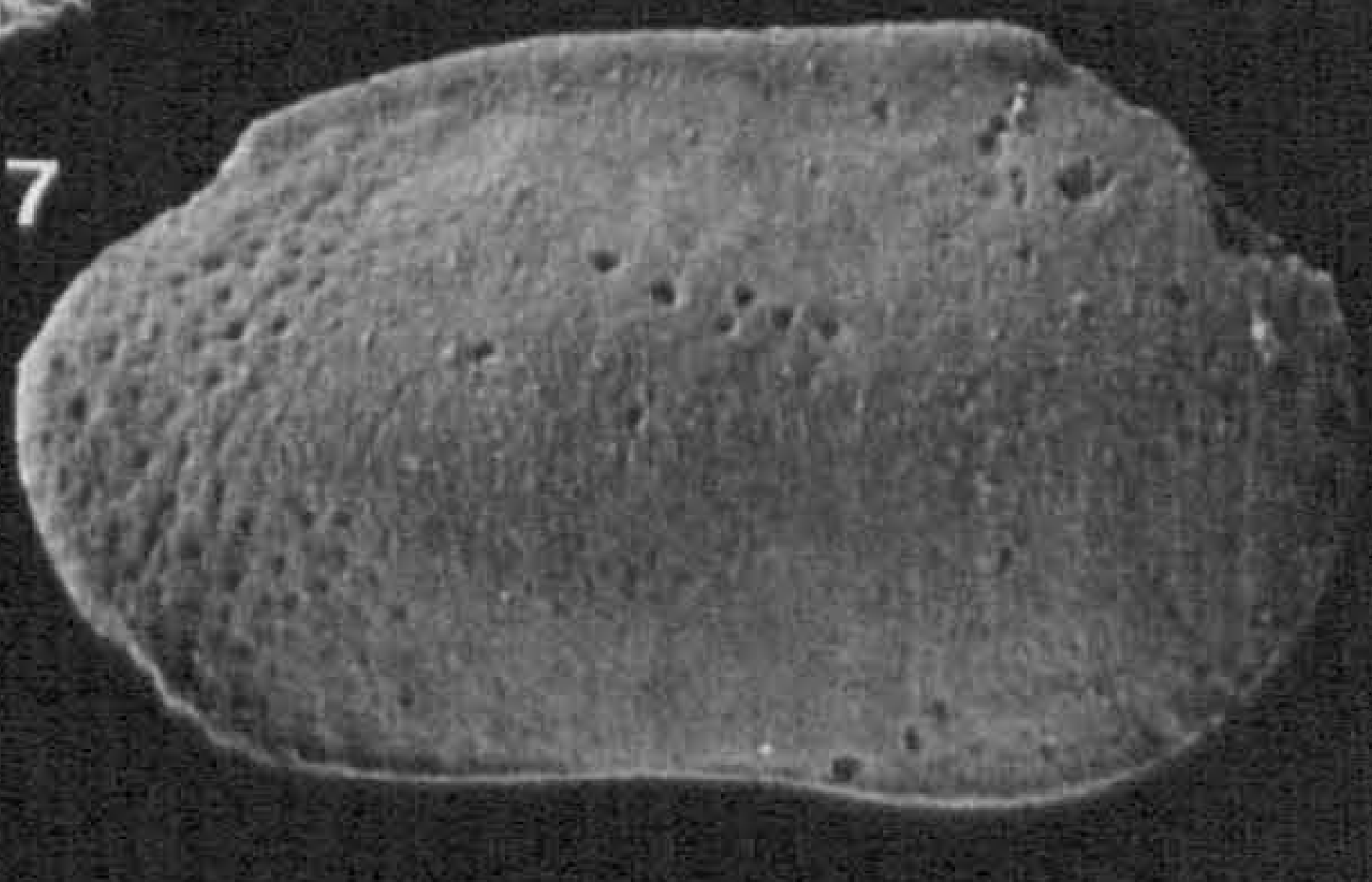

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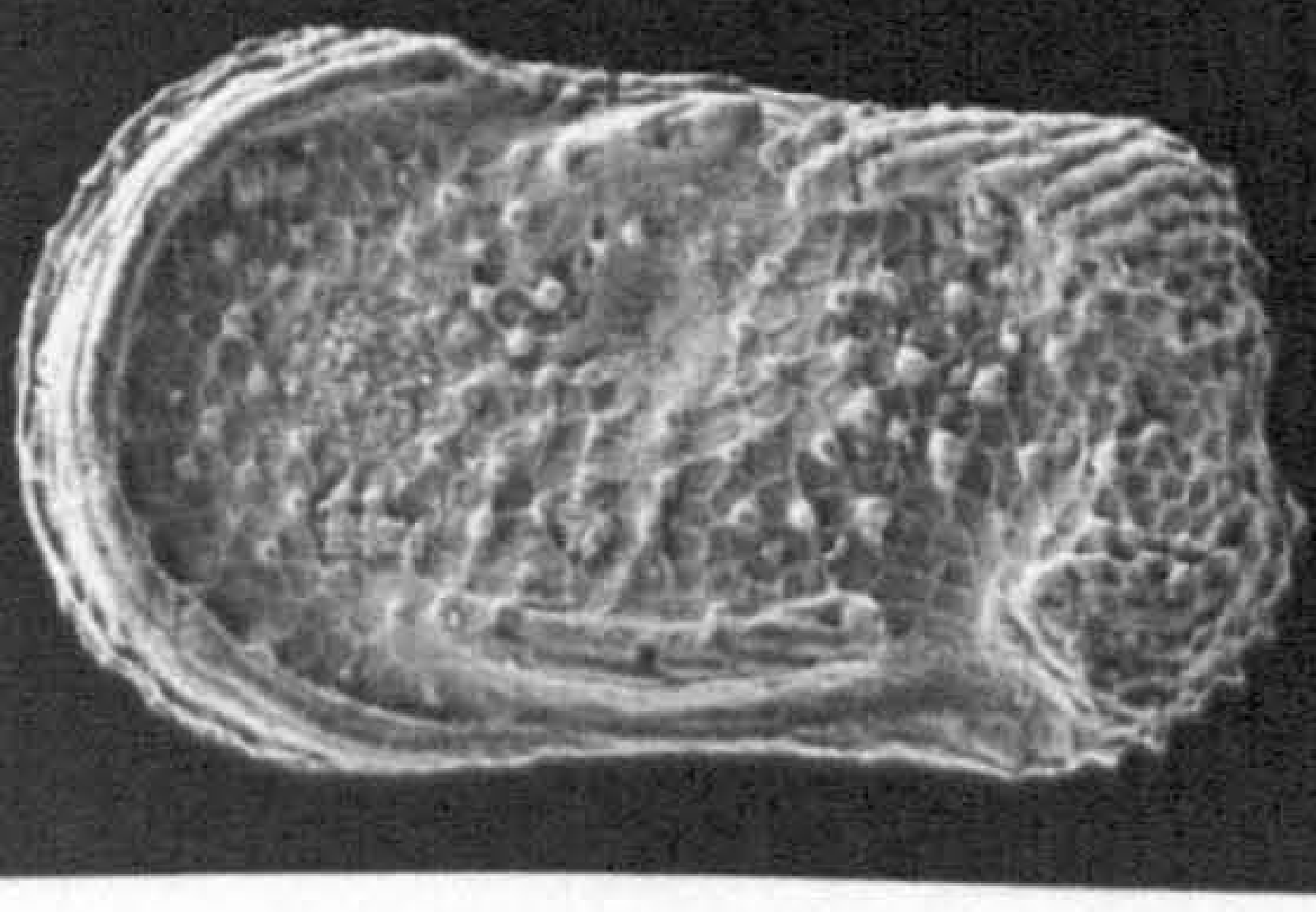

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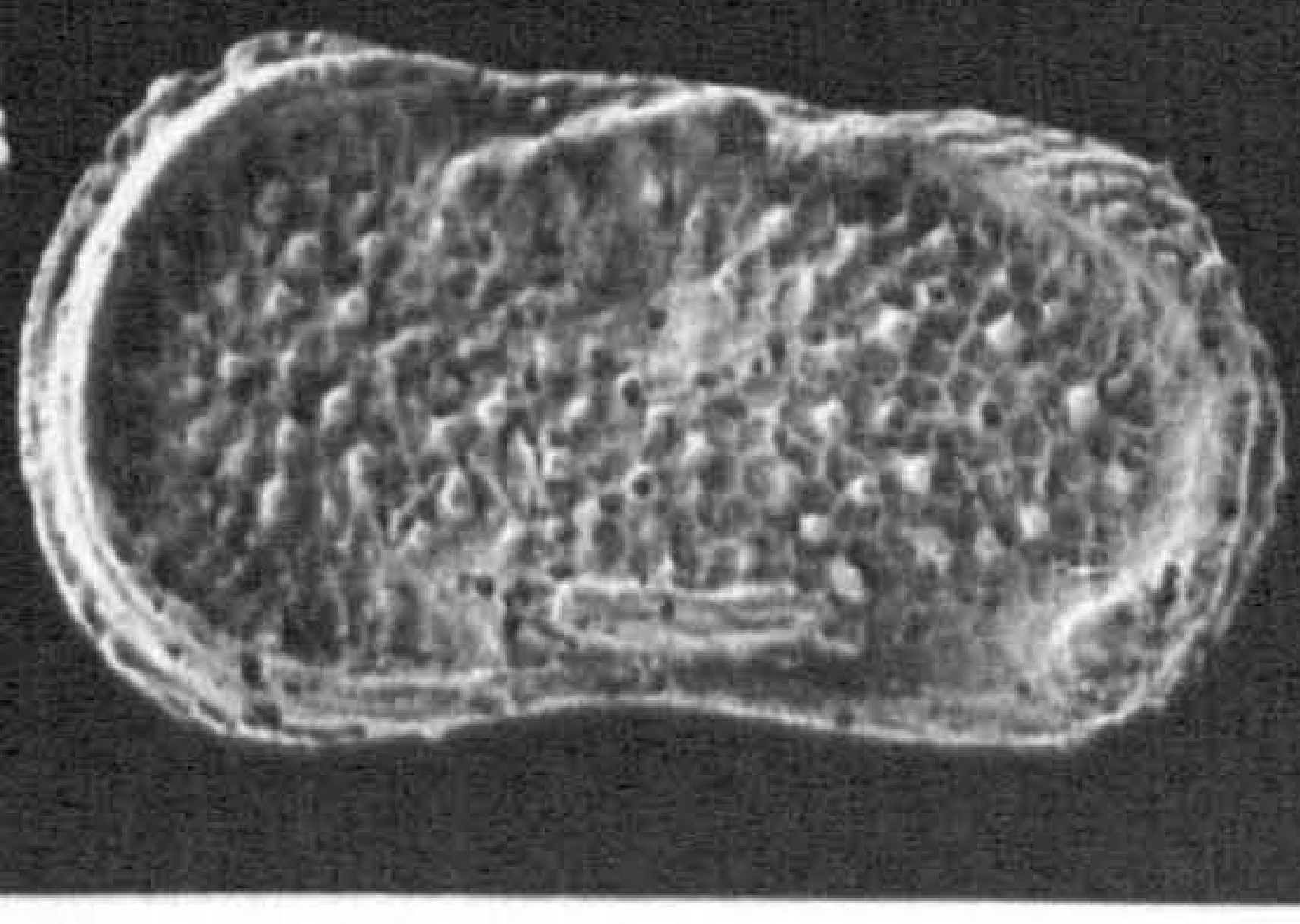

Fig.

PLATE 4

Page

Cytherelloidea granulosa granulosa (Jones, 1849) 65

LGSD25, 1m below Navigation Hardground 1, Upper Turonian.

1 Male, right valve, IJS15/3. External lateral (stereo-pair), x59.

Cytherelloidea granulosa parca ssp. nov. 68

AKSD54, Flint level below Southerham Marl 1, Upper Turonian.

2 Holotype. Female, right valve, IJS15/5. External lateral (stereo-pair), x66.

3 Female, left valve, IJS15/6. External lateral (stereo-pair), x61.

Cytherelloidea hindei Kaye, 1964a 70

ABCMR4, 2.5m above Lulworth Marl, Lower Turonian.

4 Male left valve, IJS19/35. External lateral (stereo-pair), x70.

5 Male right valve, IJS19/34. External lateral (stereo-pair), x76.

6 Female right valve, IJS19/33. External lateral (stereo-pair), x73.

7 Female left valve, IJS19/32. External lateral (stereo-pair), x71.

ABCMR3, Lulworth Marl, Lower Turonian.

8 Right valve juvenile, IJS7/1. External lateral (stereo-pair), x80.

PLATE 4

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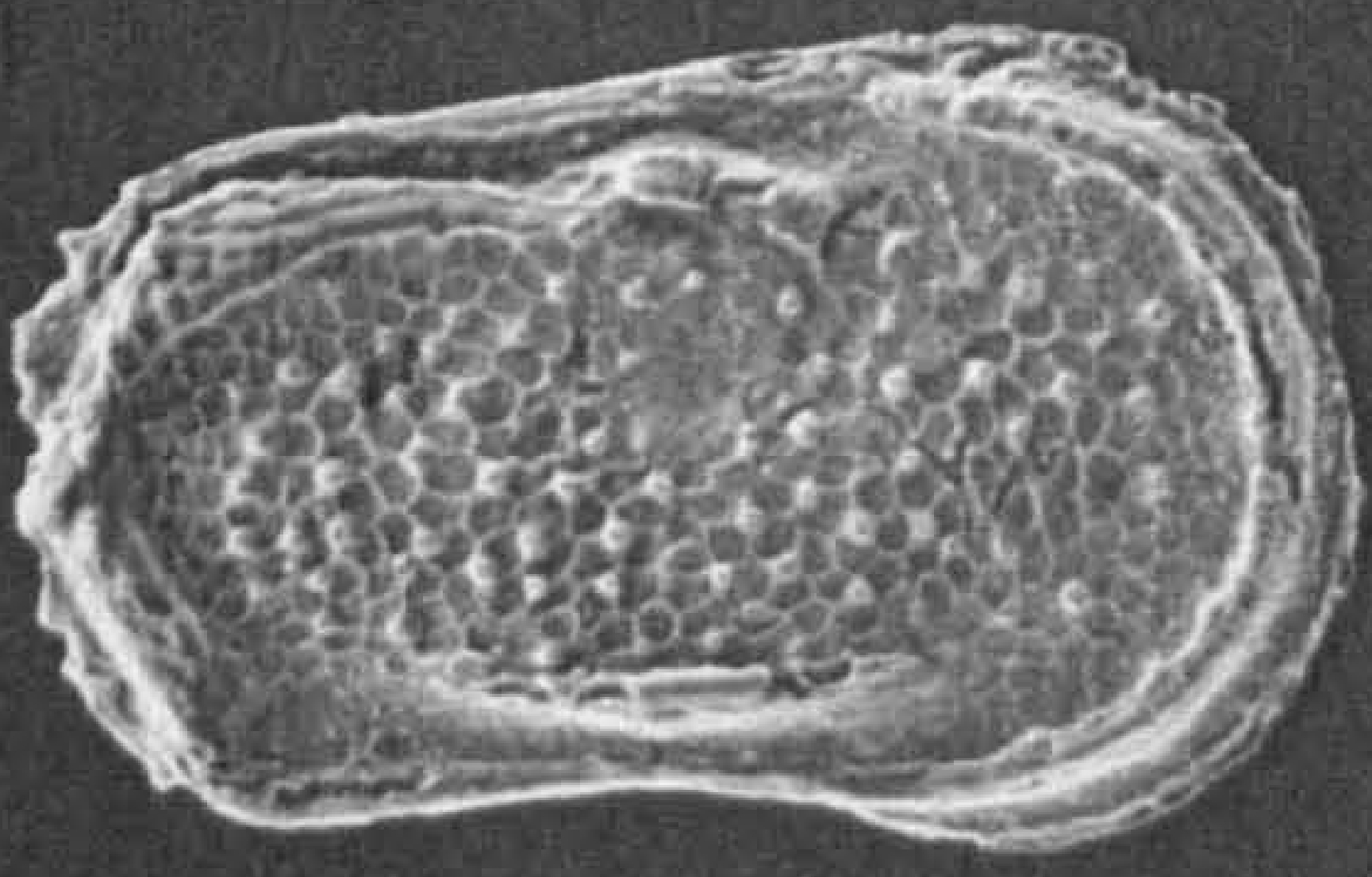

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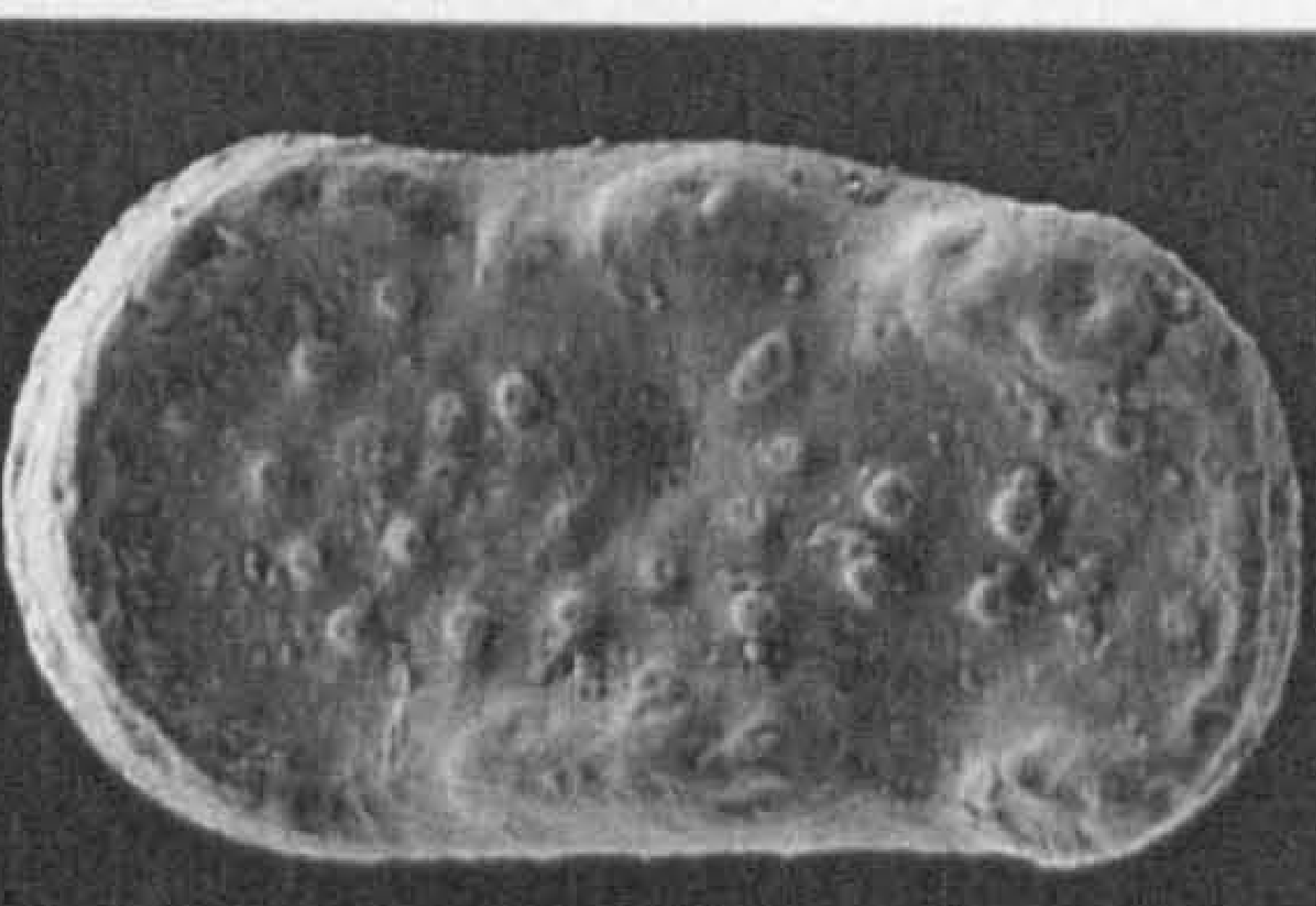

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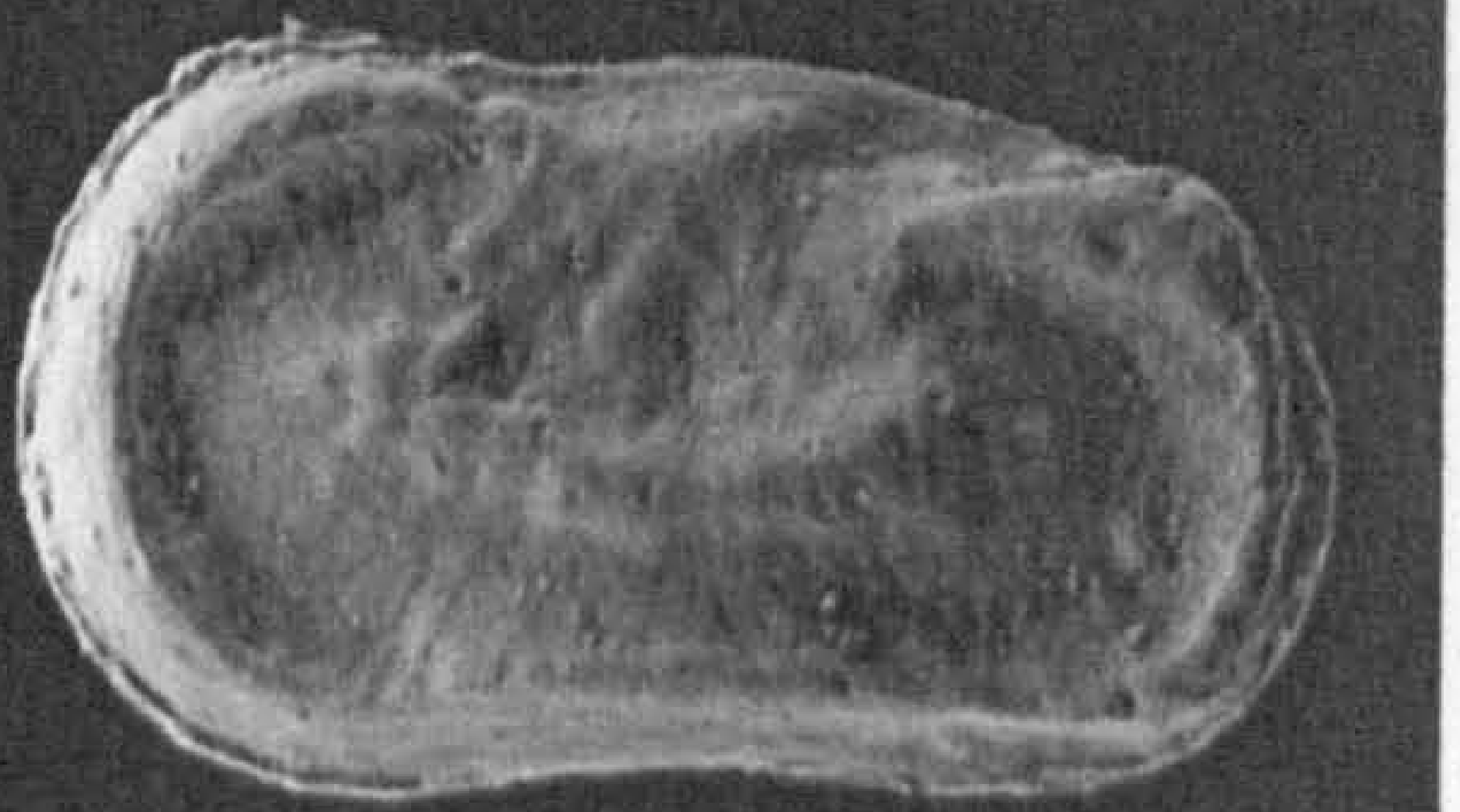

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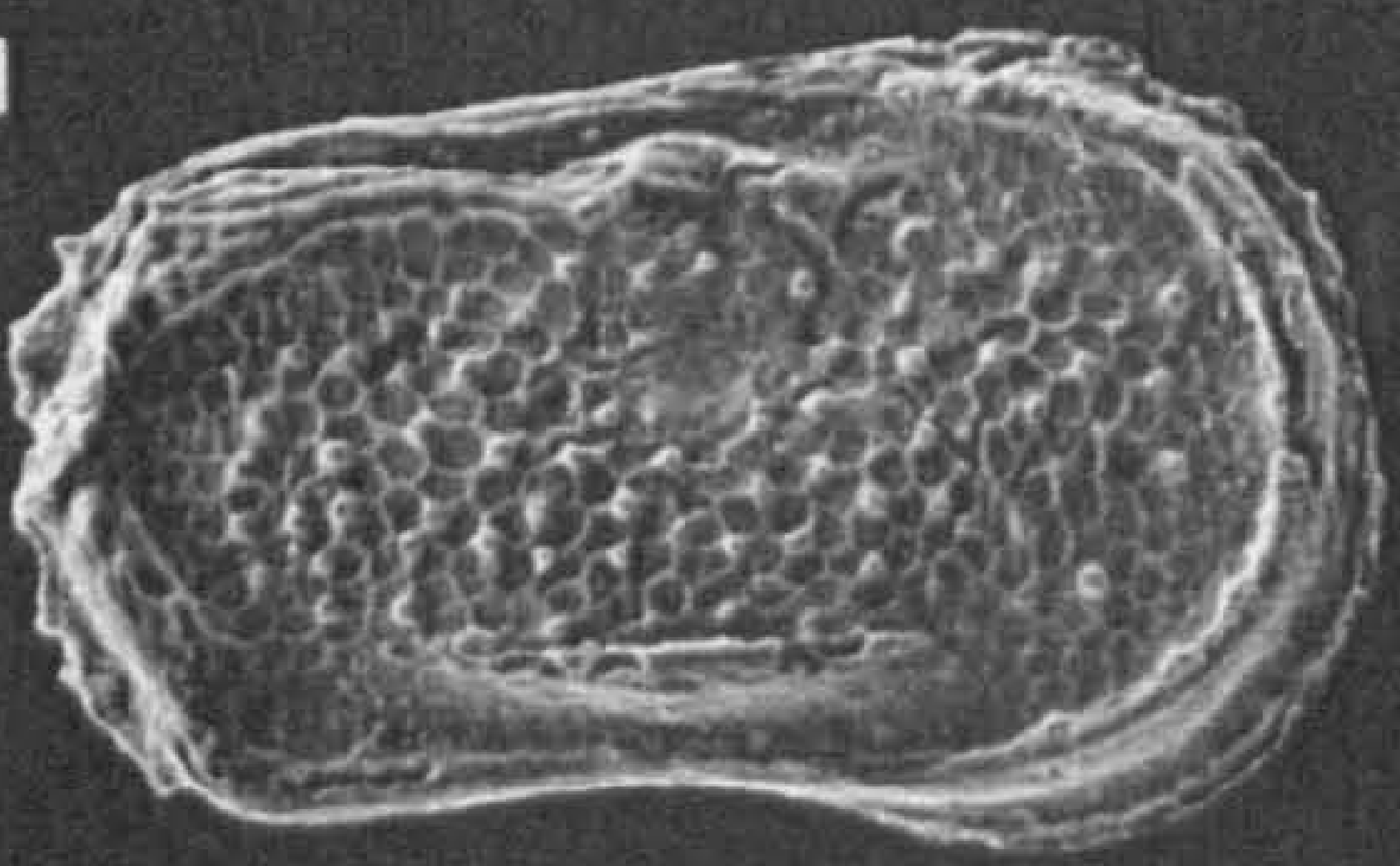

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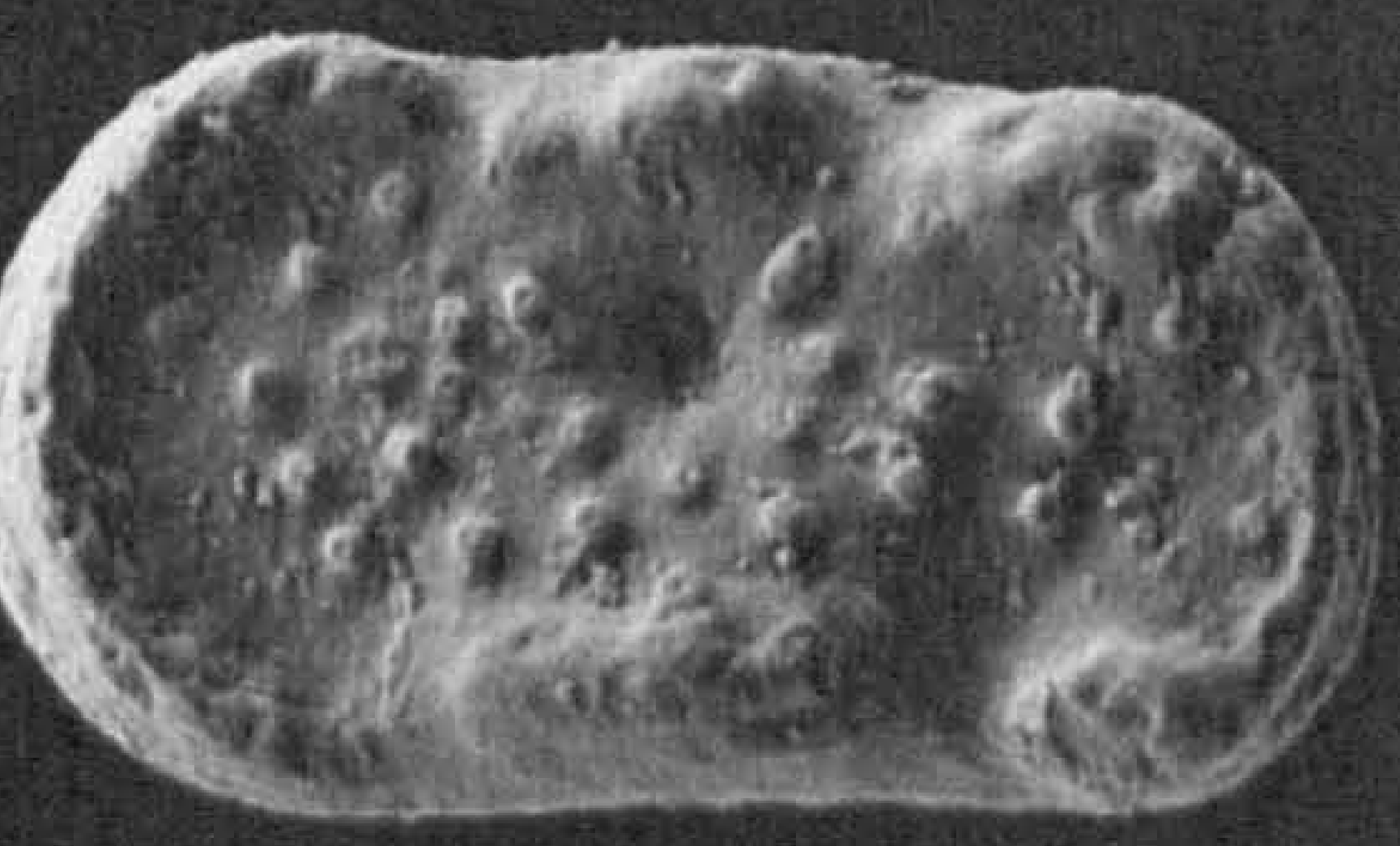

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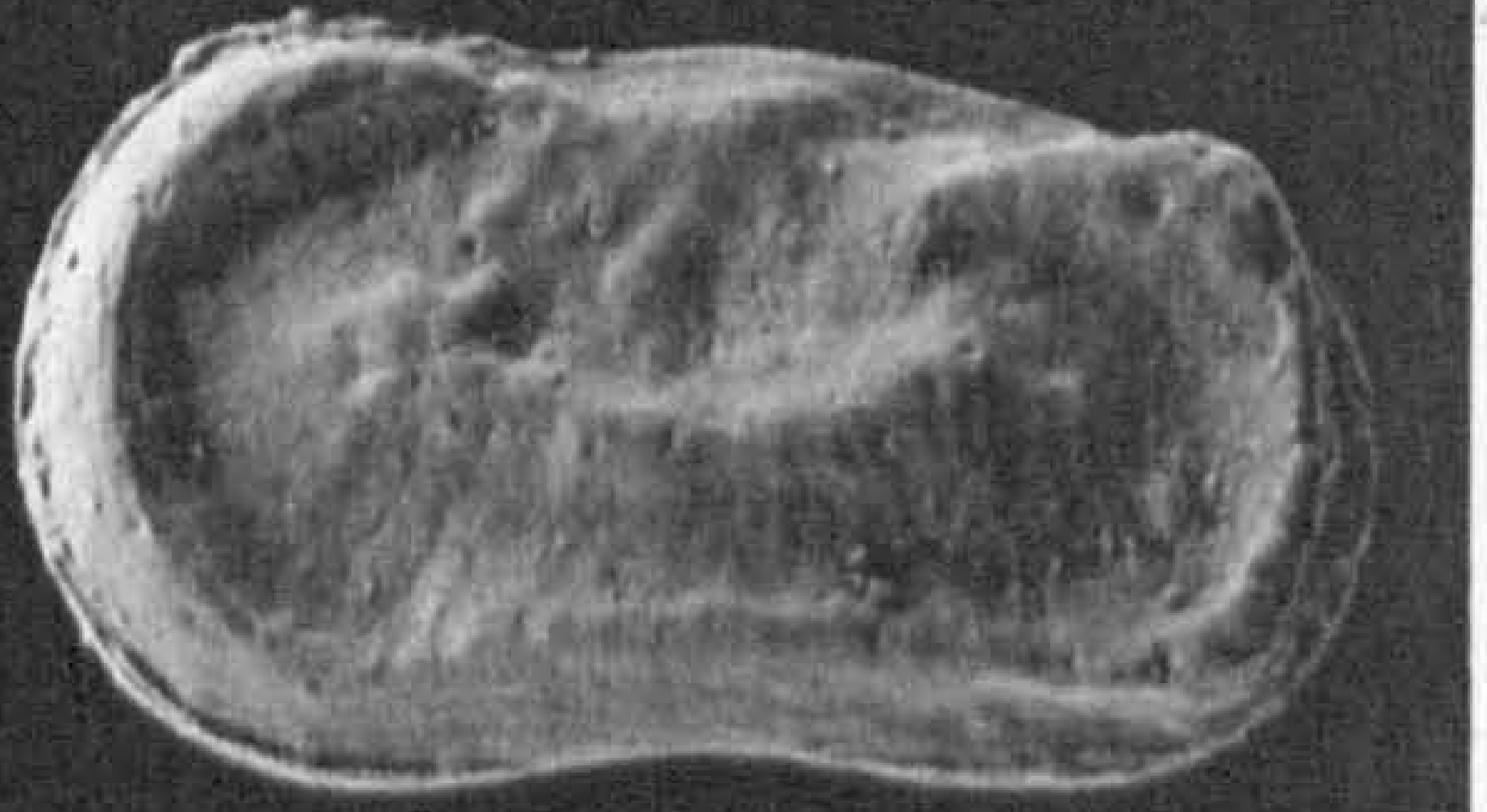

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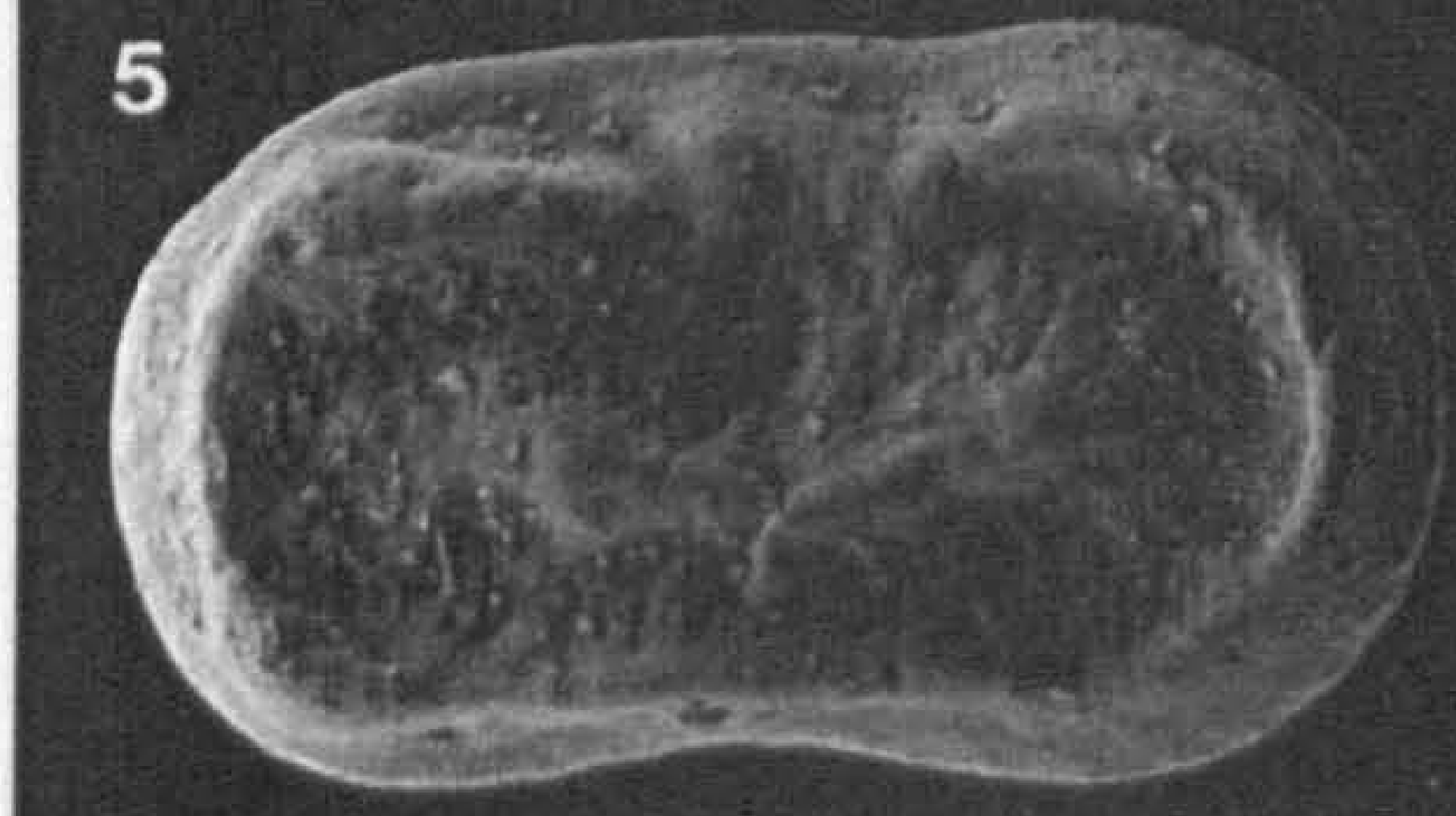

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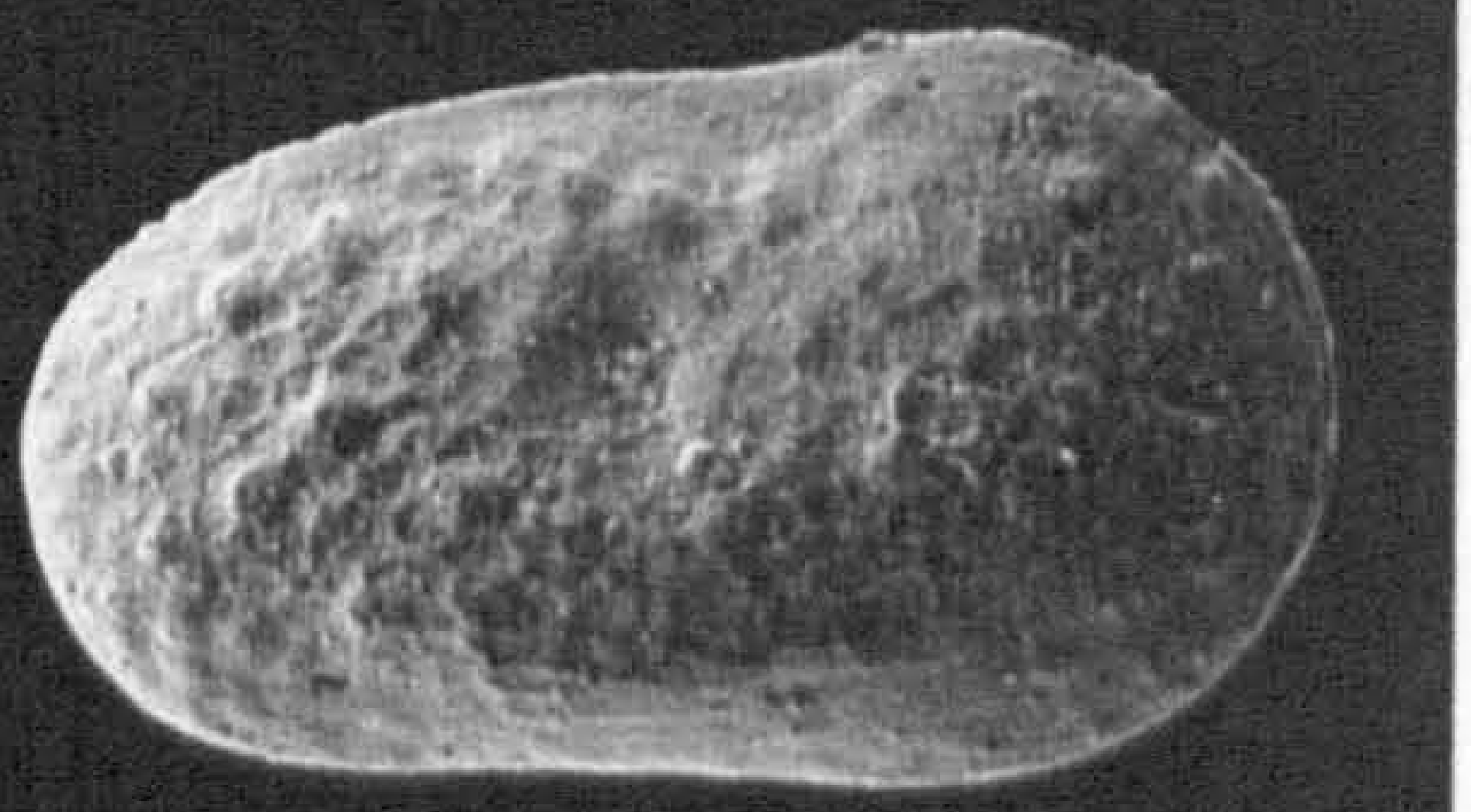

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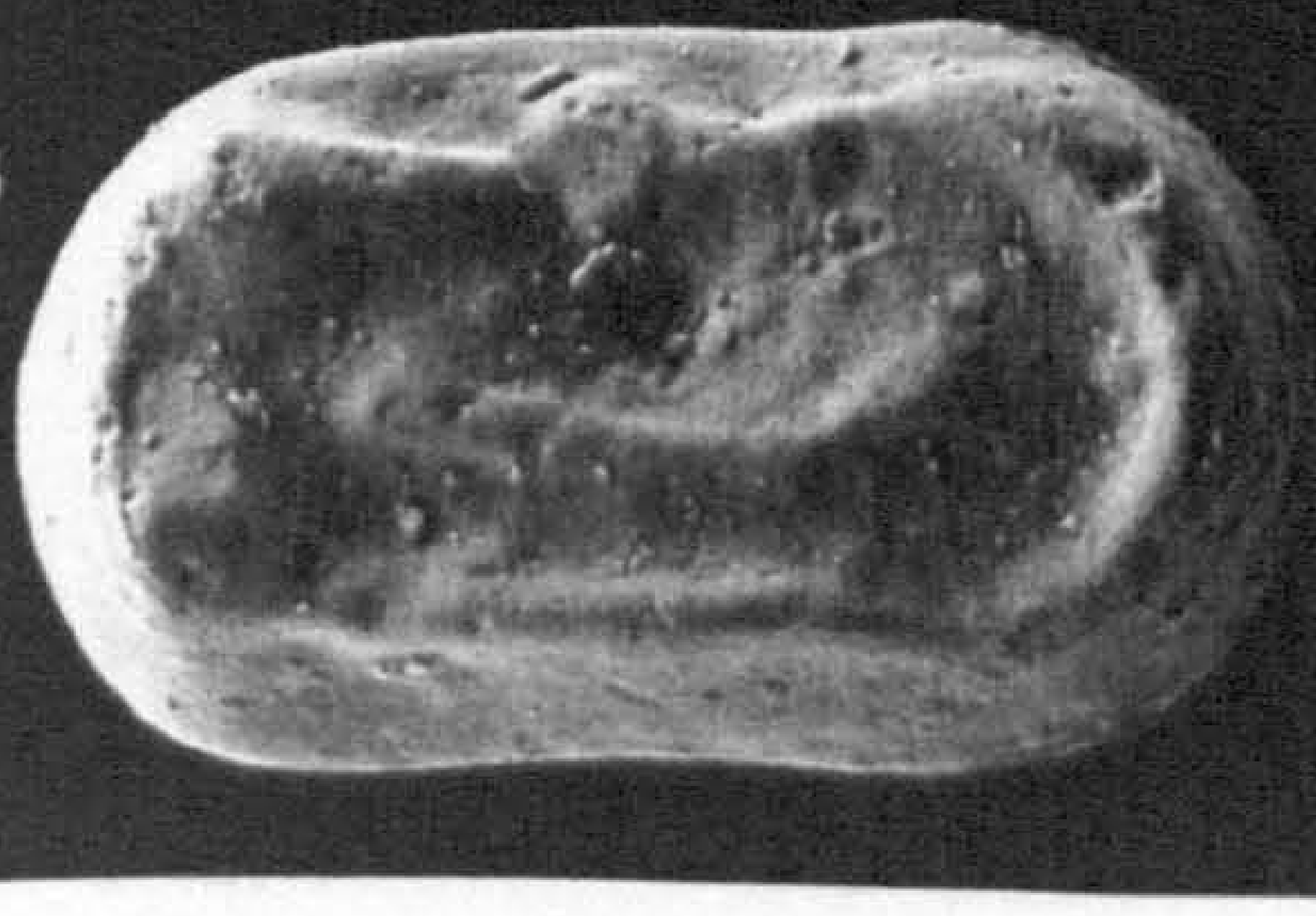

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PLATE 5

Fig.		Page
	Cytherelloidea kayei Weaver, 1982	74
	ABCMR5, 2.1m below Round Down Marl, Lower Turonian.	
1	Female left valve, IJS19/30. External lateral (stereo-pair), x82.	
	ABCMR4, 2.5m above Lulworth Marl, Lower Turonian.	
2	Female right valve, IJS19/29. External lateral (stereo-pair), x77.	
3	Male right valve, IJS19/31. External lateral (stereo-pair), x78.	
	Cytherelloidea obliquirugata (Jones & Hinde, 1890)	77
	AKSD19, 3.8m below New Pit Marl 1, Middle Turonian.	
4	Male right valve, IJS19/28. External lateral (stereo-pair), x78.	
	LGSD26, Navigation Hardground 1, Upper Turonian.	
5	Female right valve, IJS19/26. External lateral (stereo-pair), x81.	
6	Female left valve, IJS19/27. External lateral (stereo-pair), x80.	
	Cardobairdia longitecta sp. nov.	81
	AKSD19, 3.8m below New Pit Marl 1, Middle Turonian.	
7	Holotype. Female left valve, IJS20/1. External lateral (stereo-pair), x98.	
	AKSD21, New Pit Marl 1, Middle Turonian.	
8	Female right valve, IJS20/2. External lateral (stereo-pair), x100.	

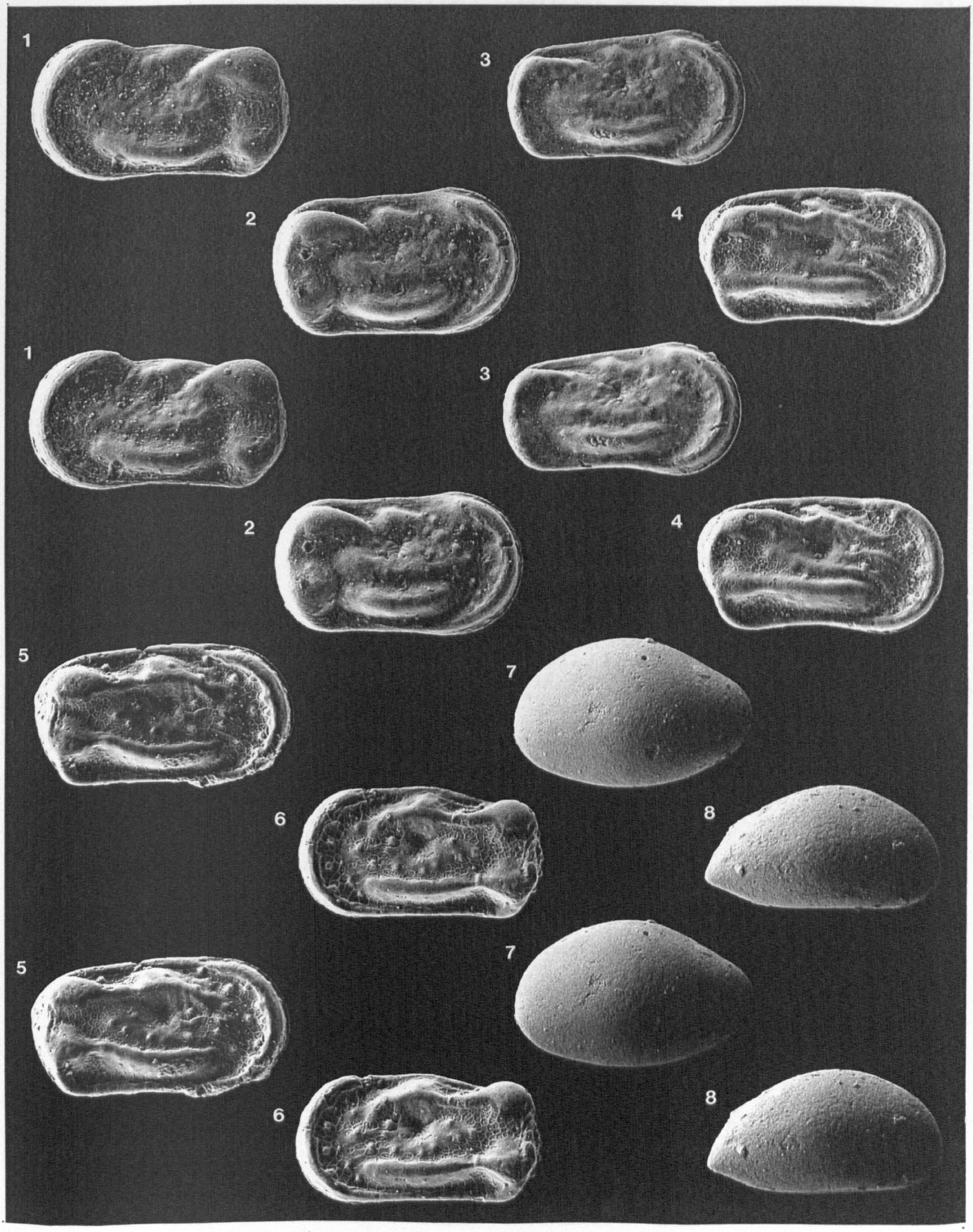
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Fig. PLATE 6 Page

Cardobairdia longitecta sp. nov. 81

LGSD26, Navigation Hardground 1, Upper Turonian.

1 Male left valve, IJS20/3. External lateral (stereo-pair), x97.

AKSD54, Flint level below Southerham Marl 1, Upper Turonian.

2 Male right valve, IJS20/4. External lateral (stereo-pair), x96.

Bairdoppilata cuvillieri omnipraesens (Pokorný, 1980) 84

ABCMR1, first marl above Ballard Cliff Member, Lower Turonian.

3 Left valve, IJS20/5. External lateral (stereo-pair), x52.

4 Right valve, IJS20/6. External lateral (stereo-pair), x54.

Bairdoppilata turonica sp. nov. 87

AKSD43, 1.5m below Lydden Spout Flint, Middle Turonian.

5 Holotype. Left valve, IJS20/7. External lateral (stereo-pair), x48.

6 Right valve, IJS20/8. External lateral (stereo-pair), x48.

Bairdoppilata septentrionalis (Bonnema, 1940) 88

LGSD11, Caburn Marl, Upper Turonian.

7 Left valve, IJS20/9. External lateral (stereo-pair), x46.

8 Right valve, IJS20/10. External lateral (stereo-pair), x49.

PLATE 6

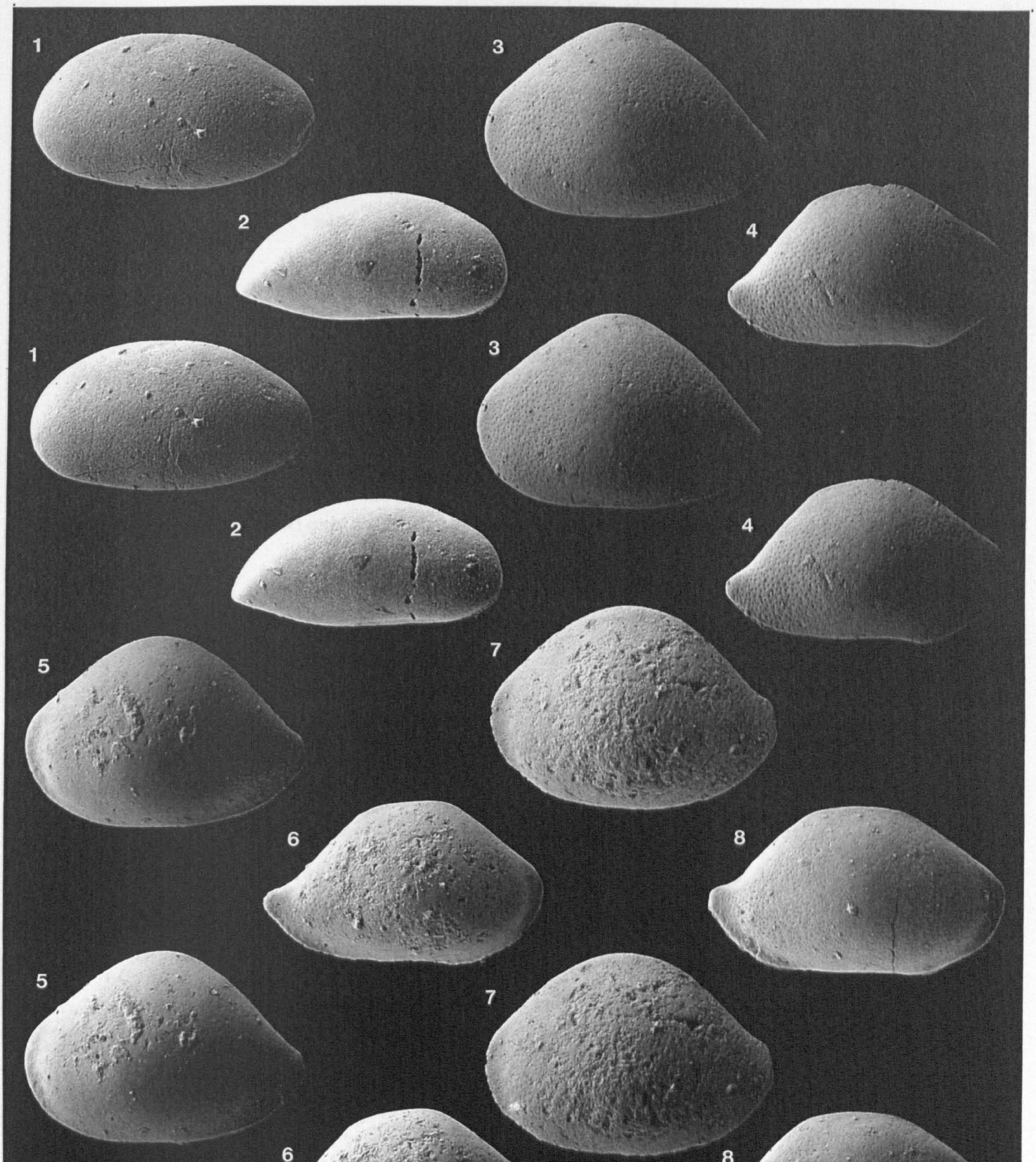

Fig.

PLATE 7

Page

Bairdoppilata sp. 1 91

AKSD43, 1.5m below Lydden Spout Flint, Middle Turonian.

1 Left valve, IJS20/11. External lateral (stereo-pair), x53.

2 Right valve, IJS20/12. External lateral (stereo-pair), x49.

Bairdoppilata sp. cf. *B. limburgensis* (van Veen, 1934) 92

LGSD5, 1.1m above Southerham Marl 2, Upper Turonian.

3 Left valve, IJS20/13. External lateral (stereo-pair), x48.

LGSD10, 0.6m below Caburn Marl, Upper Turonian.

4 Right valve, IJS20/14. External lateral (stereo-pair), x55.

Neonesidea (*Maddocksia*) *denticulata* (Marsson, 1880) 94

AKSD52, 3.2m below Southerham Marl 1, Upper Turonian.

5 Left valve, IJS20/18. External lateral (stereo-pair), x59.

DOE8A, 2.5m below Southerham Marl 1, Upper Turonian.

6 Right valve, IJS20/17. External lateral (stereo-pair), x52.

Neonesidea (*Maddocksia*) *vinicensis* (Šulc, 1932) 96

AKSD31, 2.5m below Glynde Marl 1, Middle Turonian.

8 Right valve, IJS20/15. External lateral (stereo-pair), x53.

AKS3/10, 1.2m above Southerham Marl 2, Middle Turonian.

7 Left valve, IJS20/16. External lateral (stereo-pair), x57.

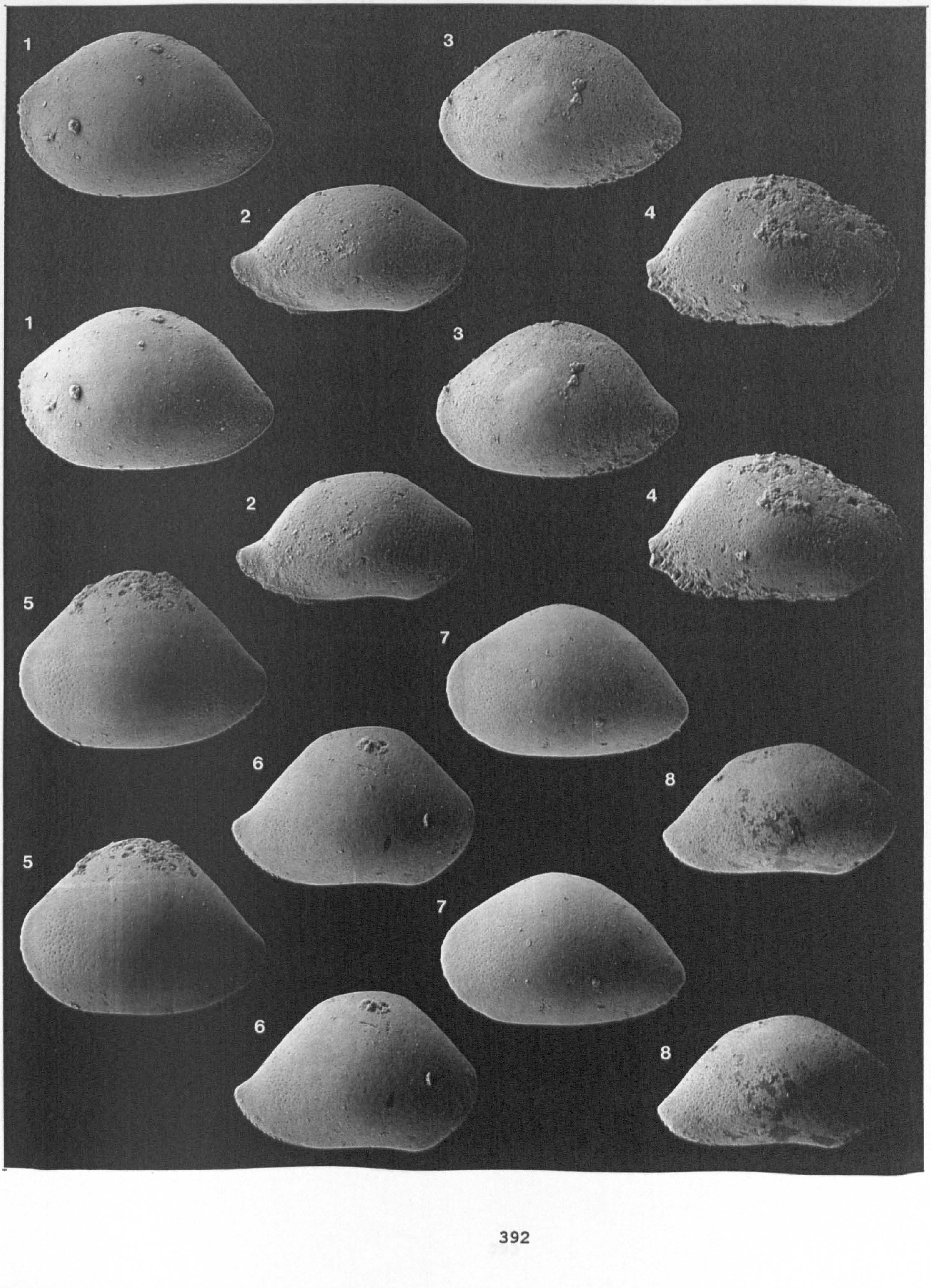
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Fig. PLATE 8 Page

Bythocypris brownei Jones & Hinde, 1890 98

AKSD17,1.7m above Round Down Marl, Middle Turonian.

1 Left valve, IJS7/4. External lateral (stereo-pair), x61.

2 Right valve, IJS7/5. External lateral (stereo-pair), x63.

Bythocypris sp. B 100

LGSD23, middle of Kingston Nodular Chalks, Upper Turonian.

3 Right valve, IJS19/25. External lateral (stereo-pair), x46.

Pontocyprella harrisiana (Jones, 1849) 103

AKSD54, Flint level below Southerham Marl 1, Upper Turonian.

4 Left valve, IJS19/21. External lateral (stereo-pair), x66.

AKSD53, 2.5m below Southerham Marl 1, Upper Turonian.

5 Right valve, IJS19/22. External lateral (stereo-pair), x70.

Pontocyprella hindei Weaver, 1982 105

AKSD33, 0.4m below Glynde Marl 1, Middle Turonian.

6 Left valve, IJS19/23. External lateral (stereo-pair), x69.

AKSD31, 2.5m below Glynde Marl 1, Middle Turonian.

7 Right valve, IJS19/24. External lateral (stereo-pair), x66.

Pontocyprella robusta cometa ssp. nov. 107

LGSD28, below Navigation Hardground 3, Upper Turonian.

8 Holotype. Left valve, IJS19/19. External lateral (stereo-pair), x60.

LGSD26, Navigation Hardground 1, Upper Turonian.

9 Right valve, IJS19/20. External lateral (stereo-pair), x62.

Pontocyprella? *bosquetiana* (Jones, 1849) 108

ABCMR4, 2.5m above Lulworth Marl, Lower Turonian.

10 Left valve, IJS19/17. External lateral (stereo-pair), x72.

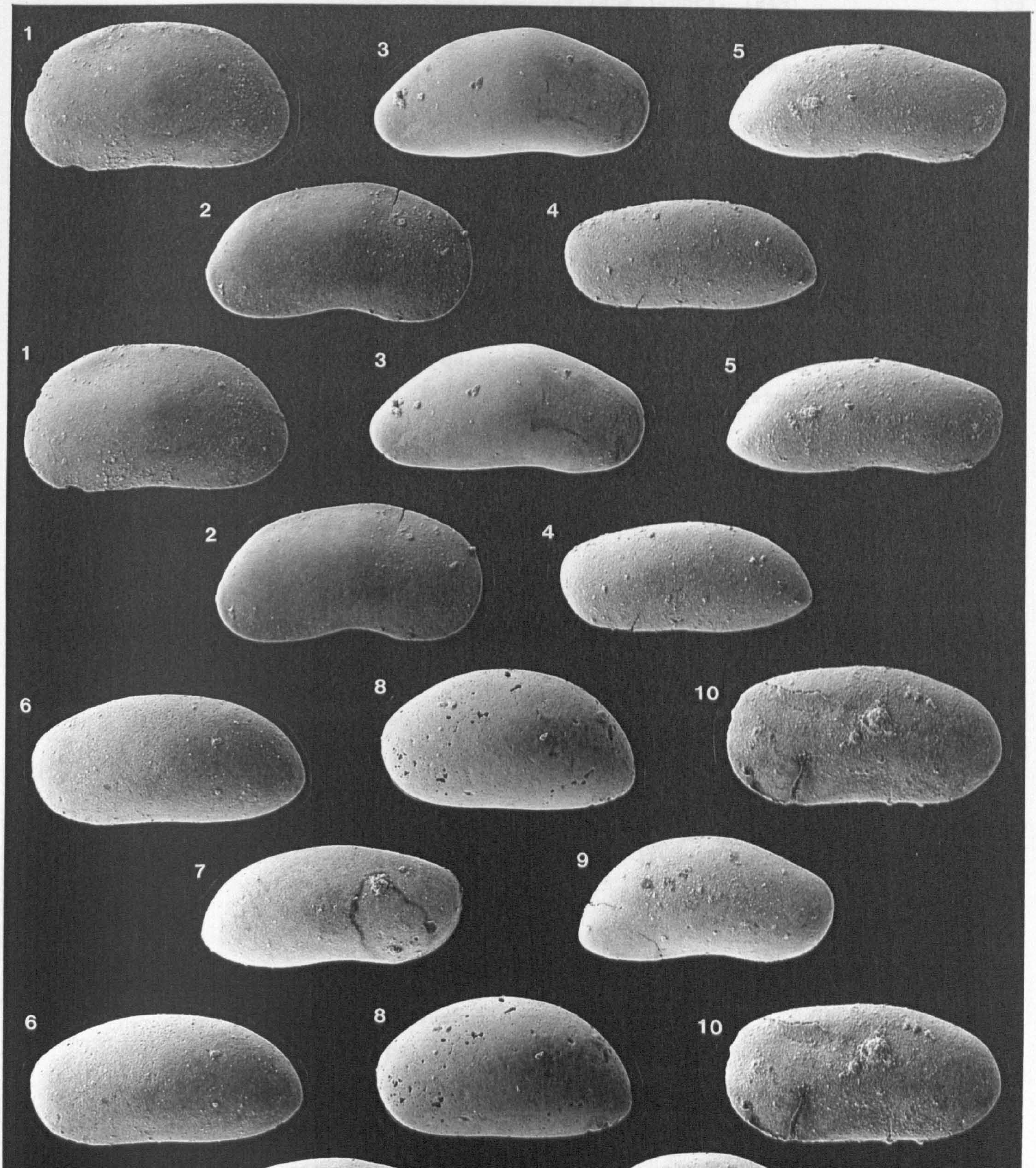
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Fig. Page

PLATE 9

Pontocyprella? bosquetiana (Jones, 1849) 108

ABCMR4, 2.5m above Lulworth Marl, Lower Turonian.

1 Right valve, IJS19/18. External lateral (stereo-pair), x73.

Paracypris siliqua Jones & Hinde, 1890 111

LGSD8, 2.5m below Caburn Marl, Upper Turonian.

2 Left valve, IJS19/16. External lateral (stereo-pair), x61.

Paracypris cf. *depressa* Bonnema, 1940 113

LGSD8, 2.5m below Caburn Marl, Upper Turonian.

3 Left valve, IJS19/14. External lateral (stereo-pair), x53.

LGSD24, top of Kingston Nodular Chalks, Upper Turonian.

4 Right valve, IJS19/15. External lateral (stereo-pair), x52.

Macrosarisa siliqua (Jones, 1849) 116

AKSD33, 0.4m below Glynde Marl 1, Middle Turonian.

5 Left valve, IJS19/13. External lateral (stereo-pair), x42.

6 Right valve, IJS7/6. External lateral (stereo-pair), x44.

Macrosarisa wrighti (Jones & Hinde, 1890) 119

AKSD33, 0.4m below Glynde Marl 1, Middle Turonian.

8 Left valve, IJS19/12. External lateral (stereo-pair), x44.

Brachycythere cf. *sphenoides* (Reuss, 1854) 122

LGSD26, Navigation Hardground 1, Upper Turonian.

7 Right valve, juvenile, IJS20/26. External lateral (stereo-pair), x72.

LGSD24, top of Kingston Nodular Chalks, Upper Turonian.

9 Left valve, IJS14/14. External lateral (stereo-pair), x68.

Pterygocythere pulvinata Damotte, 1962 124

LGSD34, 6m above Navigation Hardground, Lower Coniacian.

10 Right valve, IJS12/6. External lateral (stereo-pair), x55.

PLATE 9

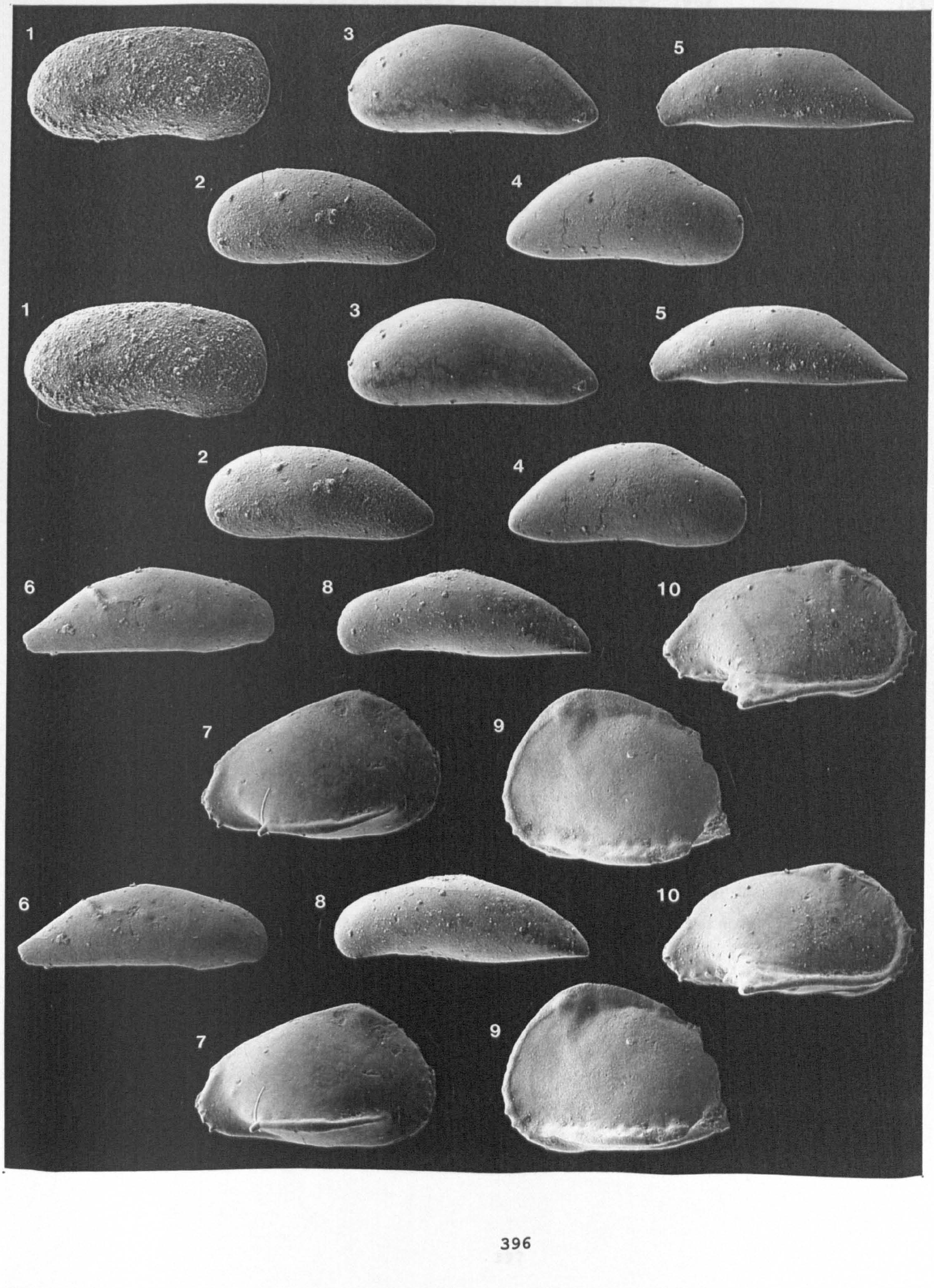

Fig.

PLATE 10

Page

Pterygocythere pulvinata Damotte, 1962 124

LGSD8, 2.5m below Caburn Marl, Upper Turonian.

1 Left valve, IJS14/11. External lateral (stereo-pair), x54.

Pterygocythere sp. A 126

LGSD26, Navigation Hardground 1, Upper Turonian.

2 Left valve, IJS14/12. External lateral (stereo-pair), x51.

Pterygocythereis (Diogmopteron) carolinae sp. nov. 130

LGSD9, 1.2m below Caburn Marl, Upper Turonian.

3 Holotype. Left valve, IJS14/10. External lateral (stereo-pair), x66.

LGSD7, 3.1m below Caburn Marl, Upper Turonian.

4 Right valve, IJS14/9. External lateral (stereo-pair), x73.

Pterygocythereis (Diogmopteron) diversum (Clarke, 1983) 133

AKSD45, 1m above Lydden Spout Flint, Middle Turonian.

5 Left valve, IJS14/1. External lateral (stereo-pair), x60.

6 Right valve, IJS2/27. External lateral (stereo-pair), x61.

Pterygocythereis (Diogmopteron) robusta (Jones & Hinde, 1890) 135

AKSD50, Flint level at base of Upper Turonian.

7 Right valve, IJS14/8. External lateral (stereo-pair), x70.

Pterygocythereis (Diogmopteron) spinosa (Reuss, 1846) 139

AKSD54, Flint level below Southerham Marl 1, Upper Turonian.

8 Left valve, IJS19/10. External lateral (stereo-pair), x61.

PLATE 10

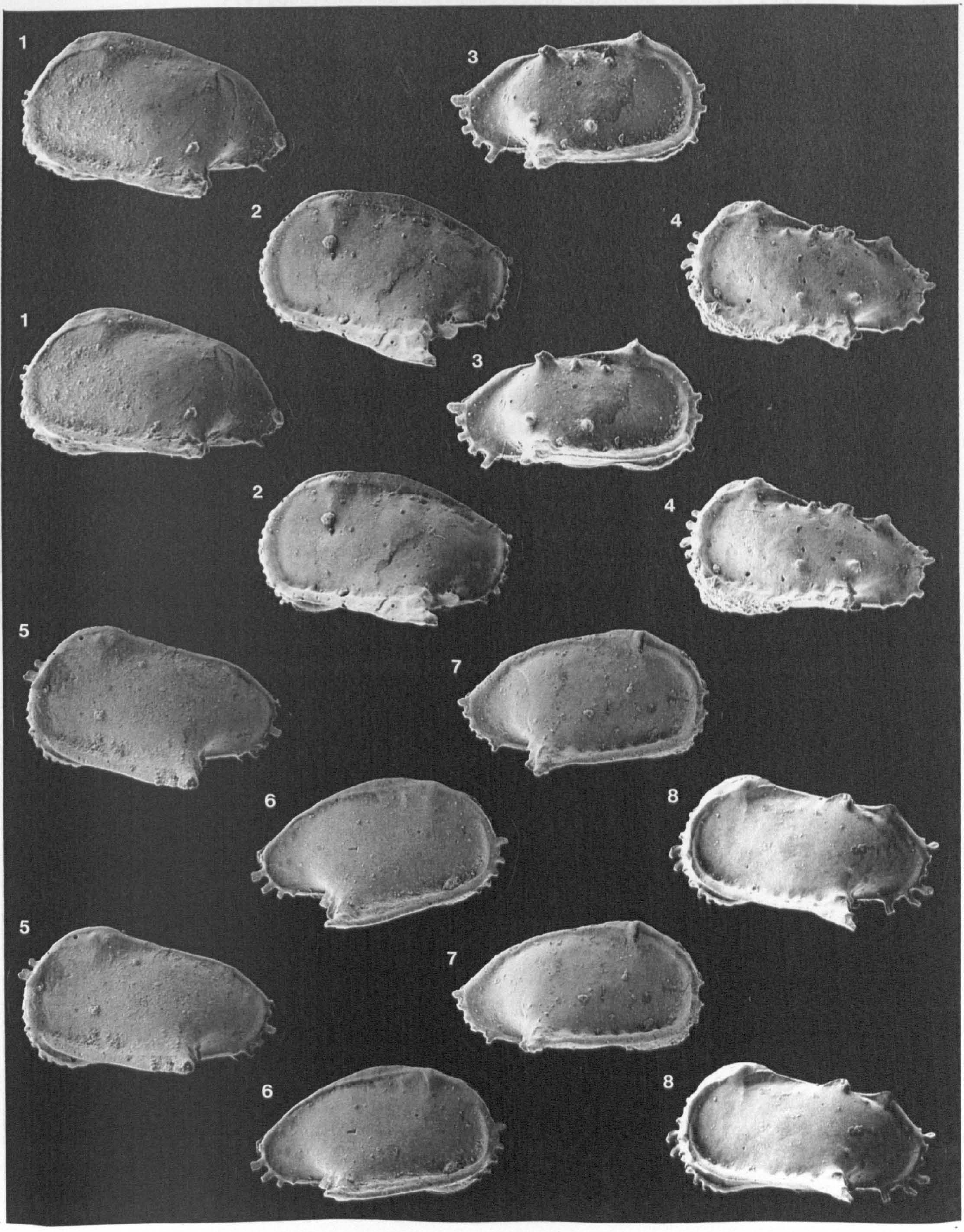

Fig. PLATE 11 Page

Pterygocythereis (*Diogmopteron*) *spinosa* (Reuss, 1846) 139

AKSD50, Flint level at base of Upper Turonian.

1 Right valve, IJS19/11. External lateral (stereo-pair), x60.

Pterygocythereis (*Diogmopteron*) sp. A 141

ABCMR3, Lulworth Marl, Lower Turonian.

2 Right valve, IJS14/6. External lateral (stereo-pair), x66.

ABCMR1, first marl above Ballard Cliff Member, Lower Turonian.

3 Carapace, IJS14/5. Dorsal (stereo-pair), x63.

Bythoceratina (Bythoceratina) sp. aff. antetumida 149

ABCMR1, first marl above Ballard Cliff Member, Lower Turonian.

4 Right valve, IJS19/5. External lateral (stereo-pair), x90.

Bythoceratina (*Bythoceratina*) *antetumida* nom. nov. 146

AKSD50, Flint level at base of Upper Turonian.

5 Left valve, IJS19/6. External lateral (stereo-pair), x73.

LGSD26, Navigation Hardground 1, Upper Turonian.

6 Right valve, IJS19/7. External lateral (stereo-pair), x67.

Bythoceratina (*Bythoceratina*) *nitidoides* (Bonnema, 1941) 150

AKS3/10, 1.2m above Southerham Marl 2, Middle Turonian.

7 Right valve, IJS12/4, External lateral (stereo-pair), x94

Bythoceratina (*Bythoceratina*) *saxa* sp. nov. 152

ABCMR1a, Gun Gardens Marl 1, Lower Turonian.

8 Left valve, broken, IJS7/10. External lateral (stereo-pair), x109.

PLATE 11

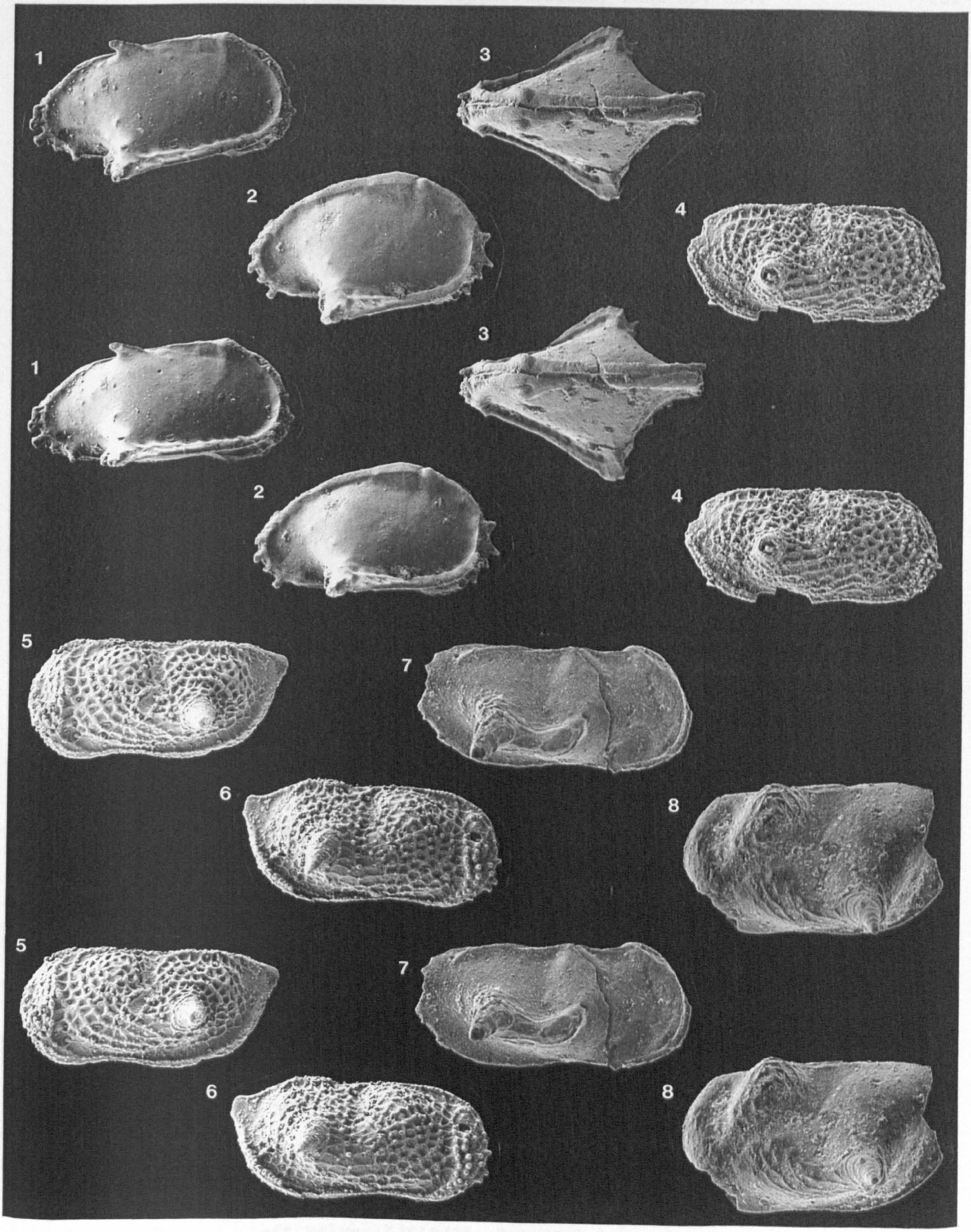

PLATE 12

Fig.		Page
	Bythoceratina (*Bythoceratina*) *saxa* sp. nov.	152
	AKS3/10, 1.2m above Southerham Marl 2, Upper Turonian.	
1	Holotype. Right valve, broken, IJS18/30. External lateral (stereo-pair), x86.	
	Bythoceratina (*Bythoceratina*) *trentoniensis* (Bonnema, 1941)	154
	LGSD26, Navigation Hardground 1, Upper Turonian.	
2	Left valve, IJS18/29. External lateral (stereo-pair), x68	
3	Right valve, IJS12/13. External lateral (stereo-pair), x81.	
	Bythoceratina (*Bythoceratina*) *umbonatoides umbonatoides* (Kaye, 1964a)	156
	LGSD26, Navigation Hardground 1, Upper Turonian.	
4	Left valve, IJS19/8. External lateral (stereo-pair), x75.	
	LGSD23, middle of Kingston Nodular Chalks, Upper Turonian.	
5	Right valve, IJS19/9. External lateral (stereo-pair), x77.	
	Bythoceratina (*Bythoceratina*) aff. *umbonatoides* (Kaye, 1964a)	159
	ABCMR2 1.5m above the *Filograna avita* bed 4	
6	Left valve, IJS7/17. External lateral (stereo-pair), x83.	
	Bythoceratina (*Bythoceratina*) sp. A	161
	LGSD26, Navigation Hardground 1, Upper Turonian.	
7	Left valve, IJS19/4. External lateral (stereo-pair), x73.	
	Bythoceratina (*Bythoceratina*) *hispida* (van Veen, 1936)	163
	LGSD26, Navigation Hardground 1, Upper Turonian.	
8	Right valve, IJS18/28. External lateral (stereo-pair), x75.	
	Bythoceratina (*Cuneoceratina*) *montuosa montuosa* (Jones & Hinde, 1890)	167
	LGSD24, top of Kingston Nodular Chalks, Upper Turonian.	
9	Left valve, IJS18/27. External lateral (stereo-pair), x69.	
	Bythoceratina (*Cuneoceratina*) *pedatoides* (Bonnema, 1941)	170
	LGSD26, Navigation Hardground 1, Upper Turonian.	
10	Left valve, IJS18/25. External lateral (stereo-pair), x54.	

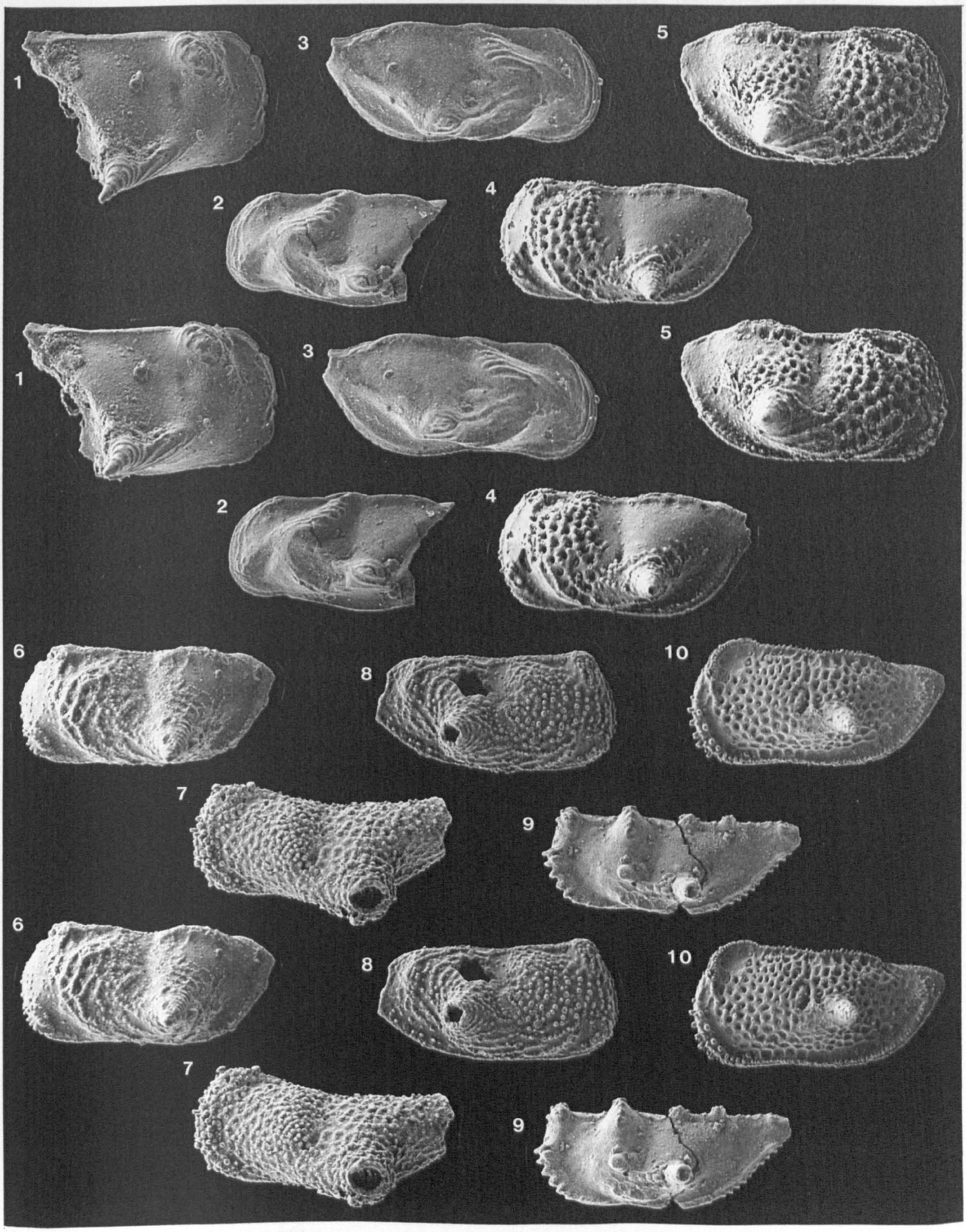
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PLATE 13

Fig.		Page
	Bythoceratina (Cuneoceratina) pedatoides (Bonnema, 1941)	170
	LGSD7, 3.1m below Caburn Marl, Upper Turonian.	
1	Right valve, IJS18/26. External lateral (stereo-pair), x56.	
	Bythoceratina (Cuneoceratina) staringi conmacula ssp. nov.	173
	LGSD26, Navigation Hardground 1, Upper Turonian.	
2	Holotype. Left valve, IJS18/24. External lateral (stereo-pair), x72.	
	Bythoceratina (Cuneoceratina) howei (Szczechura, 1964)	165
	LGSD7, 3.1m below Caburn Marl, Upper Turonian.	
3	Right valve, IJS21/1. External lateral (stereo-pair), x78.	
	Pariceratina tricuspidata (Jones & Hinde, 1890)	180
	AKSD31, 2.5m below Glynde Marl 1, Middle Turonian.	
4	Right valve, IJS19/3. External lateral (stereo-pair), x78.	
5	Left valve, IJS19/2. External lateral (stereo-pair), x81.	
	Monoceratina minangulata sp. nov.	176
	LGSD24, top of Kingston Nodular Chalks, Upper Turonian.	
6	Holotype. Left valve, IJS12/2. External lateral (stereo-pair), x83.	
	AKSD53, 2.5m below Southerham Marl 1, Upper Turonian.	
7	Right valve, IJS18/23. External lateral (stereo-pair), x78.	
	Patellacythere pseudosulcata (van Veen, 1936)	183
	ABCMR5, 2.1m below Round Down Marl, Lower Turonian.	
8	Right valve, broken posterior, IJS7/16. External lateral (stereo-pair), x91.	
	Patellacythere weaveri sp. nov.	185
	LGSD8, 2.5m below Caburn Marl, Upper Turonian.	
9	Holotype. Left valve, IJS18/21. External lateral (stereo-pair), x97.	
	Patellacythere sp. aff. *P. parva* Weaver, 1982	187
	AKSD53, 2.5m below Southerham Marl 1, Upper Turonian.	
10	Left valve, IJS18/20. External lateral (stereo-pair), x91.	

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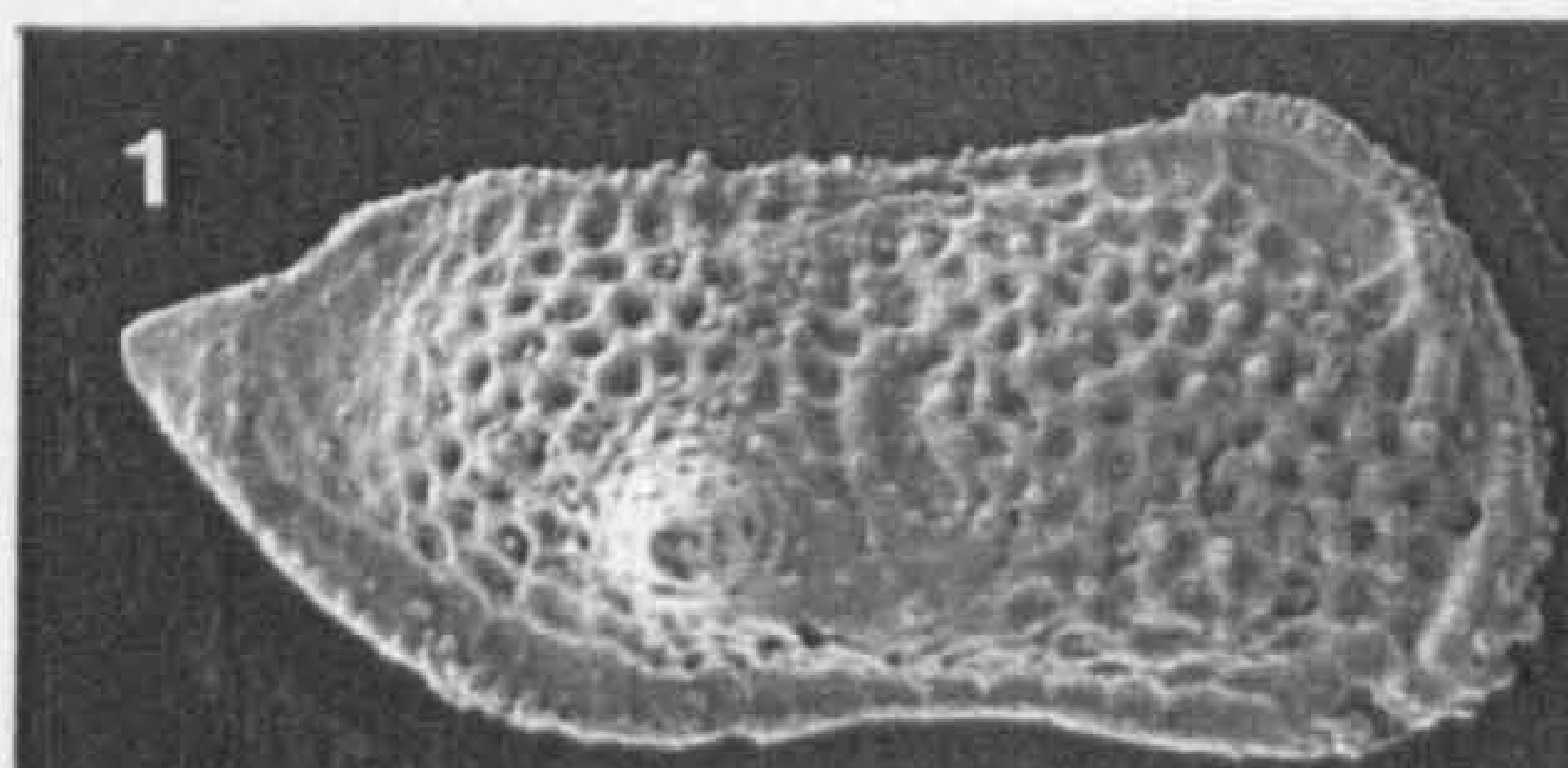

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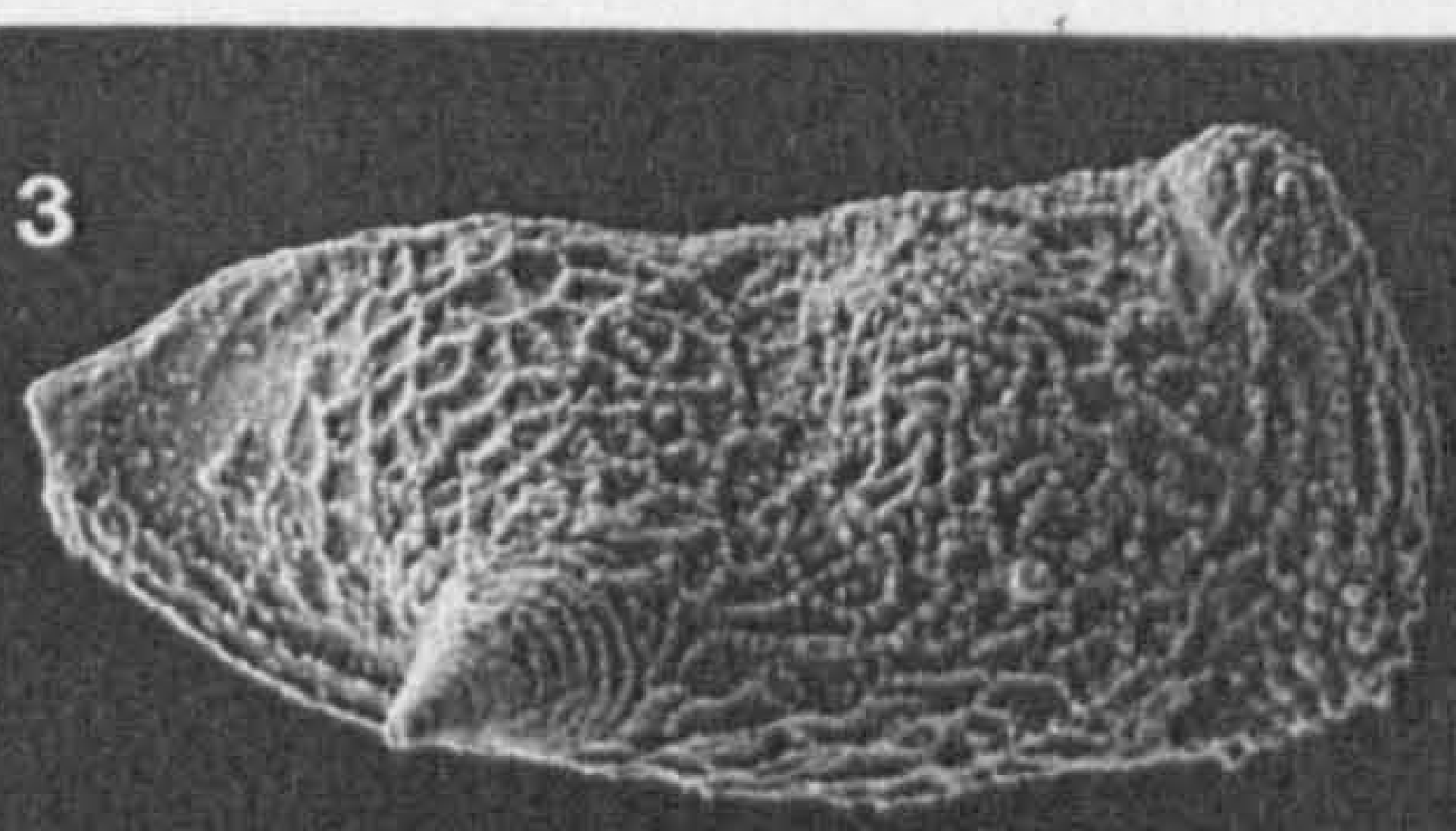

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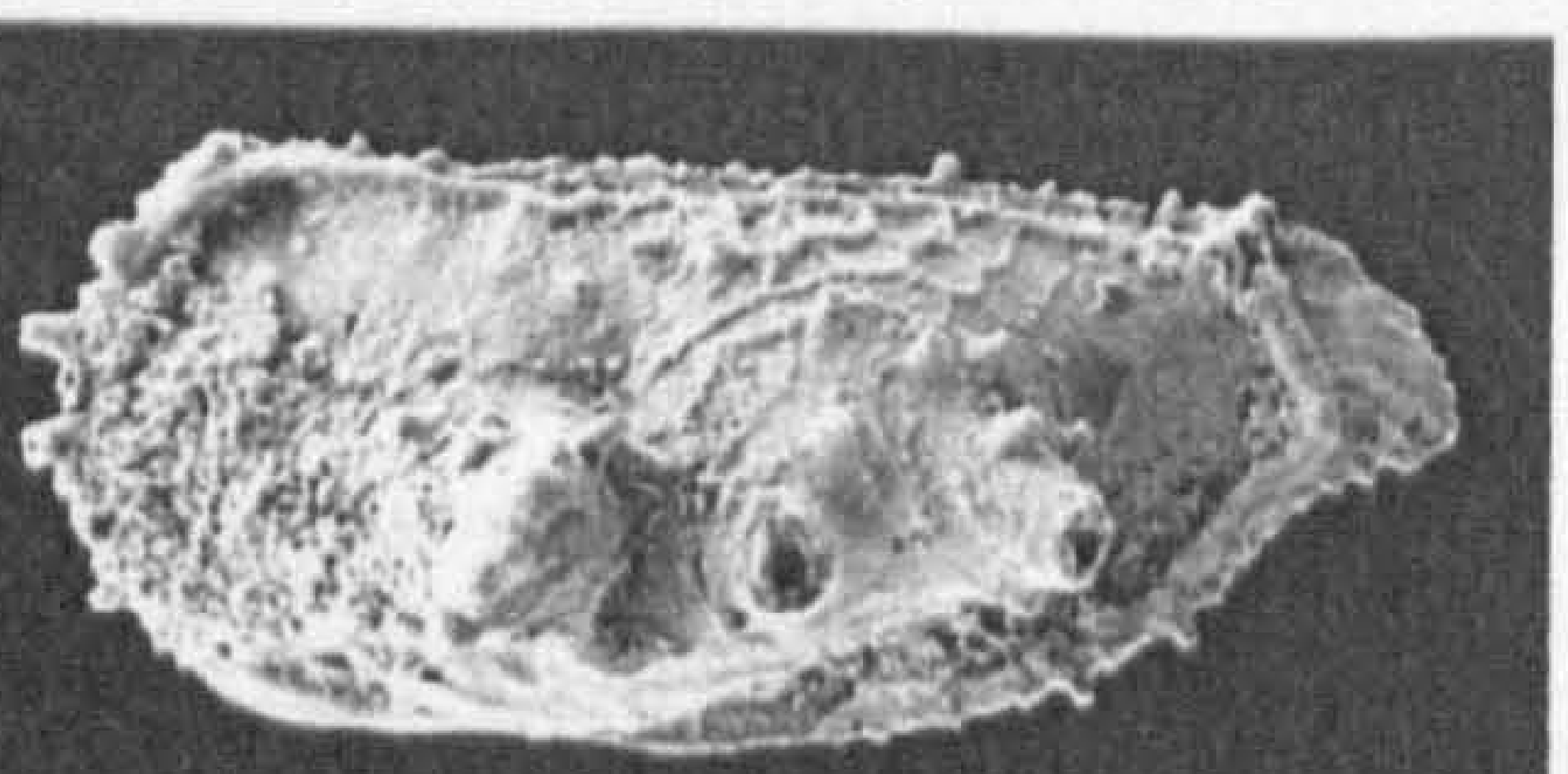

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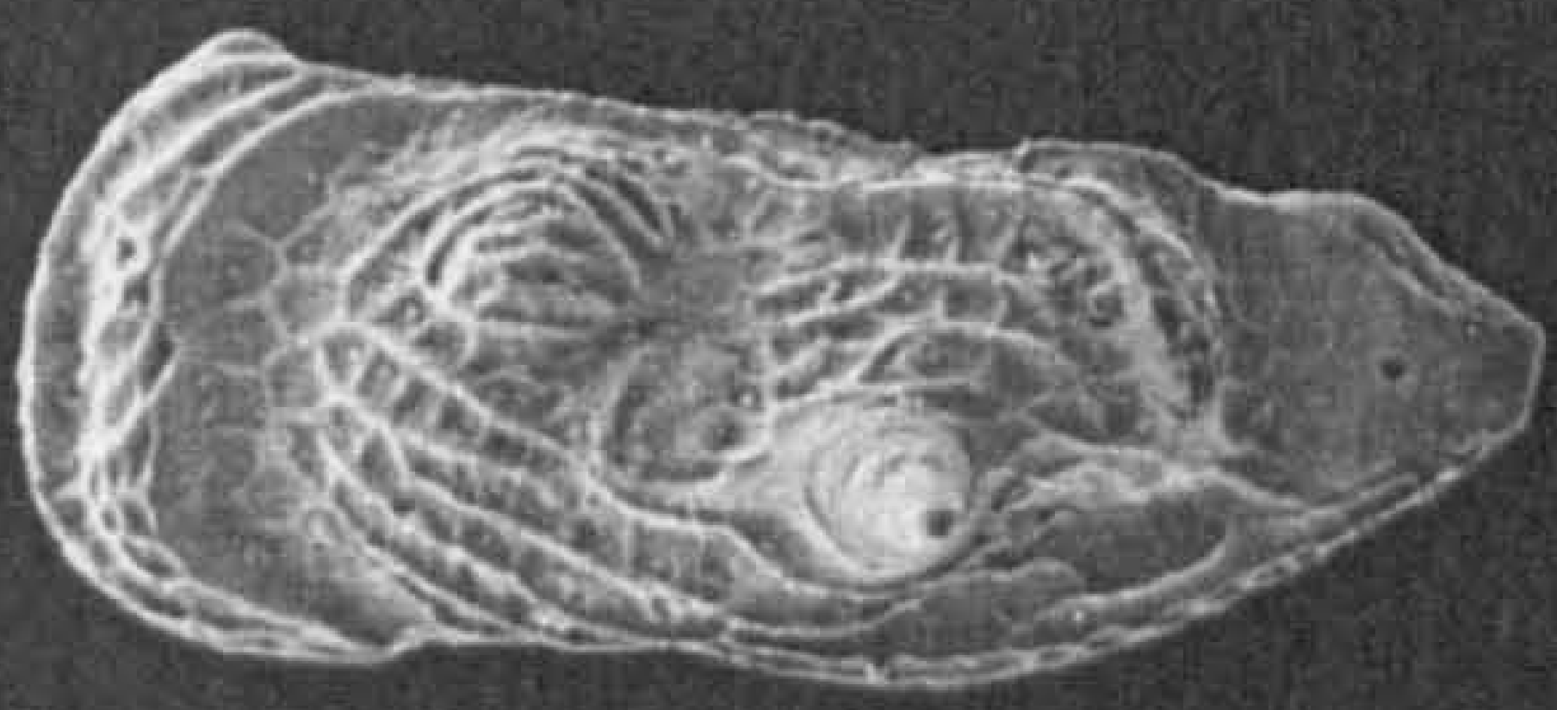

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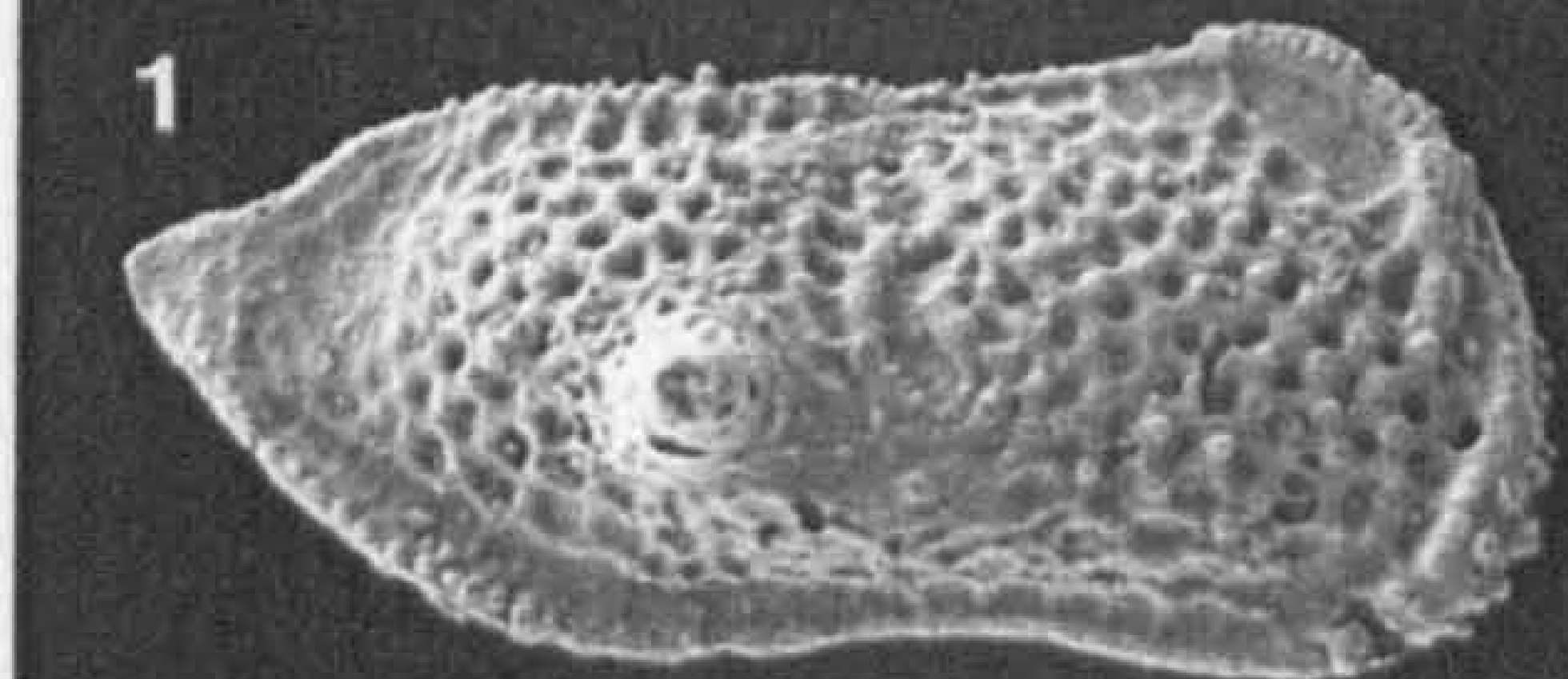

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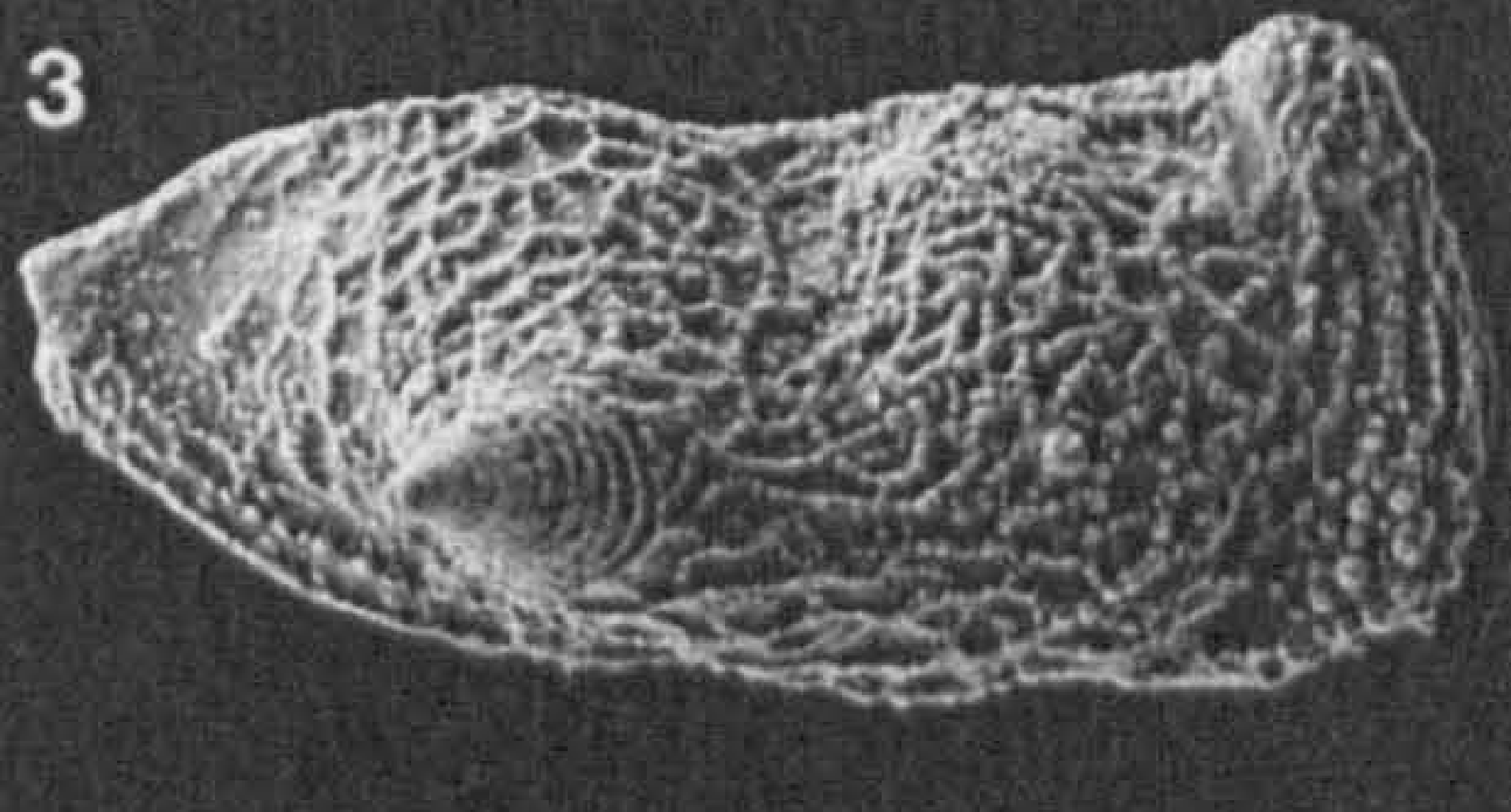

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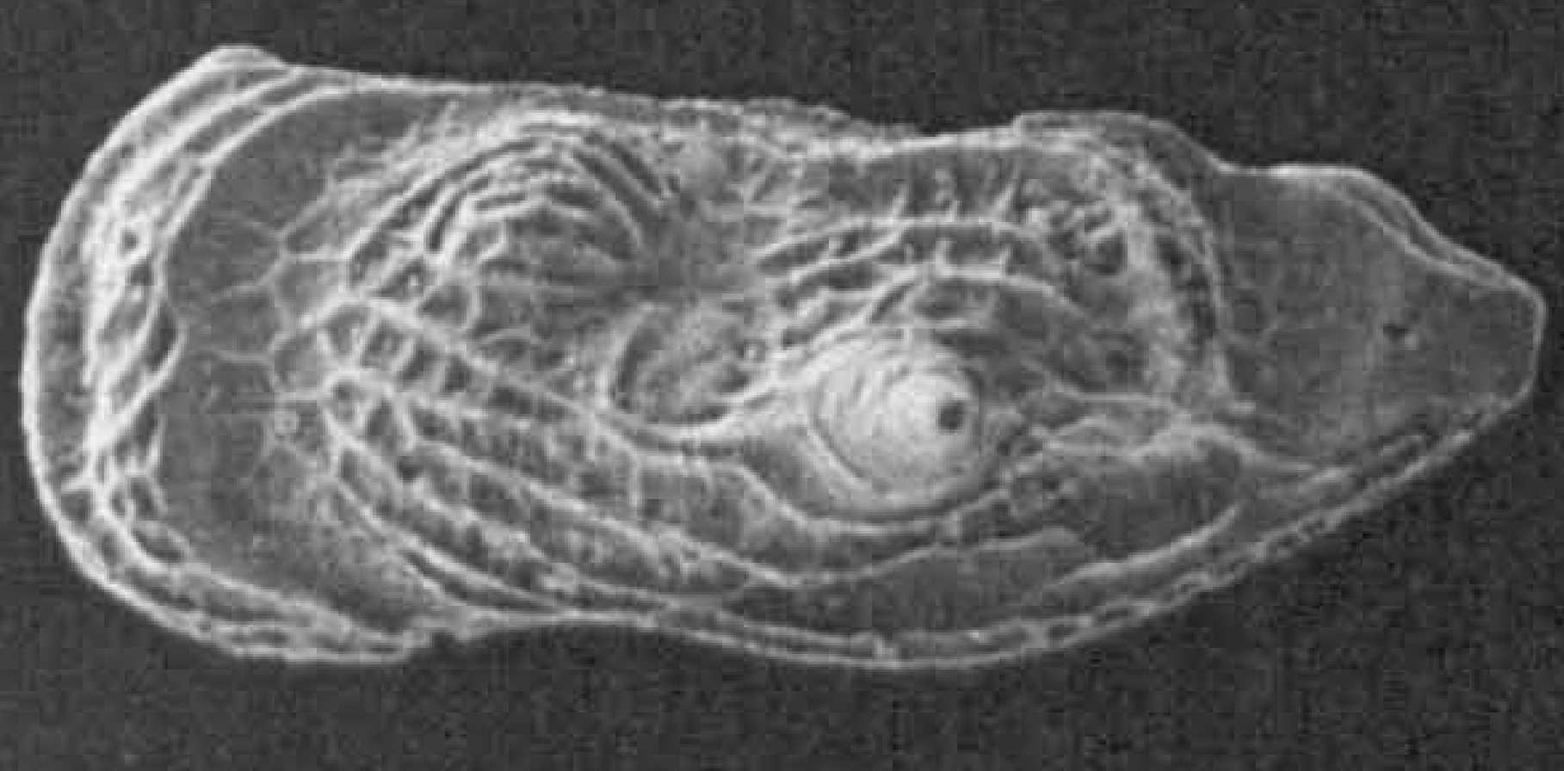

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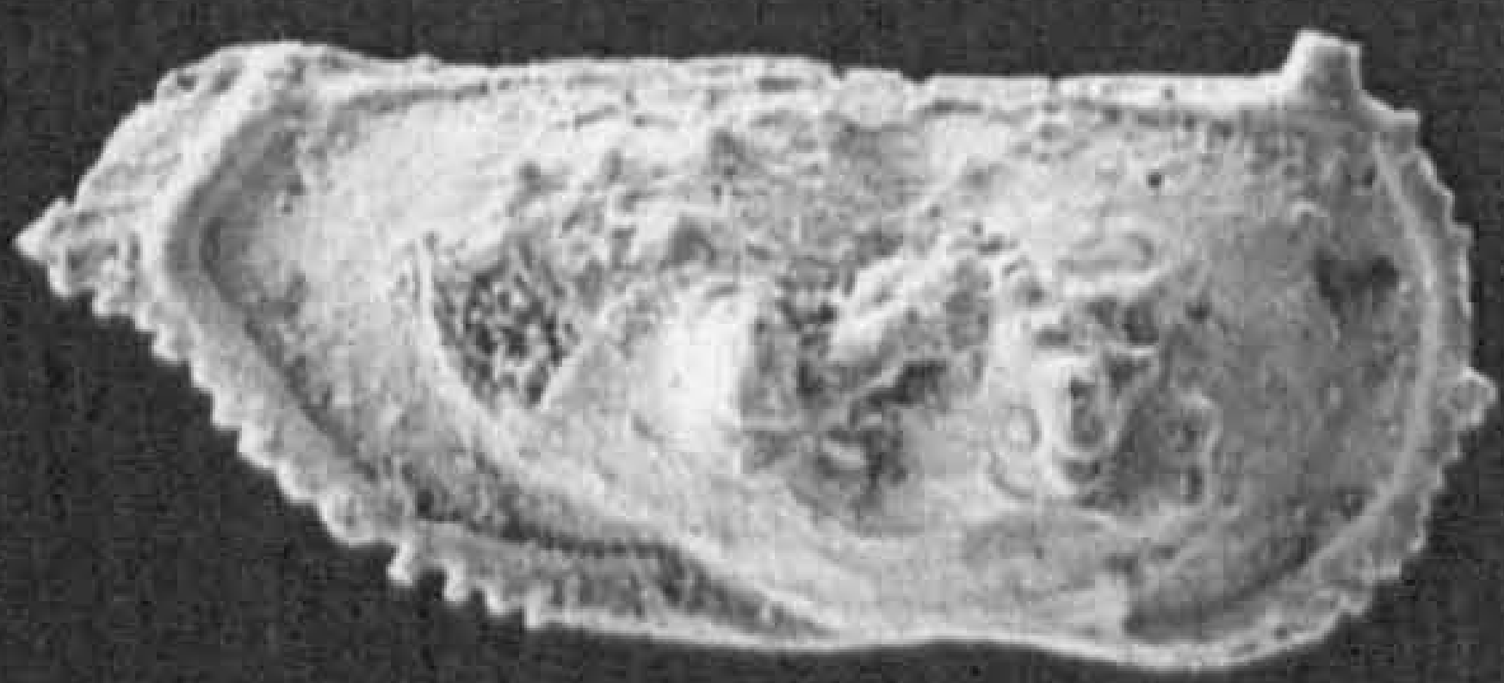

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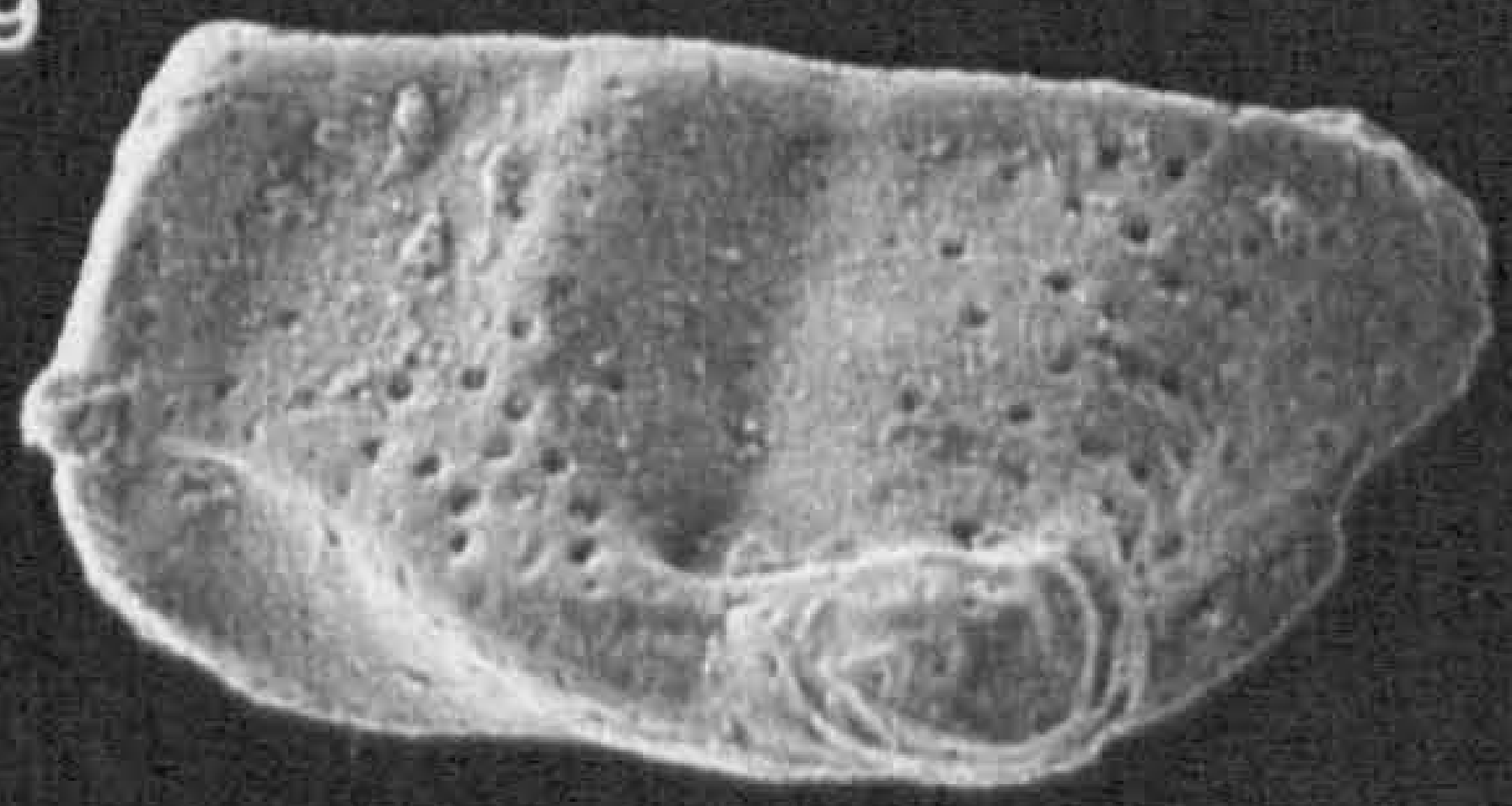

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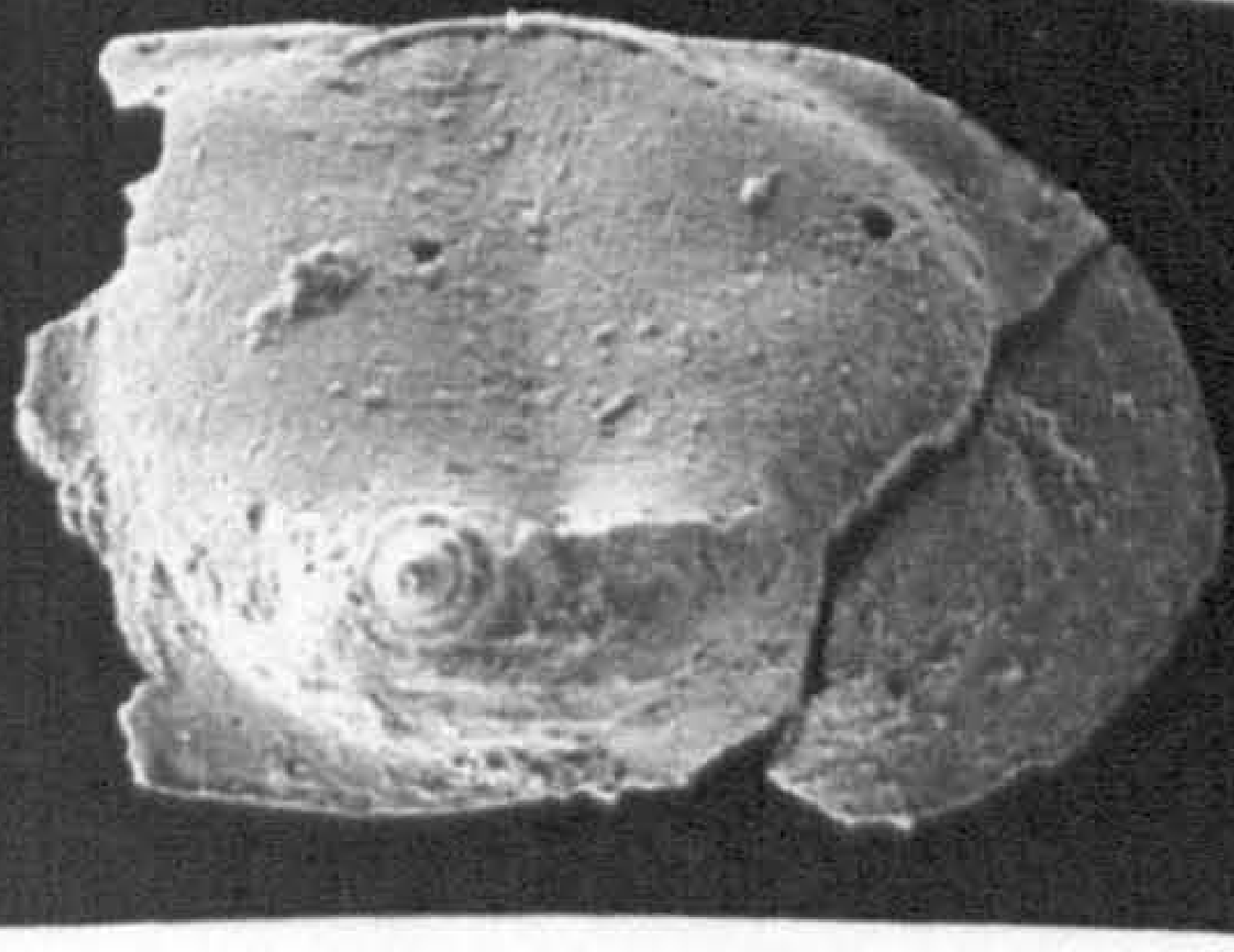

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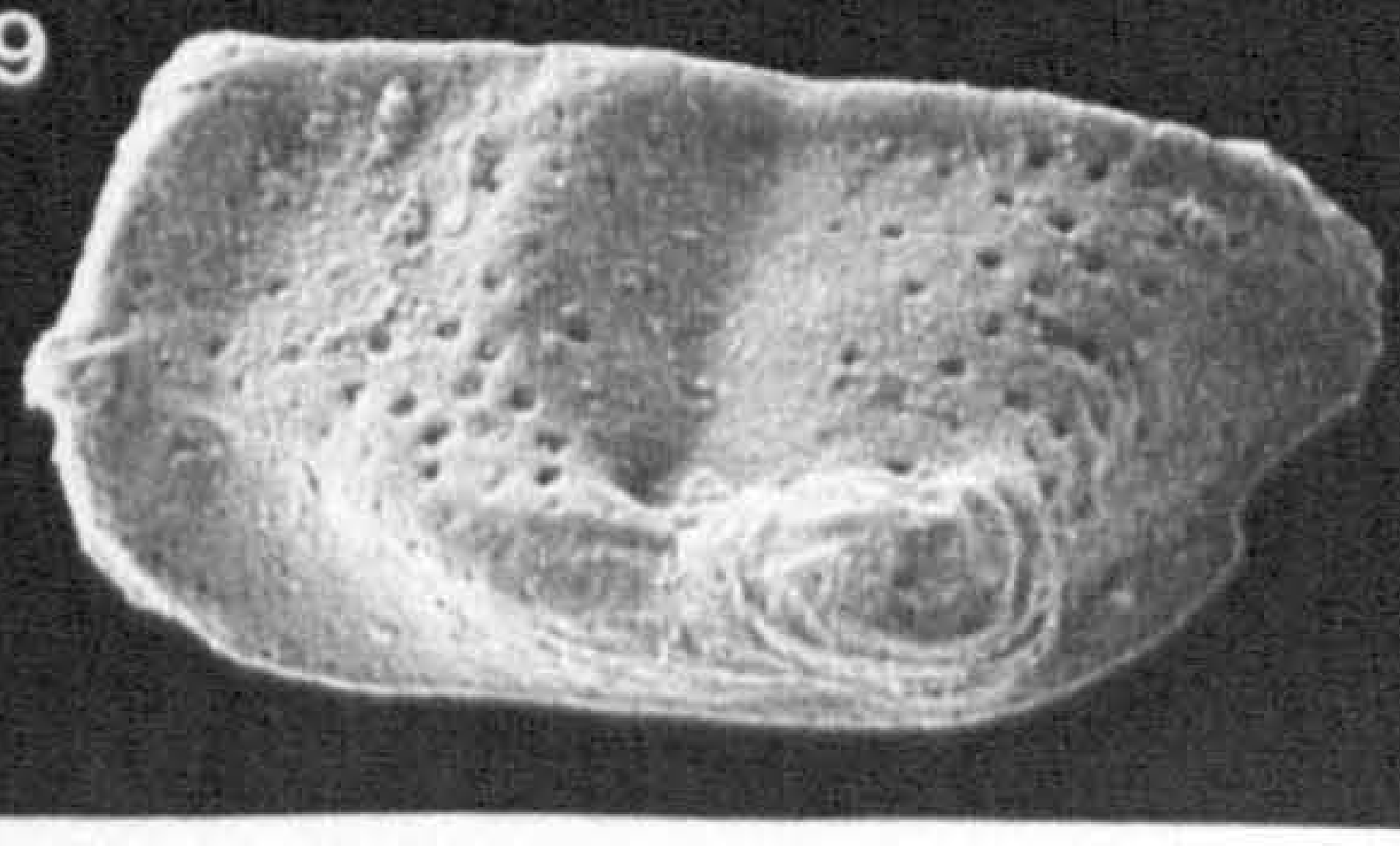

Fig. Page

PLATE 14

Golcocythere calkeri (Bonnema, 1941) 190

AKSD54, Flint level below Southerham Marl 1, Upper Turonian.

1 Left valve, IJS19/1. External lateral (stereo-pair), x74.

LGSD26, Navigation Hardground 1, Upper Turonian.

2 Right valve, IJS18/19. External lateral (stereo-pair), x74.

Asciocythere nana Nuyts, 1990 193

LGSD21, base of Kingston Nodular Chalks, Upper Turonian.

3 Left valve, IJS18/17. External lateral (stereo-pair), x120.

4 Right valve, IJS18/18. External lateral (stereo-pair), x115.

Schuleridea langdonensis sp. nov. 195

LGSD26, Navigation Hardground 1, Upper Turonian.

5 Holotype. Female left valve, IJS18/15. External lateral (stereo-pair), x79.

7 Male right valve, IJS18/16. External lateral (stereo-pair), x78.

LGSD28, below Navigation Hardground 3, Upper Turonian.

6 Female right valve, IJS18/14. External lateral (stereo-pair), x78.

Eucytherura (*Eucytherura*) cf. *E.* (*E.*) *tuberculata* Bonnema, 1941. 197

LGSD19, Bridgewick Marl 2, Upper Turonian.

8 Right valve, IJS18/10. External lateral (stereo-pair), x167.

PLATE 14

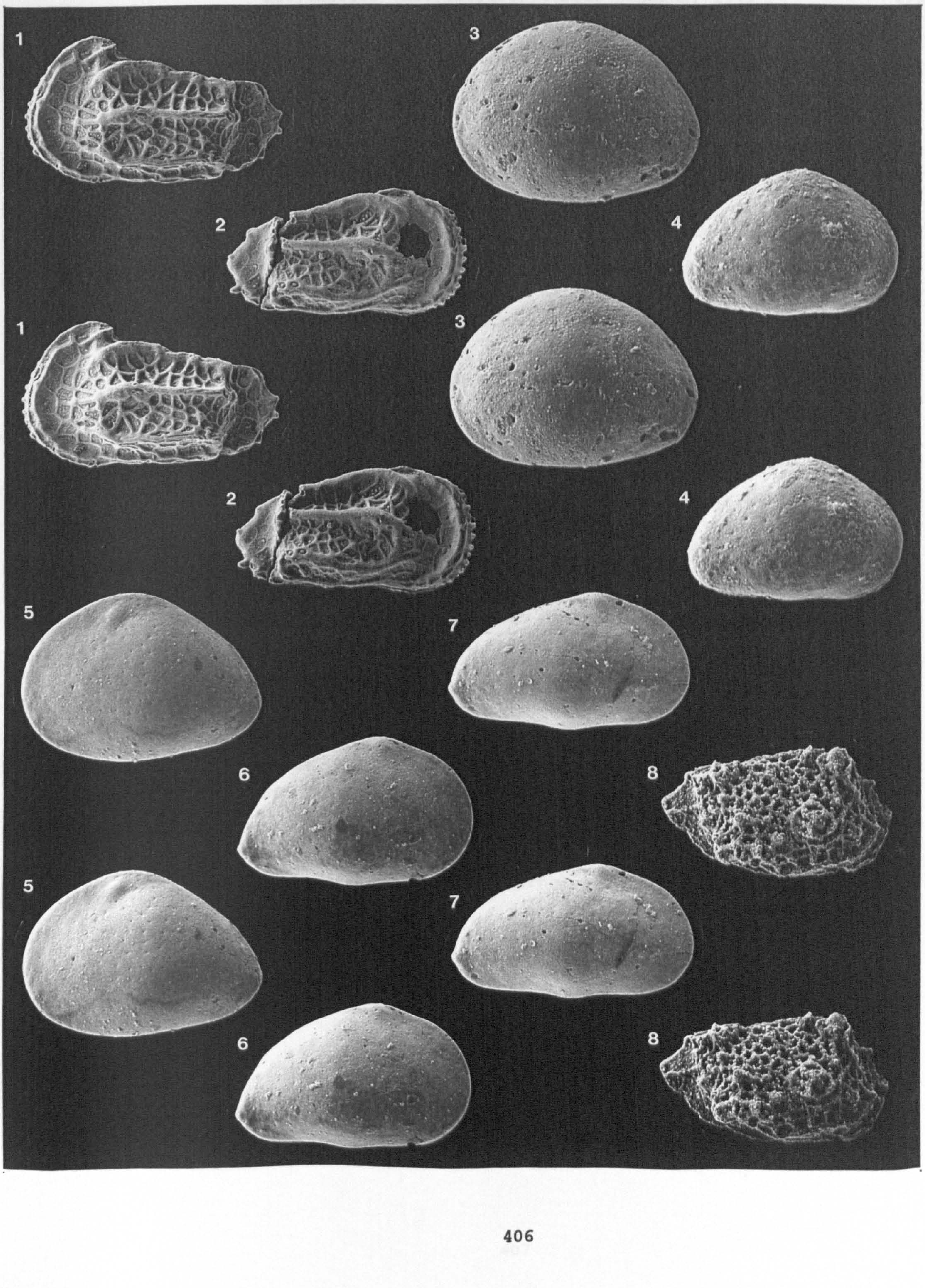

Fig. PLATE 15 Page

Eucytherura (*Eucytherura*) *tumida* Bonnema, 1941 198

LGSD5, 1.1m above Southerham Marl 2, Upper Turonian.

1 Left valve, IJS18/12. External lateral (stereo-pair), x166.

LGSD24, top of Kingston Nodular Chalks, Upper Turonian.

2 Right valve, IJS18/13. External lateral (stereo-pair), x172.

Eucytherura (*Vesticytherura*) sp. cf. *dorsotuberculata* van Veen, 1938 200

LGSD5, 1.1m above Southerham Marl 2, Upper Turonian.

3 Left valve, IJS12/5. External lateral (stereo-pair), x170.

AKSD55, Southerham Marl 1, Upper Turonian.

4 Right valve, IJS18/11. External lateral (stereo-pair), x159.

Cytheropteron (*Aversovalva*) *vscriptum* (van Veen, 1936) 203

LGSD28, below Navigation Hardground 3, Upper Turonian.

5 Left valve, IJS18/8. External lateral (stereo-pair), x155.

LGSD5, 1.1m above Southerham Marl 2, Upper Turonian.

6 Right valve, IJS18/9. External lateral (stereo-pair), x152.

Pedicythere fluitans (Bonnema, 1941) 205

LGSD26, Navigation Hardground 1, Upper Turonian.

7 Left valve, IJS18/7. External lateral (stereo-pair), x155.

LGSD5, 1.1m above Southerham Marl 2, Upper Turonian.

8 Right valve, IJS14/2. External lateral (stereo-pair), x120.

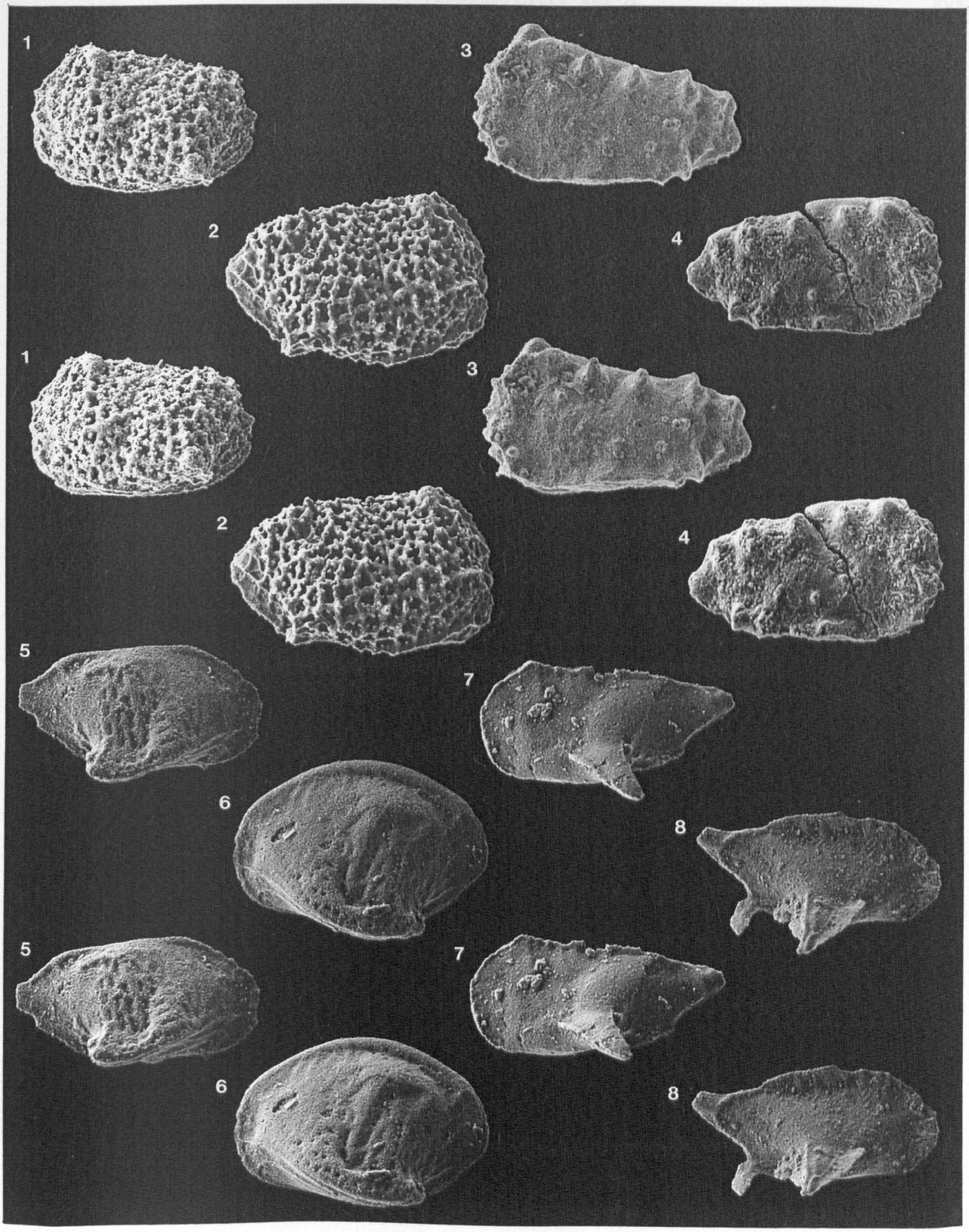
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Fig.

PLATE 16

Page

Phodeucythere sp. A 208

AKSD50, Flint level at base of Upper Turonian.

1 Left valve, IJS18/6. External lateral (stereo-pair), x80.

AKSD52, 3.2m below Southerham Marl 1, Upper Turonian.

2 Right valve, IJS18/5. External lateral (stereo-pair), x80.

Krithe simplex (Jones & Hinde, 1890) 209

LGSD26, Navigation Hardground 1, Upper Turonian.

3 Carapace, IJS18/4. Left lateral (stereo-pair), x82.

LGSD28, below Navigation Hardground 3, Upper Turonian.

4 Right valve, IJS18/3. External lateral (stereo-pair), x83.

Neocythere (*Physocythere*) *verbosa* (Damotte, 1962) 215

LGSD5, 1.1m above Southerham Marl 2, Upper Turonian.

5 Right valve, IJS18/1. External lateral (stereo-pair), x75.

AKSD41, 3.5m below Lydden Spout Flint, Middle Turonian.

6 Left valve, IJS18/2. External lateral (stereo-pair), x76.

Karsteneis nodifera nodifera (Kafka, 1886) 219

ABCMR4, 2.5m above Lulworth Marl, Lower Turonian.

7 Left valve, IJS17/21. External lateral (stereo-pair), x67.

8 Right valve, IJS17/22. External lateral (stereo-pair), x67.

Karsteneis nodifera tabasca ssp. nov. 222

LGSD26, Navigation Hardground 1, Upper Turonian.

9 Left valve, IJS17/27. External lateral (stereo-pair), x64.

10 Holotype. Right valve, IJS17/28. External lateral (stereo-pair), x65.

PLATE 16

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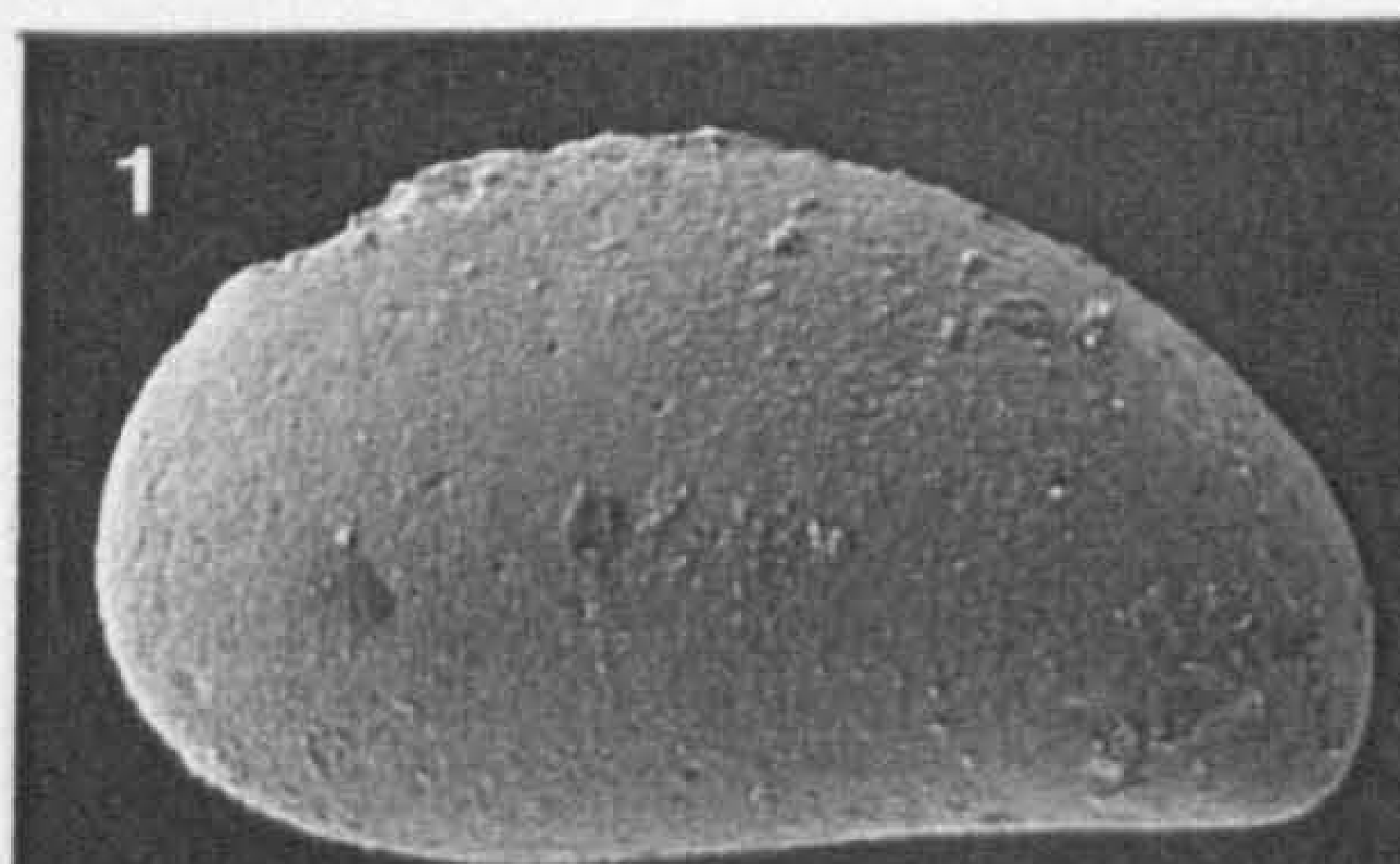

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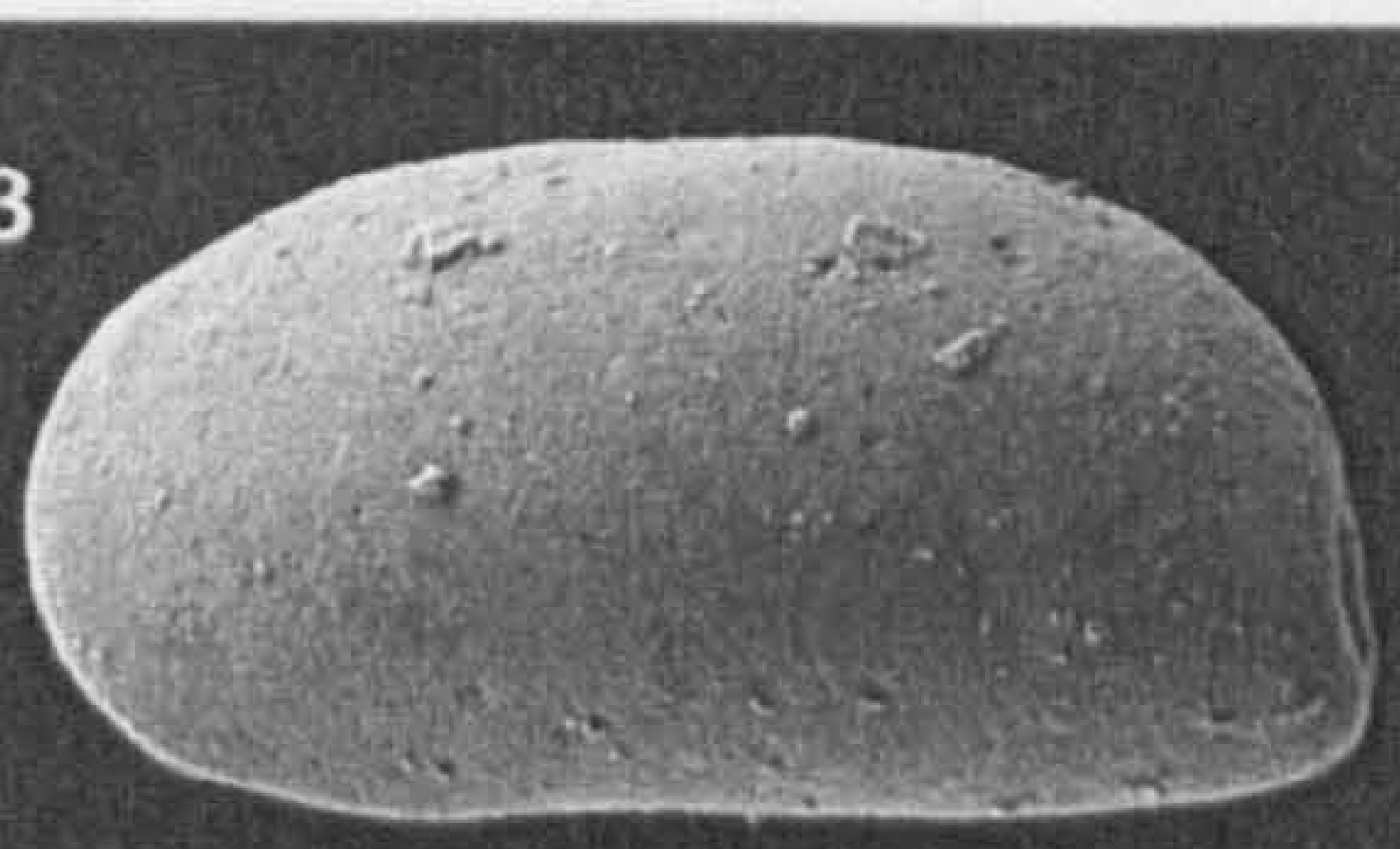

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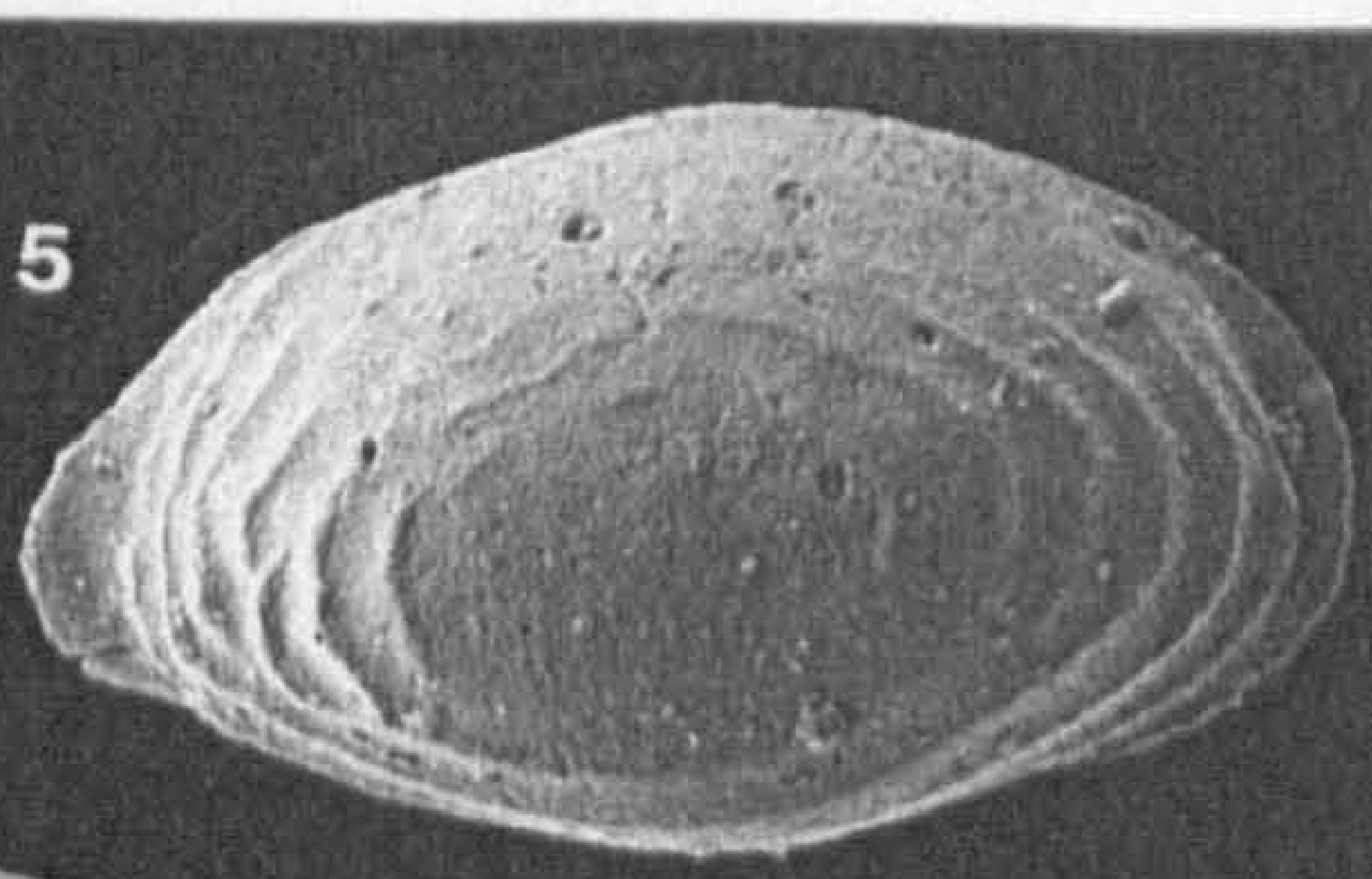

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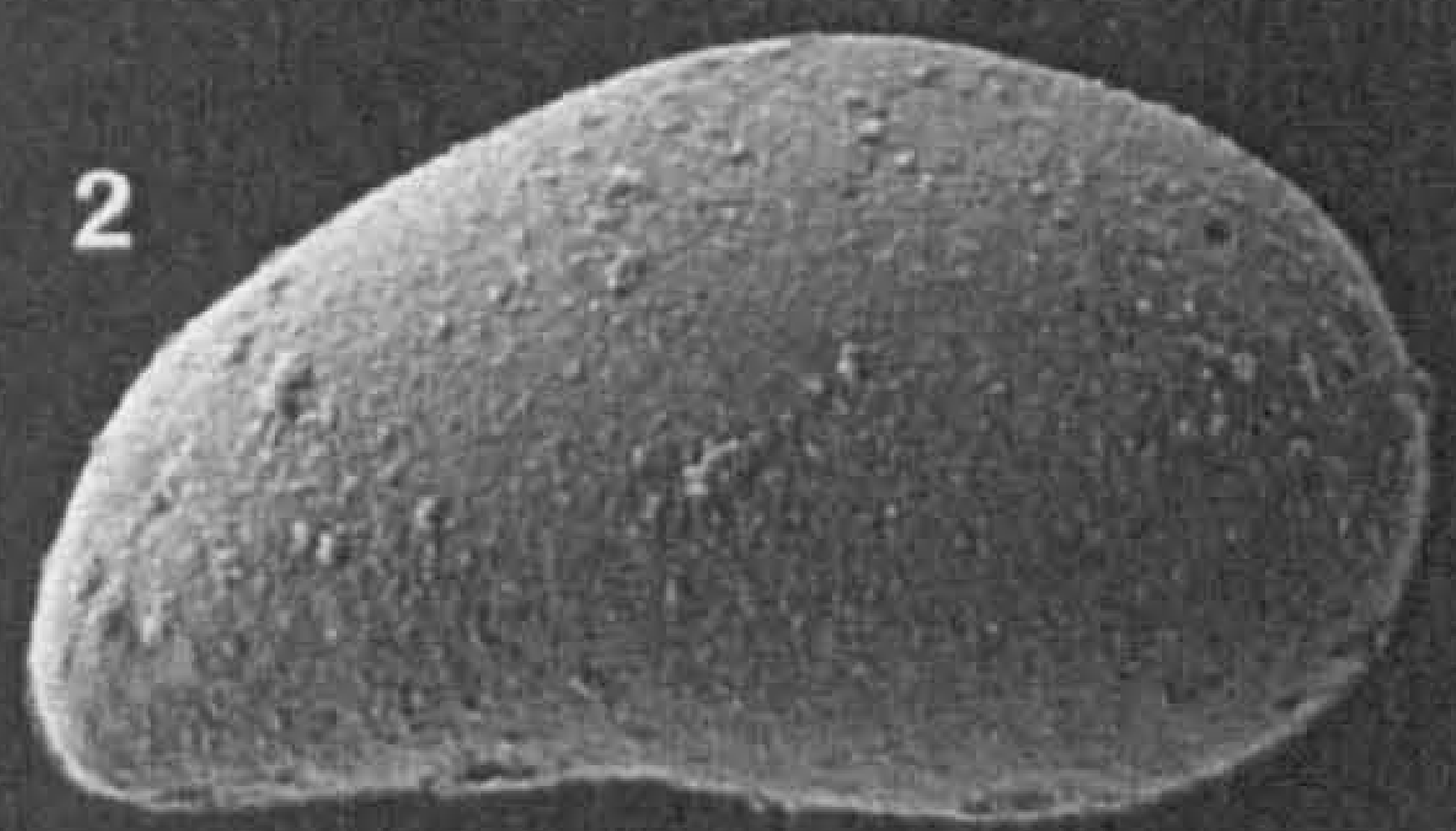

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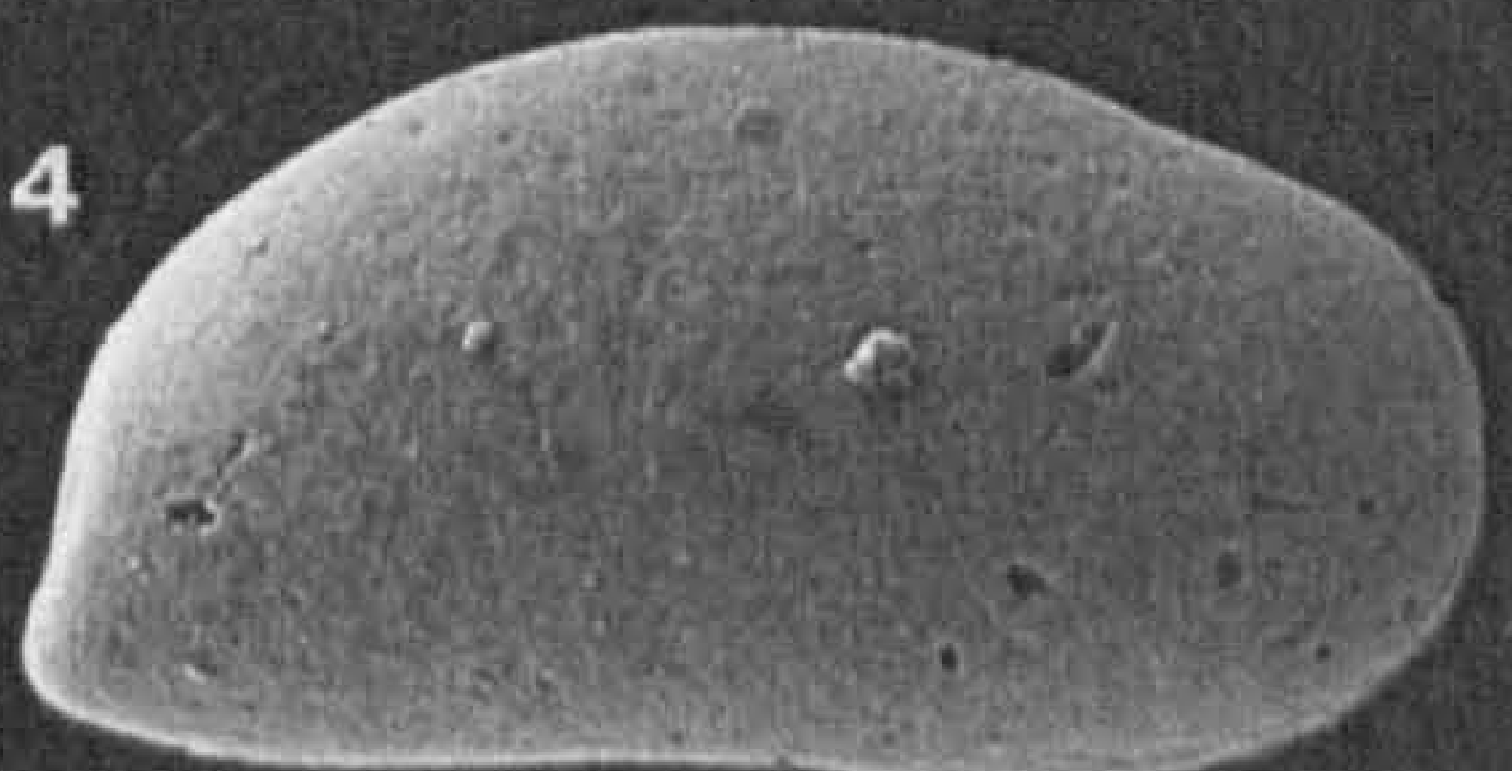

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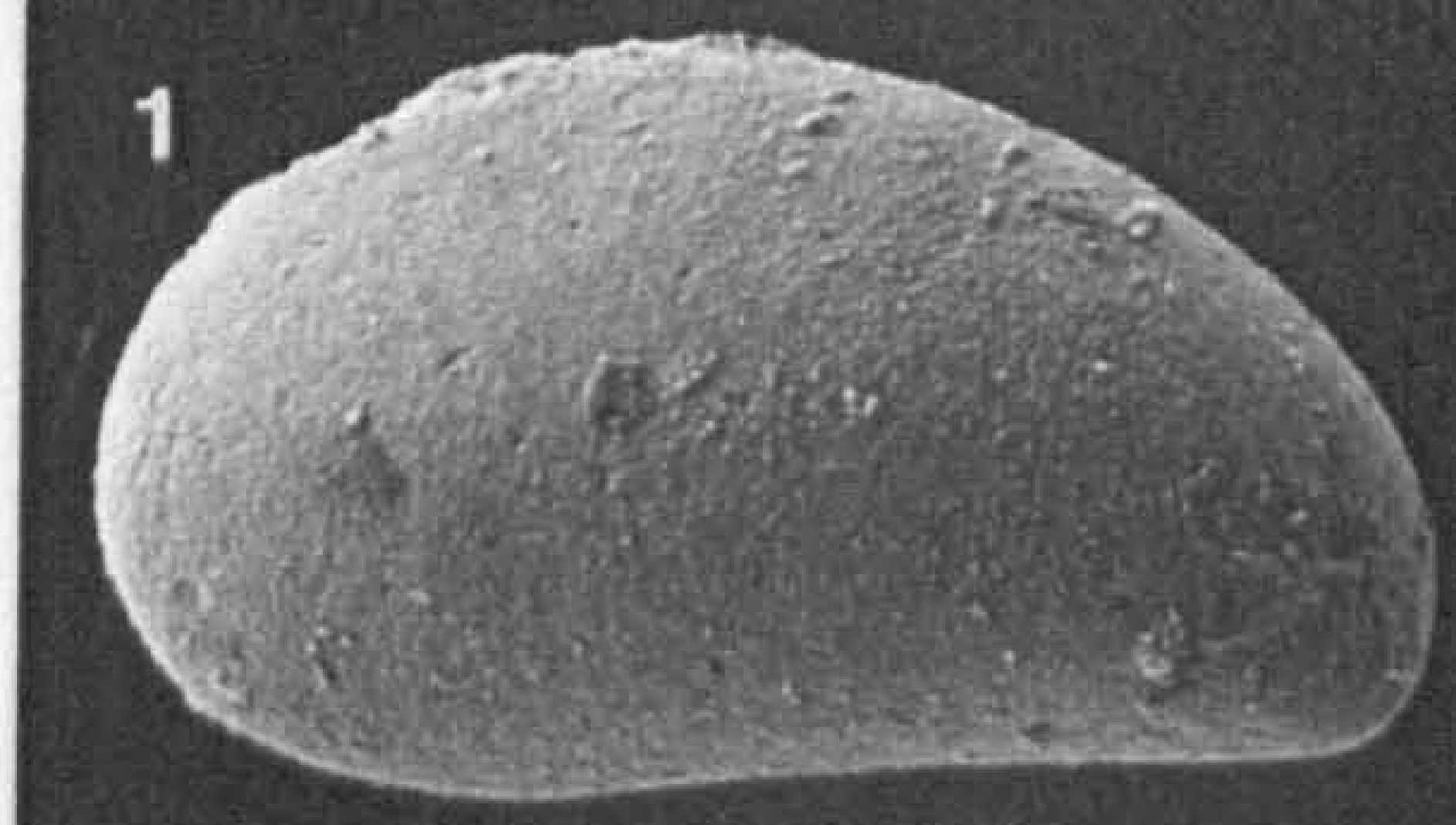

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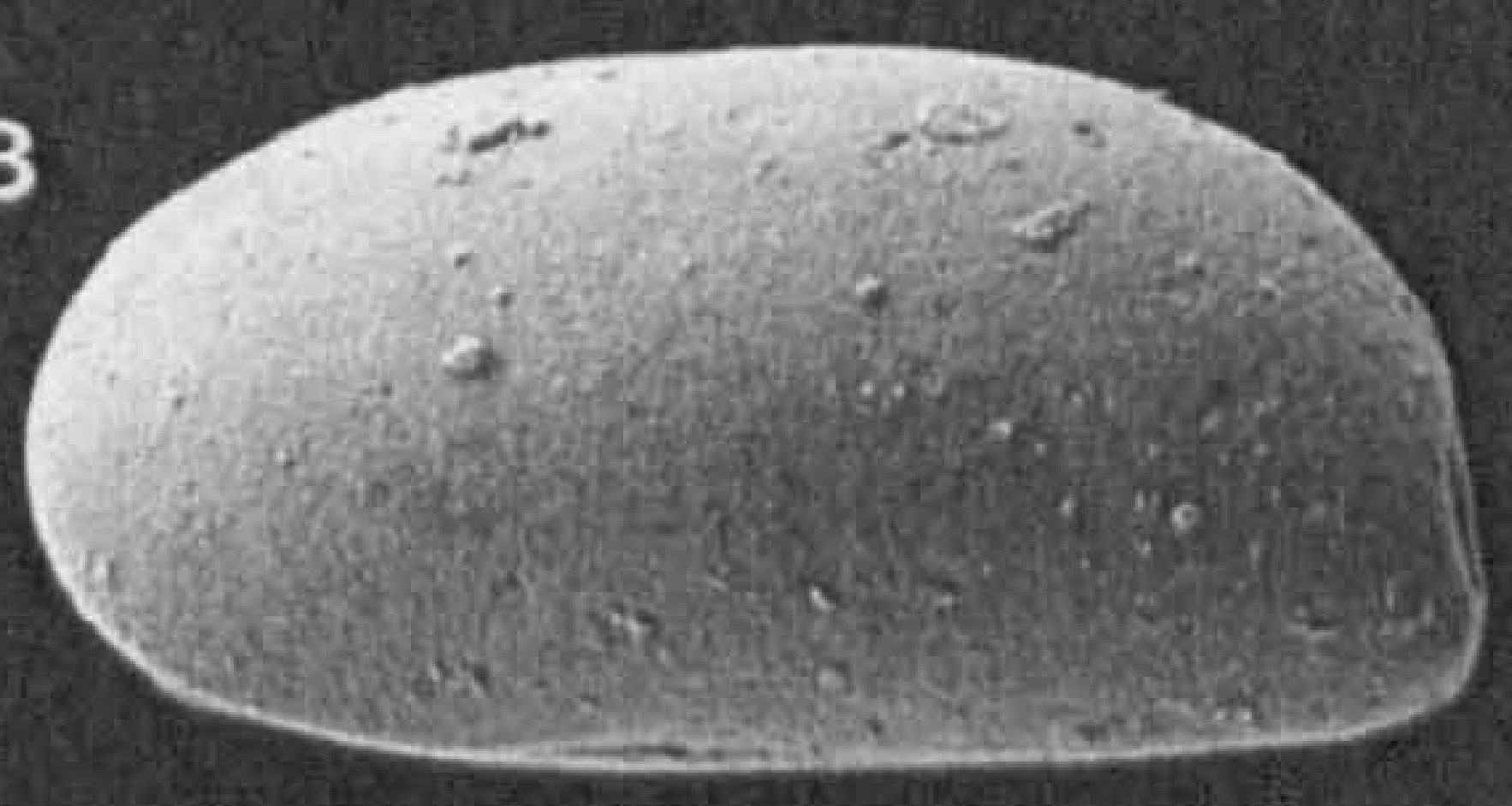

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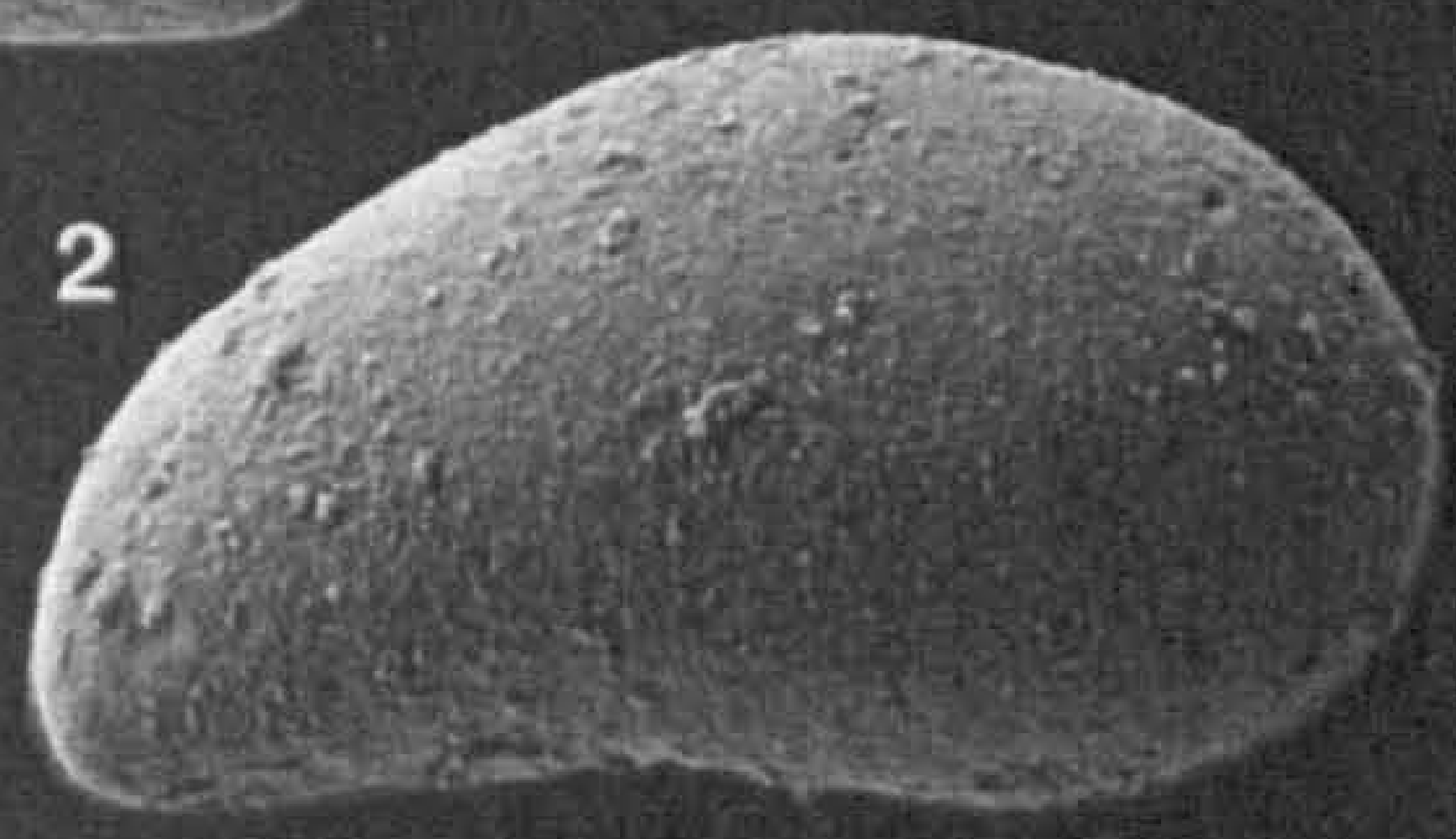

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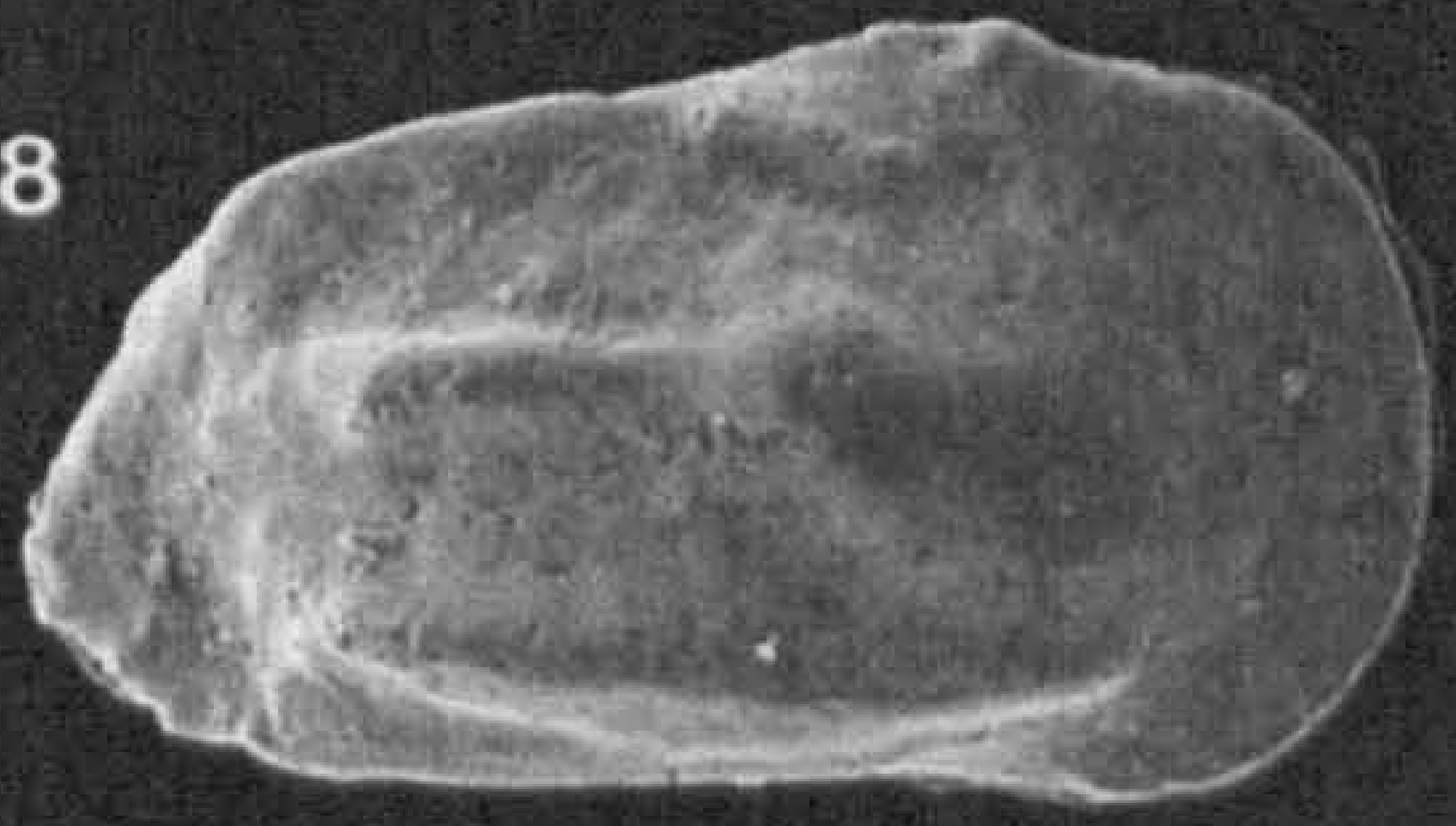

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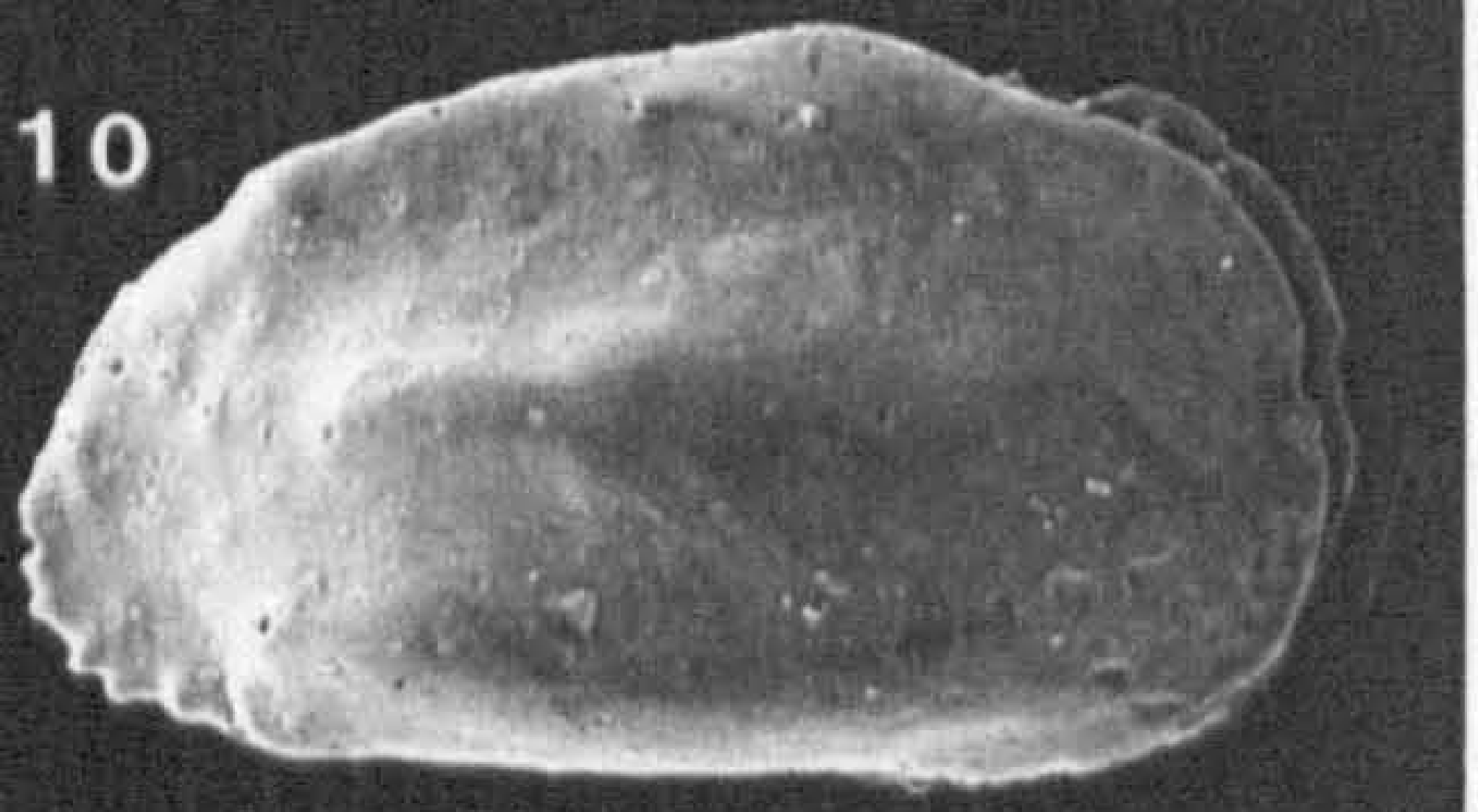

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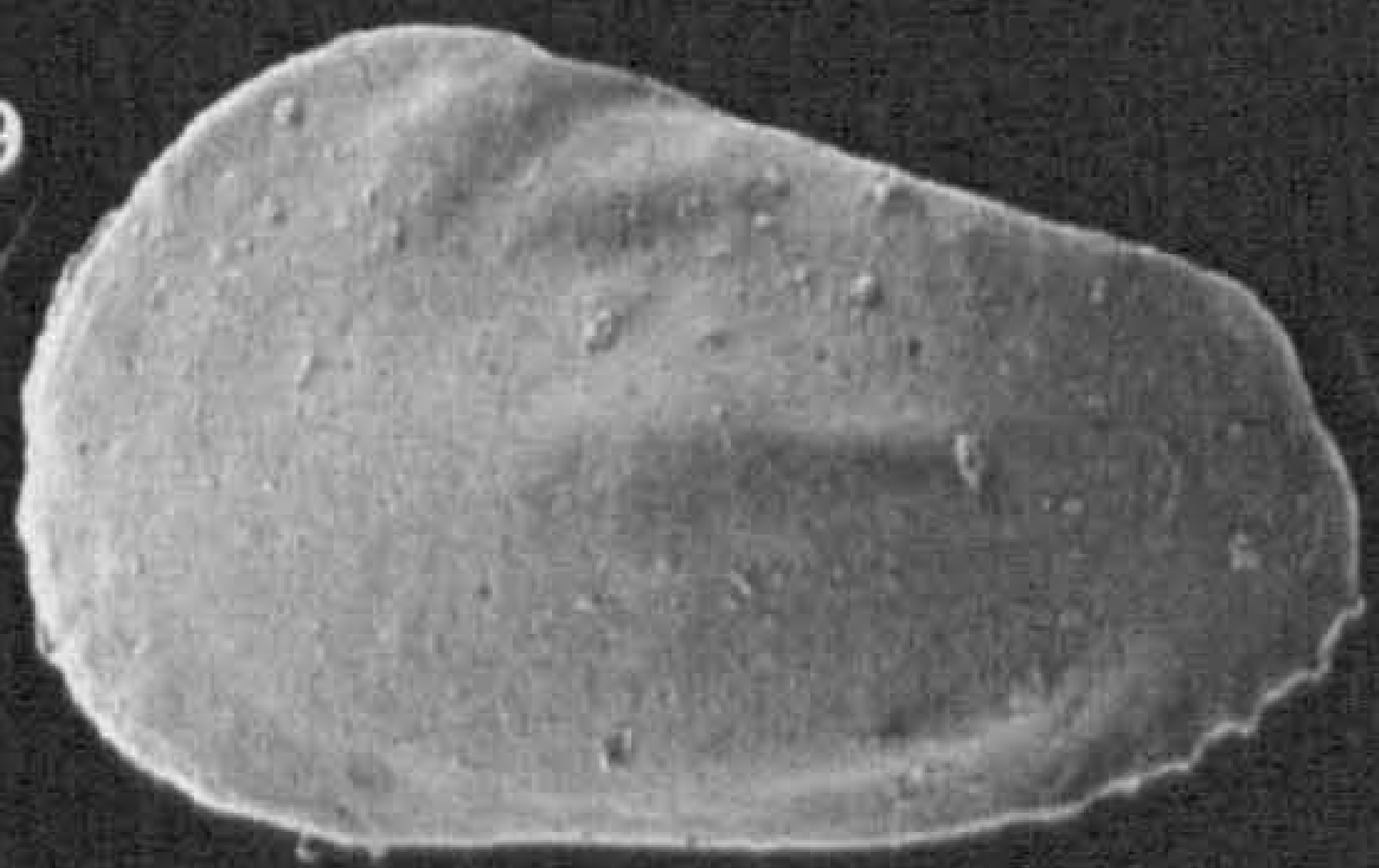

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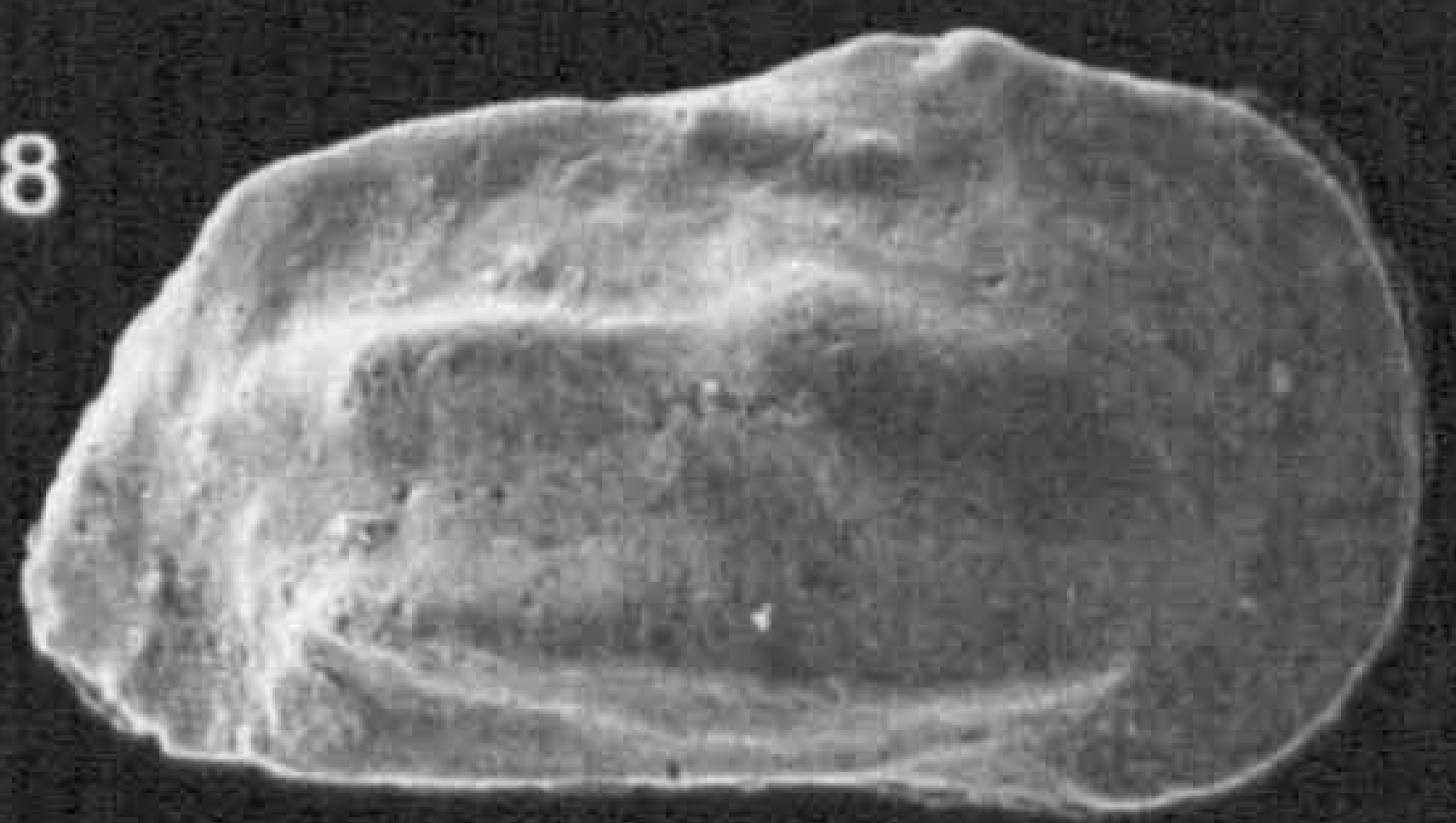

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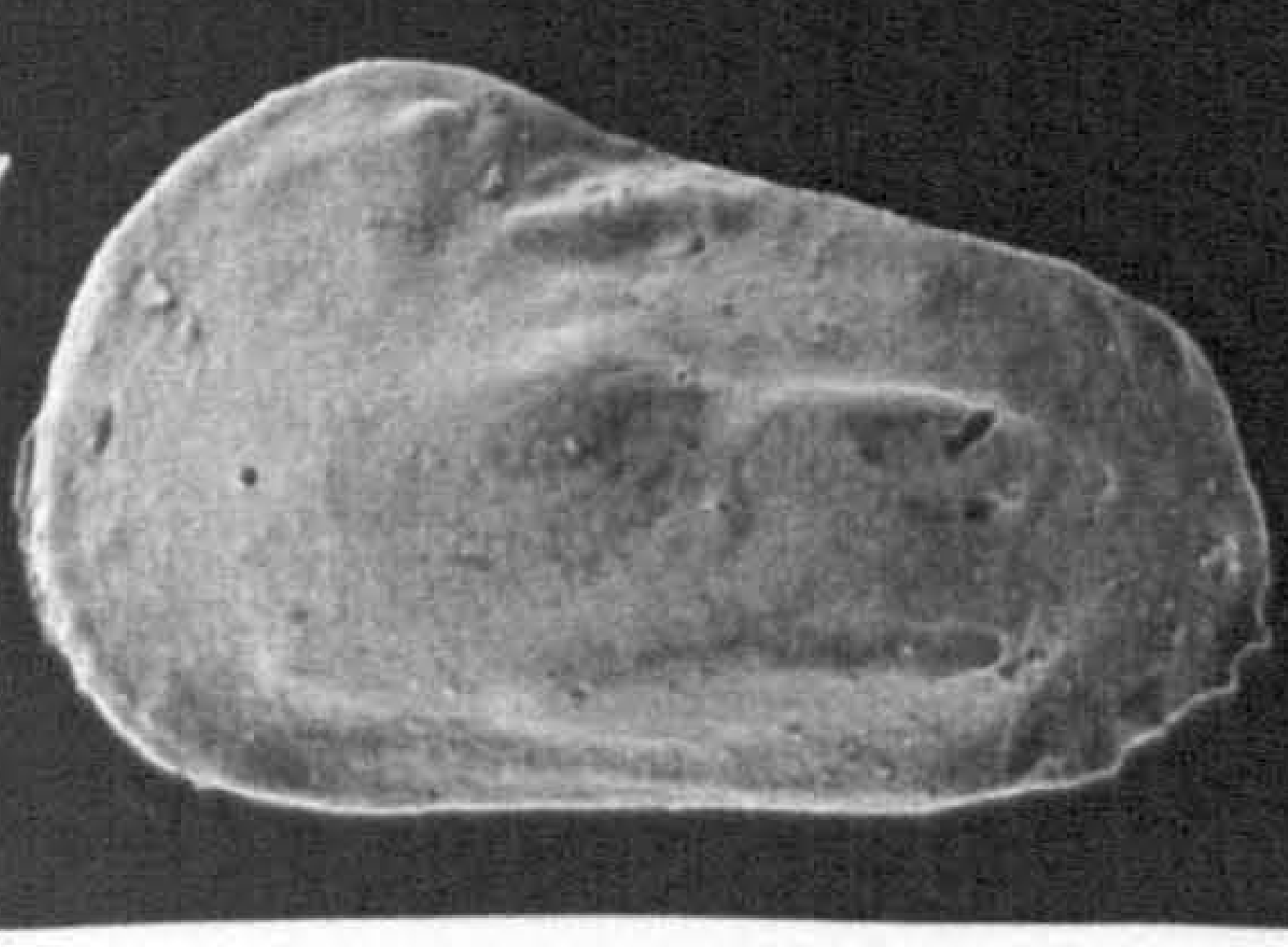

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Fig.

PLATE 17

Page

Karsteneis oculocosta sp. nov. 223

LGSD21, base of Kingston Nodular Chalks, Upper Turonian.

1 Holotype. Left valve, IJS17/29. External lateral (stereo-pair), x66.

2 Right valve, IJS17/30. External lateral (stereo-pair), x69.

Karsteneis petasus petasus sp. et ssp. nov. 225

AKSD17, 1.7m above Round Down Marl, Middle Turonian.

3 Holotype. Left valve, IJS17/23. External lateral (stereo-pair), x66.

4 Right valve, IJS17/24. External lateral (stereo-pair), x66.

Karsteneis petasus antecursor sp. et ssp. nov. 232

ABCMR4, 2.5m above Lulworth Marl, Lower Turonian.

5 Holotype. Left valve, IJS17/19. External lateral (stereo-pair), x65.

6 Right valve, IJS17/20. External lateral (stereo-pair), x65.

Karsteneis praekarsteni sp. nov. 233

LGSD1, Southerham Marl 1 , Upper Turonian.

7 Holotype. Left valve, IJS17/25. External lateral (stereo-pair), x67.

8 Right valve, IJS17/26. External lateral (stereo-pair), x76.

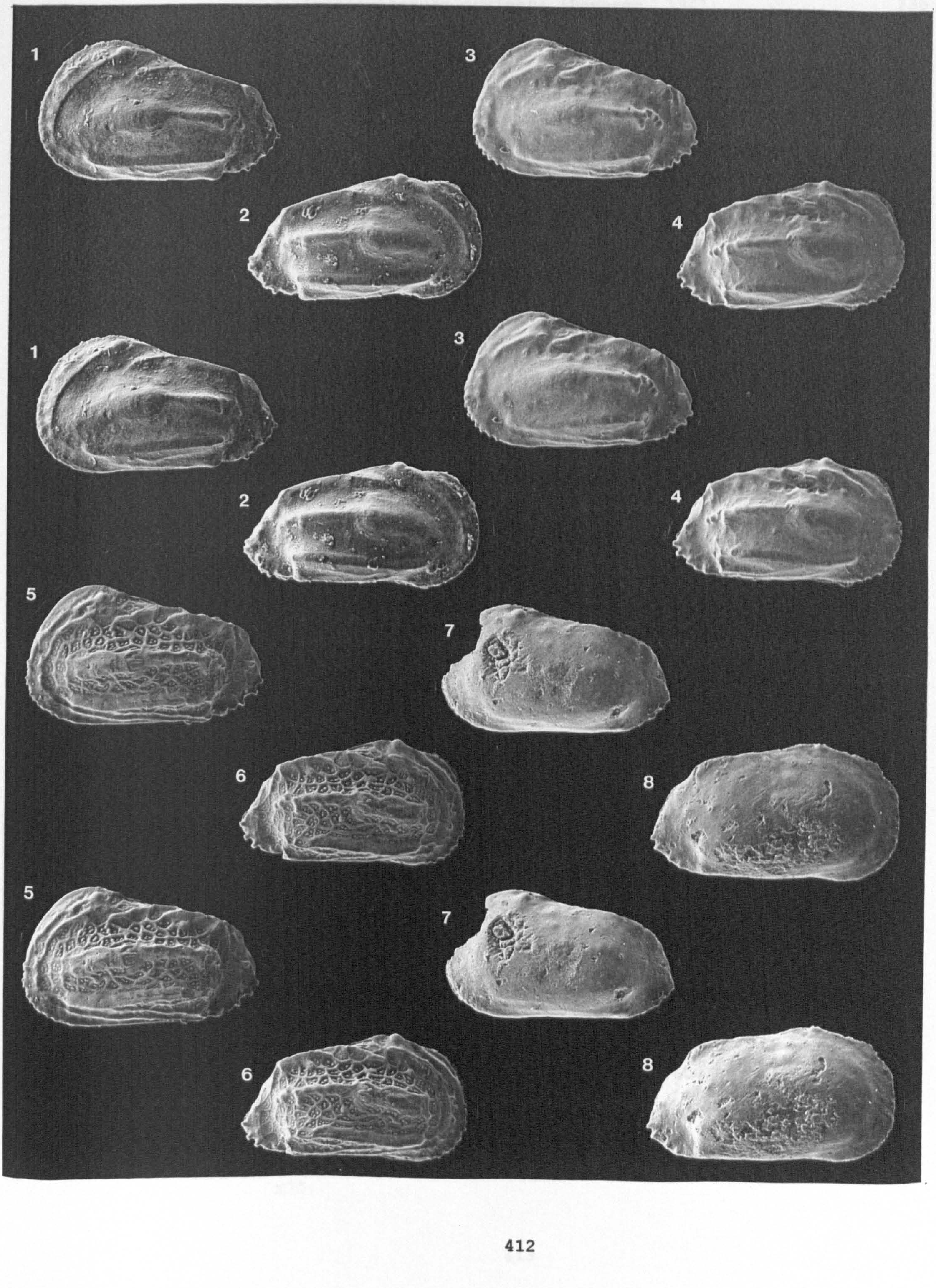
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Fig. **PLATE 18** Page

Amphicytherura aculeata (Bonnema, 1941) 236

LGSD24, top of Kingston Nodular Chalks, Upper Turonian.

1 Right valve, IJS127/18. External lateral (stereo-pair), x96.

Amphicytherura sp. aff. *A. chelodon* (Marsson, 1880) 238

LGSD21, base of Kingston Nodular Chalks, Upper Turonian.

2 Left valve, IJS17/17. External lateral (stereo-pair), x99.

Curfsina senior senior Pokorný, 1967a 241

AKSD43, 1.5m below Lydden Spout Flint, Middle Turonian.

3 Left valve, IJS17/15. External lateral (stereo-pair), x74.

LGSD28, below Navigation Hardground 3, Upper Turonian.

4 Right valve, IJS17/16. External lateral (stereo-pair), x82.

Curfsina senior calo spp. nov. 245

AKS3/10, 1.2m above Southerham Marl 2, Upper Turonian.

5 Holotype. Carapace, IJS17/14. Left lateral (stereo-pair), x74.

LGSD9, 1.2m below Caburn Marl, Upper Turonian.

6 Right valve, IJS17/8. External lateral (stereo-pair), x77.

Curfsina kafkai kafkai Pokorný, 1967a 246

LGSD9, 1.2m below Caburn Marl, Upper Turonian.

7 Left valve, IJS17/7. External lateral (stereo-pair), x75.

LGSD11, Caburn Marl, Upper Turonian.

8 Right valve, IJS17/10. External lateral (stereo-pair), x75.

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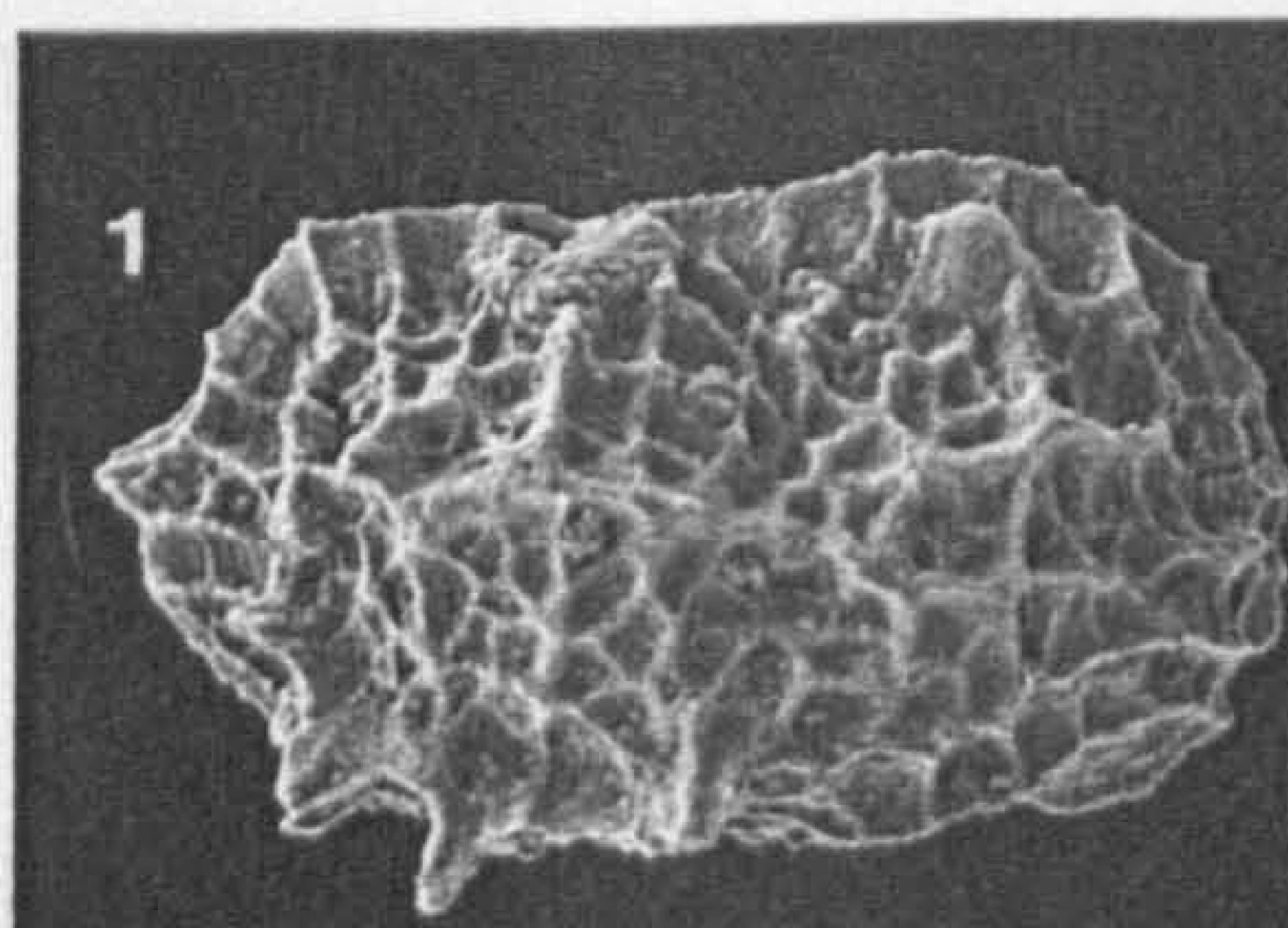

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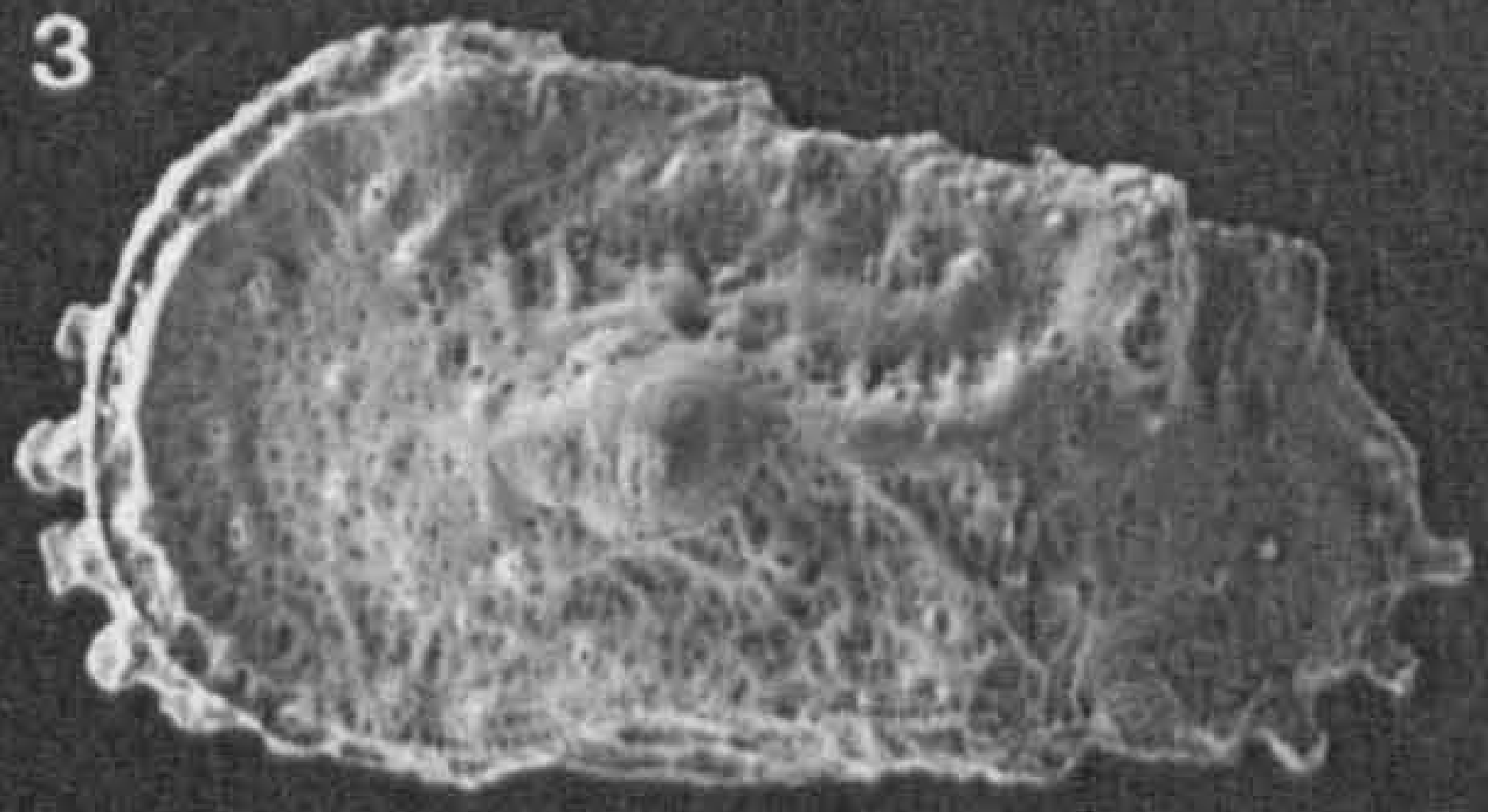

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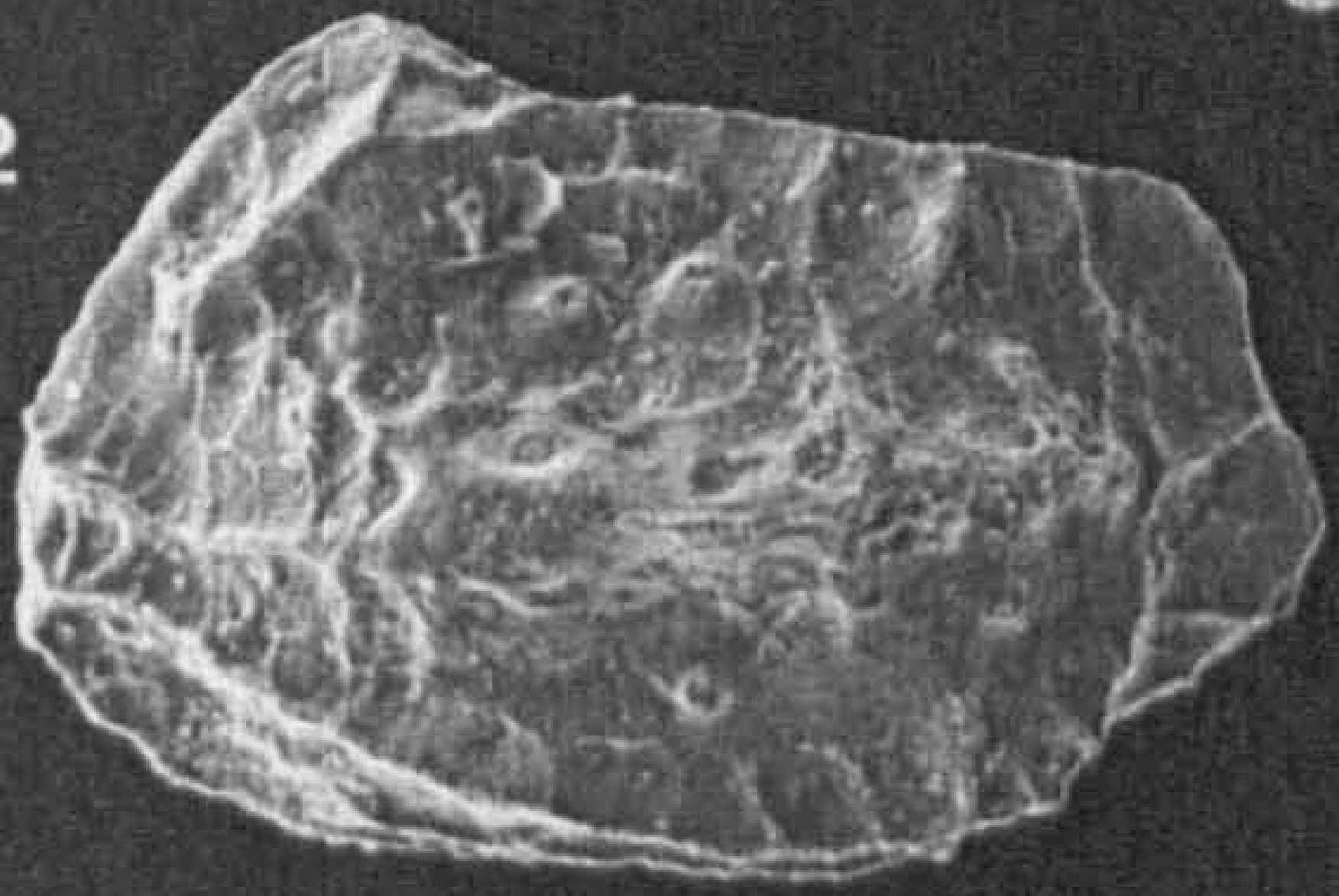

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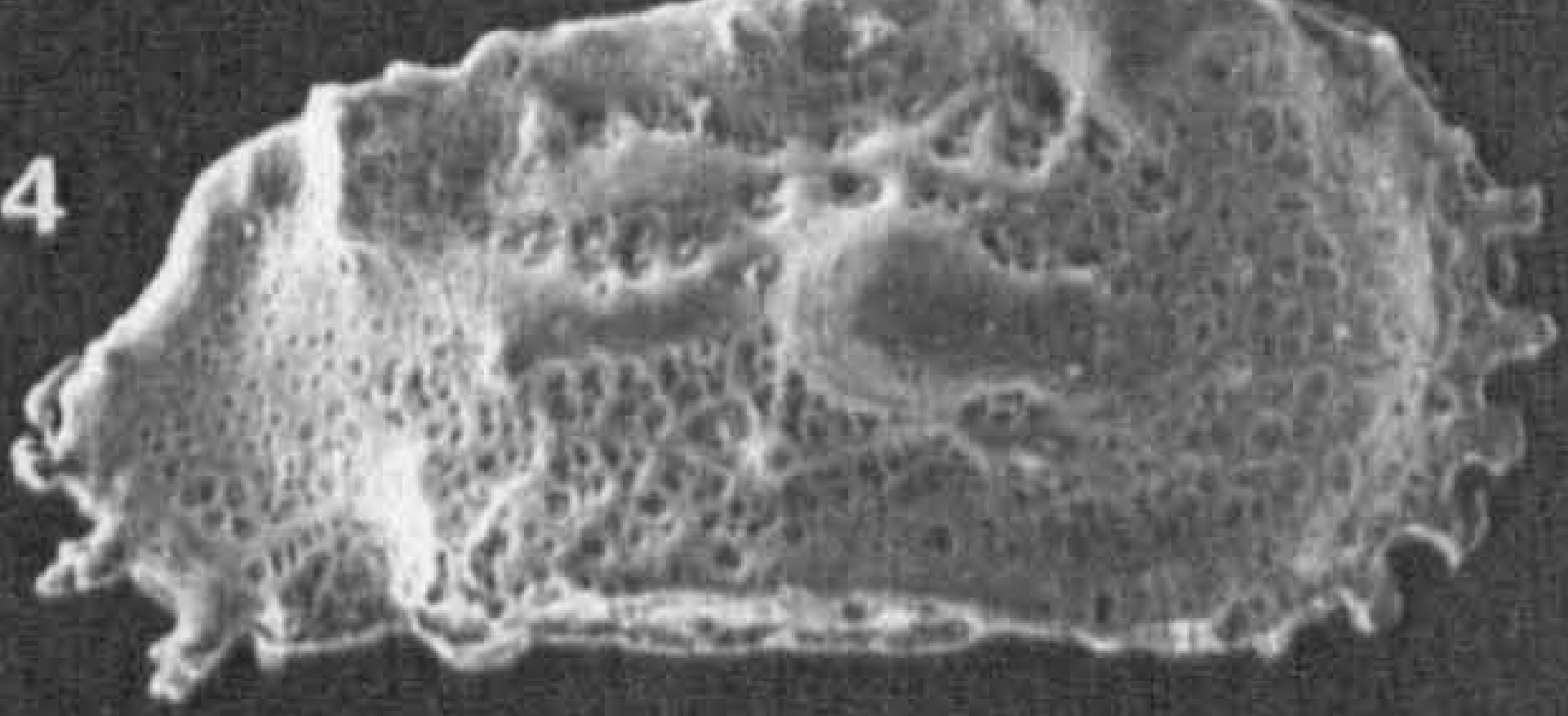

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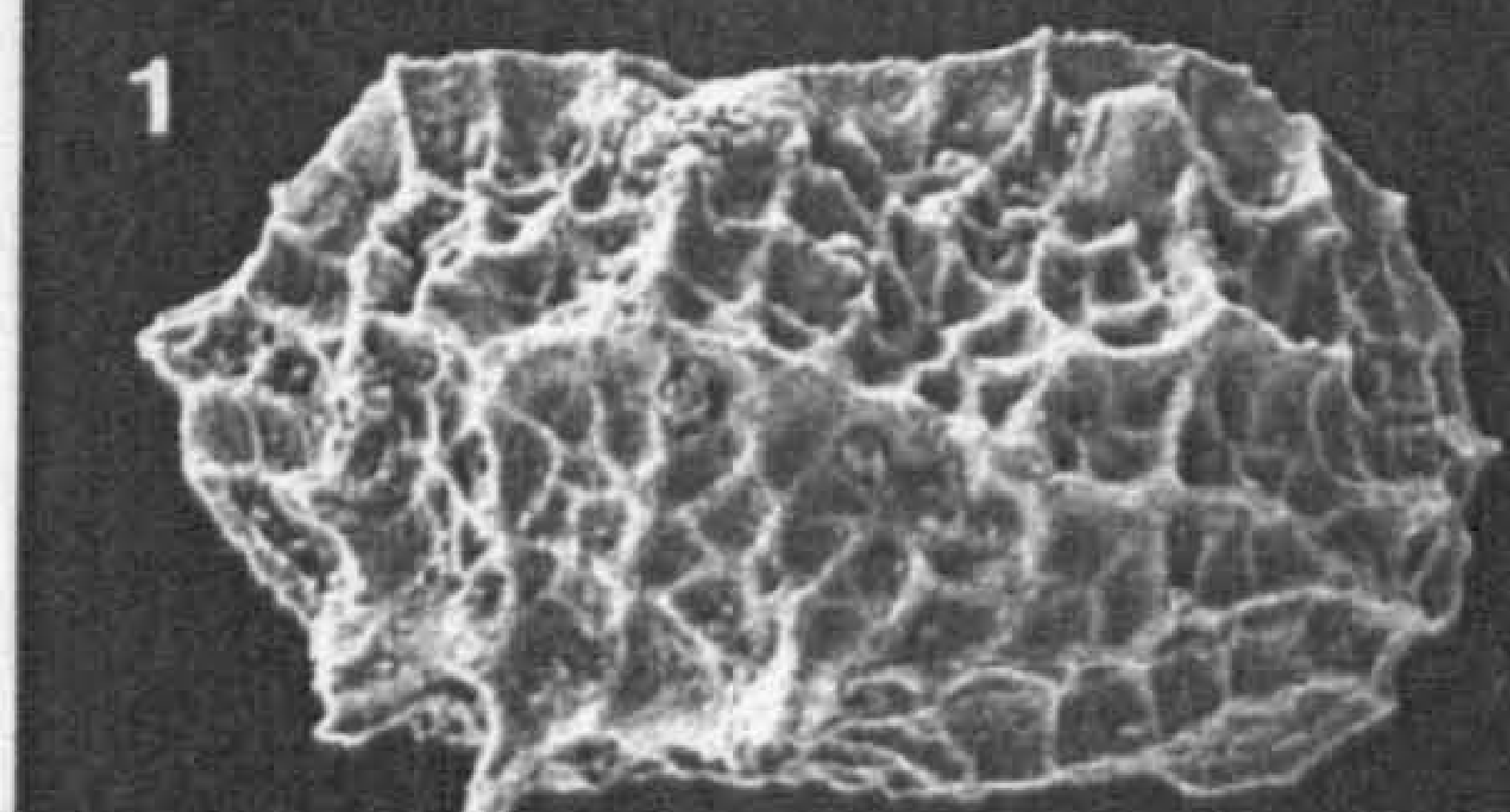

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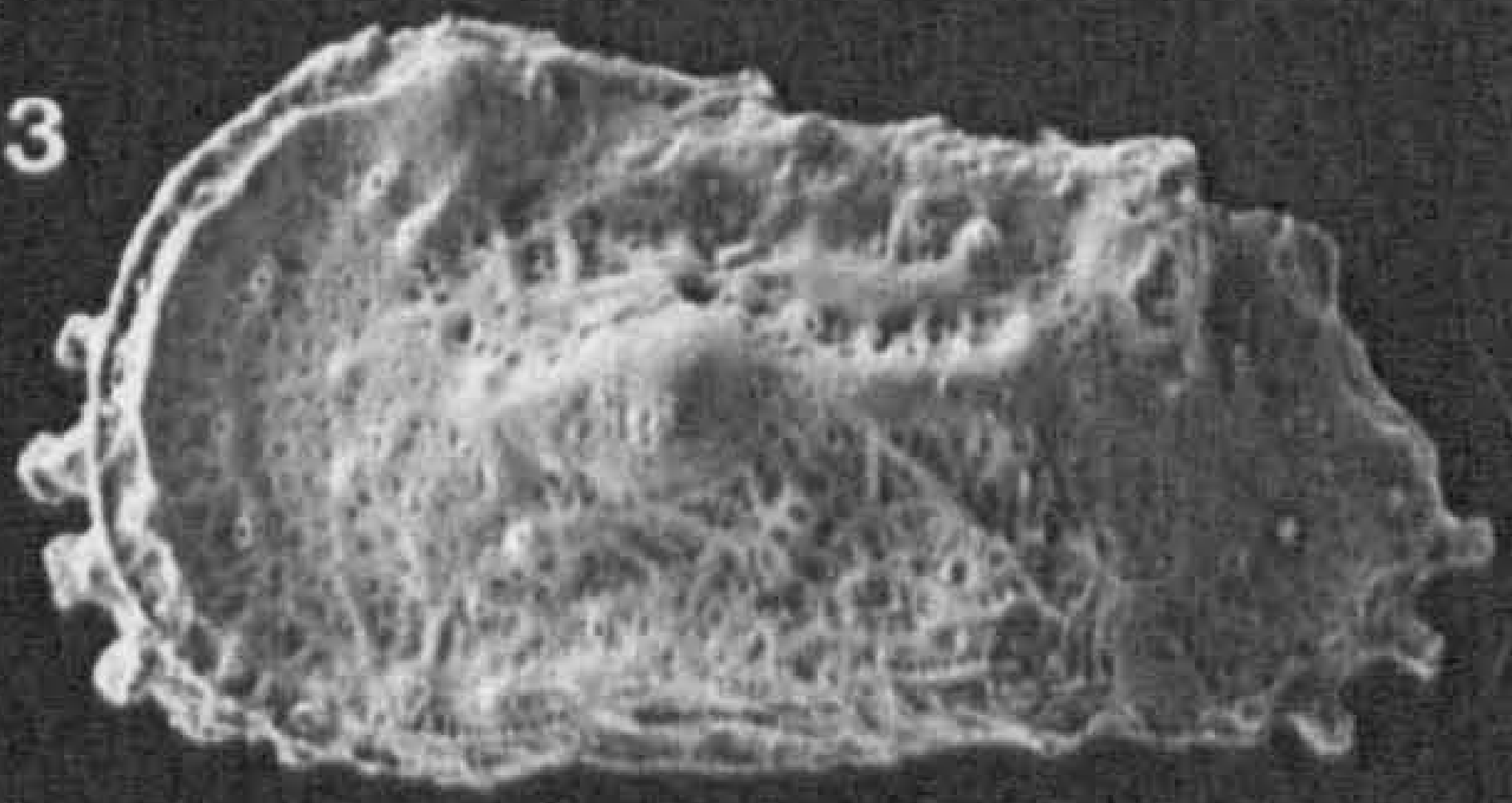

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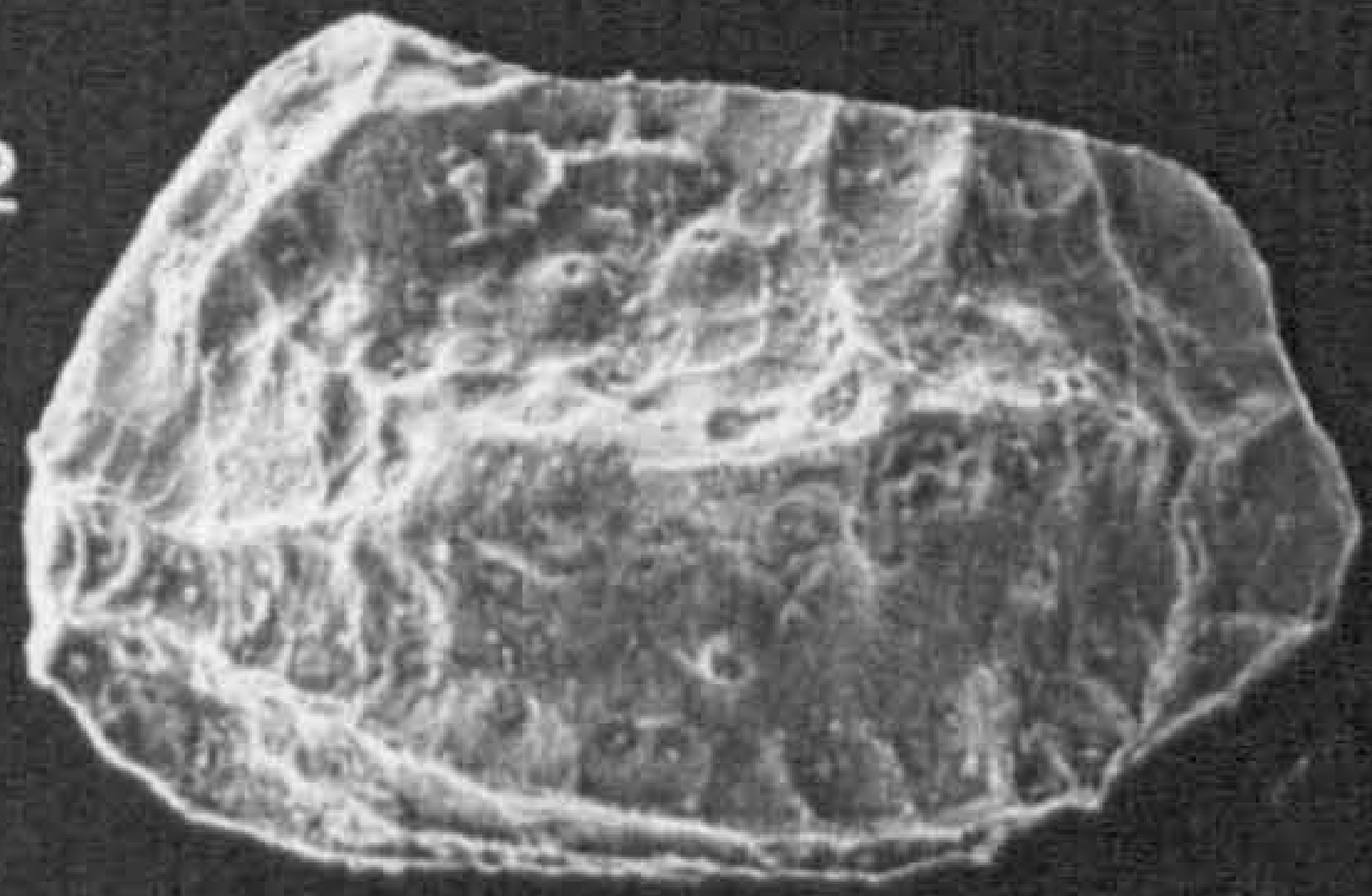

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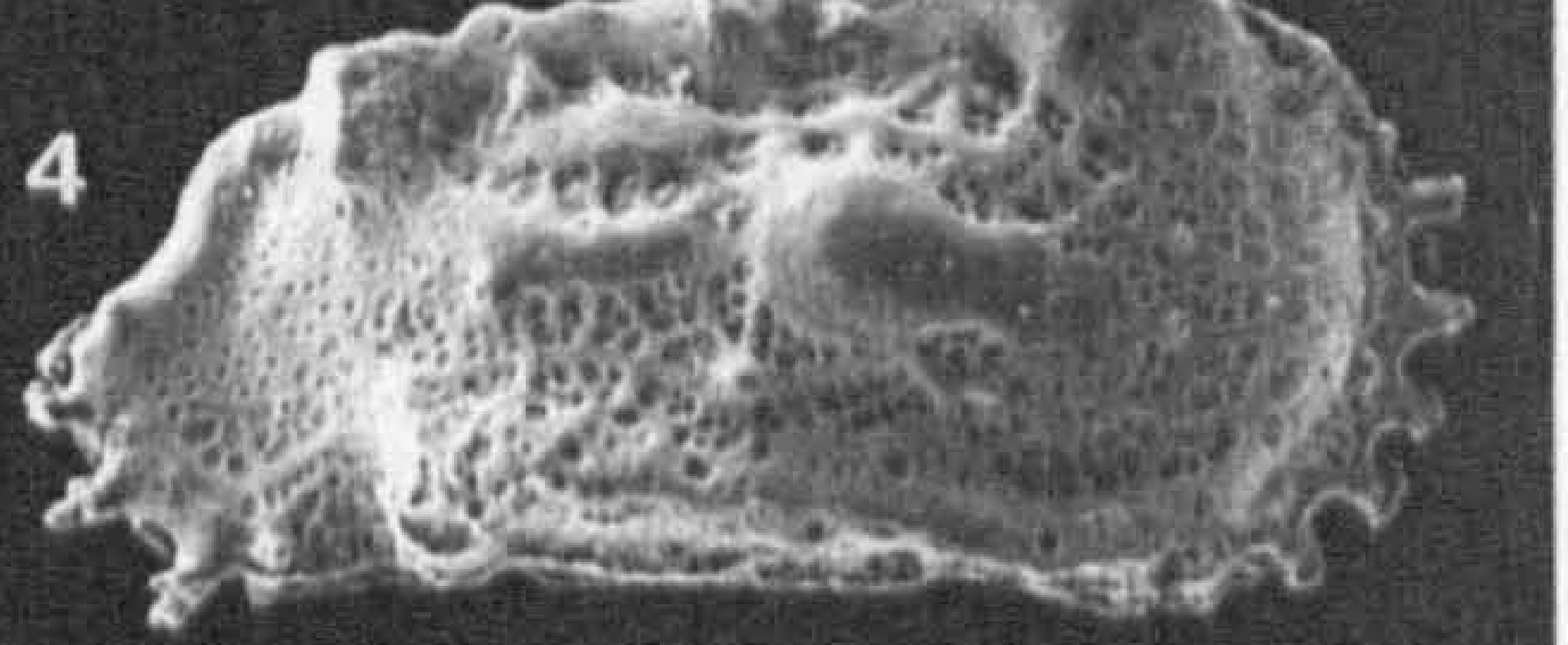

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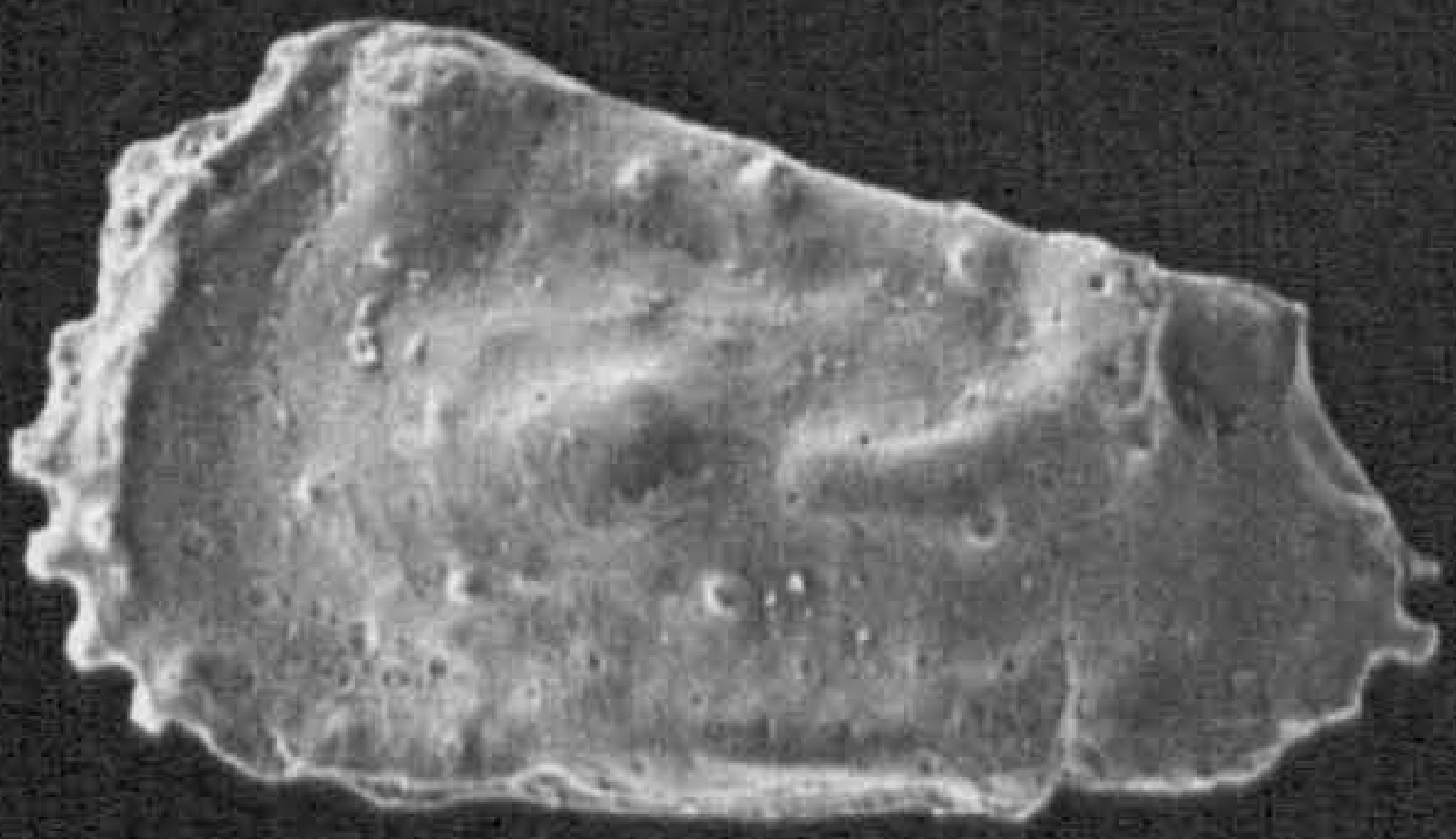

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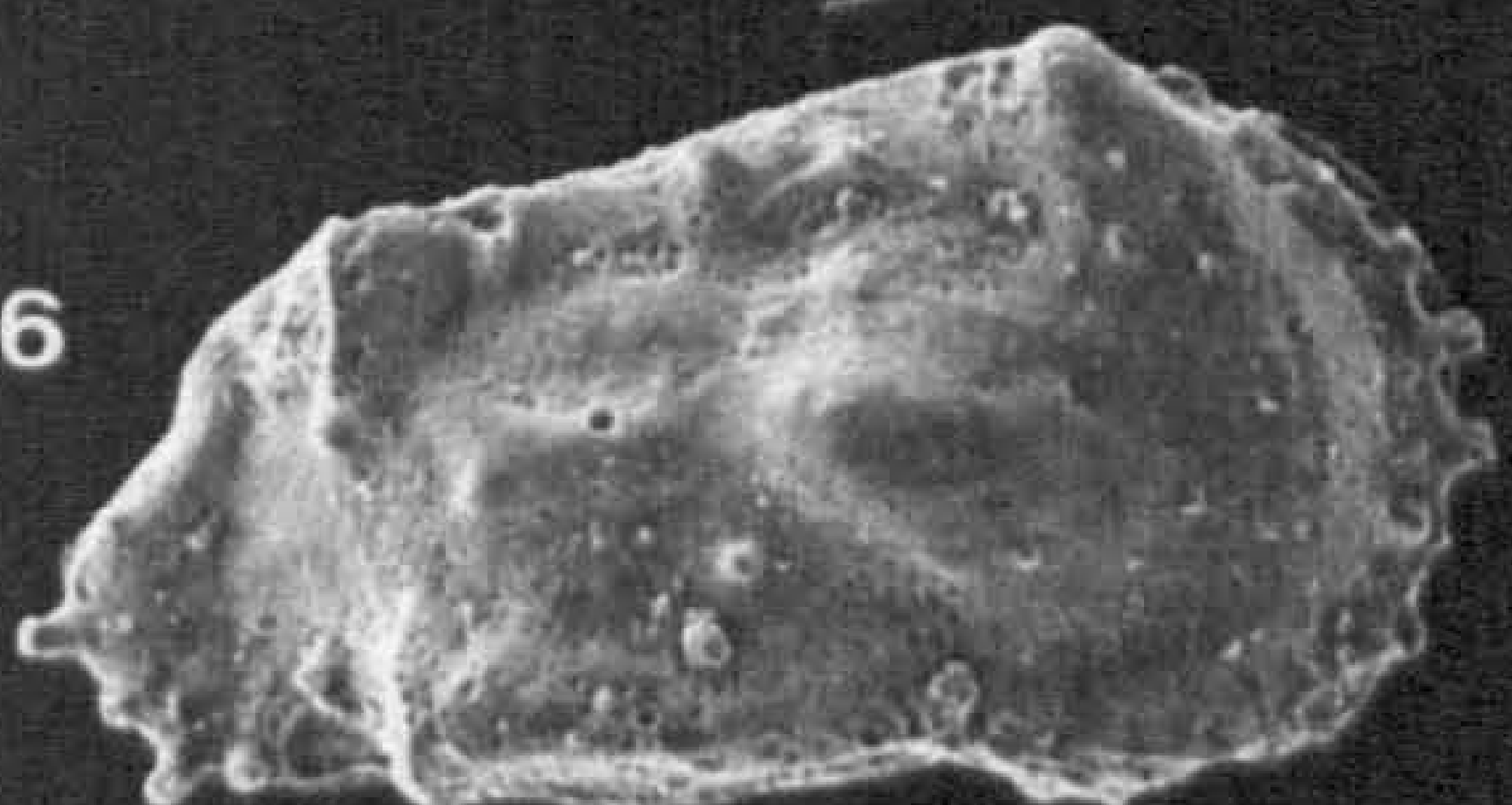

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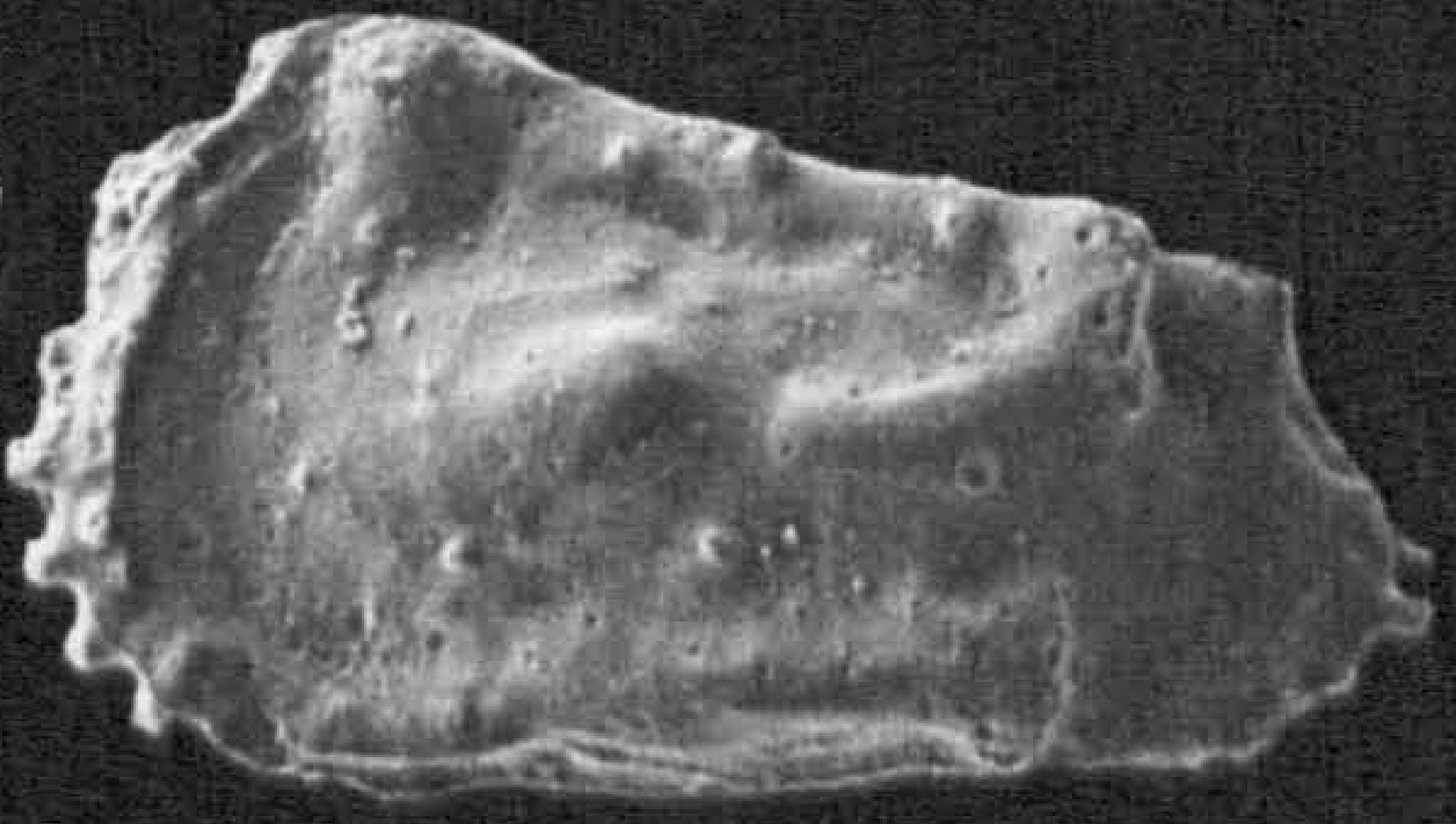

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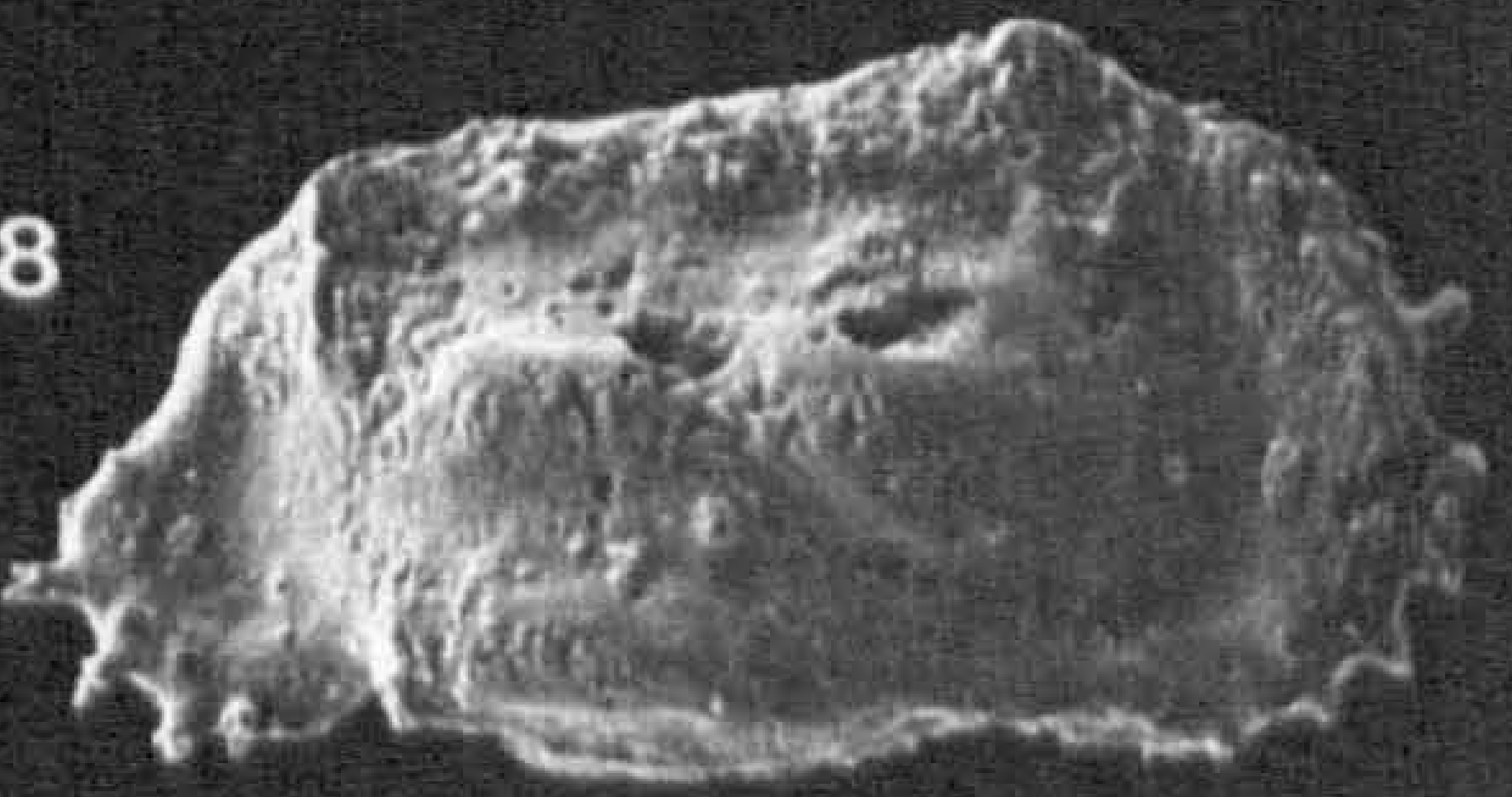

Fig. PLATE 19 Page

Cythereis longaeva longaeva Pokorný, 1963 250

AKSD30, 4.2m above New Pit Marl 2, Middle Turonian.

1 Left valve, IJS17/4. External lateral (stereo-pair), x56.

ABCMR1a, Gun Gardens Marl 1, Lower Turonian.

2 Right valve, IJS17/5. External lateral (stereo-pair), x57.

Cythereis luzicensis Pokorný, 1965a 253

LGSD24, top of Kingston Nodular Chalks, Upper Turonian.

3 Left valve, IJS12/12. External lateral (stereo-pair), x52.

LGSD23, middle of Kingston Nodular Chalks, Upper Turonian.

4 Right valve, IJS17/6. External lateral (stereo-pair), x52.

Cythereis kosticensis Pokorný, 1963 248

LGSD18, hardground above Bridgewick Marl 1, Upper Turonian.

5 Right valve, IJS16/24. External lateral (stereo-pair), x57.

Cythereis ornatissima altinodosa Pokorný, 1963 256

LGSD26, Navigation Hardground 1, Upper Turonian.

6 Right valve, IJS16/25. External lateral (stereo-pair), x58.

Cythereis paraglabrella Pokorný, 1965 259

LGSD25, 1m below Navigation Hardground 1, Upper Turonian.

7 Left valve, IJS16/18. External lateral (stereo-pair), x70.

LGSD24, top of Kingston Nodular Chalks, Upper Turonian.

8 Right valve, IJS16/17. External lateral (stereo-pair), x65.

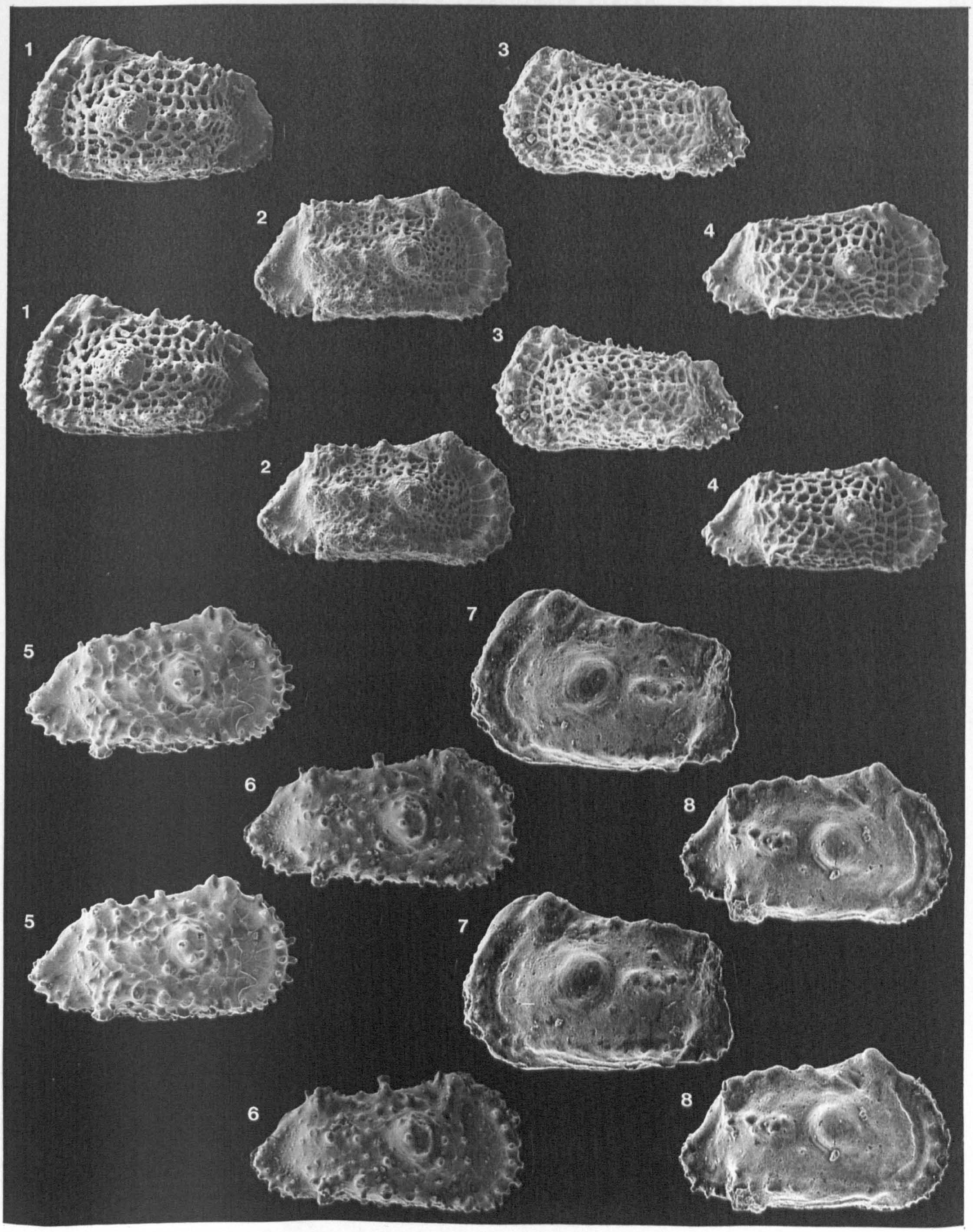
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Fig. PLATE 20 Page

Cythereis triaculeata Clarke, 1983 261

LGSD28, below Navigation Hardground 3, Upper Turonian.

1 Right valve, IJS16/26. External lateral (stereo-pair), x60.

Cythereis sp. cf. *agedincumenis* Damotte, 1964 264

LGSD24, top of Kingston Nodular Chalks, Upper Turonian.

2 Right valve, IJS16/16. External lateral (stereo-pair), x58.

Idiocythere caburnensis sp. nov. 267

LGSD23, middle of Kingston Nodular Chalks, Upper Turonian.

3 Right valve, IJS12/9. External lateral (stereo-pair), x86.

LGSD10, 0.6m below Caburn Marl, Upper Turonian.

4 Holotype. Carapace, IJS16/27. left lateral (stereo-pair), x78.

Imhotepia marssoni multipapillata (Pokorný, 1964) 274

LGSD21, base of Kingston Nodular Chalks, Upper Turonian.

5 Right valve, IJS9/4. External lateral (stereo-pair), x80.

Imhotepia marssoni anteglabra (Pokorný, 1964) 271

LGSD26, Navigation Hardground 1, Upper Turonian.

6 Right valve, IJS9/7. External lateral (stereo-pair), x75.

7 Left valve, IJS16/22. External lateral (stereo-pair), x78.

Imhotepia sp. aff. *euglyphaea* Weaver, 1982 276

AKS3/10, 1.2m above Southerham Marl 2, Upper Turonian.

8 Right valve, IJS12/3. External lateral (stereo-pair), x90.

9 Left valve, IJS9/1, External lateral (stereo-pair), x80


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Fig.

PLATE 21

Page

Mauritsina? *paradordoniensis* sp. nov. 282

AKSD19, 3.8m below New Pit Marl 1, Middle Turonian.

1 Left valve, IJS3/4. External lateral (stereo-pair), x62.

LGSD7, 3.1m below Caburn Marl, Upper Turonian.

3 Holotype. Right valve, IJS16/19. External lateral (stereo-pair), x65.

Isocythereis postelongata sp. nov. 279

LGSD10, 0.6m below Caburn Marl, Upper Turonian.

2 Holotype. Left valve, IJS12/10. External lateral (stereo-pair), x80.

4 Male, right valve, IJS16/21. External lateral (stereo-pair), x87.

Oertliella reticulata (Kafka, 1886) 286

LGSD23, middle of Kingston Nodular Chalks, Upper Turonian.

5 Left valve, IJS16/14. External lateral (stereo-pair), x74.

LGSD24, top of Kingston Nodular Chalks, Upper Turonian.

7 Right valve, IJS13/3. External lateral (stereo-pair), x63.

Parvacythereis subparva (Pokorný, 1967a) 288

AKSD53, 2.5m below Southerham Marl 1, Upper Turonian.

6 Right valve, IJS17/2. External lateral (stereo-pair), x88.

AKSD41, 3.5m below Lydden Spout Flint, Middle Turonian.

8 Left valve, IJS17/1. External lateral (stereo-pair), x89.

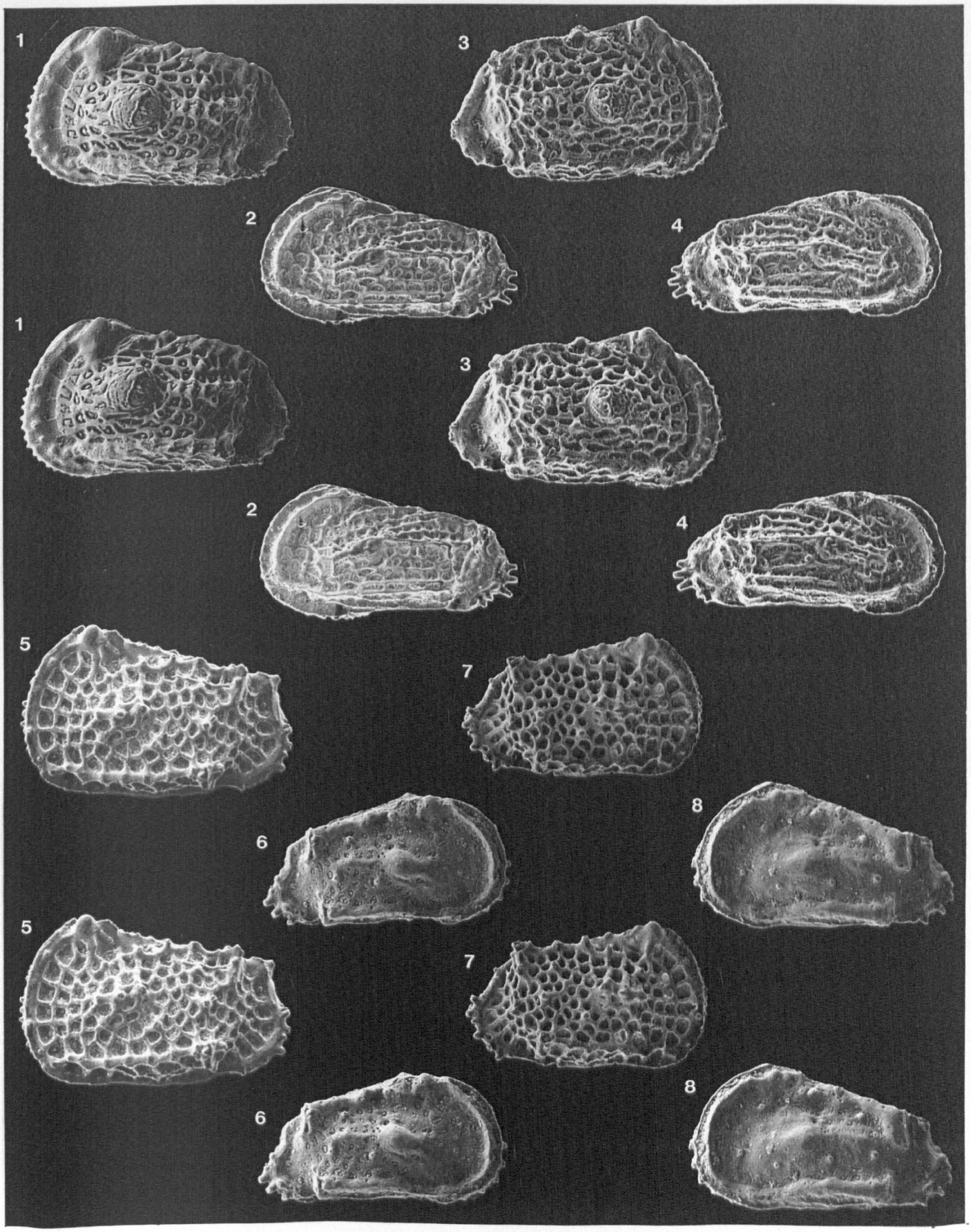
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Fig. PLATE 22 Page

Parvacythereis subparva (Pokorný, 1967a) 288

LGSD10, 0.6m below Caburn Marl, Upper Turonian.

1 Male carapace, IJS20/22. Right lateral (stereo-pair), x83.

Planileberis cuneata (Kafka, 1886) 291

LGSD5, 1.1m above Southerham Marl 2, Upper Turonian.

2 Right valve, IJS16/13. External lateral (stereo-pair), x78.

LGSD10, 0.6m below Caburn Marl, Upper Turonian.

4 Left valve, IJS12/11. External lateral (stereo-pair), x82.

Rehacythereis stellatus sp. nov. 295

ABCMR5, 2.1m below Round Down Marl, Lower Turonian.

3 Holotype. Right valve, IJS7/14. External lateral (stereo-pair), x83.

5 Left valve, IJS7/13. External lateral (stereo-pair), x82.

Rehacythereis venticursus venticursus sp. et ssp. nov. 297

LGSD5, 1.1m above Southerham Marl 2, Upper Turonian.

6 Holotype. Left valve, IJS16/12. External lateral (stereo-pair), x67.

7 Right valve, IJS22/2. External lateral (stereo-pair), x75.

Rehacythereis venticursus patbrowni sp et ssp. nov. 300

AKSD54, Flint level below Southerham Marl 1, Middle Turonian.

8 Carapace, IJS22/4. left lateral (stereo-pair), x69.

AKSD48, 4.8m above Lydden Spout Flint, Middle Turonian.

9 Right valve, IJS16/11. External lateral (stereo-pair), x62.

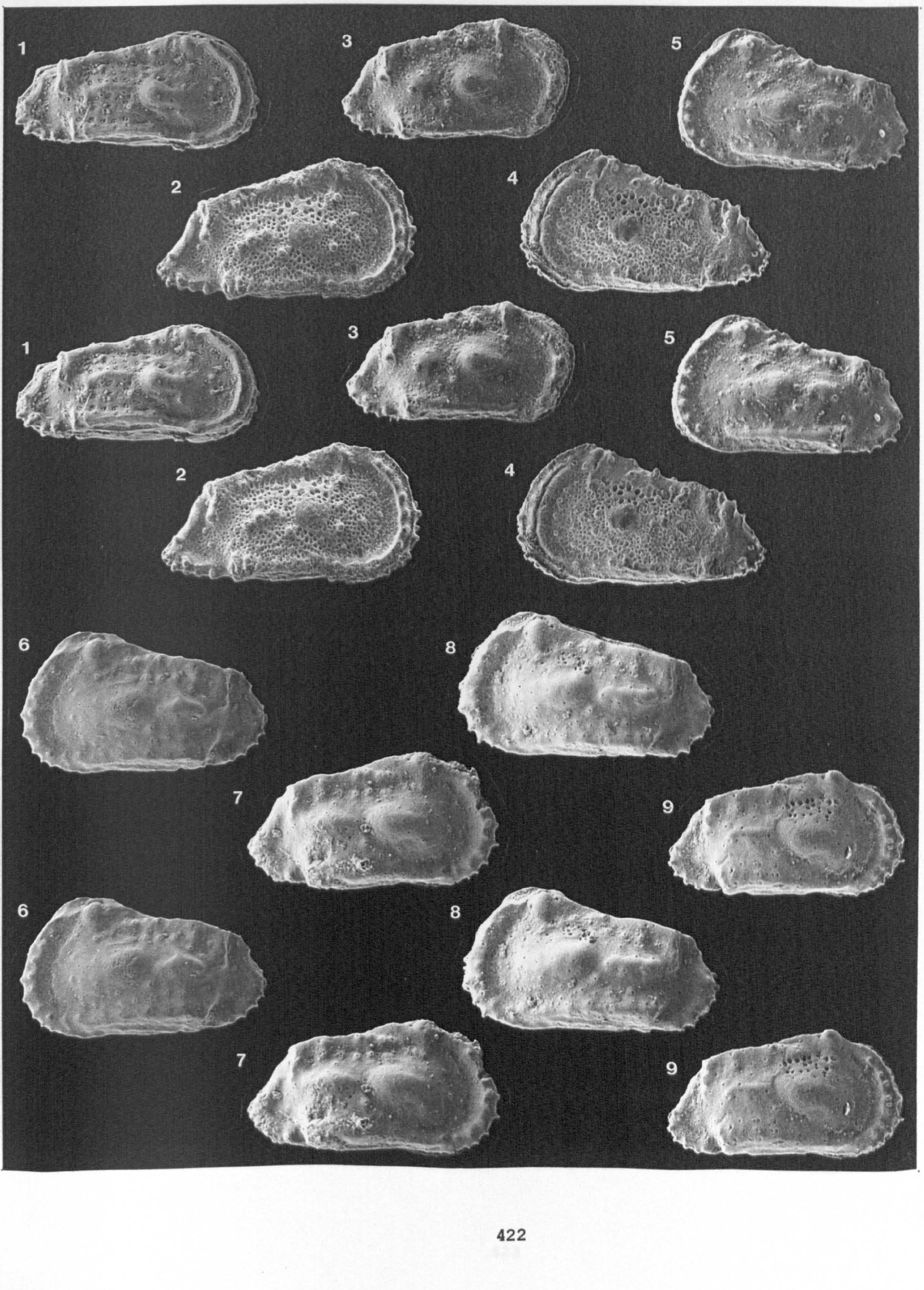
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Fig.

PLATE 23

Page

Spinoleberis krejcii Pokorný, 1969 301

LGSD18, hardground above Bridgewick Marl 1, Upper Turonian.

1 Female left valve, IJS20/24. External lateral (stereo-pair), x90.

3 Female right valve, IJS20/25. External lateral (stereo-pair), x95.

Trachyleberidea geinitzi (Reuss, 1874) 305

LGSD24, top of Kingston Nodular Chalks, Upper Turonian.

2 Left valve, IJS16/7. External lateral (stereo-pair), x74.

LGSD23, middle of Kingston Nodular Chalks, Upper Turonian.

4 Right valve, IJS16/8. External lateral (stereo-pair), x74.

Xestoleberis bidentata Bonnema, 1941 310

LGSD9, 1.2m below Caburn Marl, Upper Turonian.

5 Right valve, IJS13/4. External lateral (stereo-pair), x127.

Xestoleberis marssoni Bonnema, 1941 311

LGSD28, below Navigation Hardground 3, Upper Turonian.

7 Left valve, IJS16/1. External lateral (stereo-pair), x101.

Xestoleberis ovata Bonnema, 1941 313

LGSD18, hardground above Bridgewick Marl 1, Upper Turonian.

6 Left valve, IJS16/4. External lateral (stereo-pair), x103.

8 Right valve, IJS16/5. External lateral (stereo-pair), x101.

PLATE 23

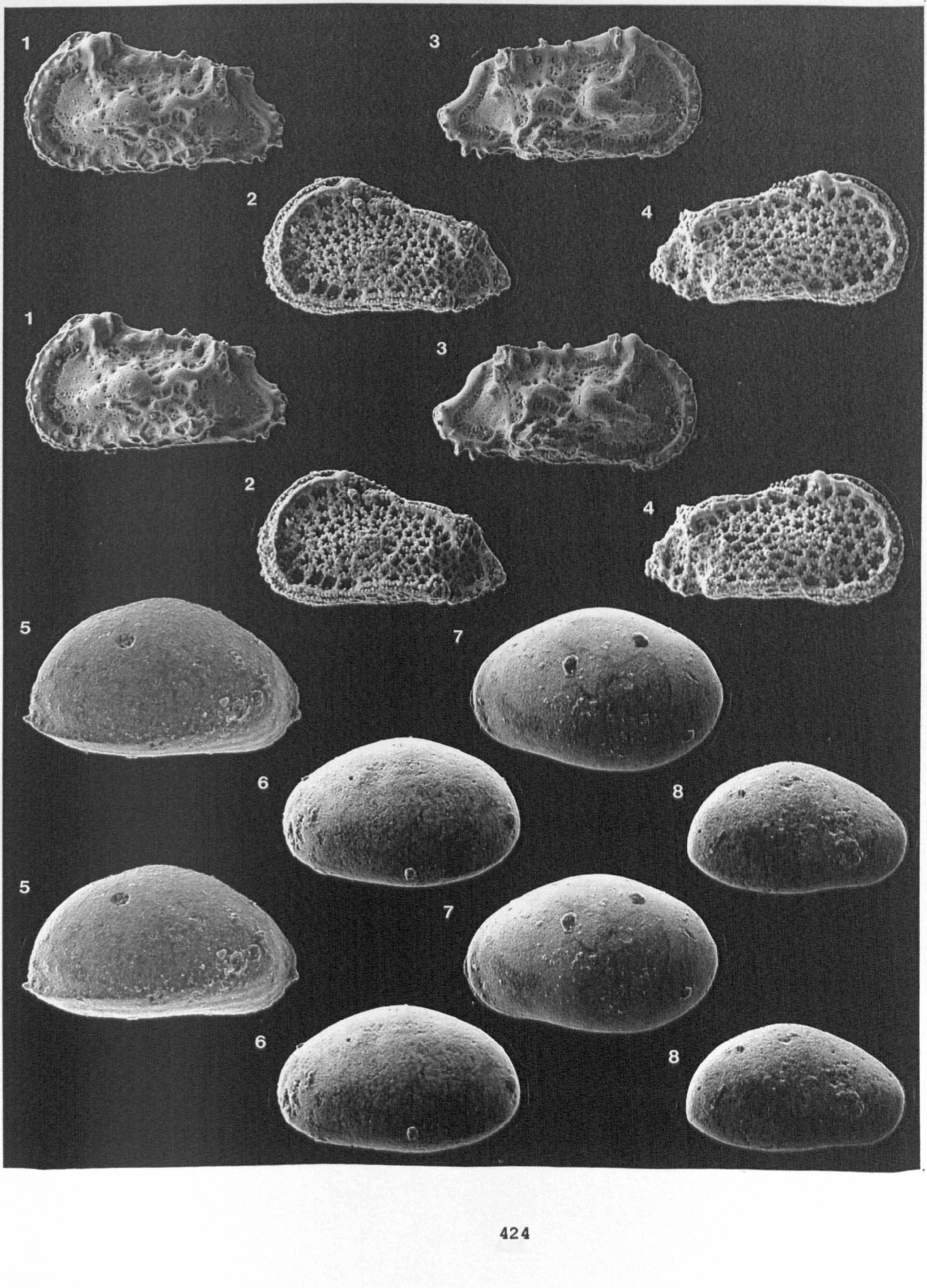

Fig.

PLATE 24

Page

Cytherella truncatoides sp. nov. 57

AKSD33, Glynde Marls, Middle Turonian.

1 Holotype. Female, right valve, IJS15/29. Internal lateral (stereo-pair), x66.

Cytherella vulna sp. nov. 60

LGSD10, 0.6m below Caburn Marl, Upper Turonian.

2 Holotype. Female, right valve, IJS15/13. Internal lateral (stereo-pair), x66.

Cytherella weaveri sp. nov. 62

LGSD7, 3.1m below Caburn Marl, Upper Turonian.

3 Holotype. Female, right valve, IJS15/11. Internal lateral (stereo-pair), x66.

Cytherelloidea granulosa parca ssp. nov. 68

AKSD54, Flint level below Southerham Marl 1, Upper Turonian.

4 Holotype. Female, right valve, IJS15/5. External lateral (stereo-pair), x57.

Cardobairdia longitecta sp. nov. 81

LGSD26, Navigation Hardground 1, Upper Turonian.

5 Male left valve, IJS20/3. Internal lateral (stereo-pair), x85.

AKSD54, Flint level below Southerham Marl 1, Upper Turonian.

6 Male right valve, IJS20/4. Internal lateral (stereo-pair), x82.

Bairdoppilata turonica sp. nov. 87

AKSD43, 1.5m below Lydden Spout Flint, Middle Turonian.

7 Holotype. Left valve, IJS20/7. Internal lateral (stereo-pair), x41.

Pontocyprella robusta cometa ssp. nov. 107

LGSD28, below Navigation Hardground 3, Upper Turonian.

8 Holotype. Left valve, IJS19/19. Internal lateral (stereo-pair), x57.

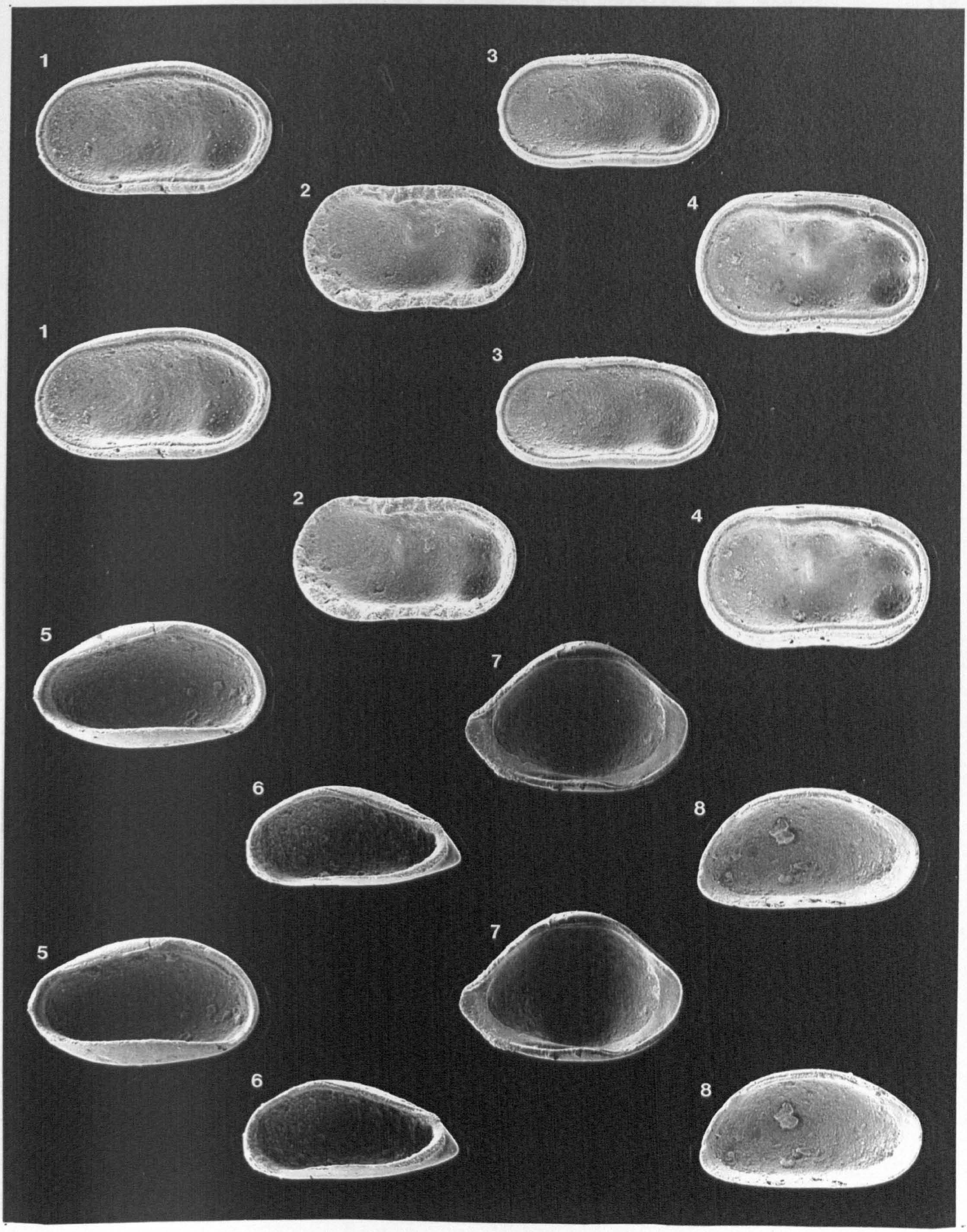
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Fig. PLATE 25 Page

Pterygocythereis (Diogmopteron) carolinae sp. nov. 130
LGSD7, 3.1m below Caburn Marl, Upper Turonian.
1 Right valve, IJS14/9. Internal lateral (stereo-pair), x65.

Patellacythere weaveri sp. nov. 185
LGSD8, 2.5m below Caburn Marl, Upper Turonian.
2 Holotype. Left valve, IJS18/21. Internal lateral (stereo-pair), x92.

Bythoceratina (Cuneoceratina) staringi conmacula ssp. nov. 173
LGSD26, Navigation Hardground 1, Upper Turonian.
3 Holotype. Left valve, IJS18/24. Internal lateral (stereo-pair), x70.

Monoceratina minangulata sp. nov. 176
LGSD24, top of Kingston Nodular Chalks, Upper Turonian.
4 Holotype. Left valve, IJS12/2. Internal lateral (stereo-pair), x70.

Schuleridea langdonensis sp. nov. 195
LGSD26, Navigation Hardground 1, Upper Turonian.
5 Holotype. Female left valve, IJS18/15. Internal lateral (stereo-pair), x75.
LGSD28, below Navigation Hardground 3, Upper Turonian.
6 Female right valve, IJS18/14. Internal lateral (stereo-pair), x75.

Phodeucythere sp. A 208
AKSD52, 3.2m below Southerham Marl 1, Upper Turonian.
7 Right valve, IJS18/5. Internal lateral (stereo-pair), x74.

Bythoceratina (Bythoceratina) saxa sp. nov. 152
ABCMR1a, Gun Gardens Marl 1, Lower Turonian.
8 Left valve, broken, IJS7/10. Internal lateral, x116.

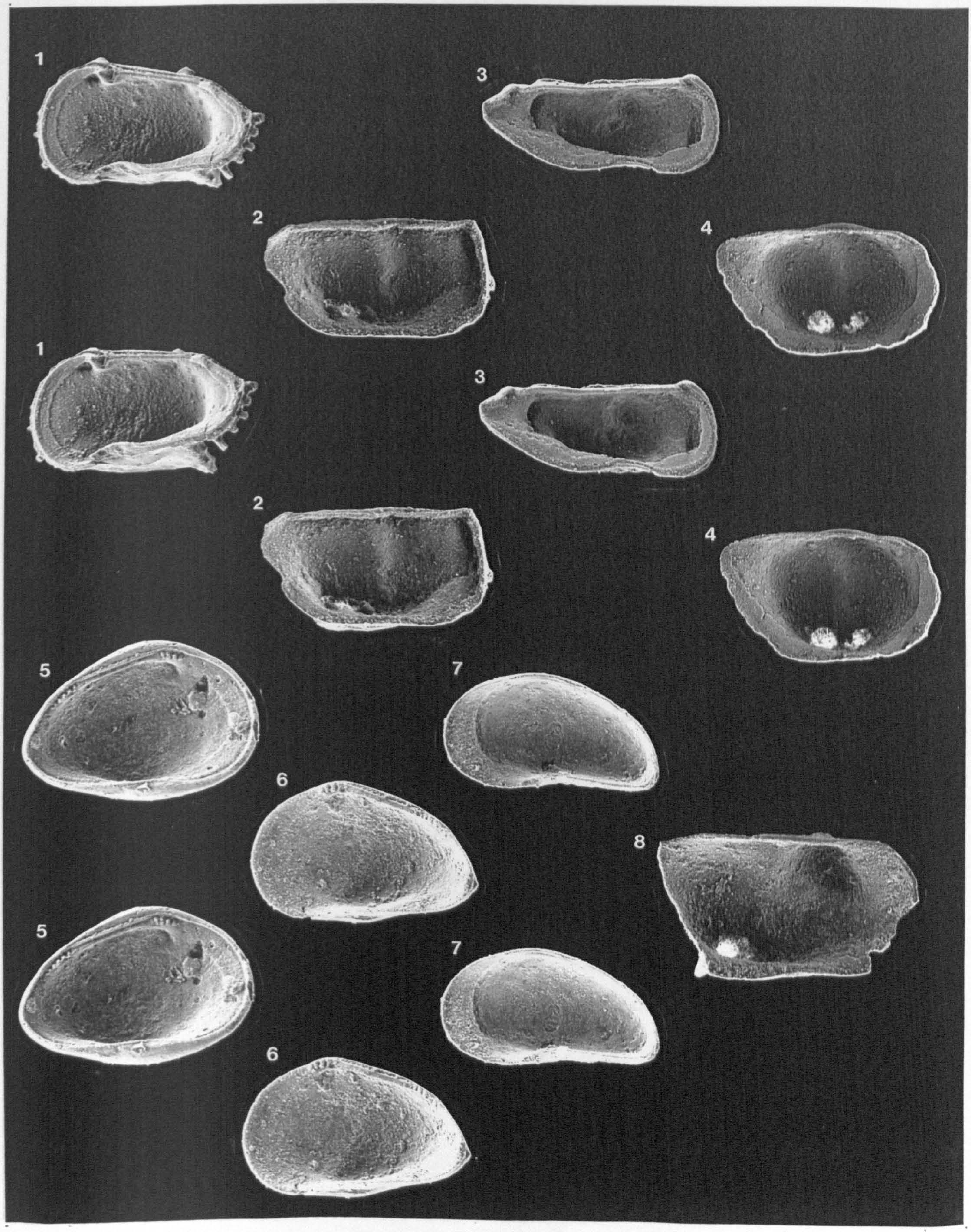
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PLATE 26

Fig.		Page
	Karsteneis nodifera tabasca ssp. nov.	222
	LGSD26, Navigation Hardground 1, Upper Turonian.	
1	Left valve, IJS17/27. Internal lateral (stereo-pair), x62.	
2	Holotype. Right valve, IJS17/28. Internal lateral (stereo-pair), x62.	
	Karsteneis petasus petasus sp. et ssp. nov.	225
	AKSD17, 1.7m above Round Down Marl, Middle Turonian.	
3	Holotype. Left valve, IJS17/23. Internal lateral (stereo-pair), x71.	
4	Right valve, IJS17/24. Internal lateral (stereo-pair), x67.	
	Karsteneis petasus antecursor sp. et ssp. nov.	232
	ABCMR4, 2.5m above Lulworth Marl, Lower Turonian.	
5	Holotype. Left valve, IJS17/19. Internal lateral (stereo-pair), x64.	
6	Right valve, IJS17/20. Internal lateral (stereo-pair), x64.	
	Karsteneis praekarsteni sp. nov.	233
	LGSD1, Southerham Marl 1 , Upper Turonian.	
7	Holotype. Left valve, IJS17/25. Internal lateral (stereo-pair), x68.	
8	Right valve, IJS17/26. Internal lateral (stereo-pair), x70.	

PLATE 26

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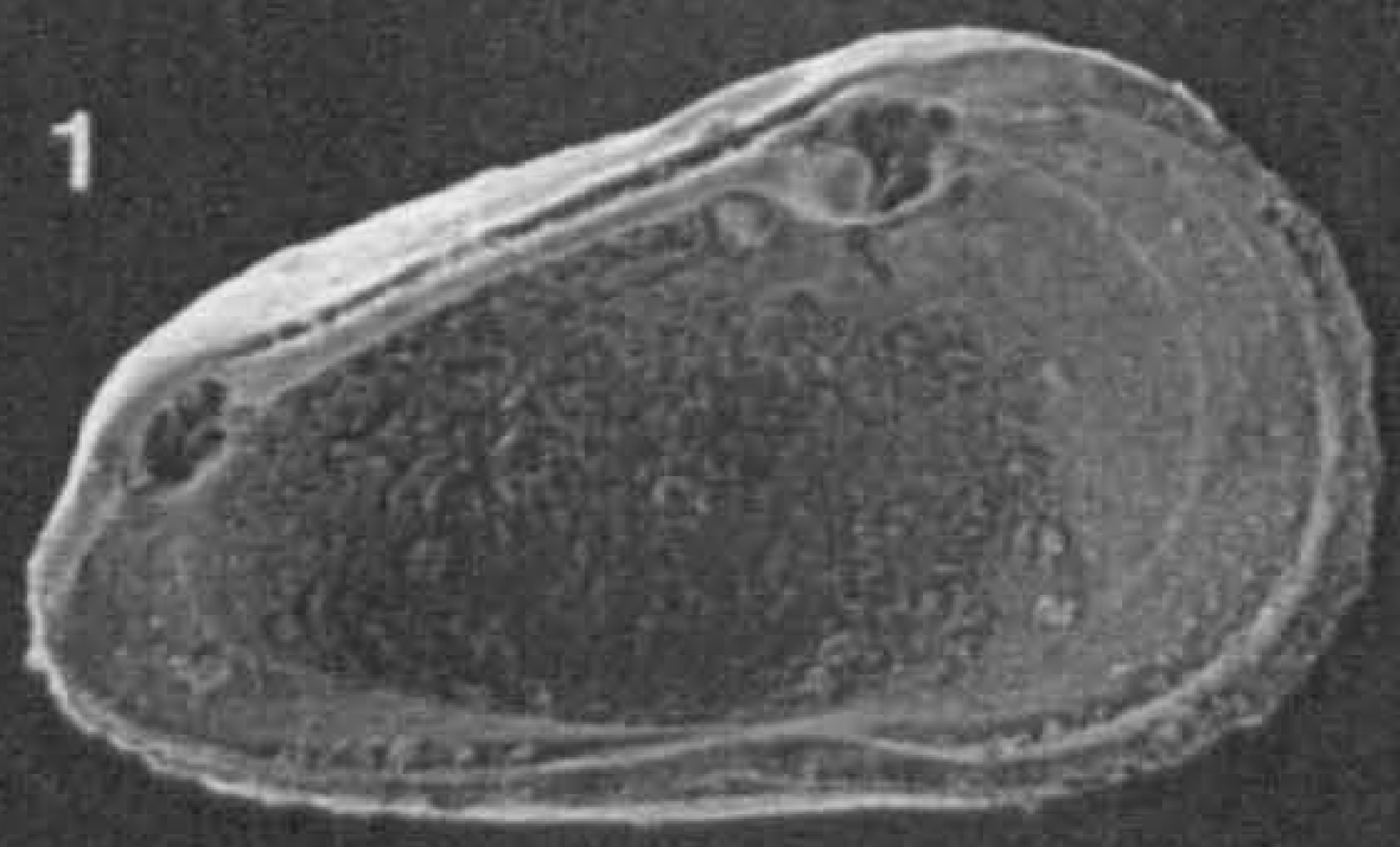

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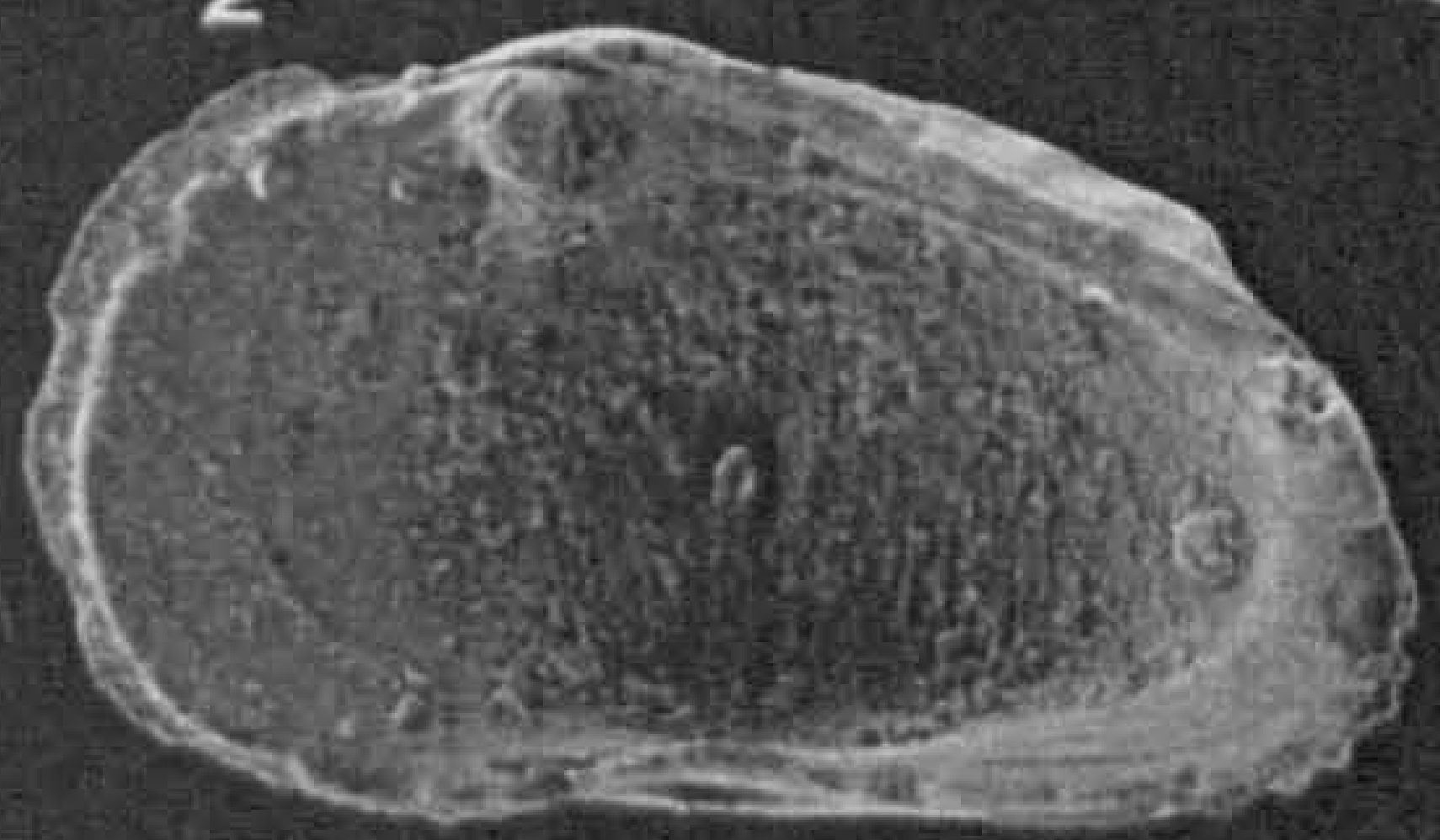

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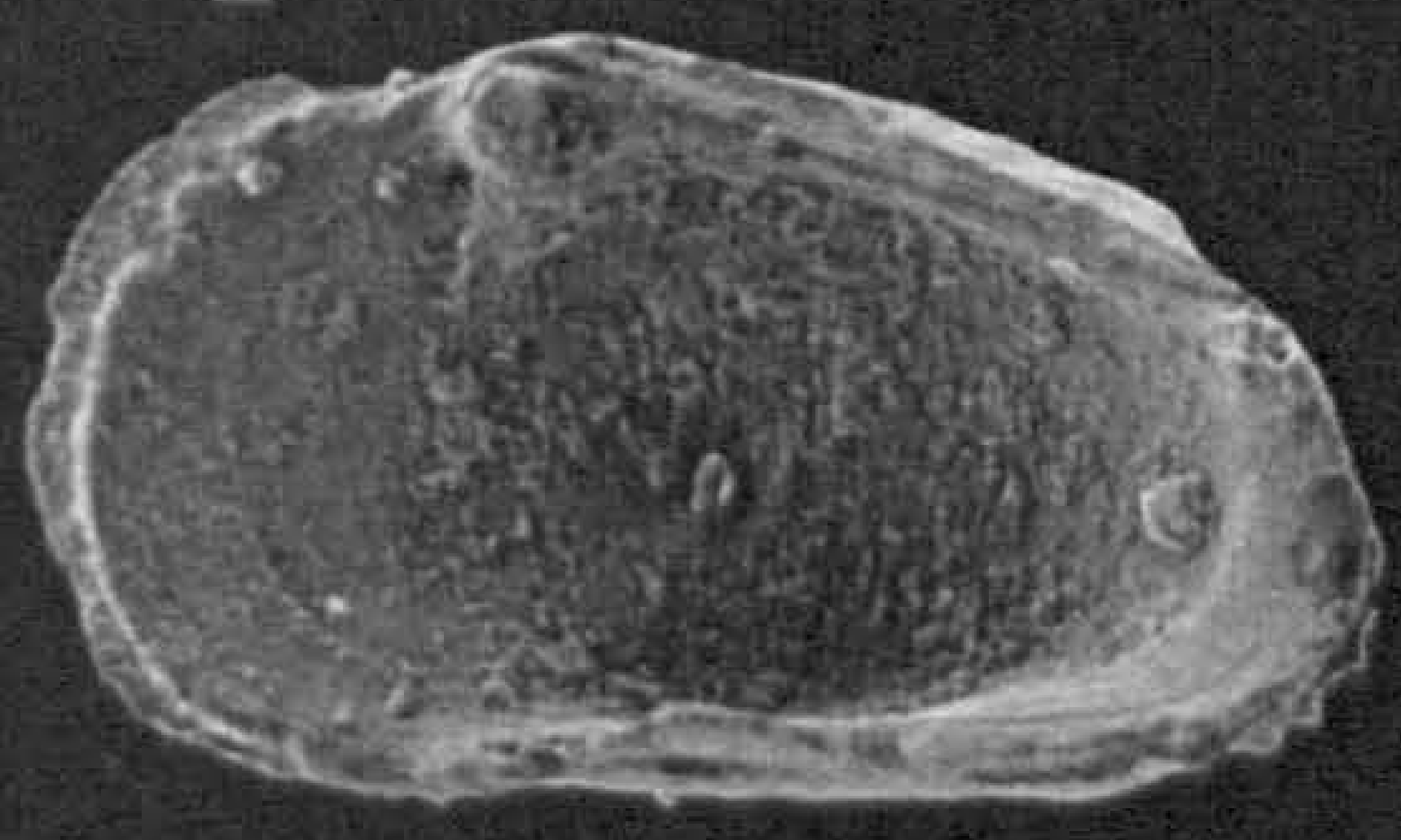

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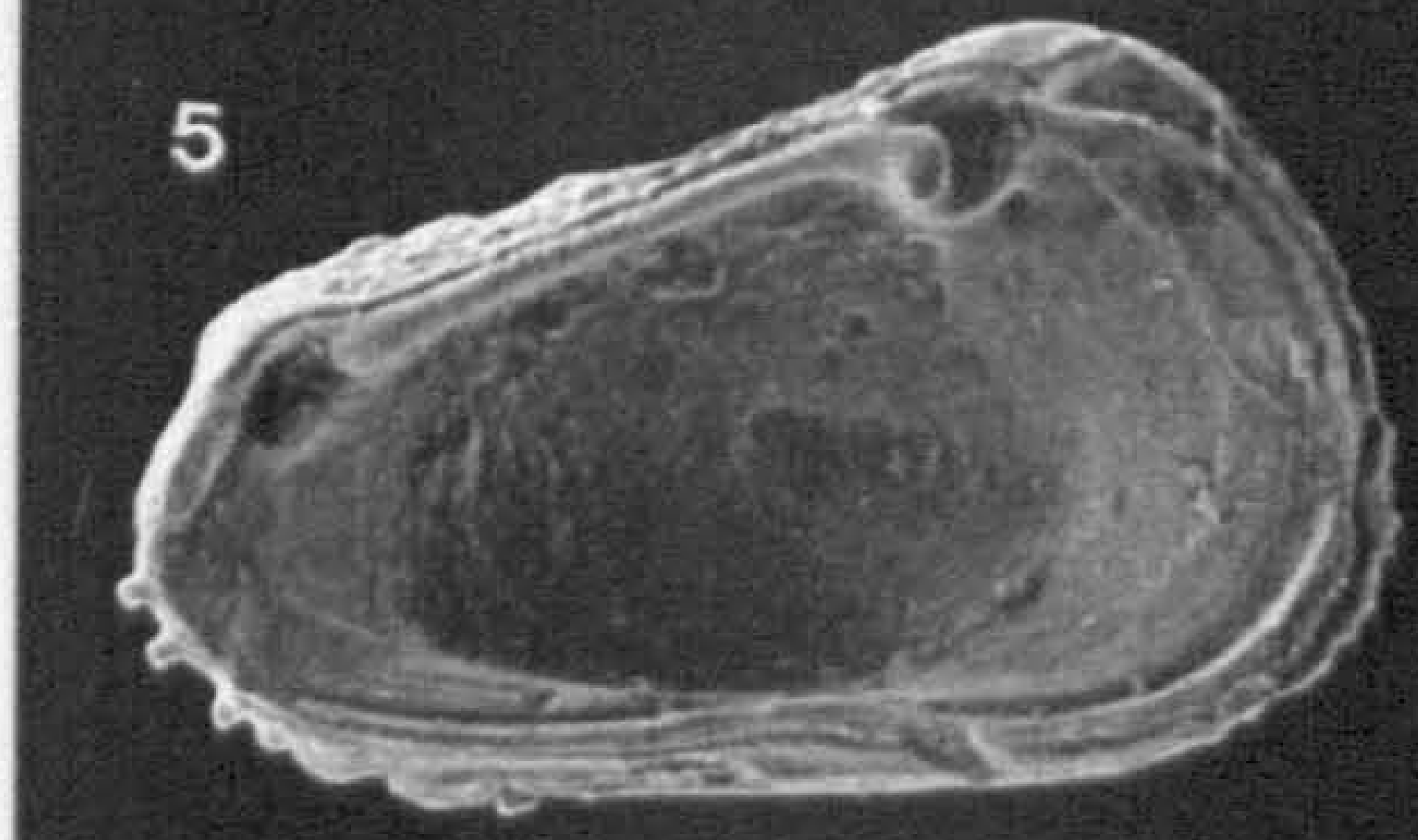

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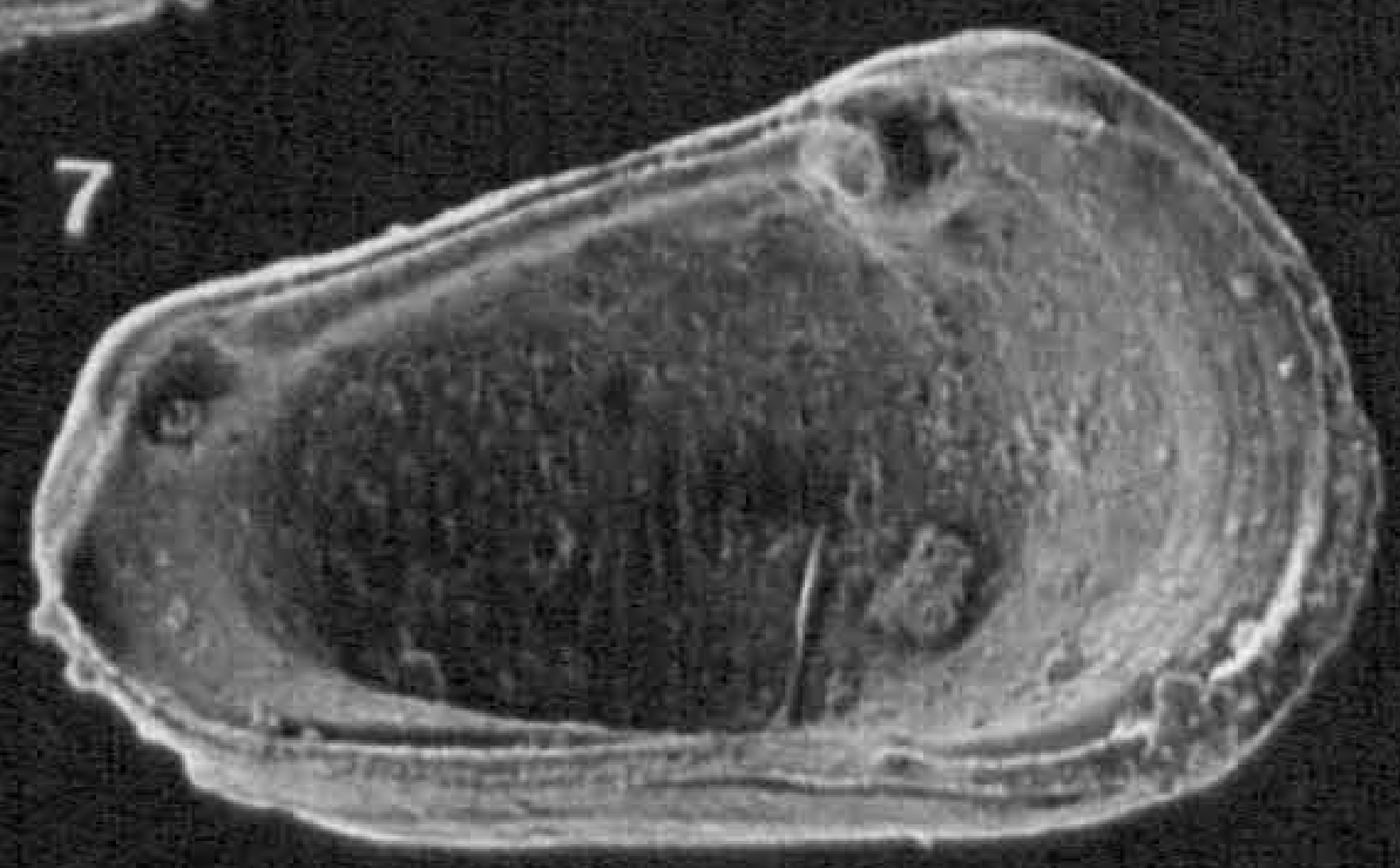

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Fig. Page

PLATE 27

Curfsina senior calo spp. nov. 245

DOE8A, 2.5m below Southerham Marl 1, Upper Turonian.

1 Right valve, IJS17/13. Internal lateral (stereo-pair), x71.

Idiocythere caburnensis sp. nov. 267

LGSD23, middle of Kingston Nodular Chalks, Upper Turonian.

2 Right valve, IJS12/9. Internal lateral (stereo-pair), x76.

Isocythereis postelongata sp. nov. 279

LGSD10, 0.6m below Caburn Marl, Upper Turonian.

3 Holotype. Left valve, IJS12/10. Internal lateral (stereo-pair), x73.

4 Male, right valve, IJS16/21. Internal lateral (stereo-pair), x72.

Mauritsina? *paradordoniensis* sp. nov. 282

AKSD19, 3.8m below New Pit Marl 1, Middle Turonian.

5 Holotype. Right valve, IJS16/19. Internal lateral (stereo-pair), x55.

Rehacythereis stellatus sp. nov. 295

ABCMR5, 2.1m below Round Down Marl, Lower Turonian.

6 Holotype. Right valve, IJS7/14. Internal lateral (stereo-pair), x85.

Rehacythereis venticursus venticursus sp. et ssp. nov. 297

LGSD5, 1.1m above Southerham Marl 2, Upper Turonian.

7 Holotype. Left valve, IJS16/12. Internal lateral (stereo-pair), x61.

PLATE 27

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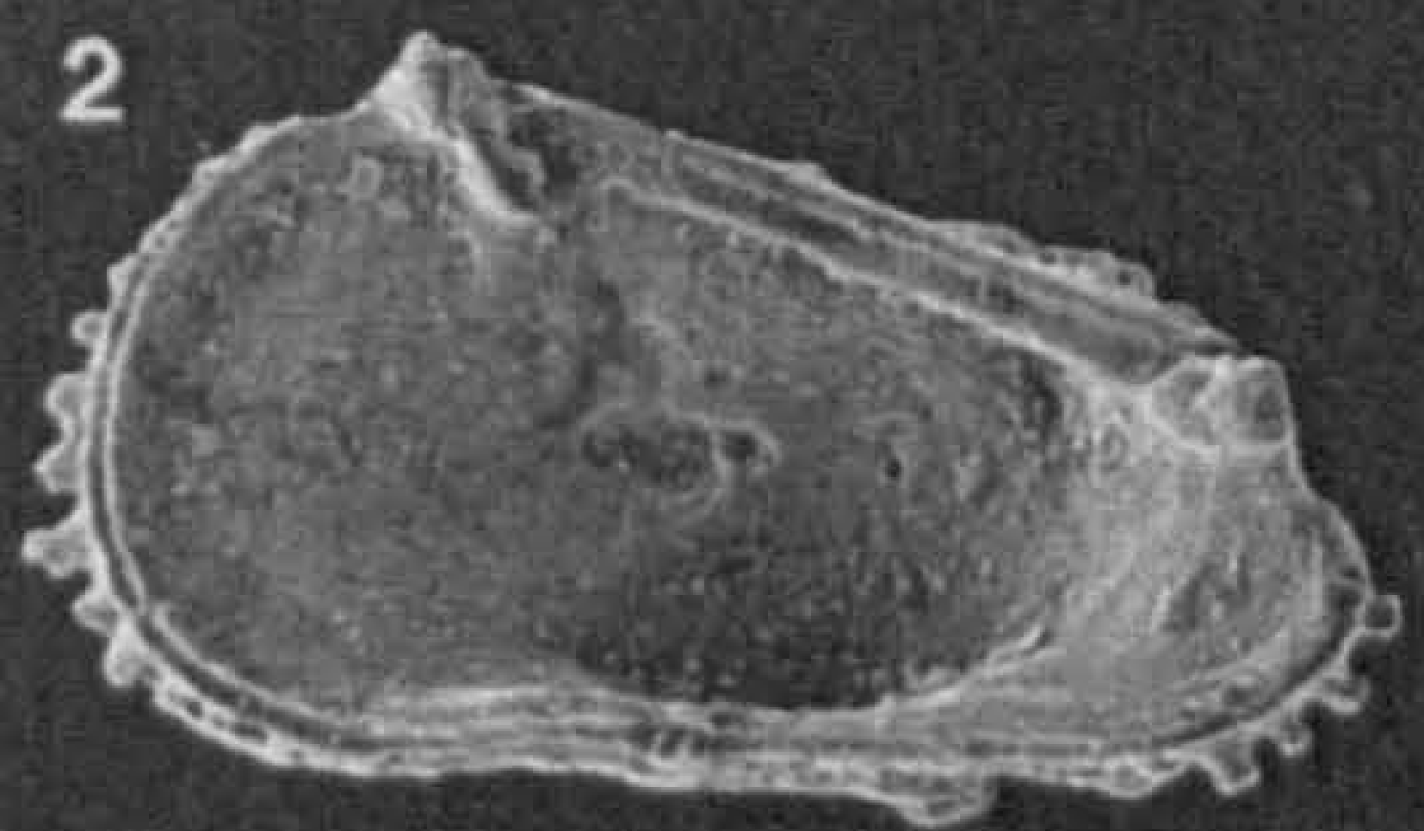

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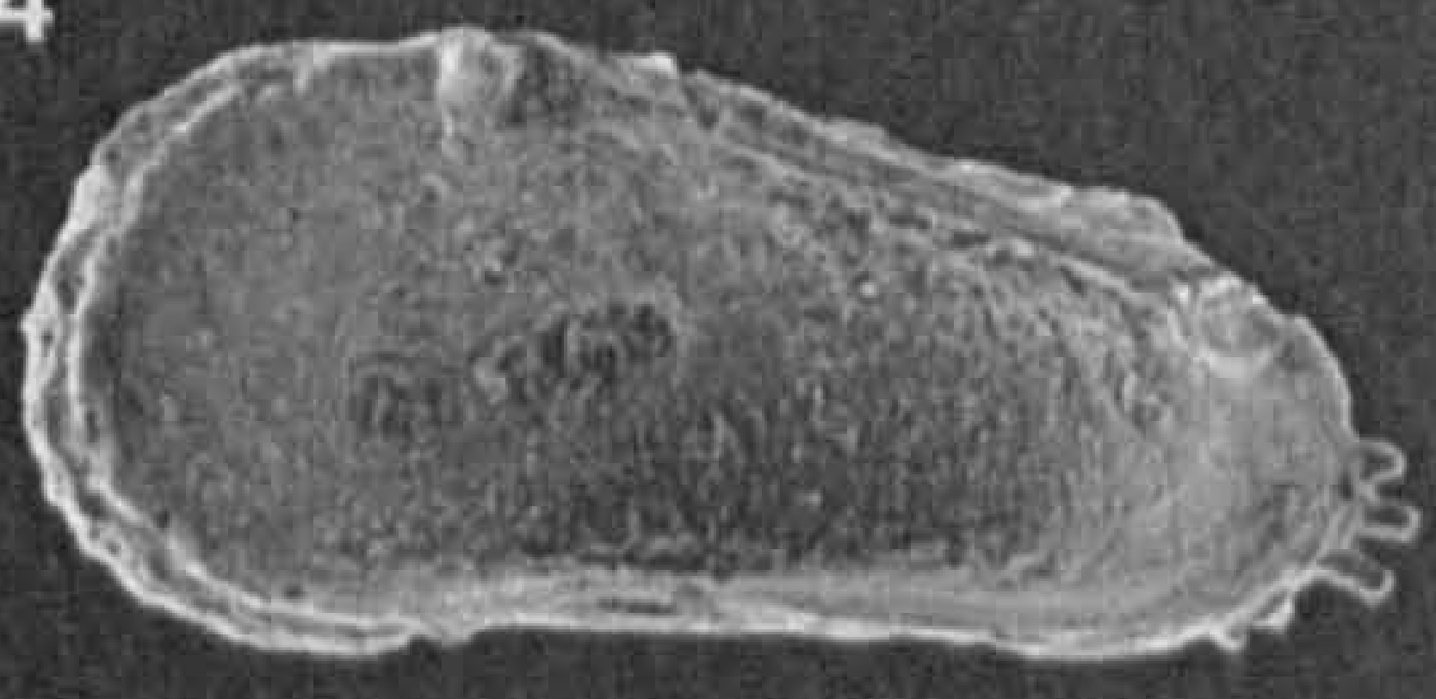

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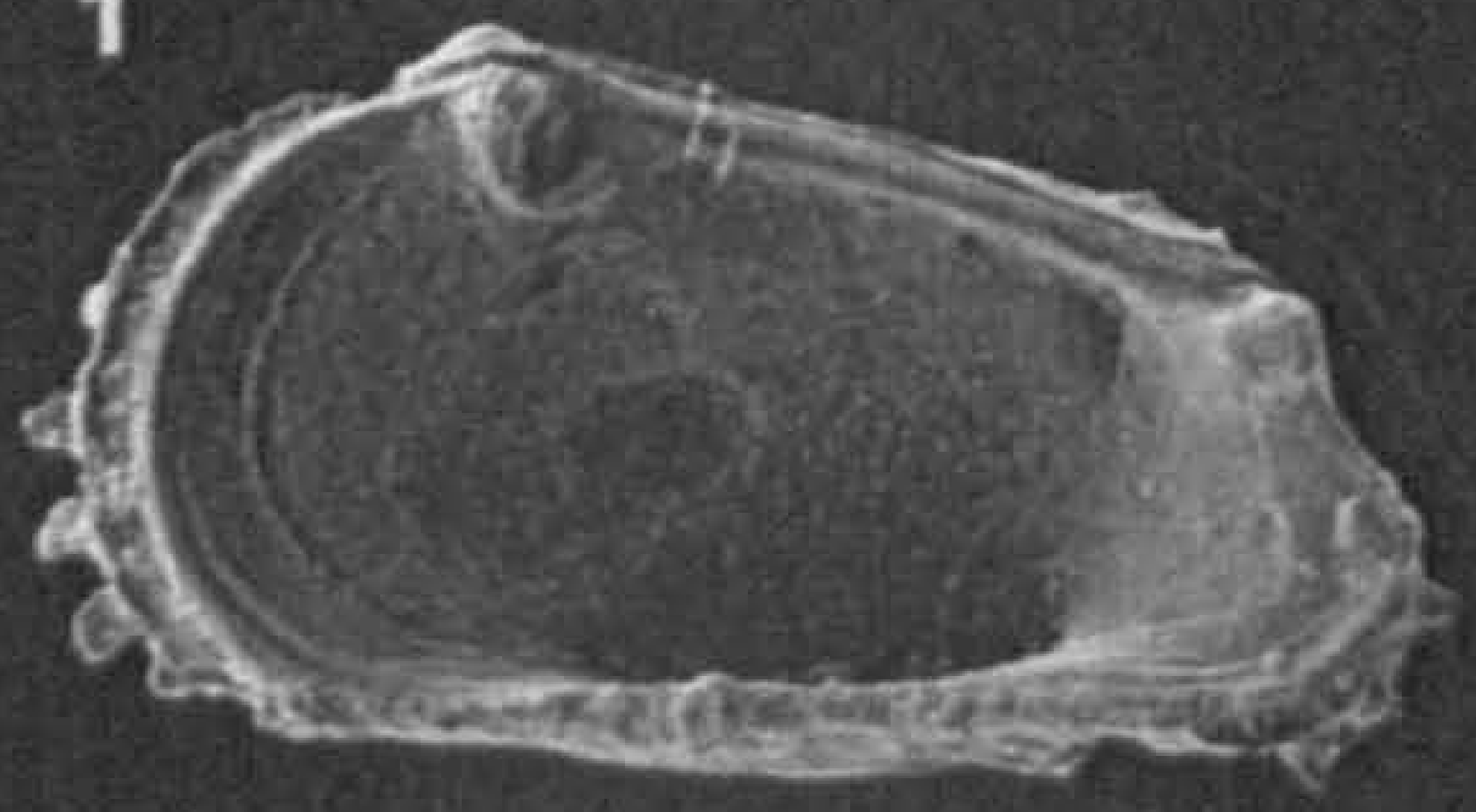

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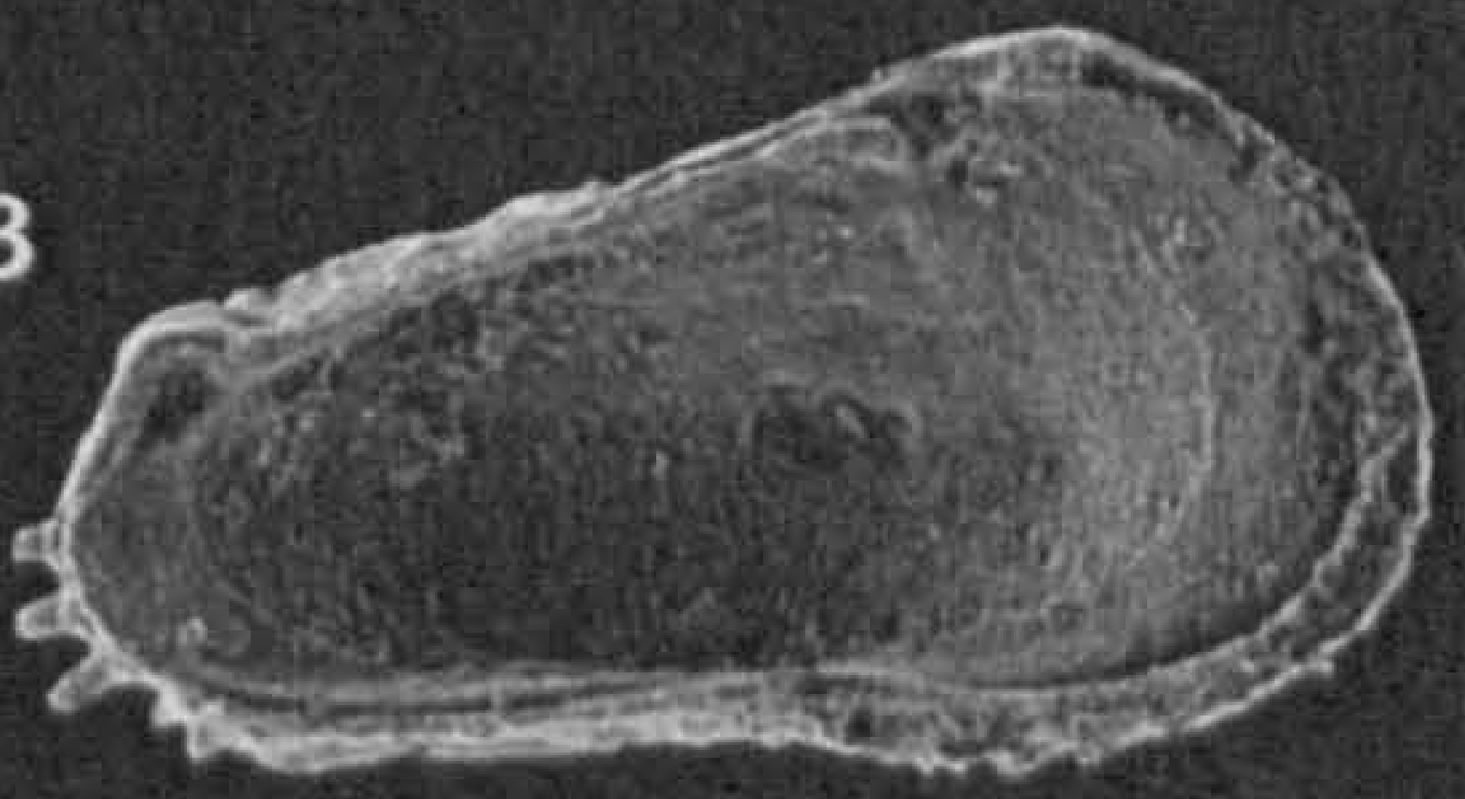

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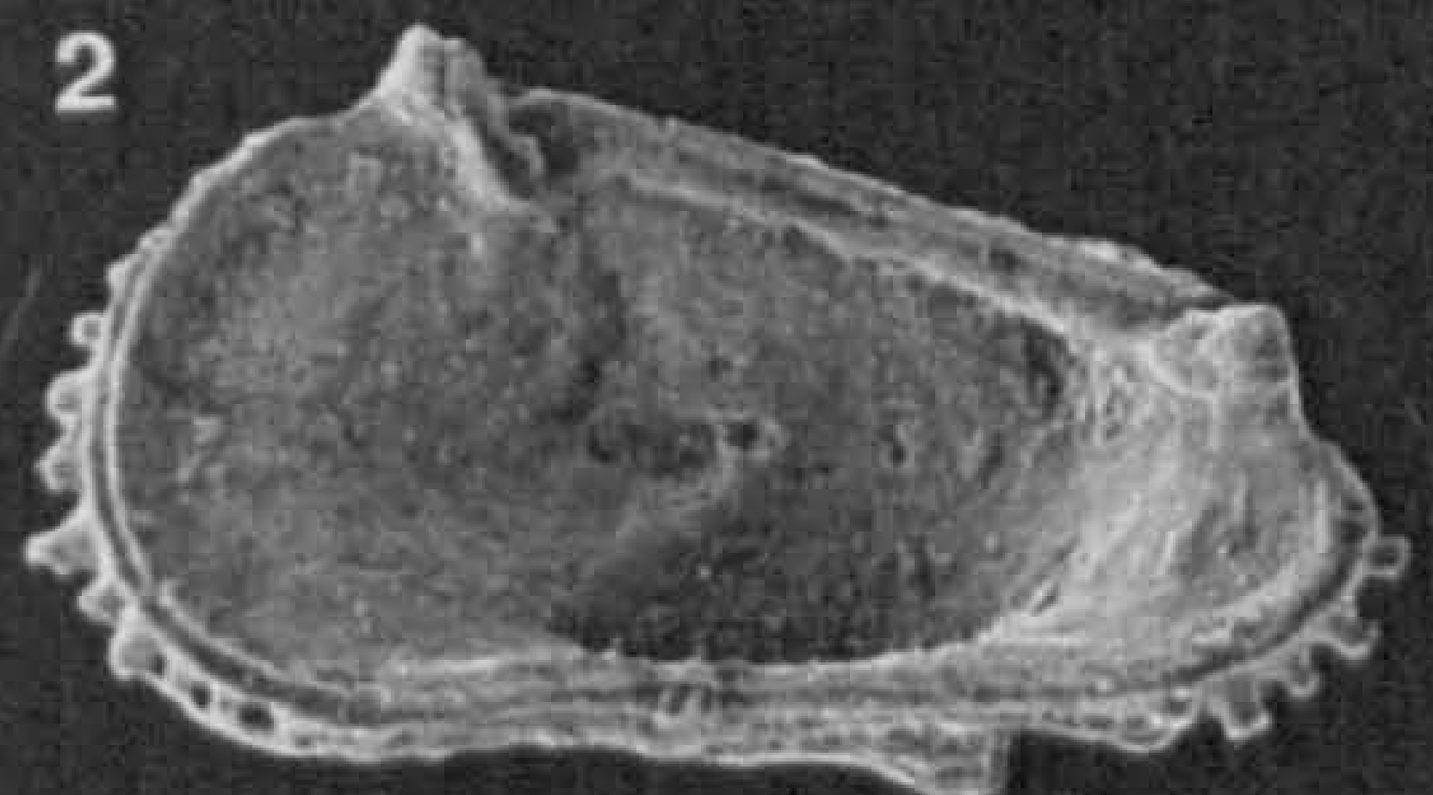

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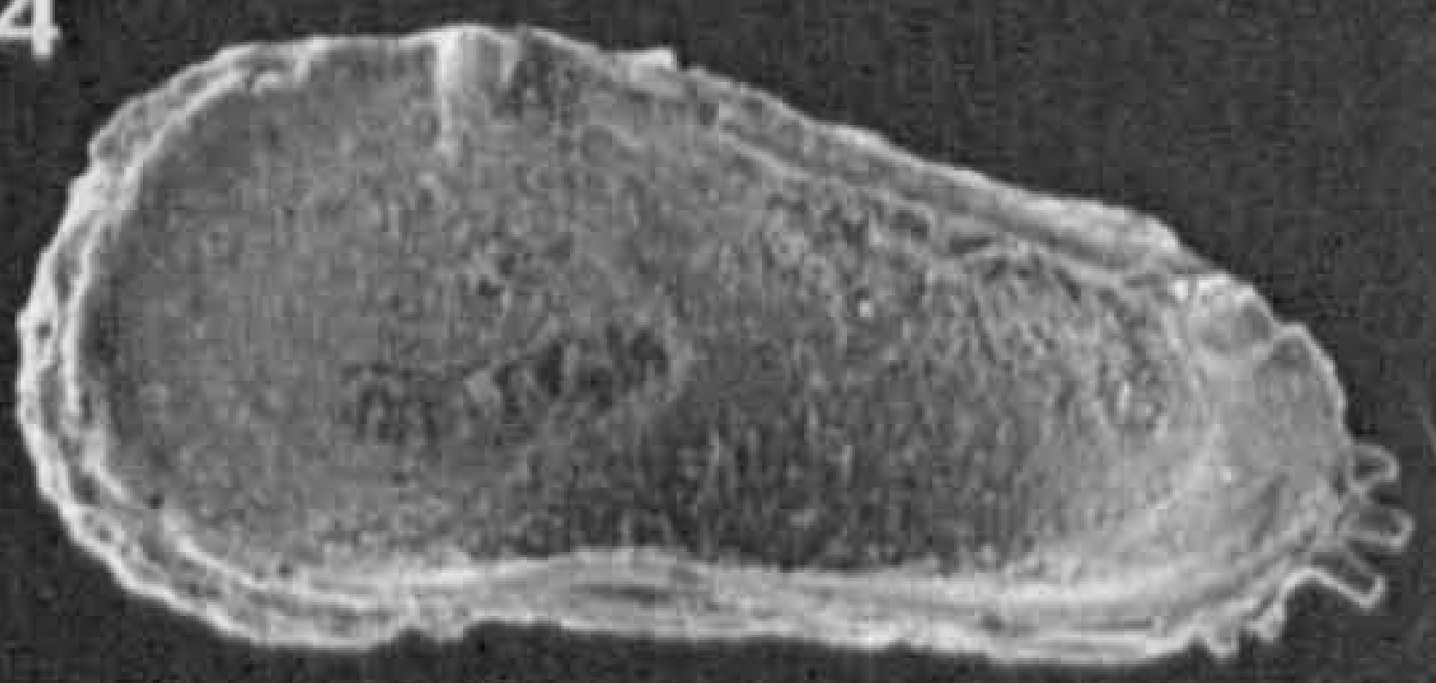

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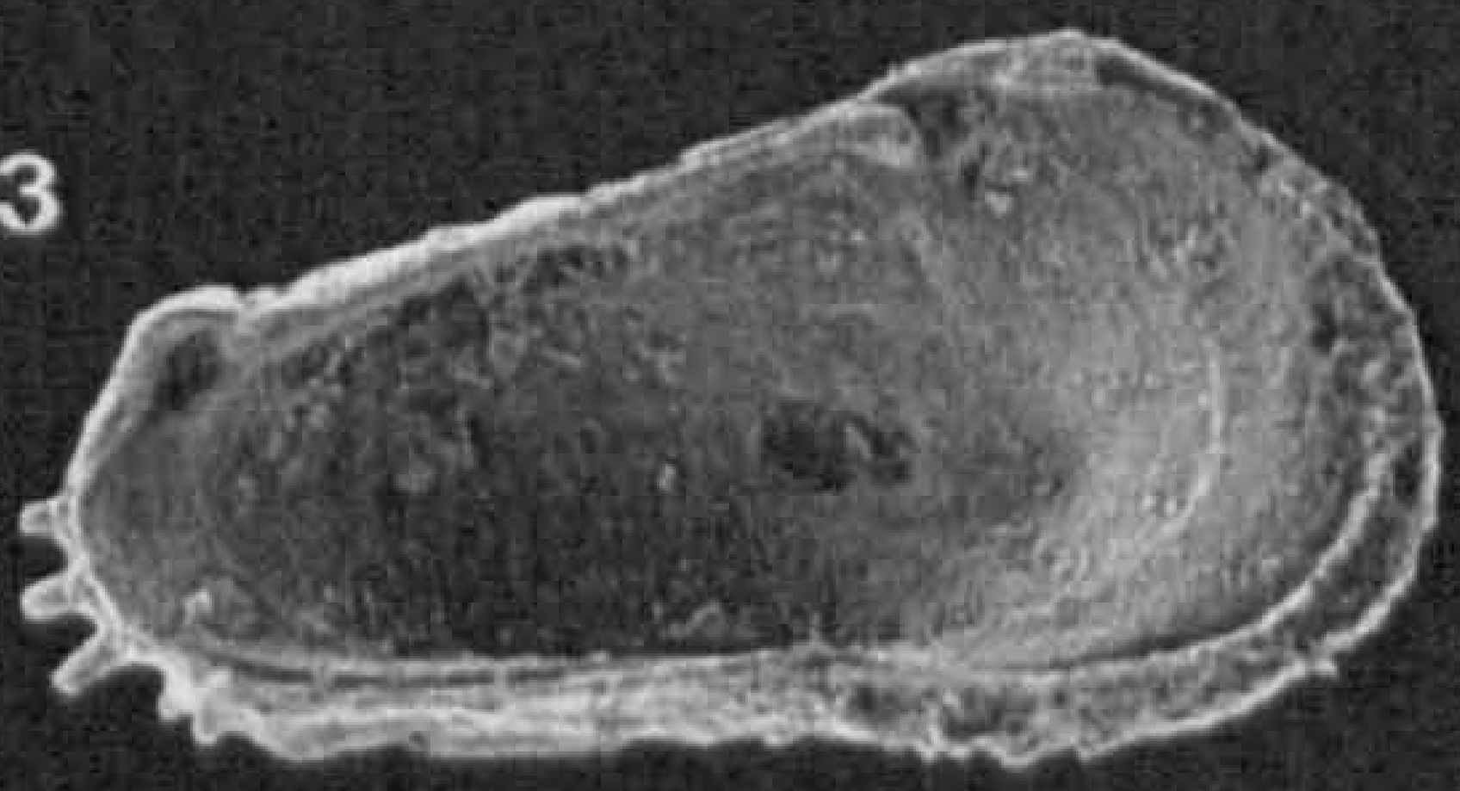

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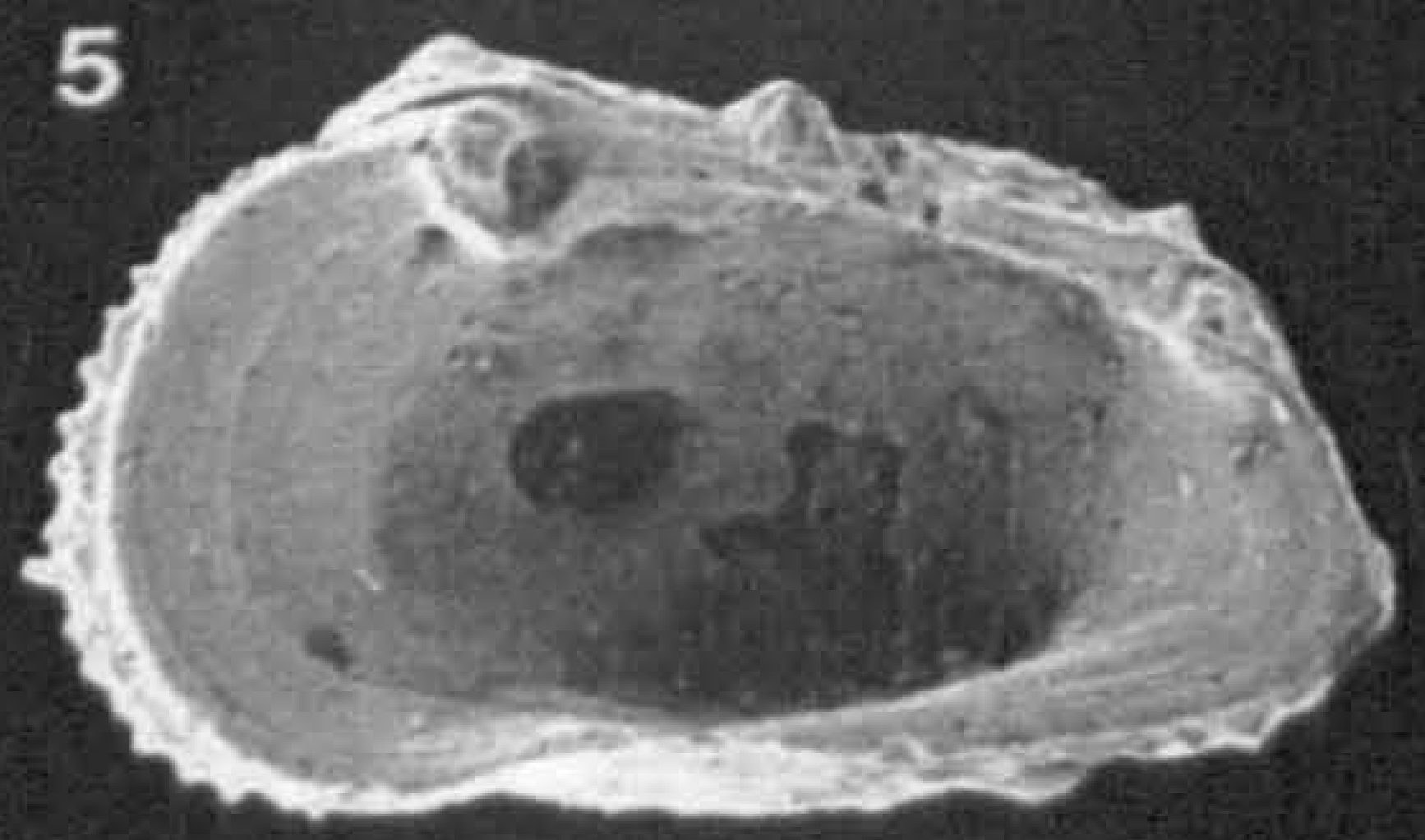

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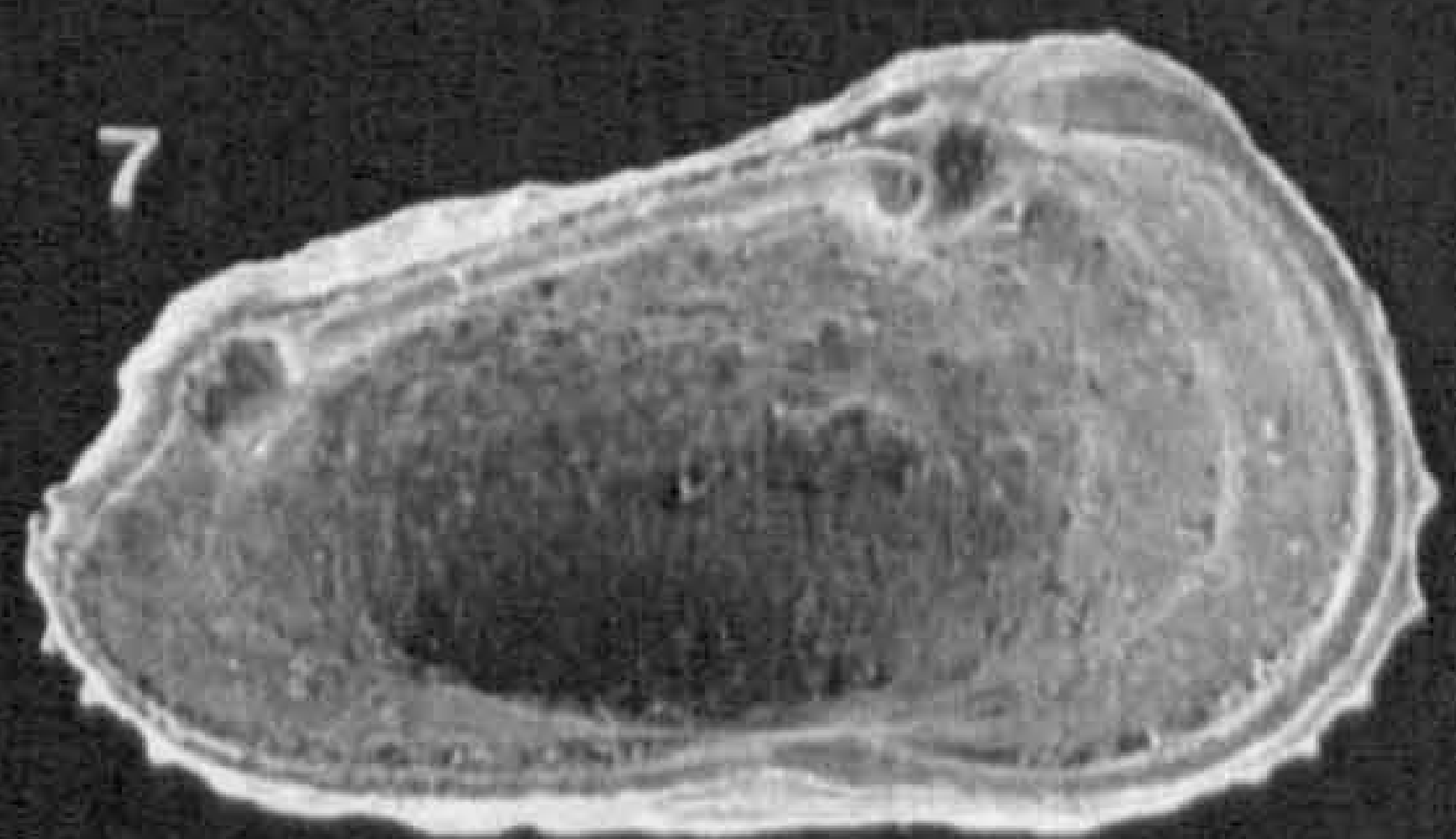

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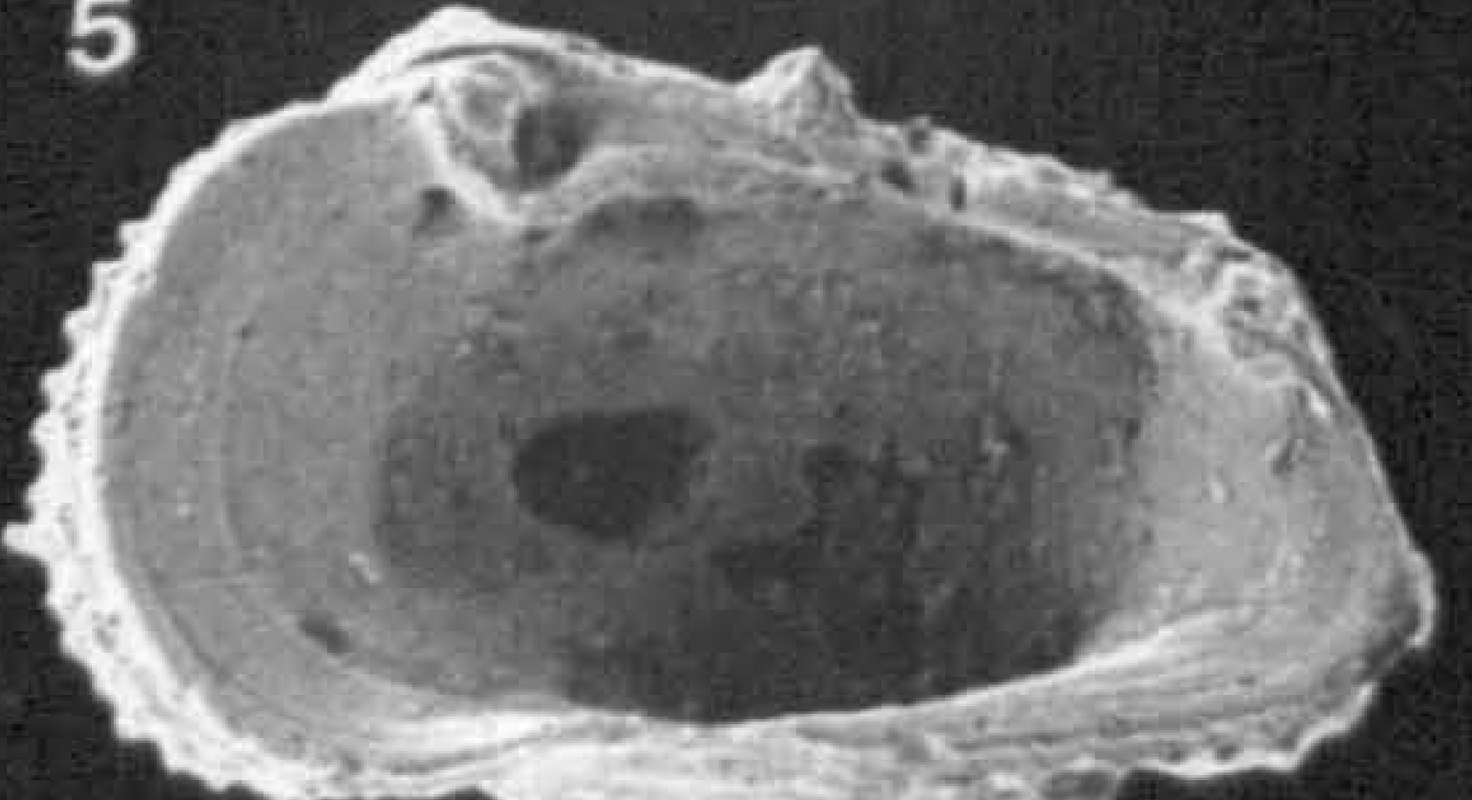

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PUBLISHED PAPERS

The author has had one paper published in the Proceedings of the 2nd European Ostracodologists' Meeting, which was held in Glasgow in 1993. This dealt with the early Turonian fauna from Abbots Cliff, and is a subset of the data in the present work.

The second paper included here has been referred to in the text as Slipper (in press, Appended). This has not yet been published, but has been submitted, reviewed and accepted for publication in the Proceedings of the 3rd European Ostracodologists' Meeting, which was held in Bierville, 1996. The Editors of that volume have supplied a preprint version of this paper which is here appended. The subject matter is more wide ranging than the present topic, since it also deals with the Lower Coniacian fauna.

The author has submitted for publication the Late Cretaceous chapter for the Biostratigraphical Atlas of British Ostracoda, to be published by the British Micropalaeontological Society. Since it has not yet been reviewed or accepted, it is not included with this work, though data obtained in the preparation of the Late Cretaceous chapter has been included here.

Early Turonian Ostracoda:
The Melbourn Rock Fauna from Abbots Cliff, Dover, England

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Medway Campus,
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ABSTRACT

Previous workers have documented the demise of the podocopid element of the ostracod fauna during the Cenomanian-Turonian Oceanic Anoxic Event, and suggested that the surviving platycopids were more tolerant of low oxygen levels. Subsequently it has been shown how the recovery of the fauna took most of the Turonian to regain Late Cenomanian diversities. A new study is made here of the ostracods from the Early Turonian Melbourn Rock. Methods of processing marls, chalks and hardgrounds are discussed, and while white spirit is suitable for breaking down marls, freeze-thaw is here recommended for the more indurated chalks and hardgrounds; this method is described in detail. 34 species in 18 genera are recorded from the *Mytiloides* spp. Zone at Abbots Cliff, Dover. Platycopina and Bairdiacea dominate the assemblages, but the Bythocytheridae are the most species diverse group of the Early Turonian. Some taxonomic notes are given on selected species. It is shown that the recovery of the fauna after the Late Cenomanian extinction event was rapid, sixteen species occurring in the basal Melbourn Rock. *Proceedings of 2nd. European Ostracodologists Meeting, Glasgow 1993,* British Micropalaeontological Society, London, 16th December 1996, 49-56.

INTRODUCTION

The first record of British Early Turonian Ostracoda was that of Horne and Rosenfeld (in: Jarvis *et al.*, 1988), who studied the faunal turnover at the Cenomanian-Turonian boundary. A diversity minimum was recognised which coincided with a positive ∂^{13}C excursion, indicating the stratigraphical position within the shelf sediments of the Oceanic Anoxic Event (OAE). This was interpreted as the result of an expanding and intensifying oxygen minimum zone, the bottom waters of the chalk sea becoming increasingly dysaerobic and causing progressive disappearances as the oxygen minimum zone impinged on the sea floor. Almost all Cenomanian podocopid ostracods became extinct, and the surviving fauna consisted of seven platycopid and five podocopid genera. Horne *et al.* (1990) presented preliminary results of a continuation of their study to the top of the Turonian. Twenty-eight species were recorded, with the diversity increasing slowly from a minimum of six species in the Melbourn Rock, to sixteen at the top of the Turonian. They suggested that this slow recovery after the OAE was because seawater oxygen levels did not return to normal levels until nearly the end of the Turonian.

The present study forms part of a larger work examining the Turonian Ostracoda of the Anglo-Paris Basin, initially re-assessing the sections at Dover, using improved processing methods. Eighty-five samples have been collected at 1m intervals and examined for ostracods; so far, over seventy species have been identified, which refutes the view of Babinot *et al.* (1985), that the depositional environment of the Chalk Sea in the Anglo-Paris Basin, during the Turonian, was unfavourable to ostracods. Results from the Melbourn Rock Beds are presented here and a detailed examination of the ostracod fauna, immediately following the extinction event at the end of the Cenomanian, is given.

THE MELBOURN ROCK

This distinct lithological unit, which marks the base of the White Chalk Formation, was first named the "Grit Bed" by Price (1877), and then "Melbourne Rock" by Hill (1886). It consists of massive beds of limonite-stained intraclastic chalk with thin wispy marls, and containing much shell debris of inoceramid and echinoderm fragments. Petrographical examination reveals calcisphere biomicrites, with mainly micritic cement and some neomorphic microspar Jarvis *et al.*, 1988).

The sections at Dover have been referred to the Shakespeare Cliff Member, Dover Chalk Formation by Jarvis *et al.* (1988) and Horne *et al.* (1990), within the lithostratigraphical outline of the North Downs, Robinson (1986). Mortimore (1986) erected a lithostratigraphy for the Chalk of the South Downs with a different scheme of Beds, Members, and Formations. Gale *et al.* (1987), noting that key marker beds could be used for correlation, suggested a rationalization of the two schemes, allowing those names which had historical precedence, to stand. Mortimore (1987), in order to avoid nomenclatural confusion, put forward a detailed correlation between the North and South Downs using resistivity to confirm the equivalence of the marker beds. It was then possible to apply the Sussex names to East Kent. Robinson (1987) argues the case for a local stratigraphy, stating that it is inappropriate to apply Mortimore's scheme to the North Downs. Since, in the light of the correlations produced by Mortimore & Pomerol (1988) across the Anglo-Paris Basin, it seems that the lithostratigraphy of Mortimore (1986, 1987) can be applied successfully to Dover. It is that terminology which will be used in this paper. The Melbourn rock is then the lowest unit within the Ranscombe Member of the White Chalk Formation.

The position is still not resolved entirely, since the Melbourn rock varies in character between Kent and Sussex, due to the condensed nature of the beds at Dover. Mortimore (1986) defines the Melbourn rock as between 2.7 and 4m thick, the overlying Holywell Beds having their base at the Mead Marl 1. This interval at Dover is probably represented by the basal 1.2m of hardgrounds since it is difficult to determine the position of the Mead Marls. This interpretation places the Melbourn Rock wholly within the Upper Cenomanian. Jukes-Browne & Hill (1903) included 10m of the "Grit" bed at Dover as Melbourn Rock; this usage has been followed by Robinson (1986), and recently by Gale *et al.* (1993) for the section at Eastbourne. This wider view places the Melbourn Rock as Late Cenomanian to Early Turonian, which is the usage followed here.

The Base of the Turonian is currently defined at the bottom of the assemblage Zone of *Pseudaspidoceras flexuosum* (Birkelund *et al.*, 1984; Hancock, 1991). Ammonites are rare within the chalk facies but it is possible to use the first appearance of abundant *Mytiloides* spp. to identify the Cenomanian-Turonian boundary (Birkelund *et al.*, 1984). Gale *et al.* (1993) have identified a Zone of *Watinoceras devonense* beneath *P. flexuosum* at Eastbourne, to mark the base of the Turonian. This has not yet been recognised at Dover, so the

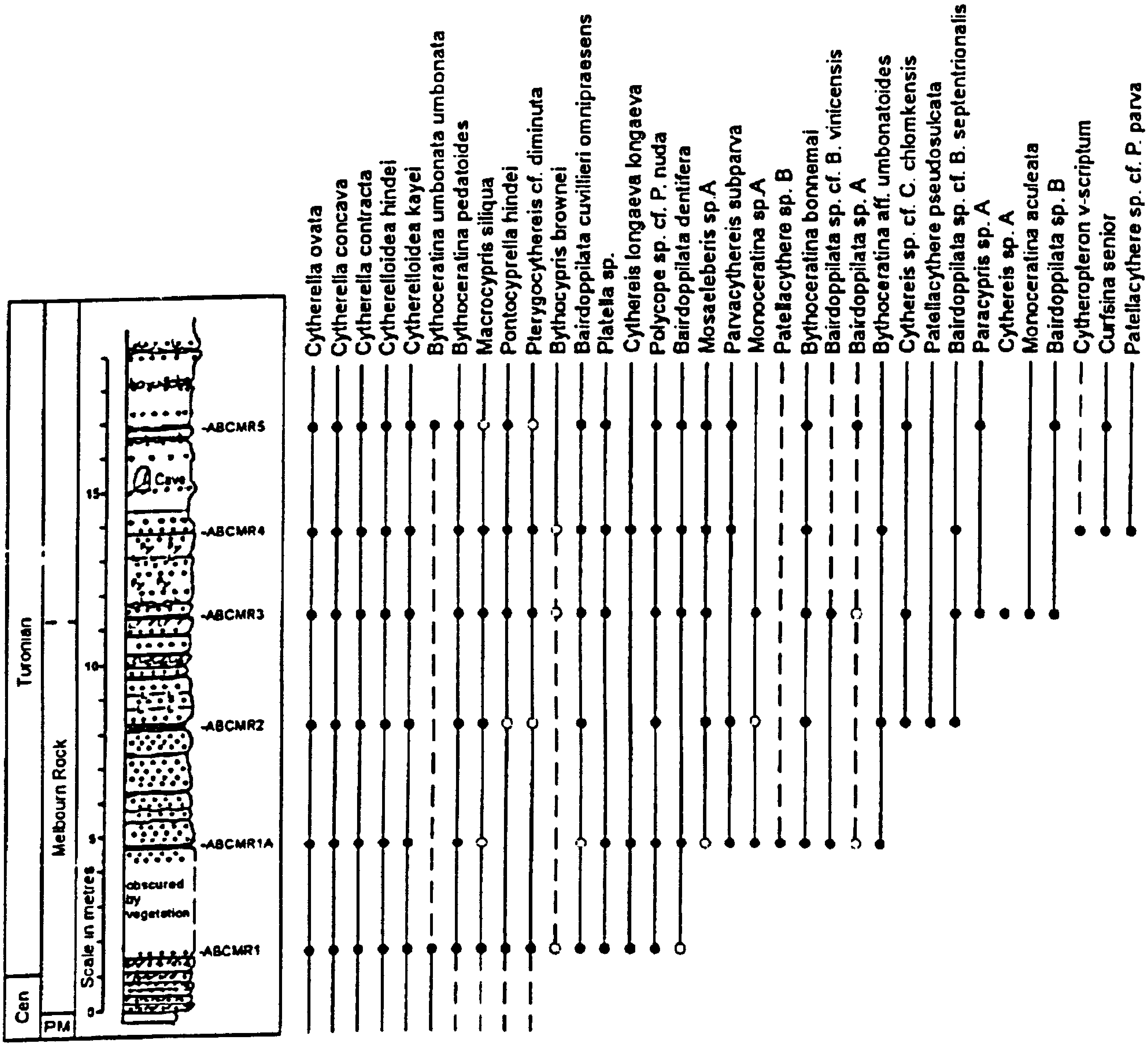

Fig. 1. Range chart for all Early Turonian ostracods, recovered from Abbots Cliff, Dover.

Zone of *Mytiloides* spp. is used here to denote the Early Turonian.

METHODS

Six samples were collected from the lowest 16m of the Turonian at Abbots Cliff Path, 5km south-west of Dover. Several methods of processing chalks, marls and hardgrounds have been tested in order to obtain the best results. The trials indicated that marl seams responded well to white spirit (turpentine substitute) methods, while chalks and hardgrounds were best treated by freeze-thaw technique. The hydrogen peroxide method used by Horne & Rosenfeld (in: Jarvis *et al.*, 1988) and Horne *et al.* (1990) was found to be unsatisfactory. Further trials of immersing cleaned *Pontocyprella robusta* Weaver in cold and hot hydrogen peroxide showed a gradual destruction of the valves, which was complete after 4 hours cold and 50 minutes hot. This represents a worst case, since during normal processing any valves would be encased in matrix.

The freeze-thaw method used here is as follows. The rock is coarsely crushed to cm sized pieces. Small grains and rock flour are discarded. 250g is weighed out, placed in a plastic 250ml beaker and placed in a fan oven to dry at 60°C for 2-3 days. A supersaturated solution of glauber salts ($Na_2SO_4.10H_2O$) is prepared. To prepare enough for 1Kg of rock requires approximately 800g of salts in 400ml water. The heated solution is poured onto the rock, covering it completely. The beaker is then returned to the oven for 3-4 hours to allow the solution to soak in thoroughly, during which time it is

Explanation of Plate 1

All measurements taken from SEM. Fig. 1 *Platella* sp. RV lat. ABCMR3. 570µm long, x120. Fig. 2 *Bythocypris brownei* Jones & Hinde 1890. RV lat. AKSD17, (4.7m above ABCMR5). 817µm long, x82. Fig. 3 *Paracypris* sp. LV lat. broken posterodorsal margin. ABCMR5. 707µm long, x100. Fig. 4 *Pontocyprella hindei* Weaver 1982. RV lat. ABCMR3. 673µm long, x95. Fig. 5 *Polycope* sp. cf. *P. nuda* Kaye 1965. LV lat. ABCMR1a. 434µm long, x130. Fig. 6 *Macrocypris siliqua* (Jones, 1849). RV lat. broken posterior extremity. ABCMR1. 1000µm long, x73. Figs 7, 8 *Cythereis* sp. cf. *C. chlomkensis* Pokorny' 1965. ABCMR5. fig. 7 LV lat. 553um long, x130. fig. 8 RV lat. 538um long, x130


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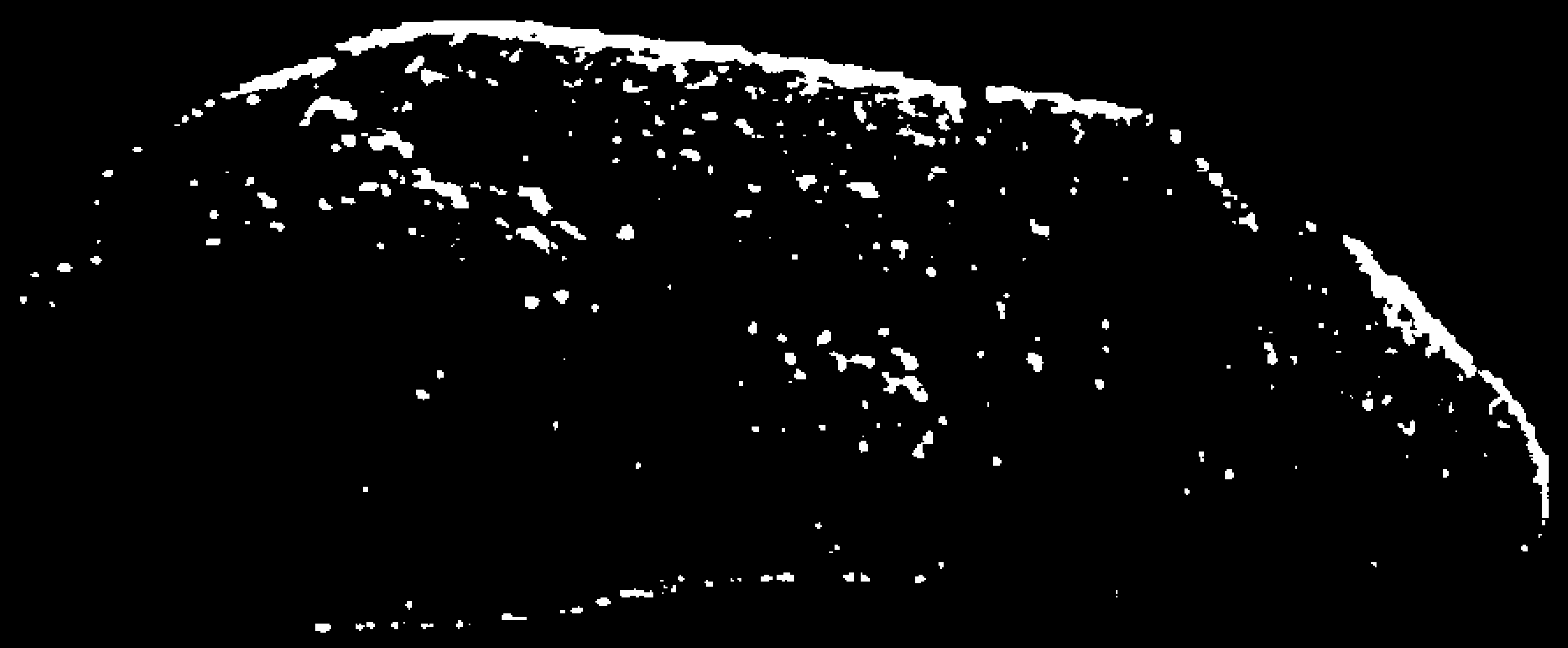
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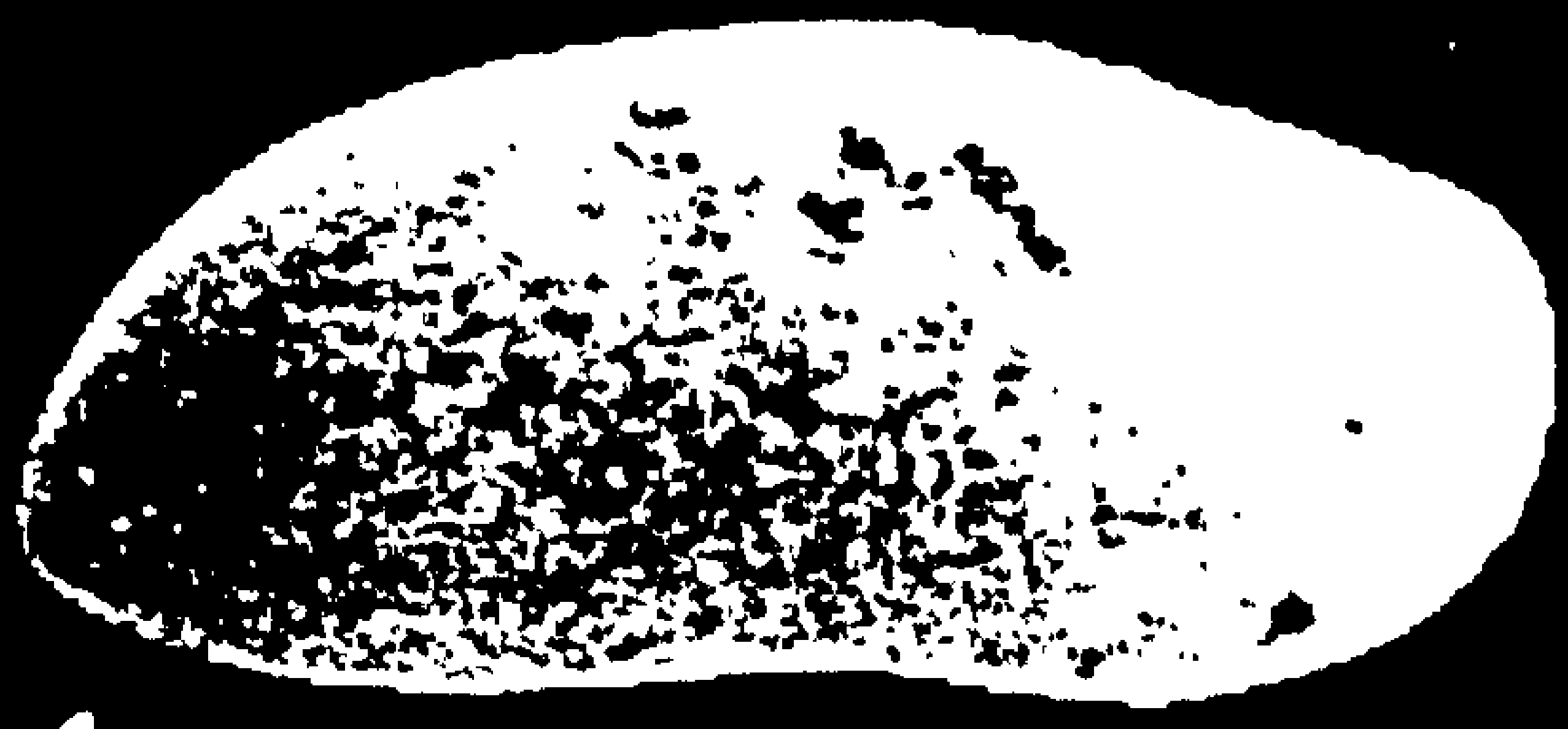
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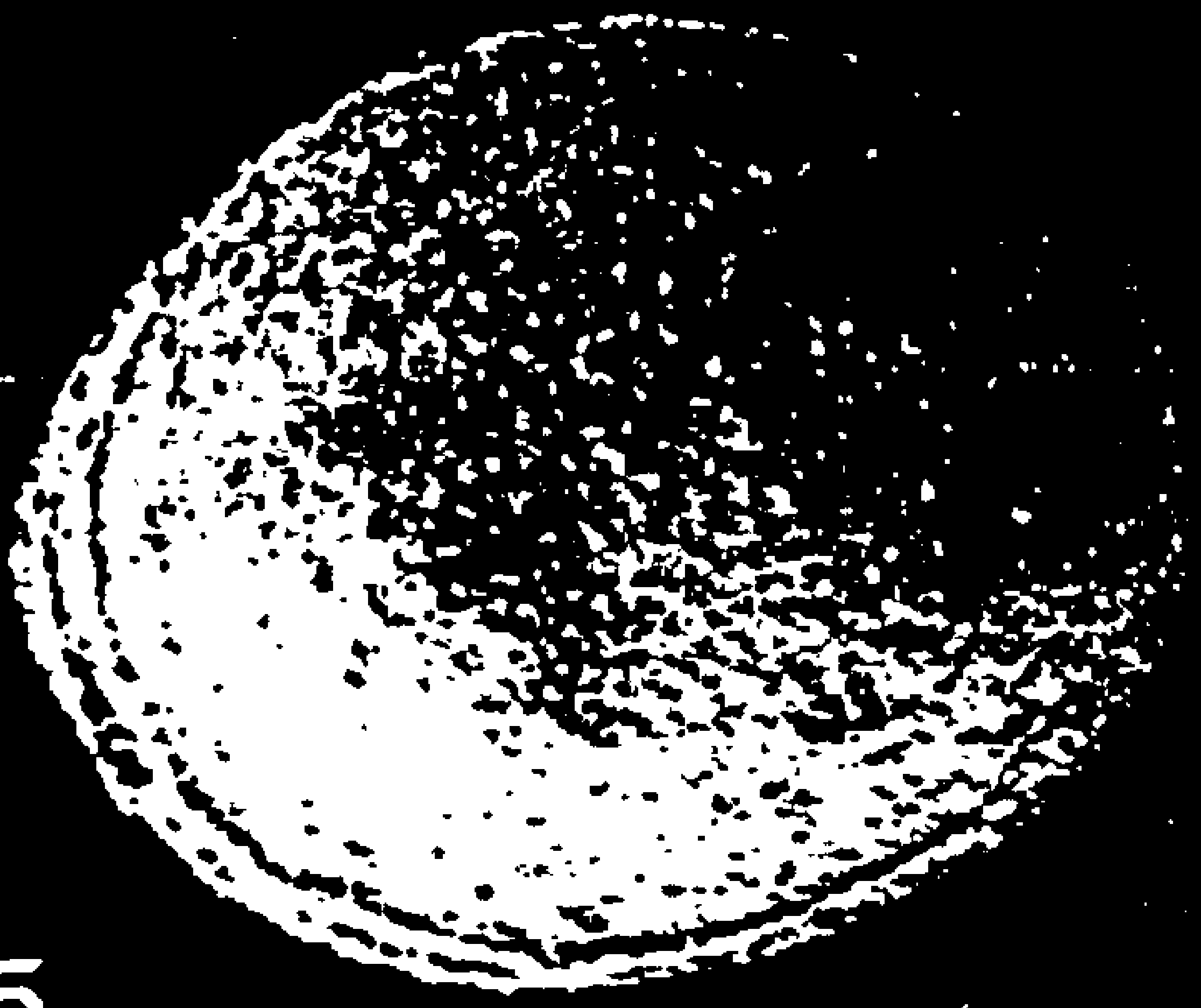
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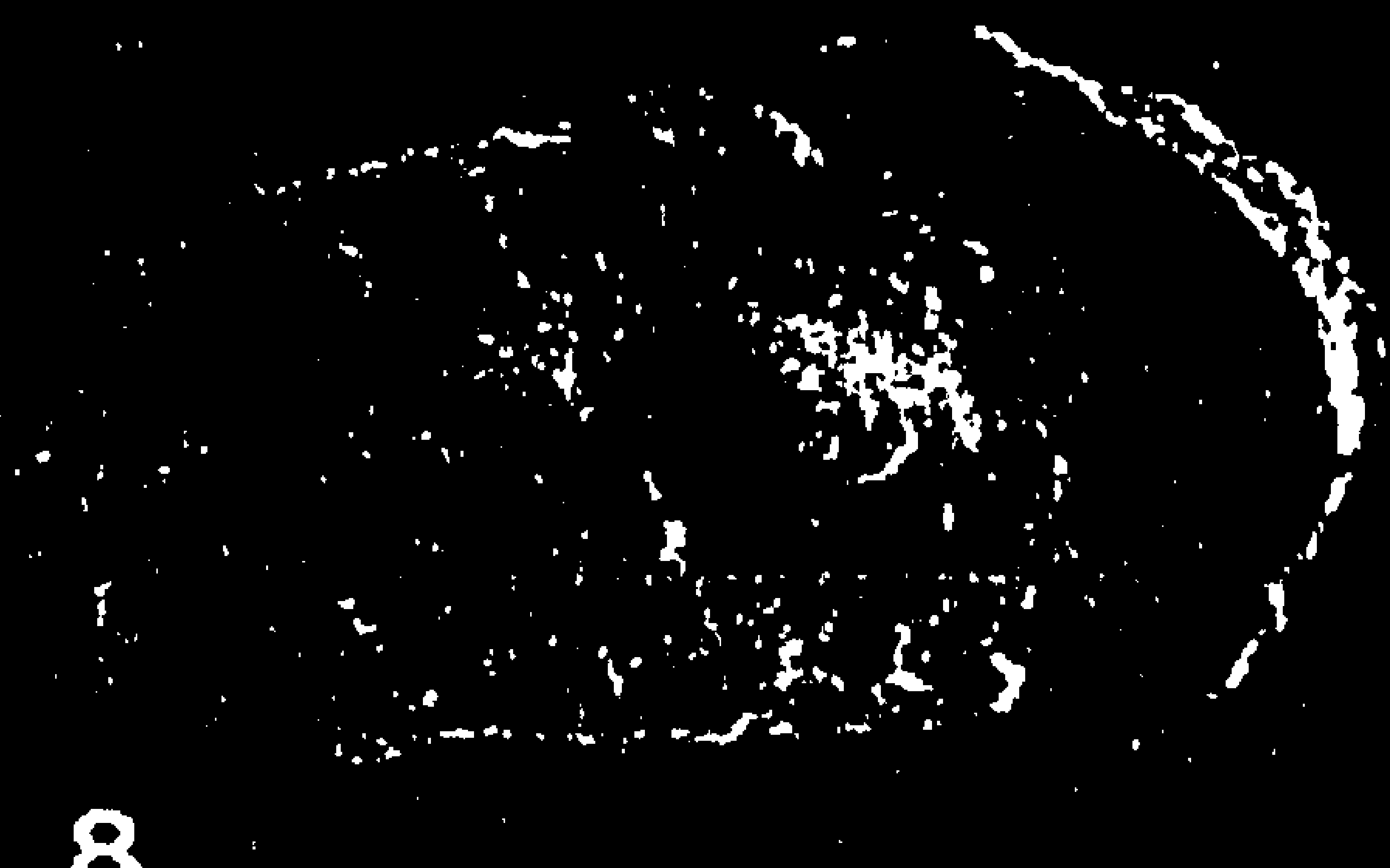
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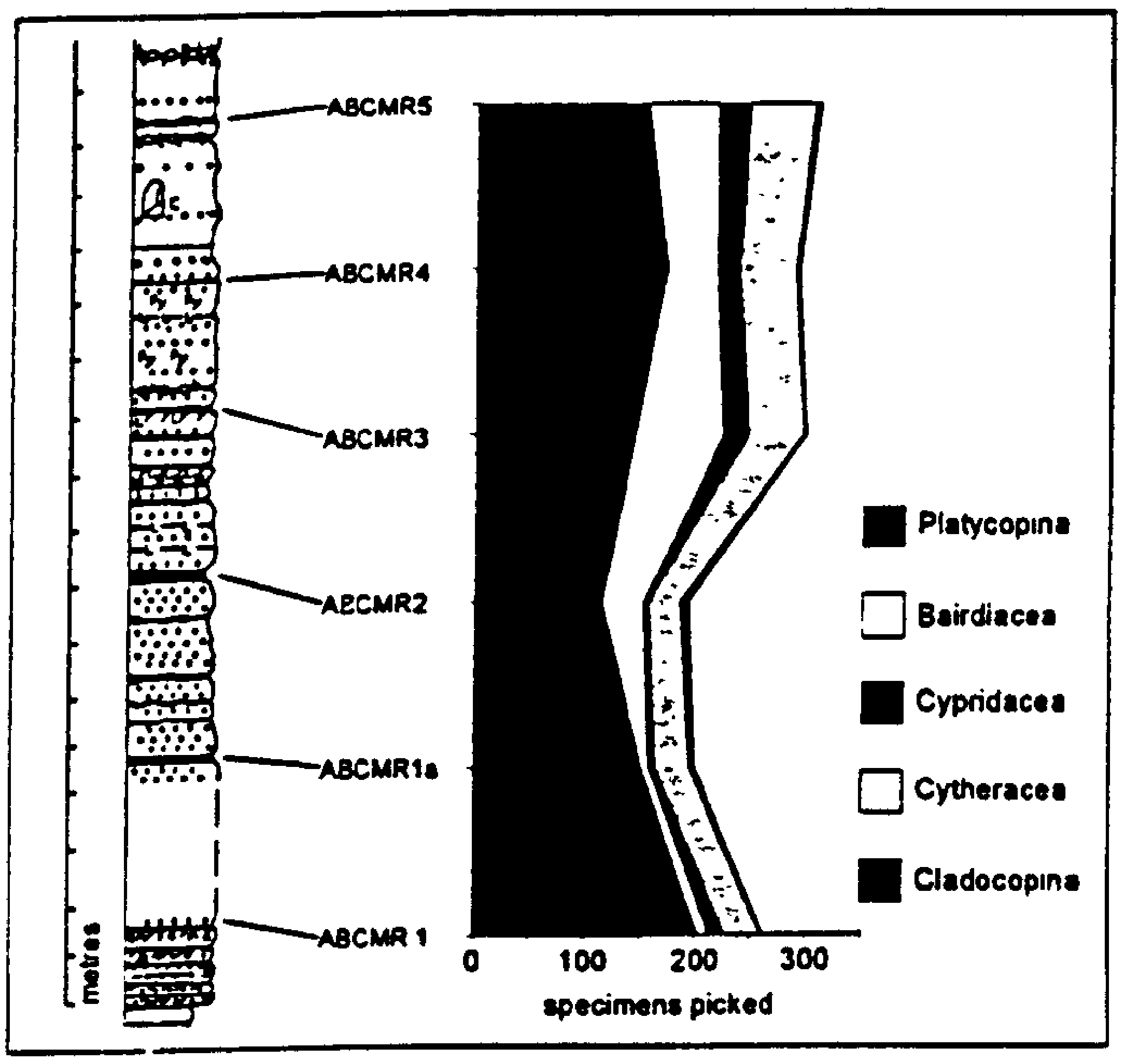


Fig. 2. Variation in relative abundance of the higher taxonomic units from ABCMR1 (lowest) to ABCMR5 (highest)

topped up with heated glauber salt solution as necessary. The liquid is decanted, to give space for expansion, and the beaker is placed in a freezer, usually overnight. Rapid chilling will ensure the high nucleation with small crystal growth required to break the rock apart gently while leaving any microfossils intact. After removing the beaker from the freezer, it is topped up with water and heated for 5-10 minutes. A microwave oven can be used to heat the sample. The problems encountered with metal pans on hot plates, where sediment tends to stick to the bottom and requires scraping off, destroying delicate specimens is thus avoided. One cycle of freeze-thaw was found to be sufficient to break down most chalks and hardgrounds. The processed sediment then requires washing through a 63µm sieve to remove the fines. Standard counts of sub-samples were made, where possible, to allow calculation of abundances. For further discussion, see Horne & Slipper (1992).

Results

Despite the indurated nature of the Melbourn rock at Abbots Cliff, good assemblages were recovered from each of the six samples. Table I shows sample statistics.

Table 1. Calculated absolute abundances for the Melbourn Rock samples

Sample ABCMR...	MR1	MR1a	MR2	MR3	MR4	MR5
Residue from 250g	54.84	58.78	73.3	68.24	50.01	52.78
wt. of residue picked	16.35	18.63	19.95	15.4	9.08	7.57
no total ostracods	262	199	195	298	296	310
ostracods in 250g calc	879	623	716	1320	1630	2161

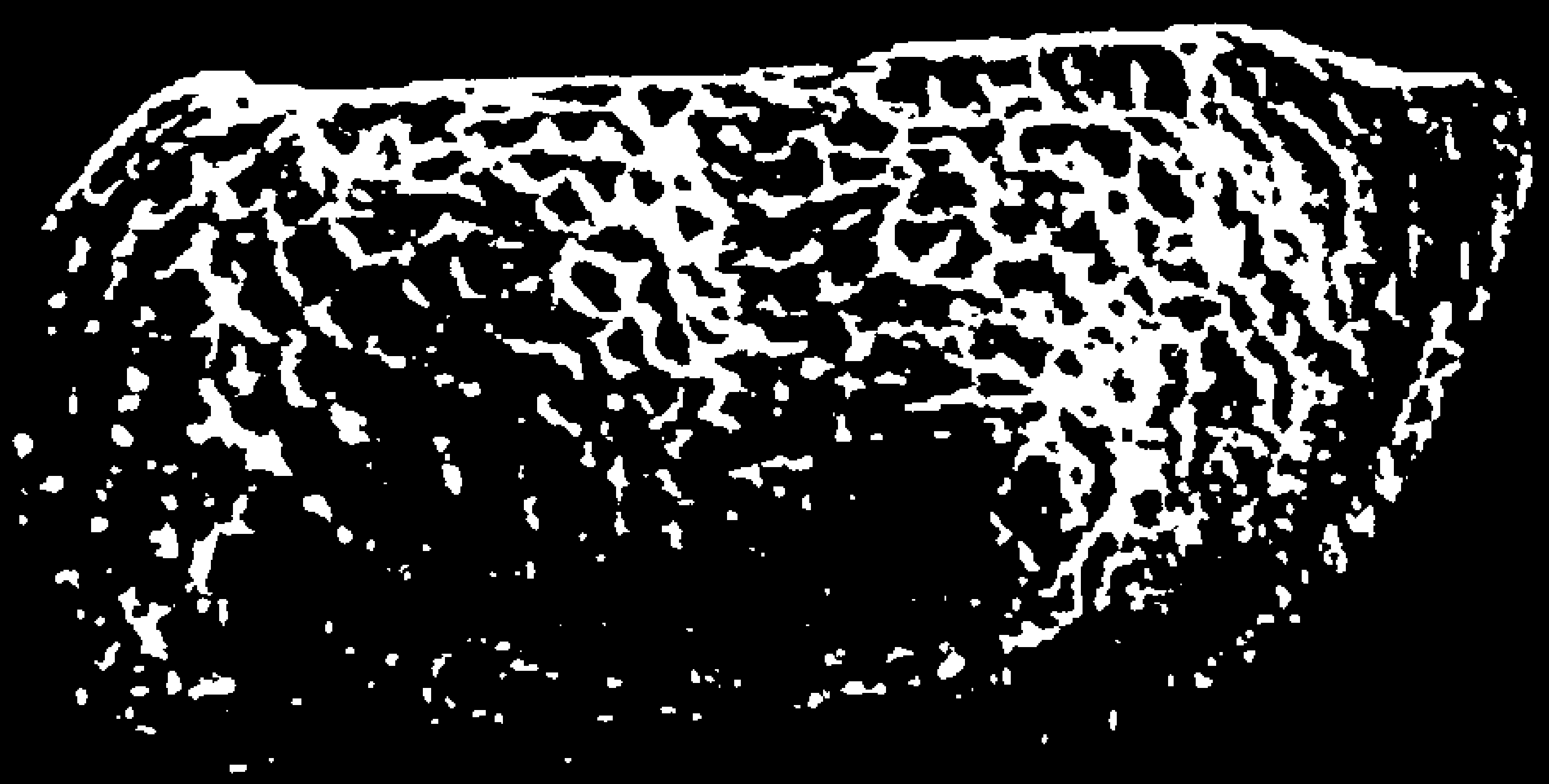
Approximately one fifth of the sample in each case remained on the 63µm sieve; ABCMR2 and 3 were more difficult to process. The absolute abundance is seen to fall initially and then to steadily rise towards the top of the section. Thirty-four species have been recovered; their ranges are shown in figure 1. The diversity also steadily increases upwards, rising from seventeen at the base, to twenty-three at the top, using simple number of species to indicate diversity. If known occurrences above this section are incorporated, the cumulative species diversity at the top of the Melbourn Rock is thirty-four. A breakdown of the assemblage is given in terms of the higher taxonomic units in figure 2. The principal feature is that the proportions of the groups remain similar, with the exception of the Bairdiacea which increase in importance above ABCMRla. The Platycopina account for 78% at the base, and 50% near thc top, they are dominated by *Cytherella ovata* with subordinate *C. contracta, C. concava, Platella* sp. and *Cytherelloidea* spp.. The Cypridacea are represented by *Pontocyprella* and *Macrocypris*. The Cytheracea component remains constant at approximately 16% of the total fauna. The remaining 2% is accounted for by the Myodocopid *Polycope* sp. cf. *P. nuda* Kaye, which is never again as frequent throughout the rest of the Turonian. A faunal list of the thirty-four species in eighteen genera is given in table 2.

Table 2.
Faunal list for ABC MR 1- ABC MR 5

Bairdoppilata dentifera (Van Veen, 1934)
Bairdoppilata cuvillieri omnipraesens Pokorny, 1975
Bairdoppilata sp. cf. *B. septentrionalis* (Bonnema, 1940)
Bairdoppilata sp. cf. *Neonesidea (M.) vinicencis* (Sulc, 1932)
Bairdoppilata sp. A
Bairdoppilata sp. B
Bythoceratina (Bythoceratina) bonnemai Deroo, 1966
Bythoceratina (B.) umbonata umbonata (Williamson, 1847)
Bythoceratina (B.) aff. *B. (B.) umbonatoides* (Kaye, 1964)
Bythoceratina (Cuneoceratina) pedatoides (Bonnema, 1941)
Bythocypris brownei Jones and Hinde, 1890
Curfsina senior Pokorny 1967
Cythereis sp. aff. *C. chlomkensis* Pokorny' 1965
Cythereis longaeva longaeva Pokorny' 1963
Cythereis sp. A.
Cytherella concava Weaver, 1982
Cytherella contracta Van Veen, 1932
Cytherella ovata (Roemer, 1840)
Cytherelloidea hindei Kaye, 1964
Cytherelloidea kayei Weaver1982
Cytheropteron vscriptum Van Veen, 1936
Macrocypris siliqua (Jones, 1849)
Monoceratina sp. A
Monoceratina aculeata Van Veen, 1936
Mosaeleberis sp. A (*sensu* Jarvis *et al*., 1988)
Paracypris sp. A *Parvacythereis subparva* (Pokorny', 1967)
Patellacythere pseudosulcata (Van Veen, 1936)
Patellacythere sp. cf. *P. parva* Weaver 1982
Platella sp.
Patellacythere sp.
Polycope sp. cf. *P. nuda* Kaye, 1965
Pontocyprella hindei Weaver, 1982
Pterygocythereis sp. cf. *P. diminuta* Weaver, 1982

Explanation of Plate 2

All measurements taken from SEM. **Fig. 1** *Bythoceratina bonnemai* Deroo, 1966. LV lat. ABCMRla. 561um long, x130. **Fig. 2** *Patellacythere pseudosulcata* (Van Veen, 1936). RV lat. broken posterior extremity. ABCMR2. 271µm high, x140. **Fig. 3** *Monoceratina* sp. A LV lat. broken anteroventral margin and posterior extremity. ABCMRla. 245um high, *x155*. **Figs. 4,6** *Bythoceratina pedatoides* (Bonnema, 1941) . RV lat. ABCMRl. 747um long, x95. Fig. 6 Juvenile, RV lat. ABCMR4. 684um long, x95. **Fig. 5** *Bythoceratina* aff. *B. umbonatoides* Kaye, 1964. LV lat. ABCMR2. 573um long, x130. **Fig. 7** *Monoceratina aculenta* Van Veen, 1936. RV lat. broken anterior and posterior margins. ABCMR3. 373um high, x120. **Fig. 8** *Cytheropteron* sp. RV lat. ABCMR4. 314µm long, x235.



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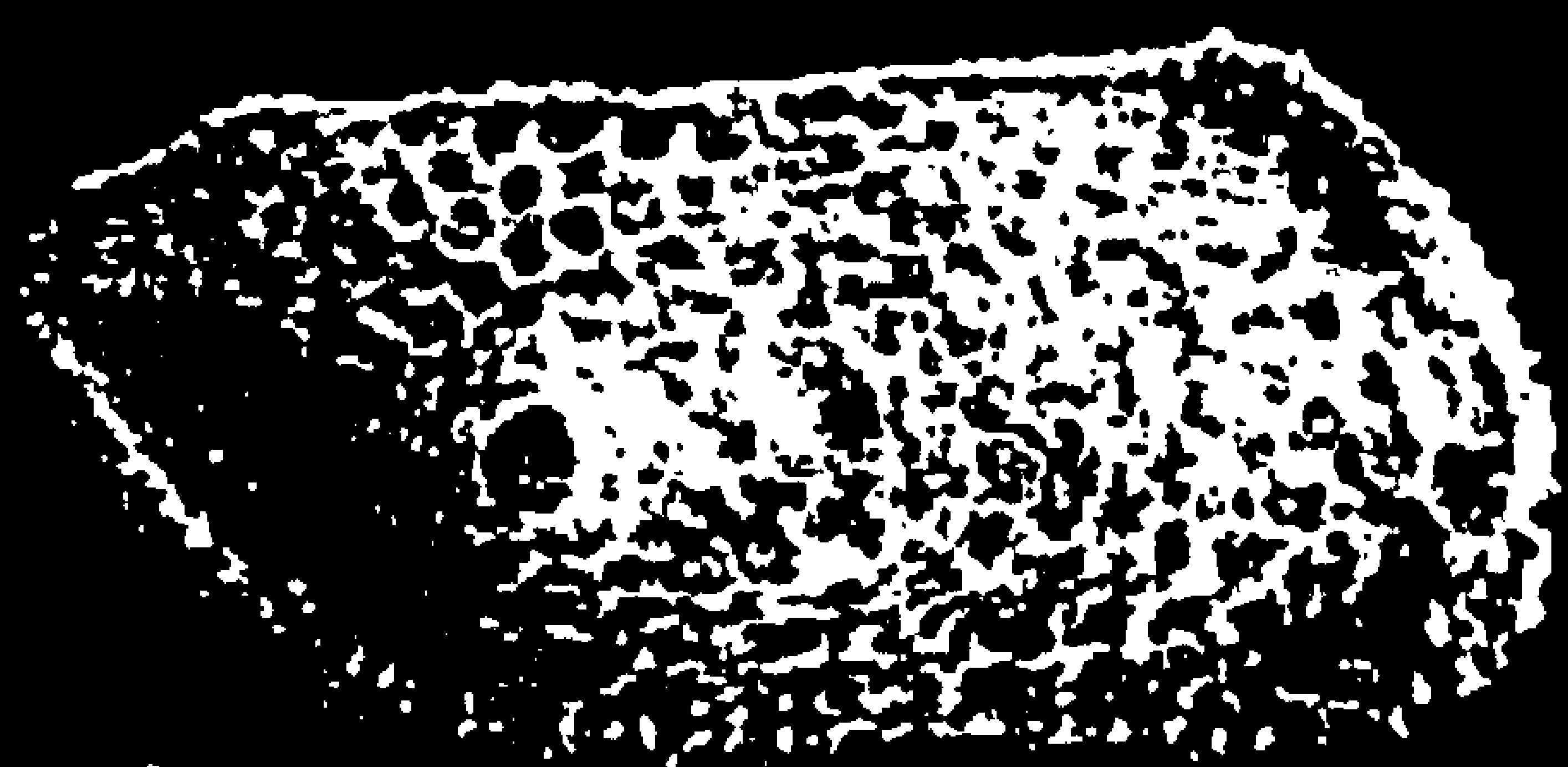

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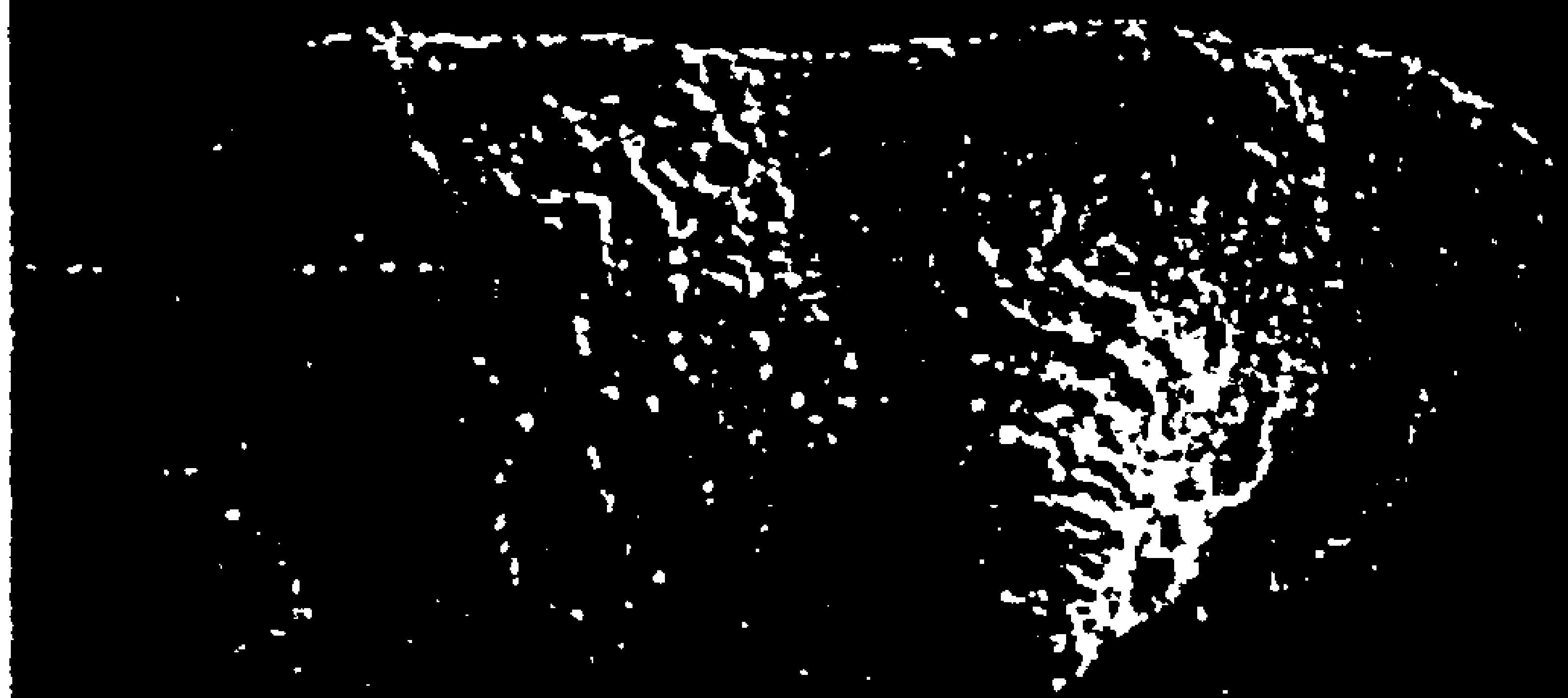

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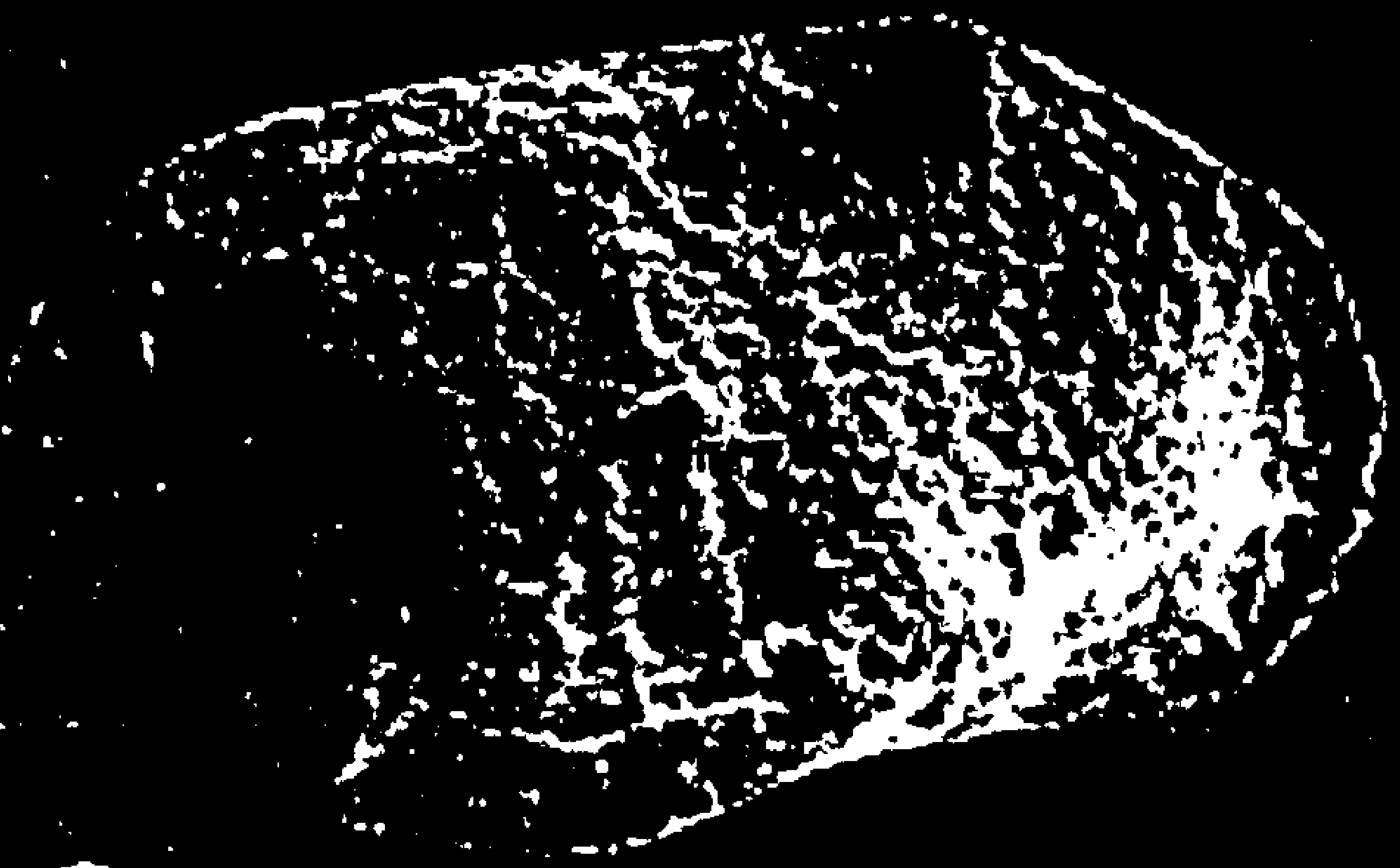

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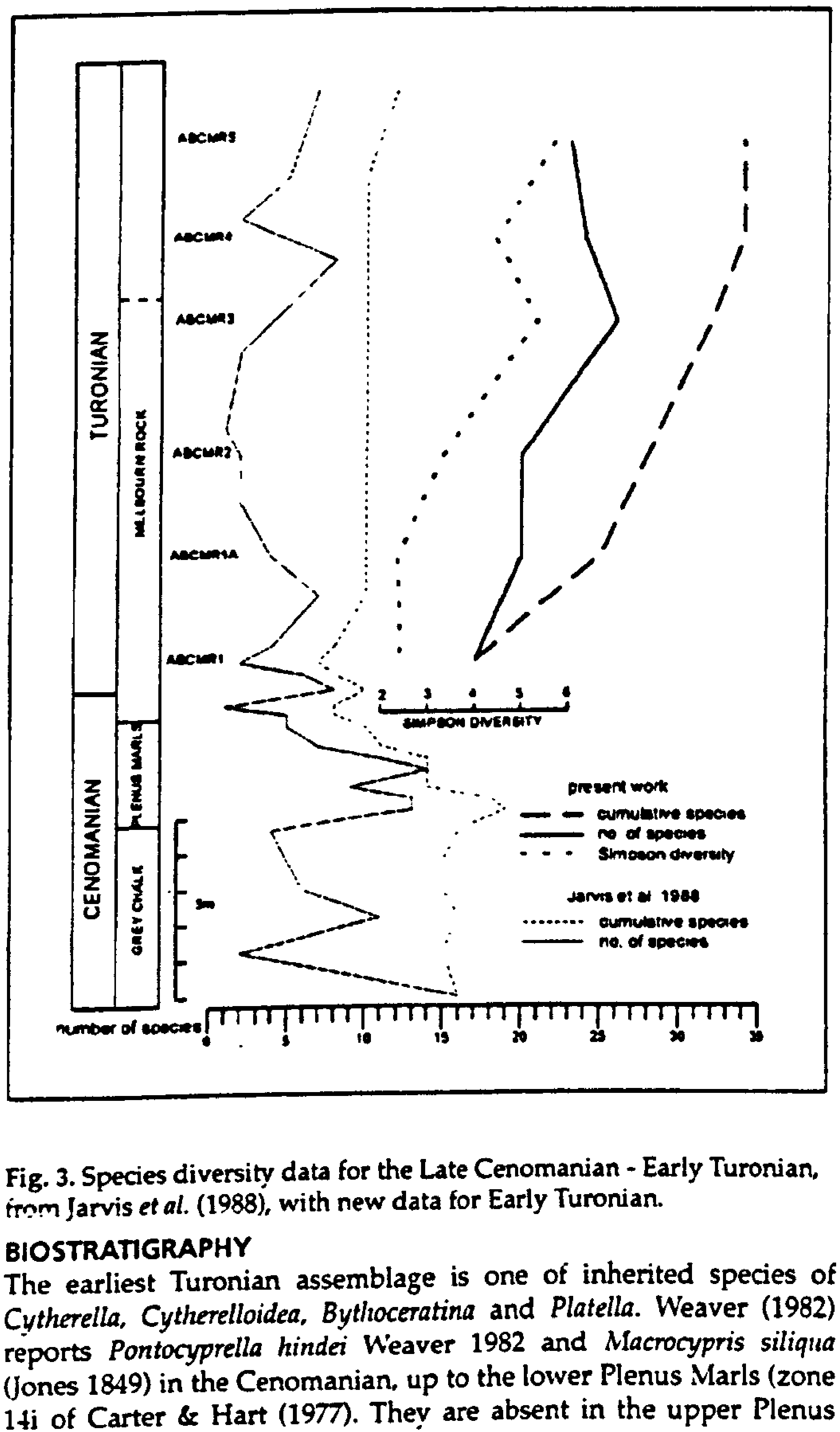

Fig. 3. Species diversity data for the Late Cenomanian - Early Turonian, from Jarvis *et al.* (1988), with new data for Early Turonian.

BIOSTRATIGRAPHY

The earliest Turonian assemblage is one of inherited species of *Cytherella*, *Cytherelloidea*, *Bythoceratina* and *Platella*. Weaver (1982) reports *Pontocyprella hindei* Weaver 1982 and *Macrocypris siliqua* (Jones 1849) in the Cenomanian, up to the lower Plenus Marls (zone 14i of Carter & Hart (1977). They are absent in the upper Plenus Marls, but make a reappearance in the lowest Melbourn Rock. *Pterygocythereis diminuta* Weaver is known from the Late Cenomanian and is found to continue into the Early Turonian. Species recorded for the first time at this level include: *Bythocypris brownei* Jones & Hinde 1890, *Polycope* sp. cf. *P. nuda* Kaye 1965 and *Bairdoppilata dentifera* Van Veen 1934. *B. brownei* is present only as juveniles at this level, and does not become abundant until the succeeding *Collignoniceras woollgari* Zone. Well preserved specimens of *Polycope* can be found throughout the Early Turonian, but then become less common. *Bairdoppilata dentifera* Van Veen 1934 and *B. cuvillieri omnipraesens* Pokorny' enter at this level and remain important components of the Turonian fauna. The first appearance of *Cythereis longaeva longaeva* Pokorny' 1963 marks the base of the Turonian.

Three metres above the base of the Turonian two important species first appear, *Mosaeleberis* sp. A (*sensu* Jarvis *et al.* 1988) and *Parvacythereis subparva* Pokorny'. A further four bythocytherids also join the assemblage at this level and range up into the Late Turonian. *Bythoceratina bonnemai* and *B. (B.)* aff. *umbonatoides* become characteristic elements of the Turonian fauna. The next influx at approximately six metres above the base of the Turonian sees the appearances of *Patellacythere pseudosulcata* Van Veen, and the third trachyleberid *Cythereis* sp. aff. *chlomkensis* Pokorny'. Towards the top of the nodular chalks of the Melbourn Rock is the single occurrence of *Cythereis* sp. A, and the first appearances of *Paracypris* sp. and *Monoceratina aculeata* Van Veen. The latter is found here as fragments, but complete specimens have been recovered from the higher Turonian. The top nodular bed marks a slowing in the rate of first appearances which does not increase again until the Middle Turonian. At this level *Curfsina senior* Pokorny is joined by *Cytheropteron vscriptum* and *Patellacythere* sp. cf *P. parva*, all of which are found in the overlying Turonian and Coniacian beds.

TAXONOMIC NOTES

A full systematic treatment for the Turonian-Coniacian of Southern England, is being prepared by the author, but it is possible with this new data to add to the taxonomic discussion of a few selected species.

Bythoceratina sp. aff. *B. umbonatoides*

(Pl. 2, fig. 5)

Both Clarke (1983) and Herrig (1967) have illustrated the variable ornament of the nominate subspecies, from the Coniacian to Maastrichtian of Germany. British specimens have been figured from the Early Cenomanian (Wilkinson, 1988), Middle Cenomanian (Weaver, 1982), Late Cenomanian (Jarvis *et al.*, 1988), and Campanian (Kaye, 1964). These demonstrate a strengthening of ornament and a reduction in length/height ratio. The heavy lattice like reticulation of the Early Turonian form does not fit into this lineage. In addition, the anterior is more rectangular, with nodes present at the cardinal angles.

Bythoceratina (B.) bonnemai Deroo, 1966

(Pl. 2, fig.1)

This can be differentiated from *B. (B.) umbonata* by the presence of a strongly raised anterior marginal rib, and a swelling in the anterior dorsolateral field. This species has been illustrated as *B. umbonatoides* by Kaye (1964, Pl. 4, fig. 2 *non* fig. 5) and Neale (1978, Pl. 14 figs. 2-6) . It can be distinguished from the latter by the reticulate posterolateral field and the raised anterior marginal rib. Clarke's subspecies *B. (B.) umbonata multireticulata* is here considered as a junior synonym.

Bythoceratina (Cuneoceratina) pedatoides pedatoides

(Bonnema, 1941)

(Pl. 2, figs 4, 6)

This is very closely allied to B. (C.) *pedatoides calcifera* Clarke 1983. That subspecies is differentiated from the nominate subspecies, by a thickening of the reticulation meshes, and by the presence of an anterodorsal rib. In his discussion of *B.(C.) herrigi*, Weaver (1982) makes comparisons with *B.(C.) pedata* (Marsson), noting the diagnostic feature as the anterior marginal ribs, but does not mention the similarity to B.(C.) *pedatoides*, which appears identical, apart from being slightly more spinose. It may be, that these are chronological subspecies of B. (C.) *pedatoides* (Bonnema, 1941). Further study of the hinge structure of these species may elucidate the problem.

Cythereis sp. aff. *chlomkensis*Pokorny' 1965

(Pl. 1, figs 7,8)

Pokorny''s specimens from the Coniacian of Luzice, only differ from this in that the ventral rib is connected to the anterior marginal rib, in the specimens from Dover, the ventral rib is separate and merges into the anterolateral field. It also resembles *Rehacythereis paranuda* Weaver 1982, from the Albian and Cenomanian. This also has connected anterior and ventral ribs but is devoid of ornament.

Patellacythere pseudosulcata (Van Veen, 1936)

(Pl. 2, fig. 2)

This is very similar to *P.* sp. A Weaver 1982 (non *P. bicostata*

Wilkinson 1988), but it can be distinguished by the broader anterior margin, and a reduced ventrolateral swelling. The species described by Wilkinson (1988) is not conspecific with *P.* sp. A Weaver 1982. From the descriptions and the illustrations given, it can be seen that there are differences in the shape of the ventral margin, posterior extremity, dorsal rib, upper ventral rib, position of lateral spine and the anterodorsal swelling. *P.* sp. A Weaver 1982 is more closely allied with *Monoceratina trentoniensis* Bonnema (1941), which has been illustrated as *Bythoceratina bicostata* n. sp. by Clarke (1983).

Pterygocythereis sp. cf. *diminuta* Weaver 1982

Complete carapaces show the characteristic overlap of the left valve by the right in the mid dorsal region, but as Jarvis *et al.* (1988) reported, some differences are present in the shape of the posterior margin. In addition, the Turonian specimens do not possess the small tubercles on the posterior edge of the alae.

Cythereis longaeva longaeva Pokorny´ 1963

The author has recently examined the collections of Pokorny at the Charles University in Prague, where many type specimens are housed. Direct comparison with the holotype indicates that the specimens recovered from the British EarlyTuronian beds are of the nominate subspecies. This corresponds to the illustrations of Jarvis *et al.* (1988, fig 18, c,f) and Horne *et al.* (1990, Pl. 1, fig. 8 non figs. 7, 9).

Platella sp.

(Pl. 1, fig. 1)

This is a small species which can be easily overlooked as a juvenile of *Cytherelloidea contracta* or similar species. Some of the specimens attributed to *C.* sp. cf. *chathamensis* Weaver by Jarvis *et al.* (1988) may have been included in this taxon. It is necessary to apply a vegetable stain to observe the delicate reticulate ornament. This could be descended from *Platella icknieldensis* Weaver 1982.

DISCUSSION

The fauna recovered from the Melbourn Rock Beds at Abbots Cliff, represents a moderately diverse assemblage in terms of number of species, but is numerically dominated by the Platycopina and Bairdiacea, as is much of the remaining Late Cretaceous. In figure 3, diversities are shown as simple number of species present in a sample (solid line) and also as cumulative species, interpolated from known ranges (broken line). A Simpson diversity index curve is also included for the Turonian samples, to show how it follows the simple species number. It indicates that the latter may be used to identify diversity trends over the whole section. Two sets of data are given: one from Jarvis *et al.* (1988), and that from the current work. It can be seen that the initially high Cenomanian diversity rapidly falls during the deposition of the Plenus Marls, to give a minimum in the lowest of the Melbourn Rock beds, just above the maximum of the carbon stable isotope excursion. The diversity suggested by the results of Jarvis *et al.* (1988) remains steady, whereas the new data demonstrates a rapid recovery of the diversity, immediately above the base of the Turonian, to a level similar to that of the pre-OAE Late Cenomanian. The number of species then steadily increases up the section.

The discrepancy between the results of Jarvis *et al.* (1988) and the new data must be explained. There are two possible causes which may account for the difference. Firstly, the two sets of data come from different localities. However, it is not thought that the separation of 3km between Akers Steps and Abbots Cliff would be enough to provide any barrier to Turonian ostracods. Indeed the section used by Jarvis *et al.* (1988) is a composite of the two sites. Secondly, the processing methods were different. The freeze-thaw technique is more suited to the harder Melbourn Rock than hydrogen peroxide. It is thought that this alone is responsible for the discrepancy. The usefulness of the data from the Cenomanian, which have been included here, is then called into doubt. The Grey Chalk Member and the Plenus Marl Formation are composed of marly chalks and marls, which are easily disaggregated by many different methods. Johnson (this volume) has obtained seventeen ostracod species from Beds 1 and 2 of the Plenus Marls at Compton Bay, Isle of Wight, using the more appropriate white spirit method. This result is similar to that obtained at Dover by Jarvis *et al.* (1988) with hydrogen peroxide, indicating that their Plenus Marls results are probably valid. The softer rock breaks down more swiftly so was not exposed to the damaging action of the hydrogen peroxide as long as the more indurated samples. It is also possible that the presence of pyrite in the nodular chalks could have reacted with the hydrogen peroxide to form sulphuric acid, the resulting decreased pH would then increase the rate of valve dissolution. It is concluded that only the Melbourn Rock data from Jarvis *et al.* (1988) are unreliable.

The suggestion by Horne *et al.* (1990), that it required most of the Turonian (about 3Ma; Haq *et al.* (1987)) for the ostracod fauna of the Chalk Sea to recover from the effect of the OAE and reach the pre-OAE Cenomanian diversity, cannot now be supported. The data indicate a rapid recovery, followed by a continued increase in diversity up the section. There is uncertainty over the rate at which this recovery occurred, since the sections at Dover are highly condensed, especially in these basal beds. Examination of a more expanded sequence, such as that at Eastbourne, is needed to test these results.

The Bythocytheridae are the most significant group within the Cytheracea which survive the boundary event, eventually reaching nine species in the Early Turonian. Jorgensen (1983) also noted the importance of *Bythoceratina* in the Danish Chalk, linking its occurrence to changes in bathymetry. The other principle taxa, *Macrocypris*, *Polycope* and *Pontocyprella*, which survive the Cenomanian-Turonian boundary, are all associated with deeper water of the Cainozoic and Recent (Coles *et al.*, 1990; Bonaduce *et al.*, 1983). The lower Melbourn Rock beds have a fauna which may be indicative of deeper water, while species which have been associated with shallower water appear higher in the sequence. The most numerous of these is *Mosaeleberis* sp. A, *sensu* Jarvis *et al.* (1988), which includes both reticulate and smooth forms. They very clearly document the relict reticulation in the centrodorsal field in transitional specimens (Jarvis *et al.*, 1988 fig 17 a-k). However, Ohmert (1971) pointed out that the smooth form *Karsteneis (Prosteneis)*, occurred in more offshore environments than the reticulate form *Mosaeleberis interruptoidea*. Both types tend to occur together in the samples from Dover, but the reticulate variety is initially more abundant.

Interpretations of sea-level over this interval tend to suggest regression (Hancock, 1990; Jeans *et al.*, 1991) based on lithological characteristics. It is difficult to reconcile the fauna discovered in the Melbourn rock with this hypothesis, since a deeper water assemblage has survived through the boundary interval. The Early Turonian fauna could also be interpreted as representing cooler water, rather than the simpler depth control. This is supported by data from Eastbourne (D. J. Horne, pers. comm.) which suggests a replacement of Tethyan species by "Boreal" species, during the deposition of the Plenus Marls. The appearance of *Mosaeleberis* could then be interpreted as the introduction of warmer water.

CONCLUSIONS

To obtain representative populations from harder chalks and hardgrounds of the Turonian, it is necessary to use freeze-thaw processing. Hydrogen peroxide is not recommended.

From the analysis of the Melbourn Rock fauna, it has been shown that the Cenomanian-Turonian OAE had only a short-lived effect on the ostracod populations. Jarvis *et al.* (1988, p. 87) note a rapid recovery in the specific diversity of planktonic Foraminifera and calcareous nannofossils. The Ostracoda can now be added to this list. The association of *Cytherella, Bairdoppilata, Macrocypris, Pontocyprella, Bythocypris, Bythoceratina* and *Polycope* indicates that the environment of the lower Melbourn Rock was of cooler or deeper water. Shallow or warmer water influences, in the higher Melbourn Rock, are evidenced by abundant *Mosaeleberis*. It is possible that more than one mechanism was responsible for the faunal turnover at the Cenomanian-Turonian boundary. Oxygen levels, changing water masses, and fluctuating sea-levels may all have to be incorporated into the final model.

ACKNOWLEDGEMENTS

This work forms part of a research degree and my thanks go to my employers at The School of Earth Sciences, University of Greenwich, who have enabled me to continue the project. For assistance in collecting the samples, I would like to thank Nicky Johnson and David Horne, who has also contributed many ideas and aided in the revision of the manuscript. The comments of Steve Tatman were much appreciated and have been incorporated into the text. The photographs were taken by the author on a JEOL JSM35C scanning electron microscope, and my thanks go to Bill Ralph for the printing.

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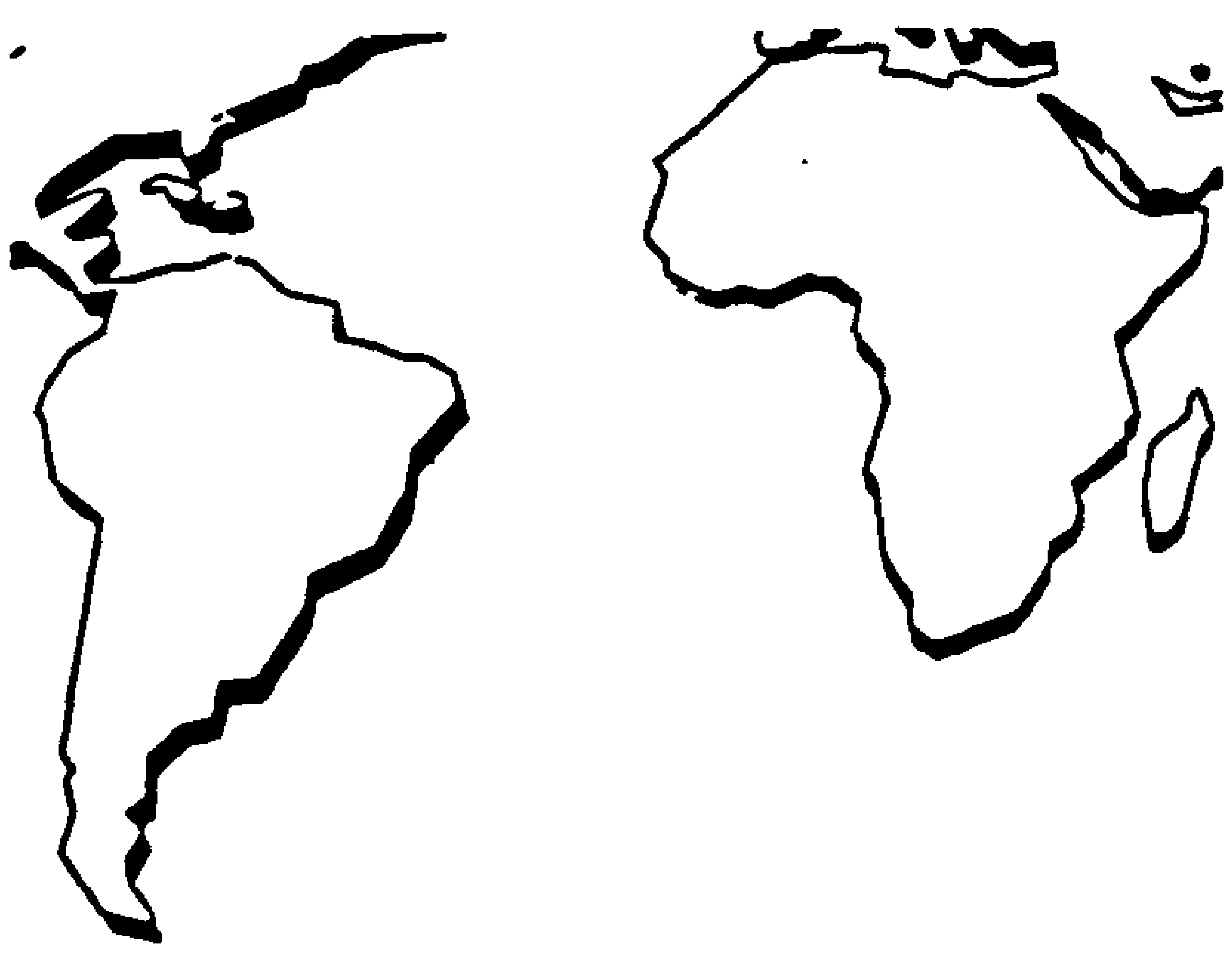
TURONIAN/CONIACIAN OSTRACODA FROM DOVER (S.E. ENGLAND)

LES OSTRACODES DU TURONIEN/CONIACIEN DE DOUVRES (S.E. ANGLETERRE)

IAN J.SLIPPER



SLIPPER, I.J. (1996). – Turonian-Coniacian Ostracoda from Dover (S.E. England); *(Les ostracodes du Turonien-Coniacien de Douvres (S.E. Angleterre).– What about Ostracoda: Actes du 3e Congrès Européen des Ostracodologistes, 1996*, xxx-xxx, 7 fig., 1 pl.; Pau, February 15, 1997. – ISSN : xxxxxxx. – ISBN : x-xxxxx-xx.

Les assemblages obtenus à partir de 39 échantillons collectés sur approximativement 1 mètre d'interval à la limite Turonien/Coniacien (Crétacé supérieur) à Langdon Stairs, Douvres, S.E. Angleterre, sont examinés à des niveaux taxonomiques élevés selon la diversité et selon des regroupements statistiques, premièrement dans le but de déterminer si les ostracodes montrent un signal stratigraphique intéressant à la limite observée, et deuxièmement pour observer les changements dans l'assemblage de la faune qui auraient pu apparaître lors de la régression du Turonien supérieur.

Les Cytheracea, Cytherellidae et Bairdiaea et Cypridacea sont utilisés comme pôles de diagrammes triangulaires pour évaluer les profondeurs des eaux dans la limite.
La séquence montre des eaux relativement profondes dans la Zone *lata* (du Turonien moyen au Turonien supérieur), puis peu profondes pendant les dépôts de Kingston Nodular Chalks et Navigation Hardgrounds (Turonien supérieur) où le niveau de la mer le plus bas de la coupe est enregistré.

Après cela, les profondeurs des eaux augmentent de nouveau.

La diversité des données démontrent une augmentation de la richesse de la faune juste avant la limite. Comme c'est au maximum de la régression, la diversité du modèle du bassin suggère que Douvres devrait être à l'extrême fin de la zone optimale. La régression du Turonien supérieur déplace la zone vers le bassin, avec une augmentation de la diversité, alors que la transgression Conacien Inférieur a pour résultat le mouvement de la zone optimale vers le rivage avec une diminution de la diversité.

Une analyse stratigraphiquement contrainte du regroupement a été menée utilisant le programme CONISS. Ceci aboutit à une division significative selon la limite acceptée de Douvres, mais coïncide avec le maximum *Zoophycos* selon Navigation Hardground 1. Le point positif pour la limite traditionelle de Navigation Hardground 3 est l'existence de flots de *Xestoleberis marssoni*.

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Mots-clés : Ostracoda, Turonien, Coniacien, biostratigraphie, paléoécologie.

ABSTRACT

Assemblages obtained from 39 samples collected at approximately 1m intervals across the Late Cretaceous Turonian-Coniacian Stage boundary at Langdon Stairs, Dover, S.E. England, are examined at higher taxonomic levels, by diversity patterns, and by statistical clustering, with the objective of determining if the Ostracoda demonstrate any useful stratigraphical signal at the stage boundary, and secondly to observe any faunal assemblage changes which may have occurred during the Late Turonian regression.

All samples were processed using the freeze-thaw method, which yielded 7349 specimens. These have been identified as belonging to 81 species and subspecies; 46 of which have either first appearance or extinction in the section.

Triangular assemblage plots of Cytheracea, Cytherellidae and Bairdiacea and Cypridacea are used to assess the relative water depths across the boundary. The sequence shows relatively deep water in the *lata* Zone (mid to Late Turonian), then shallowing during deposition of the Kingston Nodular Chalks and the Navigation Hardgrounds (Late Turonian), where the lowest sea level occurs in this section. After this, the water depths increased once again.

Diversity data demonstrate an increase in faunal richness just below the stage boundary. Since this is at the maximum of the regression, the basinal diversity model suggests that Dover would have to be at the deeper end of the optimum zone. The Late Turonian regression moves the zone basinwards, with an increase in diversity, while the Early Coniacian transgression causes the optimum zone to move shorewards with a decrease in diversity.

A stratigraphically constrained cluster analysis was carried out using the CONISS program. This resulted in a significant division below the accepted boundary at Dover, but coincides with the *Zoophycos* maximum below Navigation Hardground 1. A good marker for the traditional boundary at Navigation Hardground 3 is the flood occurrence of *Xestoleberis marssoni*.

Key words: Ostracoda, Turonian, Coniacian, biostratigraphy, palaeoecology.

CONTENTS – *TABLE DES MATIÈRES*

INTRODUCTION

In the south of England, the Turonian and Coniacian stages of the Late Cretaceous are represented by bioclastic chalks with thin marl bands or flazer marls, horizons of flints and groups of hardground surfaces associated with nodular chalks. In the cliff section at Langdon Stairs, Dover, S.E England, around the level of the Turonian/Coniacian boundary, there is approximately 20 m of chalk with three distinct groups of hardground surfaces. This stratigraphical interval has been interpreted as representing a regressive phase (Hancock, 1990). This study is to examine the response of the ostracod fauna across the boundary sequence in order to assess the use of ostracods as palaeoenvironmental indicators, in this case as pointers to relative palaeodepths within the shallow shelf sea during the Late Cretaceous.

A series of 39 samples, including 10m of flinty white chalks above and below the hardground packages has been studied, using distributions of higher taxonomic groupings, diversity patterns and statistical clustering, to see if the regressive nature of the sedimentation, and the consequent facies change, is reflected in the ostracod assemblages.

1. — PREVIOUS WORK

Very little has been published on the Ostracoda of the Turonian or Coniacian of Britain. The first record was that of Jones & Hinde (1890), of the twenty-six species and four varieties described there, twenty-one species were from Chalk Rock outcrops of the *Holaster planus* Zone at Dunstable, Chinnor and West Wycombe. This is equivalent to the Kingston Nodular Chalks (*S. plana* Zone) of the Dover section. Kaye (1964) in a revision of Jones & Hinde's work, redescribed and illustrated nine species from the Chalk Rock. Neale (1978) incorporated five Late Turonian species in his stratigraphical range chart, some of the data were taken from KING (1968). All the aforementioned treatments of Turonian ostracods only imply whether any given taxon is present in a macrofaunal Zone, and are therefore of limited use for high resolution biostratigraphy. Horne & Rosenfeld *In:* Jarvis *et al.* (1988) show the ranges of fourteen species against a detailed lithostratigraphical log of the Lower Turonian from Akers Steps, Dover. Horne *et al.* (1990) in a continuation of the previous work, presented a range chart of twenty-eight species from the Turonian sections at Abbots Cliff, Akers Steps and East Cliff at Dover, and demonstrated the recovery of the fauna after the Cenomanian Turonian Oceanic Anoxic Event. Slipper (1996) examined the lowest Turonian from Abbots Cliff using improved processing methods, and concluded that the recovery was much more rapid than previously thought. Sixteen species were found in basal Melbourn Rock, rising to thirty-four species below the Round Down Marl. The only information on British Coniacian ostracods yet published is included in Horne (1988) where a faunal list of twenty-seven species is given for the Turonian to Coniacian at Langdon Stairs. In Europe, taxonomic works including Turonian Ostracoda have been published by Grundel (1970, 1970a), Colin (1974), Damotte (1962), Babinot *et al.* (1982), Colin *et al.* (1982), Pokorny (28 papers between 1963-1987, Rocek (1982), Pokorny (1984, 1987), biostratigraphical works are given by Colin & Damotte (1985), Babinot *et al.* (1985). Ostracoda from the Coniacian have been included in works by Donze (1970), Clarke (1983), and Rodríguez-Lazaro (1988).

2. — LOCATION

Langdon Stairs (Grid Ref. TR 345424) is situated north-east of Dover and is a series of zigzag paths which were cut into the cliff face during the Napoleonic Wars. The Stairs are maintained by The National Trust, and are accessible from the car park at Langdon Cliffs. Lithostratigraphical logs (Robinson, 1986; Horne, 1988; Gale *et al.* 1993) indicate the levels of the base of each path section numbering from 1 at the level of the gun emplacements (Caburn Marl) to 6 at the top in the Late Coniacian. The entire sequence at Dover has been sampled as part of a larger project preparing a Monograph of Turonian Ostracoda of southern Britain, but for the present work samples were selected from the Middle/Upper Turonian boundary (Southerham Marl 1), which is found at beach level, up to the *cortestudinarium/coranguinum* Zone boundary (Shoreham Marl 2) at the top of path 3.

3. — STRATIGRAPHY

The stratigraphy of the Late Cretaceous now seems to be in a state of constant change which commenced in 1986 with the simultaneous publication of two mutually exclusive lithostratigraphical schemes for the white chalk of southern England (ROBINSON 1986; MORTIMORE 1986). Various modifications have been suggested to rationalise the two schemes (ROBINSON 1987; MORTIMORE 1987; GALE *et al.* 1987), and more recently GALE (1996) has erected a new stratigraphical scheme and correlation for the Turonian. In addition to this, the biostratigraphical stage and substage markers are in the process of revision and ratification following the International Cretaceous Stage Boundaries Symposium in Brussels in 1995.

3.1 LITHOSTRATIGRAPHY.

All the chalk in this study is placed in the St. Margarets Member of the White Chalk Formation, which was modified by GALE (1996) after ROBINSON (1986) to include additionally the chalk between the Pewsey Hardground phosphates and the Caburn Marl. This is equivalent to the Lewes Member of MORTIMORE (1986). In the logs accompanying the ostracod data of JARVIS *et al.* (1988) and HORNE *et al.* (1990) the lithostratigraphical scheme used was that of ROBINSON (1986). The marker beds as used by MORTIMORE (1986) have been shown to correlate across the basin (MORTIMORE 1987; MORTIMORE & POMEROL 1987; GALE 1996) and have been used by others (JENKYNS *et al.*, 1994; SLIPPER, 1996), and it is these names which will be used in the present work. To enable correlation between this and earlier ostracod records the marker bed names are given in stratigraphical order with the equivalent of ROBINSON (1986) in parentheses: Southerham Marl (Langdon Bay Marl), Caburn Marl (Crab Bay Marl), Bridgewick Hardgrounds (Bantam Hole Hardgrounds), Bridgewick Marls (Fan Bay Marls), Kingston Nodular Chalks (Lighthouse Down Hardgrounds), Navigation Hardgrounds (South Foreland Hardgrounds), Cliffe Hardground (Parlour Hardground), Hope Gap Hardground (Pines Gardens Hardgrounds), Beeding Hardground (Bay Hill Hardground) and Lightpoint Hardgrounds (Corn Hill Hardgrounds).

3.2 BIOSTRATIGRAPHY.

The traditional tripartite division of the Turonian after BARROIS (1876) is still used (JENKYNS *et al.* 1994) with modifications particularly in the lower Turonian zones where *Mytiloides* spp. has replaced *Inoceramus labiatus*. In the section of the present study, the chalk up to the base of the Bridgewick Hardgrounds is considered as *Terebratulina lata* Zone, while the chalk up to Navigation Hardground 1 is placed in the *Sternotaxis plana* Zone, that above is of the *Micraster cortestudinarium* Zone. Ammonites have been used also to erect a zonation of the Late Cretaceous (HANCOCK 1991; GALE 1996), however they are rare in the chalk facies and difficult to use. GALE (1996) has established a zonation based on ammonite records from several locations across the basin: in this work the Turonian chalk is *Subprionocyclus neptuni* Zone and the Coniacian is *Forresteria petrocoriense* Zone.

3.3 THE TURONIAN CONIACIAN BOUNDARY.

This has been defined as the entry of the ammonite *Forresteria* (*Harleites*) *petrocoriense* (COQUAND) (BIRKELUND *et al.*, 1984; KENNEDY, 1984). A single specimen has been found at the level of Navigation Hardground 3 at Langdon Stairs (GALE & WOODROOF, 1981), and the boundary is placed just below this hardground (BAILEY *et al.*, 1984). At the second International Symposium on Cretaceous Stage boundaries held in Brussels in 1995 a proposal was made that the boundary should be identified by the first appearance of the inoceramid *Cremnoceramus rotundatus*. MORTIMORE (1986) shows this to appear at the upper of the two Navigation Marls, less than 1 m above the boundary as defined in 1984.

4. — METHODS

The 39 samples were processed by the freeze-thaw method as detailed by SLIPPER (1996). Where possible 300 individuals were picked from the residues, which gave a total of 7349 specimens. Identification was often hampered by adherent matrix, which was removed by gluing the specimen to a slide using "Pritt glue stick" and prodding with the shortened bristles of a 000 sable brush. Where more cemented matrix was encountered, the specimen was cradled in the bristles of a picking brush whilst the matrix was gently removed using an acupuncture needle. Whilst this enables external features to be seen, recrystallisation has invariably destroyed any muscle scars. Coniacian specimens are on the whole better preserved than those from the Turonian, where it was possible to identify the *Xestoleberis* spot in some specimens.

5. — RESULTS

Eighty-one species and subspecies ranged in thirty-seven genera have been recovered from the Upper Turonian and Lower Coniacian of Dover. Fifty-six of these species have been described from the Upper Cretaceous of Europe, thirteen are tentative assignments requiring further study, and the remaining twelve are left in open nomenclature. It is useful to present the faunal list in sections according to their stratigraphical distribution, (figs 1 and 2)

Group 1: 36 long ranging species which first appear before the Southerham Marl 1 (Middle/Upper Turonian boundary) and whose extinction is later than the top of the *M. cortestudinarium* Zone (mid Coniacian).

Amphicytherura cf. *A. chelodon* (MARSSON, 1880)
Bairdoppilata dentifera (van VEEN, 1936)
Bairdoppilata litorea POKORNY, 1980
Bairdoppilata septentrionalis (BONNEMA 1940)
Bythoceratina (*B.*) *bonnemai* (DEROO, 1966)
Bythoceratina (*B.*) *umbonatoides* (KAYE, 1964)
Bythoceratina (*Cuneoceratina*) *pedatoides* (BONNEMA, 1941)
Bythoceratina montuosa (JONES & HINDE, 1890)
Curfsina senior POKORNY, 1967

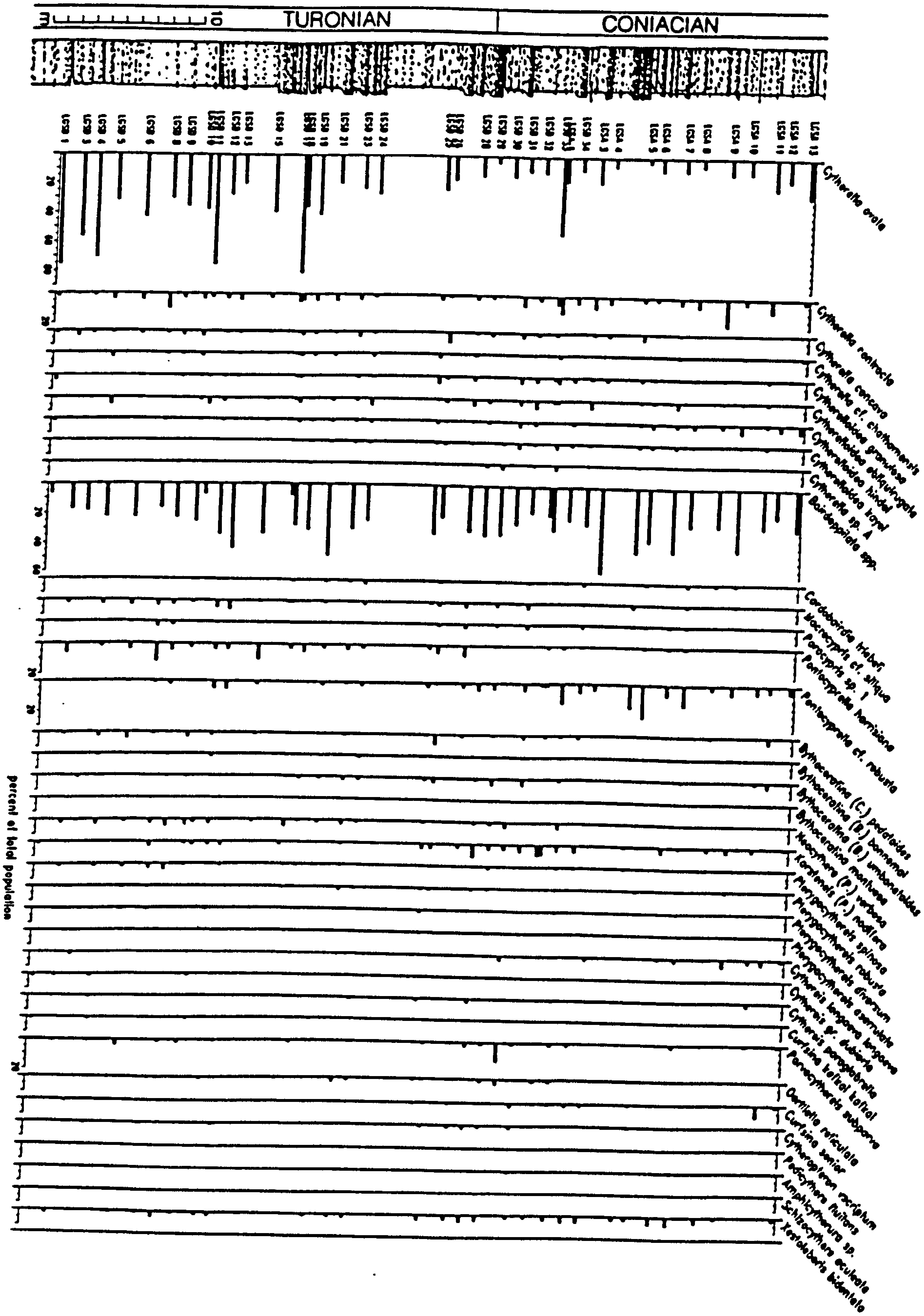

FIGURE 1

Occurrence of long ranging ostracods over the Turonain/Coniacian boundary section at Dover, as a percent of the total population.

Ostracodes à grande répartition sur la limite de la coupe Turonien/Conacien, pourcentage de la population totale.

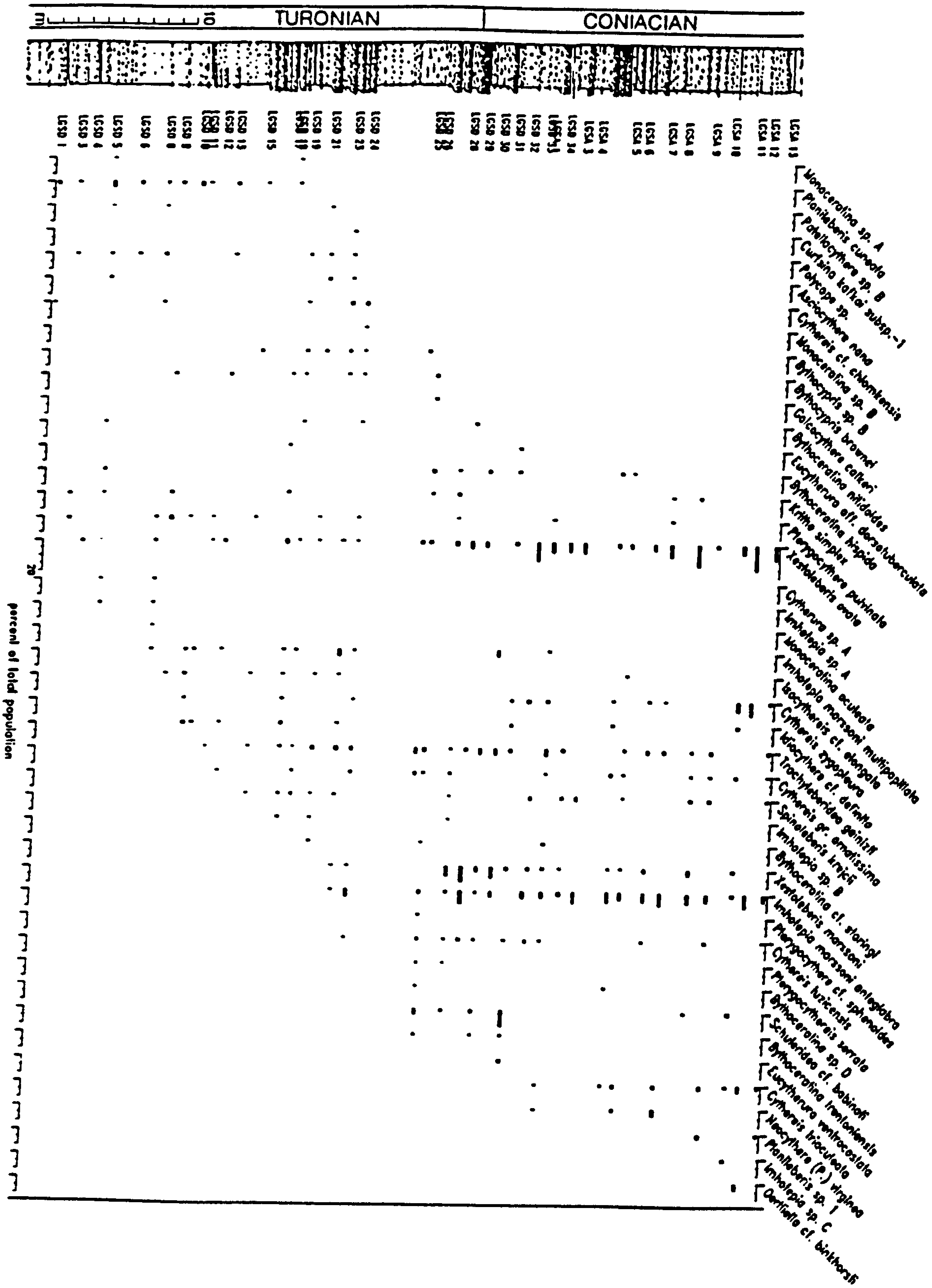

Figure 2

Occurrence of Upper Turonian and Lower Coniacian ostracods at Dover, with either first appearance or extinction in the section, as a percent of the total population.

Ostracodes du Turonien supérieur et du Coniacien inférieur à Douvres, avec soit première apparition ou soit extinction dans la zone, pourcentage de la population totale.

Cythereis gr. *dubiorta* Ohmert, 1967 (*sensu* Damotte, 1971)
Cythereis longaeva longaeva Pokorny, 1963
Cythereis paraglabrella Pokorny, 1965
Cytherella cf. *C. chathamensis* Weaver, 1982
Cytherella concava Weaver, 1982
Cytherella contracta Van Veen, 1932
Cytherella ovata (Roemer, 1840)
Cytherelloidea granulosa (Jones, 1849)
Cytherelloidea hindei Kaye, 1964
Cytherelloidea kayei Weaver, 1982
Cytherelloidea obliquirugata (Jones & Hinde, 1890)
Cytheropteron (Aversovalva) vscriptum Van Veen, 1936
Karsteneis (Prosteneis) cf. *nodifera* (Kafka, 1886)
Macrosarisa siliqua (Jones, 1849)
Neocythere (Physocythere) verbosa (Damotte, 1962)
Oertliella reticulata (Kafka, 1886)
Paracypris cf. *P. wrothamensis* Kaye, 1965
Parvacythereis subparva (Pokorny, 1967)
Pedicythere fluitans (Bonnema, 1941)
Pontocyprella harrisiana (Jones, 1849)
Pontocyprella robusta Weaver, 1982
Pterygocythereis cf. *P. aserrulata* (Bonnema, 1940)
Pterygocythereis diversum (Clarke, 1983)
Pterygocythereis robusta (Jones & Hinde, 1890)
Pterygocythereis spinosa (Reuss, 1846)
Schizocythere aculeata (Bonnema, 1941)
Xestoleberis bidentata Bonnema, 1941

Group 2: 18 species whose current distribution suggests that they are confined to the British Turonian.

Asciocythere nana Nuyts, 1990
Bythocypris brownei Jones & Hinde, 1890
Bythocypris sp. B
Curfsina kafkai Pokorny, 1967
Cythereis cf. *C. chlomkensis* Pokorny, 1965
Cytherura sp. A
Cytherura sp. B
Golcocythere calkeri (Bonnema, 1941)
Imhotepia sp. A
Imhotepia sp. B
Monoceratina aculeata Van Veen, 1936
Monoceratina sp. A
Monoceratina sp. B
Patellacythere sp. B
Planileberis cuneata (Kafka, 1886)
Polycope sp.
Pterygocythere cf. *sphenoides* (Reuss, 1854)
Pterygocythereis serrata (Bonnema, 1940)

Group 3: 3 species originating below the Southerham Marl 1 and becoming extinct in the Lower Coniacian.

Bythoceratina hispida (Van Veen, 1936)
Bythoceratina nitidoides (Bonnema, 1941)
Eucytherura cf. *E. dorsotuberculata* van Veen, 1938

Group 4: 18 species first appearing in the Upper Turonian and ranging through into the Coniacian.

Bythoceratina cf. *staringi* (Bonnema, 1941)
Bythoceratina sp. D
Bythoceratina trentoniensis (Bonnema, 1941)
Cardobairdia triebeli Nuyts, 1990
Cythereis gr. *ornatissima* Pokorny, 1963
Cythereis luzicensis Pokorny, 1965
Cythereis zygopleura Pokorny, 1965
Idiocythere sp. cf. *I. definita* Herrig, 1965
Imhotepia marssoni anteglabra (Pokorny, 1964)
Imhotepia m. multipapillata (Pokorny, 1964)
Isocythereis sp. cf. *I. elongata* Weaver, 1982
Krithe simplex (Jones & Hinde, 1890)
Pterygocythere pulvinata Damotte, 1962
Schuleridea sp. cf. *S. babinoti* Rodríguez-Lazaro, 1988
Spinoleberis krejcii Pokorny, 1969
Trachyleberidea geinitzi (Reuss, 1874)
Xestoleberis marssoni Bonnema, 1941
Xestoleberis ovata Bonnema, 1941

Group 5: 6 Coniacian species with first appearances in the *M. cortestudinarium* Zone.

Cythereis triaculeata Clarke, 1983
Eucytherura ventrocostata Clarke, 1983
Imhotepia sp. C
Neocythere (Physocythere) virginea (Jones, 1849)
Oertliella cf. *O. binkhorsti* (Van Veen, 1936)
Planileberis sp. A

6. — OSTRACOD BIOSTRATIGRAPHY

6.1. DISTRIBUTION OF HIGHER TAXA

Thirty-one first appearances and twenty-six apparent extinctions occur within this section, the rate of first appearances is fairly constant up to the Late Turonian, then somewhat discontinuous thereafter. The stratigraphical occurrence is described here for each higher taxonomic group.

The Platycopida are initially important in the Turonian (see palaeoecology), and are reduced at the Turonian/Coniacian boundary, where they are replaced by the Bairdiacea which become dominant. The Cytheracea are the most diverse group in the study and give the most useful stratigraphical information.

The Bythocytheridae are well represented in the Upper Turonian with maximum diversity reached at the level of the Navigation Hardgrounds. A faunal turnover is seen earlier at the Bridgewick Hardgrounds/Kingston Nodular Chalk complex. At this level are the extinctions of *Patellacythere* sp. B, *Monoceratina* sp. A and *Monoceratina* sp. B. (Pl.1, fig. C), and the first appearance of *Bythoceratina* cf. *staringi* (Pl. 1, fig. G). The maximum abundance of the more common species *Bythoceratina pedatoides* and *B. umbonatoides* coincides with the first appearances of *Bythoceratina* sp. D (Pl. 1, fig. F) and *Monoceratina trentoniensis* (Pl. 1, fig. M) at Navigation Hardground 1. Just above Navigation Hardground 3 are the last records of *B. nitidoides* (Pl. 1, fig. E).

Two species of *Neocythere* (*Physocythere*) represent the Progonocytheridae: *N.* (*P.*) *verbosa* and *N.* (*P.*) *virginea*. The former is present throughout the range of this study, but becomes very rare in the Early Coniacian where it appears to be replaced by *N.* (*P.*) *virginea*. (Pl. 1, fig. R). Both species coexist in the latest Coniacian.

Karsteneis (*Prosteneis*) *nodifera* occurs throughout the studied interval but shows fluctuations in abundance at the facies boundaries, but not always in a consistent manner. It is present in moderate numbers in the white chalk of the *lata* Zone, is very poorly represented during the hardgrounds of the early *plana* Zone, then shows a maximum over the hardgrounds at the stage boundary before returning to moderate/-low numbers in the flinty chalks above the Lightpoint Hardgrounds.

Species within the Brachycytheridae are generally more abundant in the Late Turonian than in the Early Coniacian. They display a pattern very similar to the above protocytherids with two maxima, one in the *lata* Zone chalk and one at Navigation Hardground 1. This later maximum coincides with the greatest diversity within the Brachycytheridae where the distinctive species *Pterygocythereis serrata* and *Pterygocythere* cf. *P. sphenoides* are found.

The Schizocytheridae and Cytheruridae are present only in low numbers in the Turonian and Coniacian but do display the same double maxima pattern of the previous higher taxa, below Caburn Marl and above the Navigation Hardgrounds.

A important component of the fauna as noted by Horne *et al.* (1990) is the Xestoleberidae. *Xestoleberis ovata* appears (Pl. 1, fig. P) above Southerham Marl 2, while *X. marssoni* (Pl. 1, fig. O) first appears in the Kingston Nodular Chalks. It is not until Navigation Hardground 1 that these species become very abundant, making up 10% of the total fauna.

The biostratigraphy of the Trachyleberididae is particularly interesting within the Late Turonian Bridgewick Hardgrounds and the Kingston Nodular Chalks. A sequence of species and subspecies of *Imhotepia* is seen which is similar to that demonstrated by Pokorny (1964, 1964a). *Imhotepia* sp. A is replaced by *Imhotepia marssoni multipapillata* in the late *lata* Zone which continues with abundance up to the top of the Kingston Nodular Chalks. This subspecies is then replaced by *I. marssoni anteglabra* (Pl. 1, fig. K) which is quite abundant through the Latest Turonian and Coniacian. *Imhotepia* sp. B (Pl.1, fig. B) occurs together with *I .marssoni multipapillata* but has a more restricted vertical range. Near the top of the section, just below the *cortestudinarium*/*coranguinum* boundary is the first appearance of *Imhotepia* sp. C, which is found together with *I. marssoni anteglabra*. *Idiocythere* cf. *definita* (Pl.1, fig. J) and *Cythereis zygopleura* (Pl.1, fig. I) appear immediately below Caburn Marl. *Spinoleberis krejcii* first occurs at the *lata* / *plana* Zone boundary. There are fewer extinction than arrivals over the boundary interval and those are concentrated at the Bridgewick-Kingston complex. *Planileberis cuneata* is last seen at the upper Bridgewick Hardground while *Curfsina kafkai* subsp.-1 and *Cythereis* cf. *chlomkensis* both exit within the Kingston Nodular Chalks. Over the boundary sequence where the maximum diversity occurs there are a number of absent trachyleberid species which are present above and below: *Imhotepia marssoni multipapillata*, *Isocythereis* sp. cf. *I. elongata*, *Cythereis longaeva*, *Cythereis* gr. *dubiorta*, *Cythereis zygopleura* and *Idiocythere* cf. *definita*.

6.2. THE TURONIAN CONIACIAN BOUNDARY

The response of the Ostracoda at the boundary sequence can be characterised by either first appearances, extinctions or by flood occurrences at either Navigation Hardground 1 or Navigation Hardground 3. These clearly define six different possibilities.

Group 1, those with events at or near Navigation Hardground 1.

A. First appearances immediately below Navigation Hardground 1.

Bythoceratina sp. D
Bythoceratina trentoniensis
Pterygocythere cf. *sphenoides*
Pterygocythereis serrata
Schuleridea cf. *babinoti*

B. Extinction immediately below Navigation Hardground 1.
Golcocythere calkeri

C. Flood occurrence below Navigation Hardground 1.
Bythoceratina pedatoides
Bythoceratina umbonatoides
Karsteneis (*P.*) *nodifera*

Group 2, those with events at or near Navigation Hardground 3.

A. Extinction immediately below Navigation Hardground 3.
Imhotepia sp. B

B. Flood occurrence below Navigation Hardground 3.
Xestoleberis spp.

C. Extinction immediately above Navigation Hardground 3.
Bythoceratina nitidoides

It is difficult to recognise the Turonian/Coniacian boundary in terms of extinctions since the species listed above in 1B, 2A, and 2C are all minor components of the fauna. It is possible that they might occur in younger strata but have not yet been discovered due to their rarity. This makes them unsuitable markers for any stratigraphical scheme. It is also difficult to use the first appearances since the strong influx of new species seems to occur below Navigation Hardground 1 rather than 3 where the boundary is traditionally placed. In addition to this, these species are also quite rare. The exception is *Schuleridea* cf. *babinoti* (Pl. 1, fig. N) which does appear suddenly and in good numbers. The only significant event to take place at the accepted boundary is the strong *Xestoleberis* signal. *Xestoleberis marssoni* has been found in the Turonian; 1 fragment and a single valve from the Kingston Nodular Chalks. However, at the boundary this species increases in numbers and accounts for 5% of the total fauna.

There is perhaps a case for considering the main faunal event, as far as the Ostracoda are concerned, to have occurred below the Navigation Hardground 1 approximately two metres below the currently accepted boundary at Dover. This interpretation agrees with Bailey *et al.* (1983) and Pomerol (1985) who noted that the macrofaunal turnover occurred below the Top Rock with the entry of *Micraster decipiens*, and Pomerol *et al.* (1987) who placed the boundary sequence between the Lewes and Navigation beds on evidence from both foraminifera and macrofauna.

6.3. CLUSTER ANALYSIS

The data from all 39 samples, resulting in 7349 specimens distributed among 82 species and subspecies was subjected to a stratigraphically constrained cluster analysis using the CONISS computer program (Grimm, 1987). The square root transformation using the chord distance of Edwards & Cavalli-Sforza (1964) was employed as this tends to upweight the rare variables (Grimm, 1987). This is a useful approach since most of the Late Cretaceous faunas are dominated by long ranging species of genera such as *Cytherella, Bairdoppilata* and *Pontocyprella*. The short ranging species which supply most of the stratigraphical information are found in lower numbers than the long ranging dominant genera, so the square root transformation extracts the useful stratigraphical information from the background. When clustering with either total sum of squares or within-cluster sum of squares, the same high level result occurred, though within cluster sum of squares gave a clearer result when the stopping rule for fusion levels from dissimilarity matrices was applied (Everitt & Dunn, 1991).

The resultant dendrogram, fig. 3, shows two significant clusters which separate between samples LGSD25 and LGSD26. This division corresponds to the Zoophycos maximum just below Navigation Hardground 1, where the ostracods demonstrate a small faunal turnover as detailed above. The numerical technique has supported the contention that as far as the Ostracoda are concerned the main event falls below the Turonian/Coniacian boundary as defined by the first appearance of *Cremnoceramus rotundatus*.

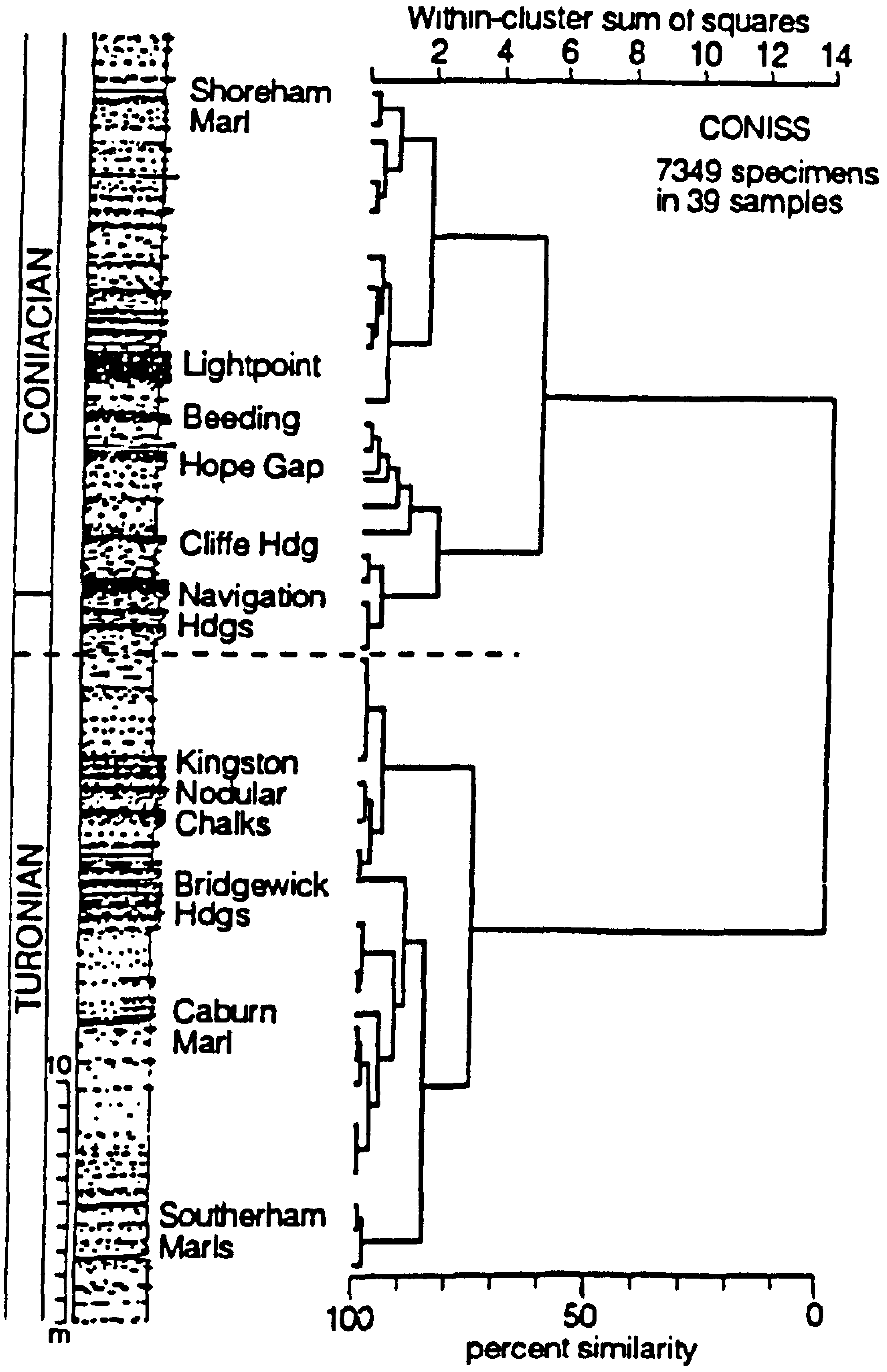

Figure 3.

Stratigraphically constrained cluster diagram using square root transformation for the Upper Turonian and Lower Coniacian ostracods at Dover. The significant clusters divide samples in the base of Navigation Hardground 1, approximately 2 m below the stage boundary.

Diagramme rassemblé stratigraphiquement contraint utilisant les transformations de racine carrée pour les ostracodes du Turonien supérieur et Coniacien inférieur à Douvres. Le rassemblage significatif divise les echantillons selon la base de Navigation Hardground 1, approximativement à 2 mètres sous la limite de la section.

7. — PALAEOBIOGEOGRAPHY

By comparing the relative timing of first appearances of species between S.E. England, as described here, the Paris Basin (Damotte 1971), Saxony (Gründel 1970, 1970a) and Bohemia (Pokorny 1979), it should be possible to identify the origins of the Late Cretaceous fauna and to indicate possible migration pathways.

There are surprisingly few species in common with the Paris Basin (Damotte, 1971, table 7), given that it is geographically closer to the English site than other locations. To compound this, it appears that the German and more distant Bohemian faunas have more species in common with the English than with the French fauna. This indicates that dispersal of ostracods within and around the Anglo-Paris Basin may have favoured east-west rather than north-south movements.

Comparison with the Bohemian Fauna

The ranges of fifteen species from the Bohemian Turonian and Coniacian (Pokorny, 1979 and unpublished data) can be compared with the ranges found at Dover, fig. 4. Three groups emerge from the ranges when considering the

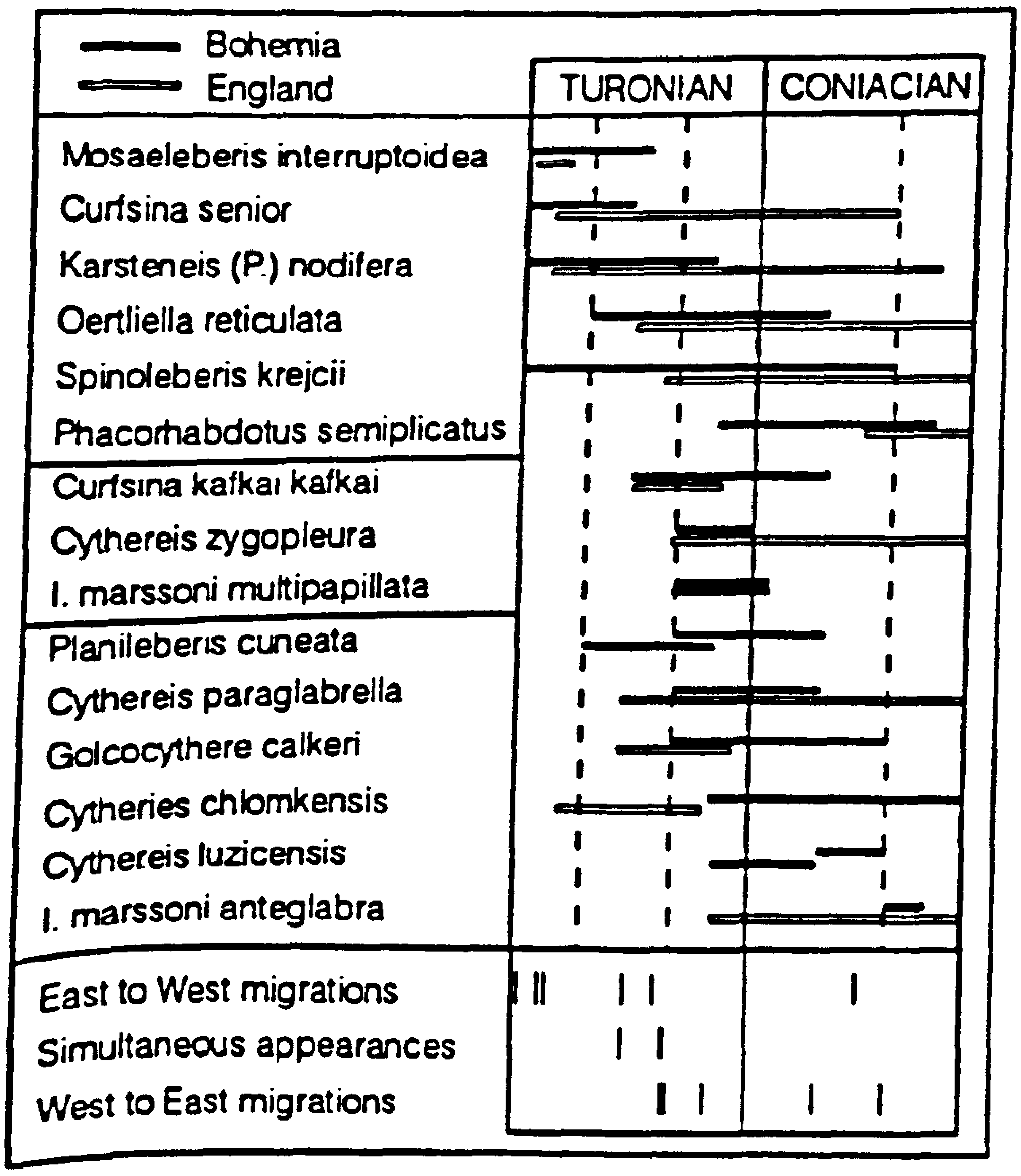

FIGURE 4

Biogeographical comparison of some common Turonian and Coniacian ostracod species in Bohemia (POKORNY, 1979) and England. Direction of migration reverses at the Mid/Late Turonian boundary.

Comparaison biogéographique d'espèces communes Turonien et Coniacien en Bohême (POKORNY, 1979) et Angleterre. La direction de la migration est inversée à la limite du Turonien Moyen/Supérieur.

timing of the later first appearance. The first group comprises those species first appearing in the Bohemian sediments, and then appearing later in the Dover section: *Mosaeleberis interruptoidea, Curfsina senior, Karsteneis (P.) nodifera, Oertliella reticulata, Spinoleberis krejcii and Phacorhabdotus semiplicatus*. The second group are those species with approximately simultaneous appearances at both locations: *Curfsina kafkai kafkai, Rehacythereis zygopleura* and *Imhotepia marssoni multipapillata*. This latter *Imhotepia* subspecies also appears at the same level in the Paris Basin (DAMOTTE, 1971). The third group consists of species and subspecies with a later first appearance in the east than in the west: *Planileberis cuneata, Cythereis paraglabrella, Golcocythere calkeri, Cythereis chlomkensis, Cythereis luzicensis* (Pl.1, fig. H) and *Imhotepia marssoni anteglabra*. In the Paris basin the first appearance of *Imhotepia marssoni anteglabra* is coincident with the later Coniacian horizon as seen in Bohemia. The records of GRÜNDEL (1970, 1970a) show some species in common, notably *Spinoleberis* sp. R. *sensu* GRUNDEL (= *S. krejcii*) and *Cythereis chlomkensis* both of which appear at intermediate stratigraphical levels between England and Bohemia.

Having established these groups, a pattern appears such that they may be characterised as stratigraphically distinct. The migrations of the first group mainly occur in the Early and Middle Turonian, the one exception to this is *P. semiplicatus*. The group with simultaneous appearances are found in the Middle Turonian and at the Middle/Late Turonian boundary. The migrations of the third group are found stratigraphically higher from the Middle/Late Turonian boundary to the Early/-Late Coniacian boundary. From this it may be suggested that migrations took place in the Lower and Middle Turonian in a westerly direction, and in the Late Turonian and Early Coniacian, this direction was reversed. The level at which this reversal took place is recognised in the field at Dover as the change in facies from white flinty chalk to hardground formation at the level of the Bridgewick Hardgrounds, the beginning of the regressive phase over the Turonian Coniacian boundary. Studies of palaeocurrent directions within marginal facies in the Bohemian Cretaceous Basin (SKOCEK & VALECKA, 1983) support this contention with evidence of unimodal non-tidal currents flowing from southeast to the northwest in the Lower Turonian, and from the northwest to the southeast in the Middle and Upper Turonian. The causes of the change in direction are not yet understood, but may relate to movement of basement blocks in Europe or larger scale oceanographic changes (T. VOIGT pers comm. 1997). Whatever the mechanism of the change, this shows how the migration of the Ostracoda are strongly influenced by the direction of oceanic currents.

8. — PALAEOECOLOGY

8.1. PLATYCOPID SIGNALS

The Platycopida represented by the genera *Cytherella* and *Cytherelloidea*, are present throughout the section and commonly make up 40% of the total population in the Turonian, but are reduced to 20% in the Coniacian. In the Turonian are four samples where the platycopids comprise 80% of the fauna. WHATLEY (1991) concluded that platycopid spikes were indicative of reduced oxygenation of the chalk sea, since the Platycopida are filter feeders and can aerate their local environment more efficiently. JARVIS *et al.* (1988) noted for the Cenomanian Plenus Marls that the dominance of platycopids in reduced oxygen conditions may be due to their having brood care. In the Turonian, each of these four samples corresponds to a thick marl band, in ascending order: Southerham Marls 1 and 2, Caburn Marl and Bridgewick Marl. In each of these spikes, excepting only the Bridgewick Marl, the Bairdiacea and Cytheracea are present, but the Cypridacea are absent. On examination of the assemblages it is clear that these have been subject to corrosion. This is most likely due to diagenetic pressure solution acting preferentially in the thick marl seams, this would destroy the thin shelled cyprids leaving the more robust valves to be preserved. However in the cases except the Southerham Marl 2, the Bairdiacea are slightly reduced to about 8% of the total fauna from an average of around 25%. Since these are also thick shelled taxa it indicates that a further process in addition to diagenetic alteration may have been operating, the environment during the deposition of the marls may have been unfavourable to groups other than platycopids. There is some evidence (DECONINCK *et al.*, 1991) that the correlatives of Caburn Marl and Bridgewick Marl 1 in the Boulonnais are of volcanic origin. Geochemical signatures from British marl seams suggests that Southerham Marl 1, Caburn and Bridgewick Marl 1 are bentonites resulting from the submarine alteration of volcanic tuffs, (D.S.WRAY, pers. comm.). This may account for the increased corrosion noted in these samples, and also the lower than expected proportion of bairdiaceans. The conclusions agree with those found for the Lower Turonian (SLIPPER, 1996), that the high percentage of platycopids in the marls may represent an initial environmental signal which has been overprinted by the later diagenetic alteration, thus artificially enhancing the true signal.

8.2. CCBC ANALYSIS.

An analysis of the fauna by the triangular CCBC plot (DINGLE, 1980, 1981) was carried out to try to determine the response of the ostracods to the changing water depths over the boundary sequence. This method involves grouping the assemblages for each sample into the proportions occupied by the Cytheracea, the Cytherellidae and the combined Bairdiacea and Cypridacea. These are plotted into triangular space, various fields within which have been defined by DINGLE (1981) as representing different depths for the Late Cretaceous chalk facies faunas of southern Africa. In simple terms it can be interpreted as the closer a point plots to the Cytheracea apex, the shallower the water. The points initially plot apparently randomly over the fields. When divided into discreet stratigraphical packages, groups of samples plot in more clearly defined areas (figs 5 and 6). The overlapping of the areas indicate the relative ages of each group of assemblages. In fig. 5, it can be seen that the Turonian group (1) plots in a relatively deep (> 500 m) field. This represents *S. neptuni* Zone samples from Southerham Marl 1 to Caburn Marl. The Turonian group (2) from Caburn Marl to the Kingston Nodular Chalks plots across three fields ranging from 300m to > 500 m. The highest Turonian and lowest Coniacian group (3) from the Navigation Hardgrounds to Beeding Hardground plots over all the fields which range from 100 m to > 500 m. A small group (4) of three samples from the Lightpoint Hardgrounds plot close together in the > 500 m field. The Coniacian group (5) which represents samples up to Shoreham Marl plots in four fields which relate to depths between 200 m and > 500 m. All depths given here are those determined for the African faunas and probably cannot be applied directly to the British situation, but the trends are probably still valid.

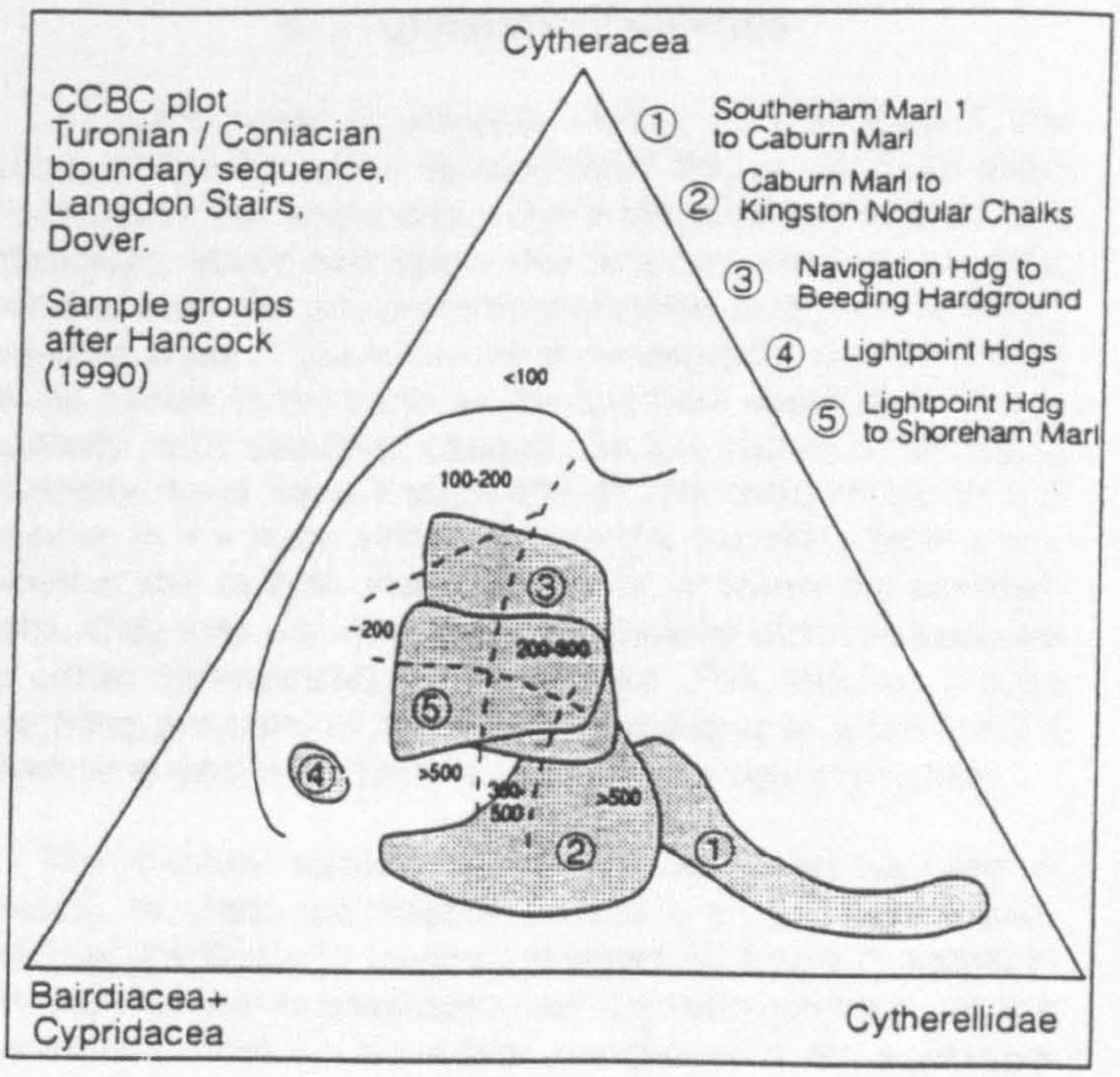

FIGURE 5

CCBC plot after DINGLE (1980) for the Upper Turonian and Lower Coniacian ostracods at Dover; samples grouped according to the facies analysis of HANCOCK (1990).

Positionnement CCBC d'après DINGLE (1980) pour les ostracodes du Turonien supérieur et Coniacien inférieur à Douvres : échantillons groupés selon l'analyse HANCOCK (1990).

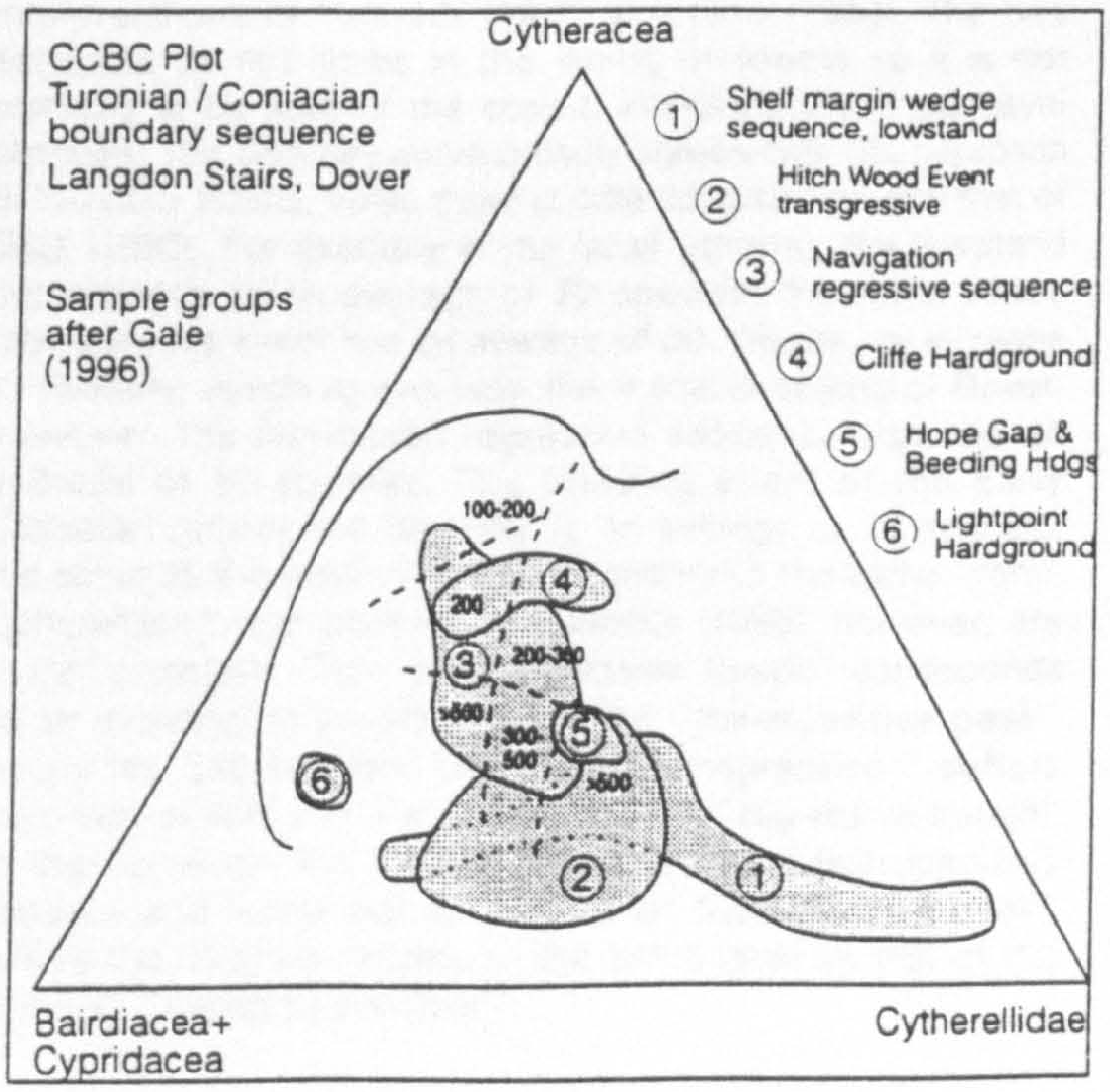

FIGURE 6.

CCBC plot after DINGLE (1980) for the Upper Turonian and Lower Coniacian ostracods at Dover samples grouped according to the sequence stratigraphical analysis of GALE (1996).

Positionnement CCBC d'après DINGLE (1980) pour les ostracodes du Turonien supérieur et Coniacien inférieur à Douvres sont groupés selon la séquence de l'analyse stratigraphique de GALE (1996).

8.3. COMPARISON WITH OTHER WORK

These findings fit well with the sea-level curves as presented by HAQ *et al.* (1988), which demonstrate a large second order regressive cycle at the Turonian/Coniacian boundary, but the resolution is not as fine as that of the sampling, so it is difficult to be certain of the timing of events. Initially the stratigraphical groups in fig. 5 were chosen to test the hypothesis of

HANCOCK (1990), who estimated sea-level changes by observing the occurrence of nodular chalks and hardgrounds which are thought to represent shallow water. The data fit this interpretation to a certain extent. HANCOCK (1990), indicates the end of a transgressive peak below Caburn Marl where the CCBC group 1 plot in the deepest field, with a dominance of cytherellids. Group 2 are representative of the "early Late Turonian deep regressive trough " of HANCOCK (1990). The data show a slight shallowing with a minimum of 300 m. There are no data points to correspond with the brief but distinct transgressive peak between groups 2 and 3 due to difficult exposure. The "early Coniacian regressive trough" of HANCOCK (1990) corresponds to samples in group 3 which show the shallowest sea-levels of the sequence at 100-200 m. The small group 4 corresponds to the last set of hardgrounds in the "early Coniacian trough", and suggests a much deeper water environment, here dominated by the Bairdiacea. This is transitional to the minor transgressive peak of late Coniacian, group 5, where the data suggest a shallower sea-level than the group 4 but deeper than group 3. Overall a there is a good correspondence between the ostracod data and the sea-levels of HANCOCK (1990).

This results given by this method do not agree so well with the putative sea-level curve given by GALE (1996) determined from sequence stratigraphical analysis. He disputed the theory of HANCOCK (1990) citing the fact that hardgrounds may develop in both regressive and transgressive environments, these could be identified by either glauconitic or phosphatic coatings respectively. By careful logging and examination of the sediment body geometry GALE (1996) has been able to accurately constrain the timing of the transgressive and regressive events during the Turonian. A second CCBC plot was made using a different grouping of samples which corresponded with the sequences identified by GALE (1996), fig. 6. The shelf margin wedge which developed at the time of lowstand occurs between Southerham Marls and Bridgewick Marls (GALE 1996 fig. 8b), where the CCBC plot suggest deep water ranging between 300-500m with majority of samples plotting in the deepest field dominated by cytherellids. The Hitch Wood Event, a complex phosphatised hardground which onlaps onto the basin margin above the Bridgewick Marl represents a short term sea-level rise (GALE 1996, fig.8a), and here the CCBC plot suggests the same depth ranges as the lowstand, between 300 and 500 m, but with a lower proportion of cytherellids. A brief sea-level fall is indicated by GALE (1996, fig 8b) at the Top Rock, which is equivalent to the Navigation Hardgrounds, and has been identified as a sequence boundary. The ostracod data support this interpretation with a distinct excursion into the shallowest field with a probable minimum depth of 100-200 m. The Cliffe, Hope Gap and Beeding Hardgrounds in the Coniacian are commonly phosphatised and have been identified as flooding surfaces (GALE, 1996). Again the ostracod data support this, with first the Cliffe Hardground falling between 200 and 300 metres, and the younger Hope Gap and Beeding Hardgrounds plotting in a restricted range at 300-500 m. The Lightpoint Hardgrounds are also phosphatised (MORTIMORE, 1986) and these indicate a progressive increase in sea-level.

9. — DIVERSITY CHANGES

An early model by POKORNY (1971), for the Upper Cretaceous Bohemian basin, demonstrated that an optimum depth zone exists for ostracods, where the diversity will be at a maximum, above and below this optimum zone the diversity will decrease. For any given transgressive or regressive event, marginal areas of the basin will show opposite diversity trends to the centre of the basin as the optimum depth zone moves spatially with sea-level change. So any report of changing diversity must have knowledge of the relationship of the position in the basin with regard to the optimum depth zone, whether the sample site be above, at or below the optimum zone. Only then can changes in diversity be correctly assigned to either transgression or regression. This requires a large sampling program to cover many positions in a basin for a given time period, and this is often not possible in practise.

The method outlined above can however be used in reverse, to obtain the relative position in a basin from known diversity changes and sea-level changes. This type of approach has applications in palaeogeographical reconstruction. At the Turonian/Coniacian boundary a regressive transgressive sequence has been identified. It is thought that at this time Dover lay close to the basin margin or near to a swell (MORTIMORE & POMEROL, 1987). So for a marginal environment the diversity would be expected to increase with transgression and decrease with regression.

Fig. 7. shows the simple species numbers diversity obtained from all samples in the study, together with sea-level interpretations of HANCOCK (1990) and GALE (1996). The two schemes do not agree in the timing of events so it is not possible to be sure of the correct interpretation of sea-level changes. The diversity curve broadly agrees with the approach of HANCOCK (1990), while there is little consistency with that of GALE (1996). For example in the latter scheme, the lowstand corresponds to an average of 22 species, the Hitch Wood transgressive event has an average of 30 species, an increase in diversity, which agrees with the marginal setting of Dover. However, the Navigation regressive sequence also has an average of 30 species. The flooding event of the Early Coniacian returns the diversity to an average of 22 species, the same as the earlier lowstand, contrary to the earlier trend. Comparisons with scheme of HANCOCK (1990), however, are more consistent. The "deep regressive trough" corresponds to an increase in diversity after the "transgressive peak" below the Caburn Marl. The "brief transgression " suffers from lack of data and is inconclusive. The "regressive trough" in the Coniacian has initially high diversity, which gradually reduces and levels out at the "minor transgressive peak" where the diversity returns to the same level as that of the Turonian "transgressive peak".

Species response to the regressive facies

As noted above there are six species absent over the regressive boundary interval at the Navigation Hardgrounds: *Imhotepia marssoni multipapillata*, *Isocythereis* sp. cf. *I. elongata*, *Cythereis longaeva*, *Cythereis* gr. *dubiorta*,

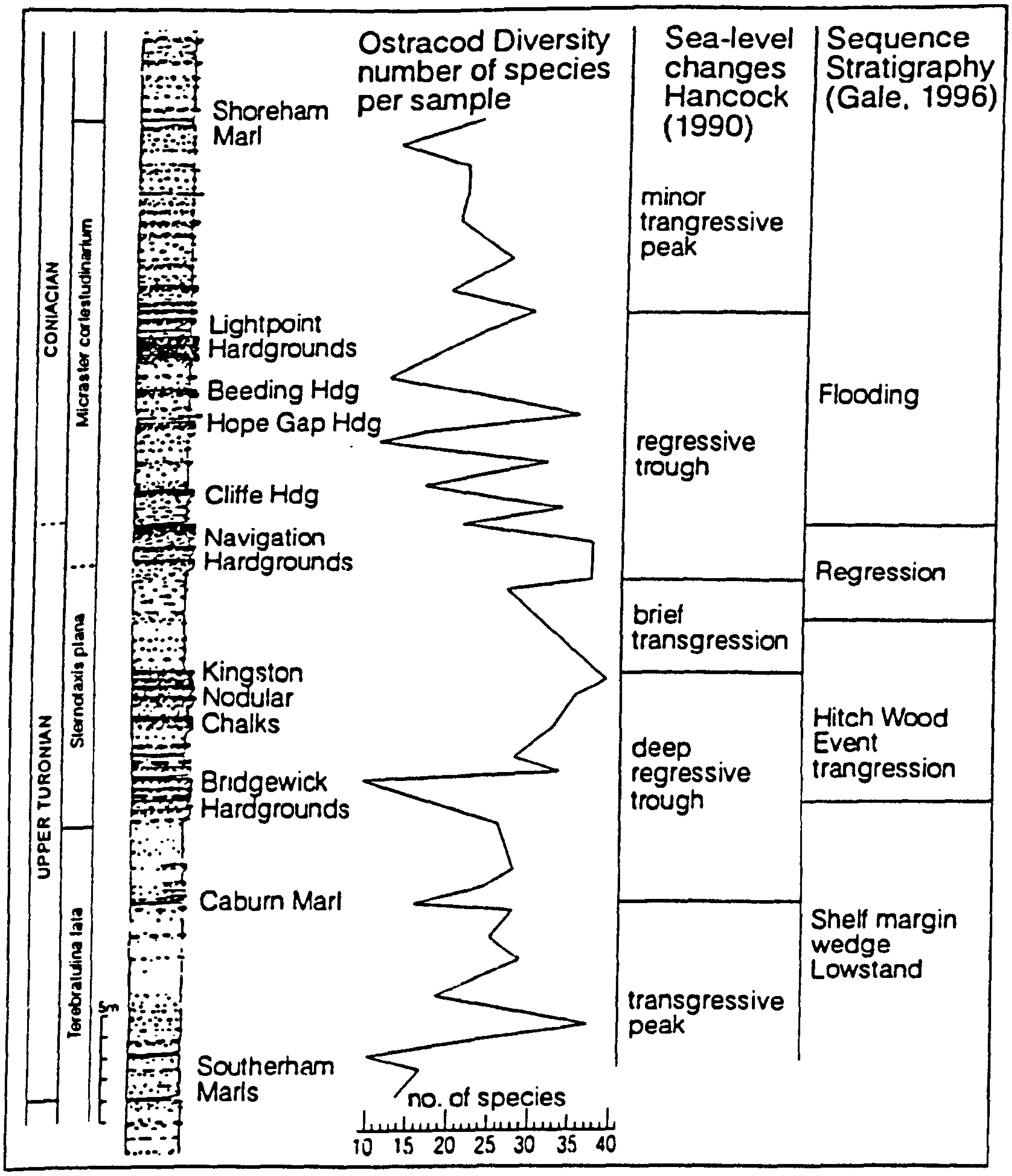

FIGURE 7

Diversity curve of simple number of species per sample for the Upper Turonian and Lower Coniacian ostracods at Dover, with comparative sea-level schemes of HANCOCK (1990) and GALE (1996) for the same section.

Diversity curve of simple number of species per sample for the Upper Turonian and Lower Coniacian ostracods at Dover, with comparative sea-level schemes of HANCOCK (1990) and GALE (1996) for the same section.

Cythereis zygopleura and *Idiocythere* cf. *definita*. It is difficult to believe that these have been missed from the residues since the recovery from these horizons was high and the diversity is at a maximum, in addition they are present both above and below. It is believed therefore that these species prefer deeper water outer shelf conditions. The absence is explained by migration out of the area during the regressive phase, followed by a return to the area during the subsequent transgression.

10. — CONCLUSIONS

1). The Turonian and Coniacian ostracod fauna of S.E. England is much more diverse than has previously been shown.

2). The main faunal event for Ostracoda is below the Navigation Hardground 1, which is below the currently accepted Turonian/Coniacian boundary.

3). East to west migrations took place in the Lower to Mid Turonian, while they occurred in the opposite direction in the Late Turonian and Coniacian. The timing of the change corresponds to the onset of the nodular hardgrounds of the boundary sequence at Dover, and is correlated with changing oceanographic currents in the Bohemian Cretaceous Basin.

4). Platycopida dominate in diagenetically altered marls.

5). Faunal analysis by CCBC plot supports the contention that the Turonian / Coniacian boundary sequence represents a regressive facies.

6). At Dover, diversity is inversely related to sea-level, thus placing the site at the deeper end of the ostracod optimum zone.

Acknowledgements

This work forms part of a research degree, I thank my employers in the School of Earth Sciences, University of Greenwich, who have enabled me to continue the project. This paper was presented at the 12th International Symposium on Ostracoda in Prague, 1994. I thank Amnon Rosenfeld for the use of his material prepared at the University of Greenwich, Dave Horne for collection of samples and use of prepared material, Andy Gale for stimulating discussion and Dave Wray for the use of his unpublished data. The photographs were taken by the author on a JEOL JSM35C, and I thank Bill Ralph and Pat Brown for the printing.

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PLATE *PLANCHE* 1

Selected ostracods from the Turonian and Coniacian of Langdon Stairs, Dover, S.E. England. All measurements taken optically.
Les Ostracodes du Turonien et Conacien de Langdon Stairs, Douvres, S.E. England. Toutes les mesures ont été prises optiquement.

Group 1, long ranging species;
A, *Pterygocythereis (Diogmopteron) spinosa* (Reuss, 1846), RV, BM OS 14603, AKSD54, 685 µm x 342 µm.

***Groupe 1**, Espèces à longue répartition;*
A, Pterygocythereis (Diogmopteron) spinosa (Reuss, 1846), VD, BM OS 14603, AKSD54, 685 µm x 342 µm.

Group 2, Turonian species;
B, *Imhotepia* sp. B, RV, AKS3/10, 575 µm x 300 µm.
C, *Monoceratina* sp. B, LV, LGSD24, 587 µm x 337 µm.

***Groupe 2**, espèces du Turonien ;*
B, Imhotepia sp. B, VD, AKS3/10, 575 µm x 300 µm.
C, Monoceratina sp. B, VG, LGSD24, 587 µm x 337 µm.

Group 3, Middle Turonian to Lower Coniacian;
D, *Bythoceratina hispida* (van Veen, 1936), LV, D-14, 662 µm x 312 µm.
E, *Bythoceratina nitidoides* (Bonnema, 1941), RV, AKS3/10, 537 µm x 312 µm.

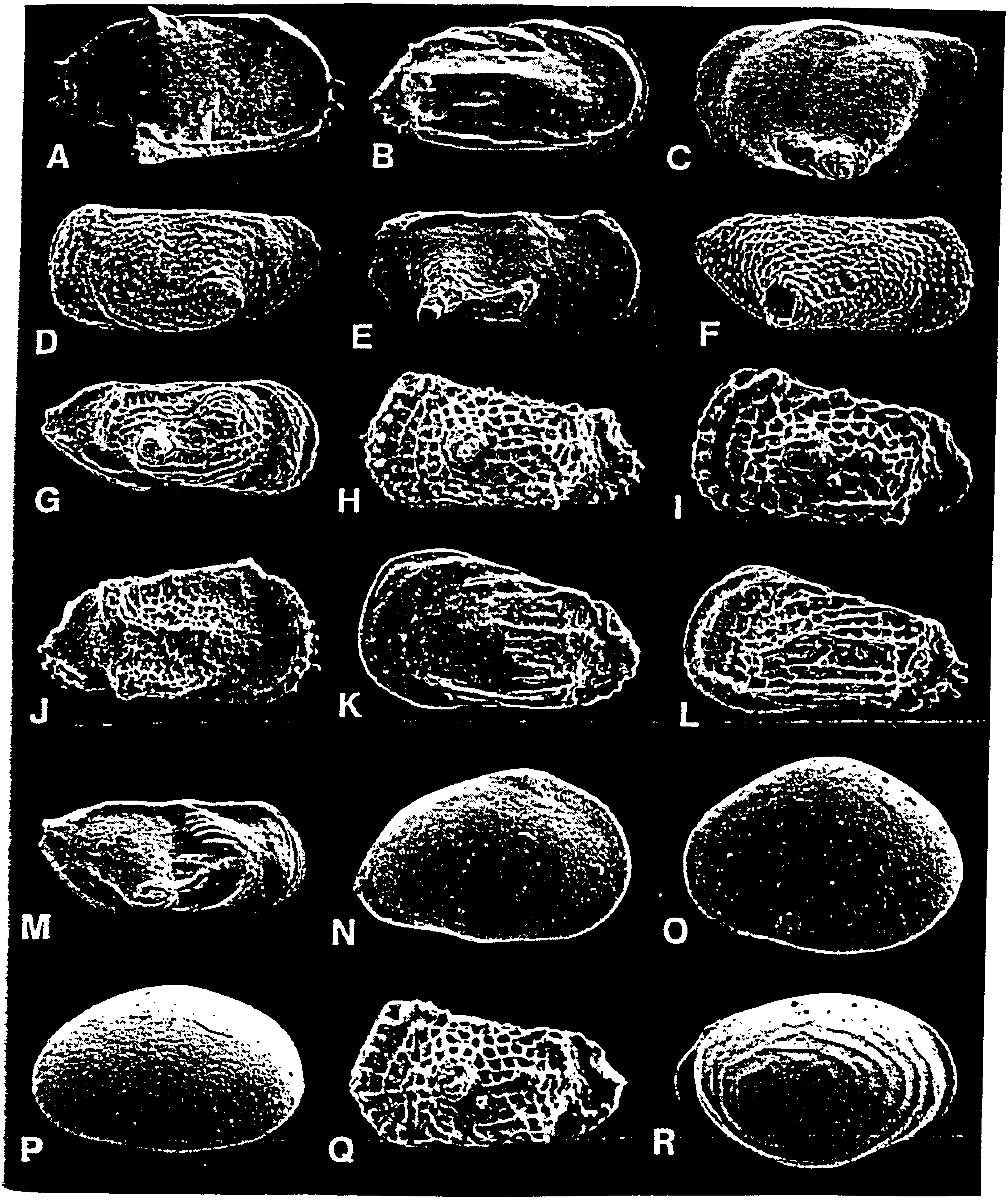
***Groupe 3**, Turonien moyen à Coniacien inférieur ;*
D, Bythoceratina hispida (van Veen, 1936), VG, D-14, 662 µm x 312 µm.
E, Bythoceratina nitidoides (Bonnema, 1941), VD, AKS3/10, 537 µm x 312 µm.

Group 4, Upper Turonian to Coniacian;
F, *Bythoceratina* sp..D, RV, LGSA5, 975 µm x 300 µm.
G, *Bythoceratina* cf. *staringi* (Bonnema, 1941), RV, LGSA2, 650 µm x 262 µm.
H, *Cythereis luzicensis* Pokorny, 1965, LV, LGSD26, 887 µm x 437 µm.
I, *Cythereis zygopleura* Pokorny, 1965, LV, LGSD34, 812 µm x 450 µm.
J, *Idiocythere* cf. *definita* Herrig, 1965, RV, LGSD23, 575 µm x 312 µm.
K, *Imhotepia marssoni anteglabra* (Pokorny, 1964), LV, LGSA13, 575 µm x 337 µm.
L, *Isocythereis* cf. *elongata* Weaver, 1982, LV, LGSD10, 600 µm x 312 µm.
M, *Bythoceratina trentoniensis* (Bonnema, 1941), RV, LGSD26, 625 µm x 275 µm.
N, *Schuleridea* cf. *babinoti* Rodríguez-Lazaro, 1988, LV, LGSD32, 575 µm x 375 µm.
O, *Xestoleberis marssoni* Bonnema, 1941, LV, LGSD30, 450 µm x 350 µm.
P, *Xestolebens ovata* Bonnema, 1941, LV, LGSD34, 450 µm x 287 µm.

***Groupe 4**, Turonien supérieur à Coniacien ;*
F, Bythoceratina sp. D, VD, LGSA5, 975 µm x 300 µm.
G, Bythoceratina cf. staringi (Bonnema, 1941), VD, LGSA2, 650um x 262um.
H, Cythereis luzicensis Pokorny, 1965, VG, LGSD26, 887 µm x 437 µm.
I, Cythereis zygopleura Pokorny, 1965,VG, LGSD34, 812 µm x 450 µm.
J, Idiocythere cf. definita Herrig, 1965, VD, LGSD23, 575 µm x 312 µm.
K, Imhotepia marssoni anteglabra (Pokorny, 1964), VG, LGSA13, 575µm x 337 µm.
L, Isocythereis cf. elongata Weaver, 1982, VG, LGSD10, 600µm x 312 µm.
M, Bythoceratina trentoniensis (Bonnema, 1941), VD, LGSD26, 625 µm x 275 µm.
N, Schuleridea cf. babinoti Rodriguez-Lazaro, 1988, VG, LGSD32, 575 µm x 375 µm.
O, Xestoleberis marssoni Bonnema, 1941, VG, LGSD30, 450 µm x 350 µm.
P, Xestoleberis ovata Bonnema, 1941, VG, LGSD34, 450 µm x 287 µm.

Group 5, Coniacian species;
Q, *Cythereis triaculeata* Clarke, 1983, LV, LGSA8, 800 µm x 425 µm.
R, *Neocythere (Physocythere) virginea* (Jones, 1849), RV, D31, 612 µm x 400 µm.

***Groupe 5**, espèces Coniacien ;*
Q, Cythereis triaculeata Clarke, 1983, VG, LGSA8, 800 µm x 425 µm.
R, Neocythere (Physocythere) virginea (Jones, 1849), VD, D31, 612 µm x400 µm.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